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Proceedings of the
18th European Conference on Games Based Learning
Hosted by Aarhus University
Denmark
3-4 October 2024



Dr. Kristine Kilså
Dr. Rajiv Vaid Basaiawmoit

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Proceedings of the

18th European Conference on Games Based Learning

ECGBL 2024

A Conference Hosted By

Aarhus University
Denmark

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Conference Proceedings Edited by

Dr. Kristine Kilså
Dr. Rajiv Vaid Basaiawmoit

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About the 18th European Conference on Games-Based Learning, 2024

The European Conference on Games-Based Learning (ECGBL) is a well-established academic conference, held annually since 2007, that serves as a hub for scholars, educators, and practitioners interested in the design, development, and application of games and gamification in education and training. The conference proceedings are published each year, contributing significantly to the research on how games can foster learning, engagement, and motivation across diverse educational settings.

ECGBL has been instrumental in advancing research on how games can transform education, offering a space for interdisciplinary collaboration between academics, game designers, and educators. It has significantly contributed to the understanding of how games can support learning in a variety of contexts and for diverse learner groups. By publishing its proceedings annually, the conference disseminates state-of-the-art research, case studies, and theoretical discussions that help shape the future of games-based learning. The conference is recognized for encouraging innovation in education and for highlighting the potential of games to engage learners, enhance motivation, and improve learning outcomes across all age groups and educational sectors.

The Proceedings of the 18th European Conference on Games-Based Learning, 2024 includes academic research papers, PhD research papers, Masters Research papers and work-in-progress papers which have been presented and discussed at the ECGBL 2024 conference. The proceedings are of an academic level appropriate toa professional research audience including graduates, post-graduates, doctoral and post-doctoral researchers. All papers have been double-blind peer reviewed by members of the Review committee.

Aims and Scope

ECGBL focuses on the intersection of games, technology, and education, aiming to advance knowledge and innovation in the field. The scope is comprehensive, addressing both the theoretical foundations and practical applications of games in various learning environments, and offering a venue for discussing new challenges and future directions in games-based learning.

Topics Covered

The call for papers for the ECGBL conference asked for contributions that considered the following topics. In addition, the committee welcomed papers o a number of specialist mini-tracks which can be seen at the end of this list.

Games-Based Learning (GBL) Theories and Models

- Exploration of theoretical frameworks underpinning games-based learning.
- Models that explain how and why games enhance learning.
- Cognitive and motivational theories related to gameplay and learning outcomes.
- The role of experiential learning and constructivism in game-based environments.

Game Design for Education

- Best practices in the design and development of educational games.
- Principles of gamification and how they can be applied to non-game contexts.

- User experience (UX) and user interface (UI) considerations for educational games.
- Collaboration between game designers, educators, and subject matter experts.

Serious Games for Skill Development

- Use of serious games to teach complex skills such as problem-solving, critical thinking, and teamwork.
- Case studies of games developed for professional training, including sectors like healthcare, military, and business.
- Games for soft skills development, including communication, empathy, and leadership.
- Assessing the effectiveness of games for skill acquisition and retention.

Gamification in Learning

- Application of gamification techniques to enhance motivation in traditional learning environments.
- Analysis of reward systems, leaderboards, badges, and progression mechanics.
- Gamification in corporate training and adult education.
- Balancing gamification elements with educational objectives.

Assessment and Evaluation in Games-Based Learning

- Methods for assessing learning outcomes in game-based learning environments.
- Use of analytics to measure engagement, progress, and knowledge retention in games.
- Adaptive learning and personalization through games.
- Challenges in standardizing assessment methods for GBL.

Games for Social and Emotional Learning

- Role of games in developing social-emotional skills, including empathy, resilience, and cooperation.
- Multiplayer and collaborative games that foster teamwork and communication.
- Addressing bullying, inclusion, and diversity through games.
- Games designed to build emotional intelligence and self-regulation.

Technology and Innovation in Games-Based Learning

- Emerging technologies in game-based learning, such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI).
- Use of mobile and tablet games for education.
- Integration of interactive simulations and immersive experiences in learning.
- Exploring the potential of mixed reality and AI-driven adaptive learning systems.

Games for Specific Learner Groups

- Games designed for early childhood education and primary school students.
- GBL approaches for secondary and higher education.
- Accessibility considerations for learners with special needs.
- Games tailored to adult learners and lifelong learning contexts.

Games-Based Learning in Formal and Informal Settings

- The role of games in formal education environments, including schools and universities.
- Use of games in informal and non-traditional learning settings, such as museums, libraries, and after-school programs.
- Community-driven game-based learning initiatives.
- Games for public awareness campaigns and societal impact.

Cultural and Ethical Aspects of Games-Based Learning

- Exploration of cultural contexts and their impact on game-based learning design and reception.
- Ethical considerations in the use of games for education.
- Addressing biases, stereotypes, and representation in educational games.
- Discussion of privacy, data security, and the digital well-being of learners in game-based environments.

Experts in the field proposed mini tracks on the following topics. Papers accepted to these tracks after the double-blind peer review process were presented as mini tracks at the conference and are also published in these proceedings.

- Citizen Science Games
- Games Promoting Critical Thinking, Scientific Communication and Literacy in STEM
- Educational Escape Rooms
- Game-based learning for lifelong learning
- Educational Non-Digital Games

The programme from the 2024 conference can be downloaded from here and full details about the conference can be seen from the conference website: https://www.academic-conferences.org/conferences/ecgbl/

ECGBL Preface

These proceedings represent the work of contributors to the 18th European Conference on Games Based Learning (ECGBL 2024), hosted by Aarhus University, Denmark on 3-4 October 2024. The Conference chair was Dr. Kristine Kilså and the Programme Chair was Dr. Rajiv Vaid Basaiawmoit

ECGBL is now a well-established event on the academic research calendar and now in its 18th year the key aim remains the opportunity for participants from around the world to share ideas and meet the people who hold them. The aims and scope of the conference is to be a forum for encouraging innovation in education and for highlighting the potential of games to engage learners, enhance motivation, and improve learning outcomes across all age groups and educational sectors. The scope of papers will ensure an interesting two days.

The opening keynote presentation was given by Pietro Michelucci from the Human Computation Institute, USA whose topic was *Gamified World: Blurring The Lines Between Education, Work, And Leisure*. The second day of the conference will open with an International Educational Games Panel Discussion on the topic of *Industry-Academia collaboration in Gaming and the future of Gaming in Education*. The panel was moderated by Rajiv Vaid Basaiawmoit, Head of Sci-Tech Innovation & Entrepreneurship, Aarhus Univeristy, and the panelists were Rikke Toft Nørgård, Aarhus University, Luke Savage, Head of Education Epic Games, UK, and Professor Deb Polson: Director of Centre of Digital Ecosystems (CODE) at RMIT University, Australia.

With an initial submission of 213 abstracts, after the double blind, peer review process there are 101 Academic research papers, 12 PhD research papers, 1 master's Research papers and 13 work-in-progress papers published in these Conference Proceedings. These papers represent research from Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, India, Ireland, Italy, Japan, Mexico, Netherlands, Norway, Oman, Poland, Portugal, Serbia, Slovakia, South Africa, Spain, Sweden, Switzerland, Taiwan, Turkey, UK and the USA.

We would like to thank everyone who participated in this conference.

Rajiv Vaid Basaiawmoit and Kristine Kilså
Aarhus University
Denmark
October 2024

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Biographies

Conference and Programme Chairs



Dr. Kristine Kilså graduated from the Dept. of Chemistry at University of Copenhagen and continued her research while obtaining a PhD degree in Physical Chemistry at Chalmers University of Technology in Sweden. After a long career in academia, bringing her from California to Copenhagen, she dedicated her career to education at the Swedish University of Agricultural Sciences, as the Head of Education and Management Support, as well as being the Coordinating Director of Studies and Assistant Faculty Director. As of 2020, she has the strategic responsibility for education at the Faculty of Natural Sciences at Aarhus University, as the Vice Dean for Education.



Dr. Rajiv Vaid Basaiawmoit graduated from the Dept. of Biotechnology at Madurai Kamaraj University in India and then completed his PhD in Biophysics from the Dept. of Biotechnology at Aalborg University in Denmark. He has been at Aarhus University since 2008 doing a series of post-doctoral stints at the Department of Nanoscience and then a business degree (MBA) from the Business School at Aarhus University. Combining his science and business knowledge he has been teaching entrepreneurship, especially to science and technology students since 2013. Since 2016 he joined the Faculty of Science & Technology and has continued his role as Sci-Tech Head of Innovation and Entrepreneurship where he designs and embeds entrepreneurship into science courses at a master's level across various disciplines. As an award-winning educator, Rajiv has pioneered the use of games in entrepreneurship education and is a big proponent of game-based learning in the higher ed space

Keynote Speakers



Pietro Michelucci is the director of the Human Computation Institute, an innovation center that develops crowd-powered systems to address societal problems. He is founding editor of the journal Human Computation. Michelucci received a joint-PhD in cognitive science and mathematical psychology from Indiana University and spent ten years advising federal research agencies on Artificial Intelligence. He currently leads several citizen science projects, including Stall Catchers, which engage 60,000+ public volunteers to tackle Alzheimer's disease, related dementias, and stroke. Michelucci has appeared on PBS, Science Friday, BBC World Service, and been covered by the Wired, Fast Company, and MIT Technology Review.

Mini Track Chairs



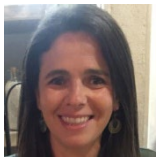
Stavroula Andreopoulos is a Professor, Teaching Stream, in the Department of Biochemistry at the University of Toronto. In 2017, she was recognized by the Temerty Faculty of Medicine for her multi-year contribution to undergraduate teaching with the Sustained Excellence and Innovation in Life Sciences Education Award. More recently (2023), she was awarded the provincial Ontario Confederation of University Faculty Associations (OCUFA) Teaching Award of Distinction.



Panagiotis Fotaris is Principal Lecturer at the University of Brighton, UK, specialises in Game, Narrative, and User Experience Design. As a seasoned educator and researcher deeply passionate about game-based learning, Dr Fotaris champions the pedagogic potential of escape rooms, generative AI, and immersive technology in higher education. His diverse background, fusing computing with arts, games, and music, enhances his innovative teaching methodologies. Leading projects on educational escape rooms for cybersecurity awareness and information literacy, Dr Fotaris is at the forefront of shaping a future marked by immersive and impactful game-based learning experiences.



Nour El Mawas is a Full professor at Université de Lorraine and CREM Laboratory (Pixel team). Her research is in the Technology Enhanced Learning (TEL) Field. She coordinates with J.M. Gilliot the "TEL for lifelong learning" working group supported by ATIEF and is also member of Ikigai scientific committee. The Ikigai consortium gathers operators in education, cultural mediation and research aiming at revitalizing teaching and mediation through gamification. It builds and distributes educative games, provides large scale usage datasets and is involved in the development of new digital data interoperability standards in education, essential for assisting learners throughout their life.



Sónia Pais, PhD in Education, is an Associate Professor at the Polytechnic of Leiria. She is a researcher at CiTUR - Centre for Tourism Research, Development and Innovation. Her research interests are in educational sphere, including how best to teach math subjects. She has interest in Mathematical Education, Educational Technology, Pedagogical Innovation and Game Based Learning.

Workshop Facilitators



Luuk Collou finalized his PhD in 2020 at the University of Twente during which he developed and tested a simulation model and serious game for strategic human resource management (HRM). Currently Luuk is working as an associate lector for the research group strategic HRM of Saxion University for applied Sciences in Enschede, the Netherlands. In addition to his work for Saxion university, Luuk is employed as managing consultant research & data at BMC/Randstad.



Guido Bruinsma With a background in work- and organizational psychology Guido finished his Ph.D. at the University of Twente on a simulation model on the orchestration of complex multi-organization collaborative work. Building on his passion for research methodology, technology and human behavior Guido's research focusses on the development and implementation process of gamebased interventions (serious games) and the development of health, performance, and data driven systems for esports performance enhancement. Guido was one of the founders of the esportslab at the University of Twente and Gamelaboost in the municipality of Enschede. Guido furthermore is involved in several startups and organizations in the field of organizational improvement, applied gaming, and esports.



Ton Spil teaches in the area of Business Information Systems for MBA and Management of Risk Management and Business and IT. He did his PhD thesis on the effectiveness of information strategies and after that he specialized in the application area healthcare and professional organizations. He is track chair e-health in main conferences and published on ISI A level. He was (guest) editor of JSIS and associate editor of several health journals. In 2017 his main topics are adoption of IT, business modeling, serious gaming and digital strategies applied on (tele) health, music and banking. He creates digital strategies for (social) media & health.

Game Designers' Experiences with Educational Game Design Elements: From Practice to Conception!

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Abstract: Educational game (EG) designing processes have adopted various processes and approaches over the last decades. While many articles report EG design elements that can potentially assist in effective EG design, not much research exists on whether game designers use/agree with those elements. In considering the aforementioned, the questions arise with game designers' practices: *how do they approach EG design elements in their process? Are there any core elements they include in their EG designing practices? Are there any other aspects that influence their EG designing process?* Therefore, this paper reports on the above-addressed questions and how game designers and their experiences in designing EGs can present insightful gaming elements associated with EGs. Based in Australia, a phenomenological approach was adopted to conduct semi-structured interviews to gather the *essence* of their experiences. Seventeen game designer participants attended two-hour interview sessions. Interpretive thematic analysis was used to identify emerging themes until saturation was achieved (Braun and Clarke 2012). The analysis was concurrently grounded through the concepts of the *theory of experience*, including *continuity*, *interaction*, *situation*, *freedom*, and *desire* which drives the purpose to apply and contextualize the *growth* of experience (Dewey 1938). In conclusion, an "Essential" Educational Game Elements (EGEs) framework is proposed with design elements collating all relevant elements/factors, necessary theories, and mechanics suggested by game designers for consideration in the design process as they have practiced. Lastly, researchers in educational/serious games are encouraged to consider the application of the proposed framework in designing EGs to further expand its limitations.

Keywords: Educational Games Design, Design Process, Game Elements, Framework, Experience, Serious Games

1. Introduction and Relevant Literature

The game design process varies in complexity across different genres, and the creative abilities of game designers in approaching such complexity are intriguing. Australian Game Development report demands for highly skilled employees have sufficiently increased, including programmers, artists, and game designers (Williams, 2021, Curry, 2021). Previously published research indicated that the Australian video game field has relied purely on economic and industrial metrics, often overlooking the interrelation of lived experiences of those within the field or the prior experiences of experts (Keogh, 2021, Sotamaa and Svelch, 2021). The emphasis on game designers (GDs) is to ensure that the *balance* is maintained in the system between the realistic and imaginative context of design (Kalmpourtzis, 2018, Schell, 2008). The need to conduct more empirical research that involves GDs' lived experiences, practices, and reflective thought-processes is essential for a growing industry. Still, there is niche research on GDs' thought-processes for designing games and educational games.

GDs are the artists, who direct and conceive game-making processes across various fields as discussed above (Koster, 2013, Darchen, 2017). GD roles, their skills, and the education that is needed to 'design the designer' suggested that there is an expectation and a particular skill level that is required within the gaming industry (Potanin and Davies, 2011). GDs take on multiple personalities to visualize what a game design should have and strive to create interactive narratives with meaningful experiences as they are play-testing to address the boundaries between imagination and reality (Garner, 2013, Kalmpourtzis, 2018, Schell, 2008). As Kalmpourtzis (2018, p.44) states, "*They challenge our way of thinking and help us grow. In this aspect, games are only limited to their designers' imagination*". GDs also experience a continuous play experience across various genres to adapt to a new and playable game with meaningful play (Ahmad, 2022, Ahmad, 2024).

The next section lists and discusses existing EG design elements, principles, factors, and also quality factors that have been prominently considered by other gaming researchers in the field over the past decade.

1.1 Existing EG Design Elements Review

Educational games designed for learning take both play and fun into account. Definitions by (Ogar et al., 2014) in (Ibrahim et al., 2010) defined game design as a learning system, that realizes some or all components of the learning process (learning theory, gaining skills and experience, and estimation of knowledge level) in a game context. EGs have been specifically designed to teach people about certain subjects, expand concepts, reinforce development, understand historical events or cultures, or assist them in learning a skill as they play (Singh et

al., 2008). Generally, EG is a game that combines both game design principles and learning theories with the integration of learning content of specific subjects or learning outcomes purposely to enrich learning for intended audiences.

It has been highly discussed over the past few years that educational games are designed for learning. Stenros (2017) discusses ten (10) principles that are required for an efficient instructional design, which include theory classification, learning out classification, the assessments of serious games, and four different types of learners. Pedagogically designed games are based on learning outcomes as stated in the course syllabus to match with the authentic syllabus as suggested (Fisch, 2005, Lepper and Cordova, 1992). As educational value through games has been systematically researched, it has been suggested that the cognitive consequences and learning outcomes reflect the player's prior actions to further progress in the assessments towards goals (Mayer, 2014). The learning outcomes should be based on the first three levels of Bloom's taxonomy (Forehand, 2010): knowledge, comprehension, and application. Another concept is scaffolding which requires feedback to be provided in the form of learning material to enhance students' learning process (Fisch, 2005, Graci, 1992). Finally, EG designed for self-learning purposes is used by students to enhance their understanding and assess their learning performance. These concepts were integrated into the game model proposed in (Garris et al., 2002). Theorists other than Prensky also identify key elements. Van Staalduinen and de Freitas (2010) listed 12 game elements from the literature and grouped them into four dimensions of their proposed 4-Dimensional framework. Some of the game elements appearing in the four dimensions are also mentioned in the core elements of a well-designed game and elements of an effective game (De Freitas and Jarvis, 2009, De Freitas and Oliver, 2006). This framework is used to choose an appropriate EG and learn to earn knowledge correctly (De Freitas and Jarvis, 2009, De Freitas and Oliver, 2006). The list of elements of learning specifics, pedagogy, representation, and context can be grouped with game elements as elaborated in (van Staalduinen and de Freitas, 2010).

Games motivate learners to take responsibility for their learning, which leads to intrinsic motivation contained by the method itself (Rieber, 1996). Four characteristics of games that contribute to an increase in motivation and eagerness to learn new knowledge are, namely, challenge, fantasy, curiosity, and control (Malone, 1980, Malone and Lepper, 1987, Snow et al., 1980). Challenges in a game tend to fight students' boredom and keep them engaged with the activity by utilizing adjusted levels of difficulty. Fantasy in a game increases enthusiasm by providing an appealing imaginary context, whereas curiosity offers interesting, surprising, and novel contexts that stimulate students' needs to explore the unknown. Finally, the control characteristic gives learners the feeling of self-determination. The requirements/guidelines for effective EG design. Due to various researchers proposing game design elements, this study combined four different game design elements into one Figure 1 to have a more visual representation of the game design elements proposed.

Games deliberately designed for education require some degree of effectiveness in order to be accepted by stakeholders. Researchers suggested that effective games should combine good game design and good pedagogy (Amory and Seagram, 2003, Klopfer et al., 2009b). Games design has similar concepts applied in entertainment games that should be adapted into EGs so they can offer certain degrees of engagement as it is in entertainment games. Game design with a fun aspect includes challenges, goals, feedback, and game stories. These elements derive the concepts of the game as described by various authors(Garzotto, 2007, Novak, 2011). These elements are said to be crucial in a game to really behave as a game (Grassioulet, 2002, Klopfer et al., 2009b, Owen, 2005, Prensky, 2003, Sauvé et al., 2007). Without those elements, games cannot be claimed as a games, but rather similar to edutainment concepts as suggested by (Klopfer et al., 2009a). See Figure 2 for a summarized list of existing EG elements.

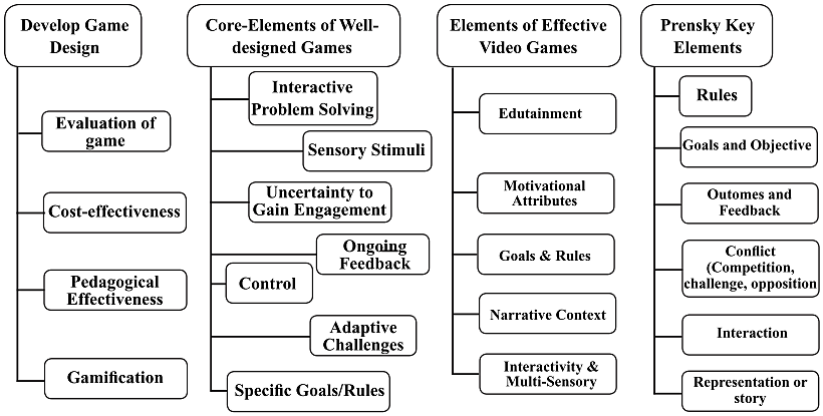


Figure 1: Adapted from various studies: Elements of developing a game design (Moreno-Ger et al., 2008, Holland et al., 2003, Whitton, 2007, Whitton, 2012), Core-elements of well-designed games (Shute and Ke, 2012), Elements of effective video game (Dondlinger, 2007), and Key elements of game (Prensky, 2003)

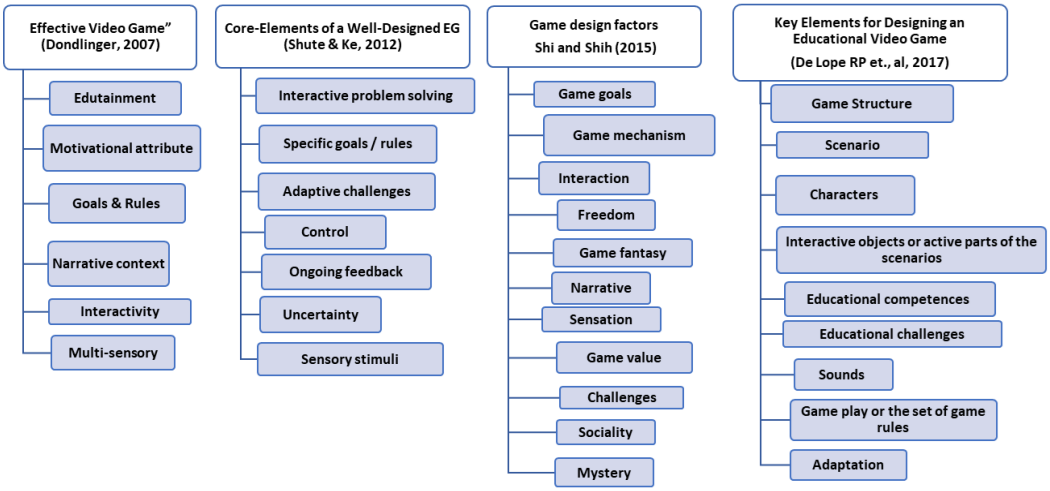


Figure 2: Adopted from Elements of an effective video game (Dondlinger, 2007), Core-elements of well-designed games (Shute and Ke, 2012), Game design Factors (Shi and Shih, 2015), and Key Elements for Designing an Educational Video Game (De Lope et al., 2017).

When the quality of EG is discussed, the quality characteristics must be also highlighted. Calderon & Ruize (2015) proposed 18 quality characteristics of EG for assisting in evaluating the process. A study analyzed primary studies (102) assessing learning outcomes through the application domains in which the assessments took place, the categories of serious games assessed, and the main features considered to assess the educational effectiveness of serious games (Calderón and Ruiz, 2015). Consequently, the procedures followed for assessing the learning outcomes of serious games and show that a key quality to be assessed is the effectiveness of EGs in terms of knowledge acquisition (Calderón and Ruiz, 2015). Usability and experience are also frequently assessed. Among the published research being reviewed, the methods for assessment being used are limited to testing the games after the games are fully developed. Other reviews on EGs for providing educational aspects do not analyze in detail how these EGs are evaluated. A non-systematic literature review presenting 41 games used for teaching different computing knowledge areas (Gibson and Bell, 2013). Besides characterizing the games, the authors also present some guidelines on how to determine if the use of a game is promising for computing education. Moreover, the Elemental Tetrad (Schellm 2008) was evolved by Kalmpourtzis (2018) as Elemental Pentad which includes Pedagogy in the center for educational purposes in the games. This was further used to develop categorization on sub-elements within the EGs design (Ahmad, 2022, Ahmad, 2023), which shed light on more clarity on aesthetics, mechanics, the storyline of the game, and technology. Petri & von Wangenheim (2017) reported that they have observed a diversity of quality factors evaluated but they did not identify a clear pattern. Frameworks such as MEEGA (Savi et al., 2011), use quality factors (e.g. Attention, relevance, competence, satisfaction) and the ARC model by (Keller, 1987); that decomposes the motivation concept. According to Keller

(1987), motivation is viewed as an unpredictable and changeable factor, and it can be influenced by teachers or a designer as they have no control over it. As a result, designers and teachers tend to ensure that their responsibility is to provide a good quality instruction, and they tend to assume that it is learner's responsibility to decide whether they take this opportunity to learn or not.

The explosion of EG design elements in research has clearly created duplication of some existing elements proposed previously, though some criteria changes in terms of the way type of game design, or using the terms effective, efficient, quality factors, and core elements. Not only does this lead to confusion but also leads to a misunderstanding of many other elements and their importance in EG. Therefore, there is a need to comprehend the reflective practices of game designers who have used and tested EG design elements in their design processes.

2. Theoretical, Conceptual, and Methodological Approach

The conceptual and theoretical frameworks adopted in this paper relate to Dewey's experience theory (1938): growth of experience, purpose, and continuity. Since these concepts are related to research epistemology and ontology, constructivism is used as a model for constructing new knowledge that welcomes the subjectiveness of individual experiences (Dewey, 1938b). The growth of experience is how a person develops in his or her career, experiences everyday activities to gain knowledge, learns to achieve his or her objectives, maintains his or her understanding of phenomena, and continues to develop in his or her experience. The aspects of "growth" are driven by the desire to formulate a "purpose" that returns to the growth of experience with the intelligence of the individual mind. In this context, adults who combine work and study, theoretical and practical exposure, are very well-known and productive in their expertise. The *purpose* is simple when a desirable quality *"…which identifies freedom with power to frame purposes and to execute or carry into effect purposes so framed. Such freedom is, in turn, identical with self-control; for the formation of purposes and the organization of means them are the work of intelligence"* (Dewey 1938, p.67). Dewey's description of an actual purpose is that it begins with an impulse. It is always equipped with *"end-view"* – *which is involving "the foresight of the consequences that may result from acting upon that impulse"* (p.67). Teachers create their meaning through their actions, and when games are played or tested, they reflect constantly through their actions, while game designers have similar ideals. Therefore, the creation of an enhanced experience shows the individualized aspect of learning by playing games, learning by doing, and adjusting the experience throughout the process.

The principle of *Continuity* is each experience taken from the past affects the future experience of the individual. In contrast, interaction refers to the situational and teacher's influence on student's experience. He believes that the elements of interaction and the situation in which they occur are *"inseparable from each other"* (1983, p. 41). Despite the importance of experience, some challenges may be encountered, such as *"that all experiences are genuinely or equally educative"* (1938, p.13). Thus, teachers must first understand the nature of human experience and explain how the value of this experience affects the person's present and future, and the ability to contribute to society. This is directly related to the way teachers in their classrooms interact with the needs of each person to support his or her cultural and social differences and enable them to learn equally and freely. Similarly, game designers help design EG design experiences by emphasizing and understanding players', designers', and game design processes. It is therefore crucial that teachers and game designers position the changing experiences in order to understand their perspectives, which may be enjoyable, but they cannot contribute to personal growth or experience without consistency, a situation that does not necessarily lead to a cumulative learning basis for future learning.

2.1 Participant Recruitment Criteria, Data Collection Method, and Analysis

Based in Australia, with criterion and snowballing recruitment procedures, semi-structured qualitative interviews with 17 game designers participated in this study. The criteria set for the recruitment process are shown in Table 1. Each interview session is approx. 2 hours and 30 minutes. This paper interprets one central theme (from six themes) emerging through the coding analysis. Consequently, the phenomenological approach is adopted to allow the researcher to uncover the *essence* of lived experiences described as the qualitative researcher pursues to identify the phenomenon of human experience and then derive a description representing the nature of experience (Kafle, 2011). The *essence* should not be viewed as a vague idea but rather the ability to identify the meaning embodied in the lived experience (Merleau-Ponty and Smith, 1962). Please note that all names are pseudonyms in the analysis.

Table 1: Participant recruitment criteria in this study

Criteria	Participants Details
Location	Within Australia (Victoria, New South Wales, Queensland, South Australia)
Years of Experience	Between 5 years – 15 years
Type of experience	Game designing and Developing (all types of genres).
Types of Players' Demographic	All Demographics. Primary school players' demographics are beneficial.
Participants in the study	17

2.2 Data Analysis and Interpretation Approach

The interviews were audio-recorded, transcribed, and time-stamped. An initial hand-coding approach was adopted before an in-depth thematic analysis using NVivo 10 software. This research adopted a six-step thematic analysis approach (Braun and Clarke, 2006). This analysis aims to allow game designers' perspectives discussed through reflective experience, their experience designing both types of gaming systems (its *growth* and *continuity*), and the way they criticize the conceptualization of games before they are designed (framing the purpose of designing games). Interpretive results are discussed through the interpretivism approach, where hermeneutic analysis is adopted to allow the subjectivity of game designers' experience. Interpretive thematic analysis was adopted to code emerging themes until saturation was achieved (Braun and Clarke, 2012). The analysis was concurrently interpreted through the concepts of the *theory of experience*, including *continuity*, *interaction*, *situation*, *freedom*, *intelligence*, and *desire* drives the purpose to apply and contextualize the *growth* of experience (Dewey, 1938a). Interpretive data analysis of GD's perspectives established six main themes and the *theory of experience,* and its concepts are deeply embedded within contexts where games are centered. Additionally, GDs demonstrated their preferences, attitudes, beliefs, desires, and purpose in using and designing games. By contextualizing the experiences of GDs, designing EGs corresponding to their beliefs shows potential towards what is essential, core, and what factors are considered in designing practices. Please note that all participants are addressed as pseudonyms to maintain anonymity(ethics approved).

3. Findings and Interpretive Results Discussion

Understanding how game designers approach the design of EGs is crucial to contextualize their experiences and practices that have transformed over time. Due to its generalization and adaptability of game designing processes, this theme explores a prompt question: *How do they consider designing elements for designing EGs, and based on your experience of designing EGs, what were the necessary factors to consider during designing processes?* While this question was open-ended, all game designers immediately acknowledged it as they reflected and (re) iterated their game designing approaches (Ahmad, 2023).

While all game designers indicated their preferences to begin designing EG with the way they approached 'games', two out of seventeen mentioned specific additions in the EG designing processes and altered their approach to accommodate EGs. As evidenced [**Raymond and Charlie**] justified how their designing processes were altered based on their previous experiences reflected with the ***bottom-up approach*** [Raymond] and using the ***Verbs*** in the curriculum to help guide the design process of EG [Charlie]. For instance, [Raymond] explained:

> *"..bottom-up approach works for me with educational games because the smallest interactions need to be considered in the beginning and defining all the necessary educational terms beforehand needed to be established…I know the biggest issue is that no other models have helped this process and this contains the essentials as I already know the game mechanics but I just need to define gameplay with a verb to complement with appropriate setting, content, and story relations to centre the core of the educational game…".*

As emphasized by a game designer their understanding of the designing process involves the relation of game designers' cognition to enable such designing processes that are institutively used and understood by themselves (Kuhnen, 2007). The *verb* layer consists of actions that players undertake during play and enforces the low-level micro-decisions to enable an immersive and memorable gaming experience. A good example presented and explained (Kuhnen, 2007) for the Grand Theft Auto game is that if "in-car" is a game state, then "accelerate" and "brake" might be good game verbs. In an EG like Minecraft, if "create" is a game state, then "build" and "break" might be a good game verb. This is then related to mechanics, the player's action, core features, and context.

Similarly, [**Charlie**] emphasized on the use of '*verbs'* in the designing process but there were no specific models/processes that were mentioned. However, the description of designing EG in the extract presented shows similarities with the bottom-up approach to an extent. She acknowledges that the core of the game is organized around *doing,* which is agreed with (Squire, K 2006). As shown:

> "*Unfortunately, I don't think there is a specific designing process for educational games because I usually tend to use the idea from game designing, as they are about playing and learning and not necessarily about knowledge, but players get knowledge by doing/interacting with games. What worked for me was using terms of verbs, listening, and brainstorming what we needed the students to understand and do in the game with some mechanics or actions. This is sometimes the first process I begin with…verbs can also be relevant to curriculum or learning objectives*".

With that, other game designers' participants explained how they have designed EGs and what were the necessary features, elements, and processes, that were undertaken in their experiences. Therefore, there are four emerging themes: Core features/necessary considerations, for whom (player's psychology), Combining Leaning and Gaming elements, and Positioning Pedagogy and learning principles; discussed in the following sections.

3.1 Core Features and Necessary Consideration

As the game designers mentioned that their EG designing processes are transferred and adapted towards EG designing, I prompted a question*: In your opinion, what are the required game design elements/features you always consider in educational game design? Or the "Necessary" elements?* The core of the game (central role in the player's experience are the content and features) and the context that allows players to have a general impression of the game world and its *essence*. The concept occurs to ensure the content and gameplay are constructed simultaneously. The two sub-themes below are discussed in relevance with: Rules, and choices in play, and balancing player's experiences and expectations (classroom).

3.1.1 Rules and Choices in Play

The game designers believed that EGs require an explicit set of rules that allow the learners in the classroom context to 'feel' the serious setting, as [**Blaire**] mentioned, "*the set of rules for educational games are solid and refined, to match the seriousness of the setting*". Moreover, [**Ross**] added that "*rules also relate with player's experience and the reason why game's purpose is educational and how that is controlled appropriately within it*". This relates to the clearly formed *purpose* of designing a game for a specific *situation* as a classroom, where the *interactions* between players and the game system demonstrate its *continuous* form of learning (Dewey 1938). Another relevant point related to rules and their influence on a player's gameplay where boredom may occur, is evidenced below:

> [**Anne**]: "*But one thing I know is a big hurdle for using educational games in the classroom is the rules and learning rules, along with introducing the rules because rules are so boring. Yet, students don't want to listen!"*
>
> [**Paige**]: "R*ules are core and essential, but they are tedious to finalized because it is a constraint on educational use! making the rules understandable to ease the 'figuring out during play' while being in a classroom and to get some fun and engagement together is difficult…rules control them [players] which isn't true. Rules control gameplay for fairness*".

Here, the concept of *freedom* and *social control* was observed in their description which I agree as rules are designed within the game to enable various play/learning experiences in a 'standardized' manner, however, players/learners neglect. In addition, adaptable rules within the games may encourage more interactive gameplay, as [**Nora**] mentioned, "*Once I designed an educational game with rules that were relevant to certain game elements and changed according to their [players] actions and interactions, which was successful!"*

Another point relevant to rules was the demonstration of 'instructions or 'guidance' provided to players through the gameplay are interconnected. Game designers advocated that the instructions "*need to be precise and not like an essay!*" [**Max**], and "*the rules should be differently displayed and the instructions of how to finish a level or activity should be separately presented to players*" [**Warren**]. This suggests that the players/learners make their choices based on what they understand through the play, but teachers act as 'external guidance' to boost their confidence during play or accomplish a sense of mastery. Mastery is when playing a game where the player's choices and actions can lead to a successful outcome, hence, "feeling of mastery that helps remind you that you can succeed…have control" (Schell, 2008, p.442). Here, the *freedom* of choice provided to players allows their abilities, *social control* as rules and guidance, and *interactions* are ideally necessary within EG.

Dewey believes that *freedom* allows one's mind to freely explore the possibilities without being restricted to taking actions or assuming it as a careless act as the players evaluate their own choices without complete guidance (Dewey, 1929).

3.1.2 Balancing Player's Experience and Expectations (Classroom Situation)

This sub-theme expands on players as learners who play games within the classroom context. Game designers highlighted that there is a need to *balance* the play expectations and experiences to ensure that they are memorable. In terms of memorable experiences, game designers advocated that EGs fail due to the play experiences and memory of playing games in the classroom. For instance:

> [**Zack**]: "*if the game being played in the classroom isn't designed in considering the expectations of experiences that the players will have, then the game will fail, and players will hate educational games because that is what they played in the classroom!*".

> [**Cathy**]: *"…memorable experience is so crucial, and I usually design it alongside any fun element or animation in the design, so I don't miss it!".*

With the fun element, another feature associated with memorable experiences was integrating problem-solving tasks/activities that can trigger memorable experiences, emotions/feelings, and affirmation beliefs (winning /losing), as shown below:

> [**Raymond**]: "*You need to engage players with some problem-solving tricks where they get into the play and show their emotions like excitement or anger if they fail*"

> [**Betty**]: "*Usually I find that players remember how they solved a problem or challenge they faced during their play and I think that's a memorable experience shared! I think when they win or lose, it helps them understand what they did wrong and master their choices, redo, and win!*"

Another feature influencing a player's experience is the level of difficulty that reveals appropriate pace and instruction, [**Anne**] added, "*the division of difficulty levels is so crucial in players' experience because if they fail too much, they will get frustrated!*". GD participants believed that a gradual transformation between levels positively affects the progress of learning and forms a *continuous* pace that enables *freedom*, "*they need to feel that they are progressing with some challenges, of course! But the challenges should level with how they progress and make choices. You can't design a game with full freedom, but you need to show that through a progression*" **[Tia].** Here, they asserted that challenging tasks and difficulty levels can be designed separately and are sometimes highly complex (Arnab et al., 2015, Schell, 2008, Kalmpourtzis, 2018). For instance, [**Tia**] pointed out, "*the difficulty level can be controlled one task at a time, but the challenges could be mini ones that pop up during one of the levels… so that's slightly hard to balance because it needs to be universally understood by the players, otherwise I don't add in design*". On that note, [**James**] added that, *"…challenging tasks are highly required because it triggers their mind, and they make choices which they sometimes speak out as reactions especially when they win! So, it encourages memorable experiences*".

With game levels, challenges, and choices, game designers mentioned the need to allocate the appropriate amount of time, that is required to complete the task in the classroom.

> [**Timothy**]: "*I usually design the task and difficulty levels differently to ensure that it can be completed in a certain amount of time… the threshold is to avoid players getting irritated!*"

> [**Terry**]: "*I just don't know how much time a classroom session has these days…my experience didn't let me have the luxury of knowing or being in the classroom to observe but I design based on the challenges that one task can encompass and make them mini so they can feel they completed a challenge.*"

With challenging tasks, some participants emphasized the need to 'communicate concepts appropriately' through design and they encourage curiosity and surprising features, [**Raymond**] added, "*there's something about the experience of communicating concepts and making a way to develop surprising elements, which lets the design level to speak directly to the players*" and this was paired with the interactivity of the player with the game, as [**Ross**] added:

> "*The way in which we [game designers] think that levels and challenges may evoke curiosity or surprise them with a new character or rule, it can directly communicate with players through play, but it can't assure us that it worked… it's a complex thought to anticipate about*."

As Schell (2008) emphasized that "*it is the root of humor, strategy and problem-solving […] random sprays considered the experience much more pleasurable*" (p. 26-27). In relevance with memorable experiences and surprise elements, [**Anne**] expressed that:

> *"One of the most significant elements in game design is surprising. Basically, introduces randomness, or 'gotcha' mechanics, so that your friends figure out what you have in your hands. Then, they can steal a bunch of cards off you because they figured out exactly what you have. So, those are examples like surprises are memorable."*

With surprises and experiences, communication between players and the game world (game as a system) is crucial to address as, "*it's an art... communicating what I want to design as challenges and levels and how they[players] understand it…and then, if they play with their friends in the class, you can hear what they understand too!*" [**Timothy**]. Moreover, game designers also believed that achieving communication and competition within EG design is relevant to the game mechanics that may be selected at the beginning of the designing process. For instance, [**Nora**] added, "*the communication of game elements and learning in the design and how players understand that is also related to how well the mechanics delivered what I meant!*". In addition to that, [**Anne**] suggested that EGs need to accommodate player's experiences through experimentation or trial-and-error based tasks which are aided by communication between their peers, "*it is crucial to let them experiment continuously to achieve the goal, explore, and communicate what they have done to allow their creativity, and collaborative learning within the classroom*". Here, ***Anne*** also mentioned that the goal drives their experimentation, communication, and collaborative learning and creates memorable experiences. It indicates that Dewey's *interaction* and *situation* concepts advocate their intimacy by positioning experience that occurs in a setting(*situation*) and formation of the *purpose* of the EG design that relates to how game mechanics aid with communicating EG design.

4. Concluding Remarks and "Successful" EG Design Elements

To conclude, the game designers experienced in EG designing processes were able to discuss and reflect on their successful EG design elements that enabled a more effective EG. These suggestions were enlightening to some existing literature discussed while others were connected with other elements that represent a successful combination to deliver memorable gameplay. Therefore, Figure 3 proposes the summarised interconnectedness of EG design elements as "essential"; which are practiced by GDs in Australia.

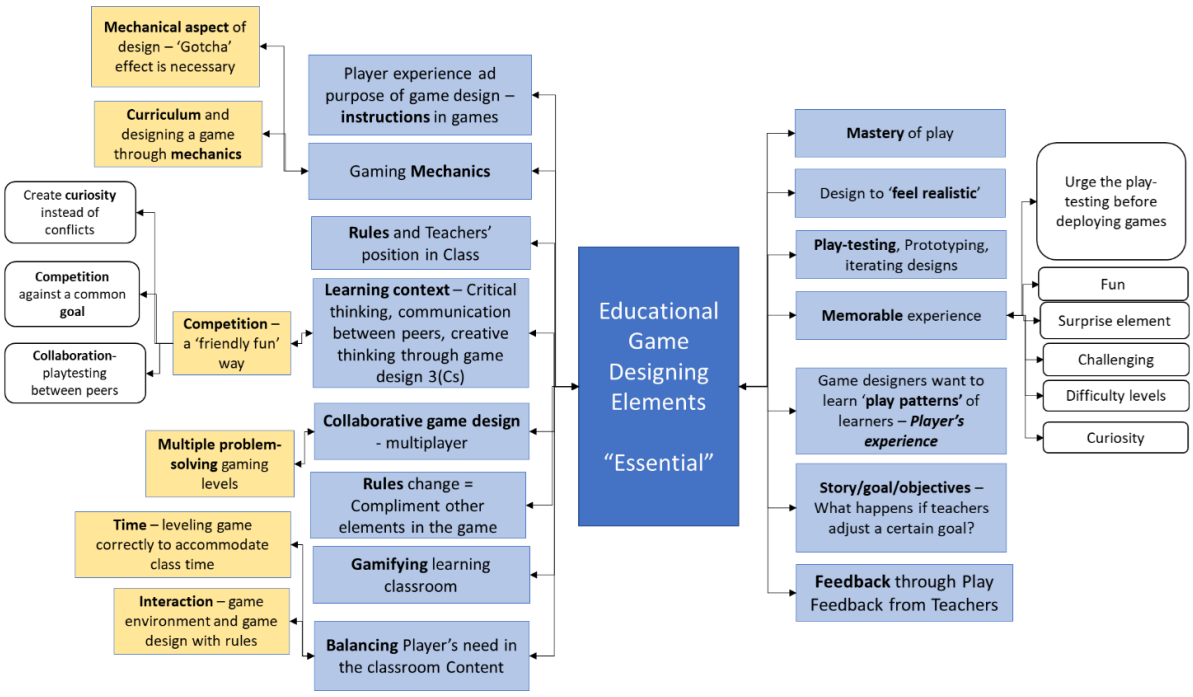


Figure 3: The "Essential" Educational Game Elements (EGEs) for designing EGs

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A Conceptual Framework for the Development of Effective Serious Games for Learning

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Abstract: Currently, the interest in using serious games as a tool for learning and teaching in traditional educational processes has increased significantly. Therefore, serious games for learning are gaining increasing attention from researchers and domain experts (educators), as they are both looking for methods and tools to improve the quality of learning. Even though there are many existing design frameworks, models, and methodologies that offer valuable insights into the possibilities and limitations of serious games for learning, they focus mostly on high-level aspects and requirements of these games. Therefore, they do not fully help in understanding how such aspects can be concretely fulfilled. In this research, we investigate, characterize, and categorize the functional requirements and aspects needed for developing effective serious games for learning. This investigation aims to construct a conceptual framework to fill the gap in the current design frameworks. The proposed conceptual framework is used to understand the game´s structure and behavior with a focus on both aspects of serious games (educational and entertainment aspects), in other words, providing a way to think about the relationships between serious game components and the learning objectives of the game. The main contributions of the proposed conceptual framework are to facilitate and support the design and development process of these games as well as to enhance the collaborative work within a multidisciplinary development team. Finally, to show the feasibility and applicability of the conceptual framework, a practical example is presented to demonstrate the use of this framework. Furthermore, we conducted an evaluation process for implementing the conceptual model. The evaluation shows promising results in helping participants, particularly those with gaming experience, to understand and identify the roles of each component in the game and recognize the game's learning objectives. This will eventually lead to design and develop effective learning games in a flexible and easy-to-use way.

Keywords: Serious Games for Learning, Serious Games Development, Serious Games Design, Conceptual Framework, Design Model.

1. Introduction

Designing an effective serious game for learning is a challenging task, which requires a lot of knowledge and diverse skills. Development teams don't only have to deal with the inherent technical complexity of the game design but also have to be able to integrate learning activities in a way that is educationally effective and enjoyable at the same time (Silva 2019; Zarraonandia et al. 2015). Furthermore, the complexity and development of current computer games, in terms of representation, interaction mechanisms, and rules, might prevent domain experts from being capable to develop their serious games or even from participating in their design due to the lack of technical knowledge and the domain vocabulary (Avila-Pesantez 2019). Therefore, the development process of a serious game must be entrusted to a highly professional game development team, which is typically associated with high costs. Thus, the challenge here is to facilitate the development of an effective serious game for learning in a flexible, easy-to-use way and adapt the game's learning content, thereby helping reduce the effort and costs associated with the development process. To address this challenge, we develop a conceptual framework that facilitates the design and development of effective serious games and helps collaboration among stakeholders. This is achieved by investigating various requirements across serious games and highlighting the important components to develop a conceptual framework. The proposed framework is developed in three separate stages: first, analysis of existing methodologies and models for designing serious games; second, identifying the functional requirements across serious games; and finally, providing a conceptual framework. The Proposed conceptual framework consists of three models: one for describing the game structure, another for describing the behavioral dynamics of the game, and a third aims at enhancing user experience within serious gaming environments.

In our research, the framework and its models encompass high-level concepts for expressing games and pedagogical aspects to provide the development team with access to high-quality and up-to-date components. Finally, to evaluate the framework's applicability, it was used to design a serious game that aims to learning children how to read the clock. The aim is to demonstrate how effectively the model can be employed to design an efficient serious game for learning. Furthermore, we conducted an evaluation process for implementing the conceptual model. The evaluation shows promising results in helping participants, particularly those with gaming experience, to understand and identify the roles of each component in the game, and recognize the game's learning objectives.

Therefore, as a first step towards this goal, we introduce in this paper a conceptual framework that is organized in a modular way and with different design perspectives. In order to help the development team, the requirements that are often considered in the literature as significant in producing engaging, fun, and educational game experiences, have been included in the model through a set of design components. Furthermore, the components of the framework offer support in the reuse of their foundational building blocks to produce different forms of the same game, which can be used to match different learning purposes, in a quick and flexible way. Moreover, it enhances the collaborative work within a multidisciplinary team.

The paper is structured as follows: in the second section, we provide a brief overview of existing literature related to serious games, with a specific focus on those, which introduce methodologies, frameworks, and models for designing serious games. In the third section, we introduce the conceptual framework, and we discuss and evaluate the applicability and feasibility of the proposed conceptual framework in the fourth section. Finally, we present the conclusions of the work in the fifth section.

2. Literature Review

To uncover the factors influencing the success or failure of serious games for learning and to address their design issues, researchers have developed models, frameworks, and methodologies for investigating and analyzing these games. Examining these frameworks helps in comprehending how serious games achieve their both aspects and also in revealing the connection between the game's design process and the underlying pedagogical aspects, as well as how the game is played. Understanding this issue is crucial as it allows for examining the components of serious games, providing insights into their mechanisms, and ultimately contributing to the development of better serious games for learning.

The six-facet framework proposed by Marne et al. (2012) outlined a conceptual framework for serious game design by assigning specific types of expertise to each facet. It aimed to resolve design challenges and enhance stakeholder communication using a design pattern library. However, while the framework clarified the roles of team members, it lacked a proper methodology for the actual game design process. The Activity Theory-based Model of Serious Games (ATMSG) was introduced by Carvalho et al. (2015) to understand the relationship between serious game components and educational objectives. This model applied activity theory, dividing a serious game into three components: gaming, learning, and instructional, each with corresponding actions, tools, and goals. The ATMSG was implemented in two phases: activity analysis and action analysis, further broken down into four steps. Although the model offered valuable insights for serious games, it was more suited for analysis rather than design. Lope et al. (2017) introduced a comprehensive five-phase methodology (startup, design, production, testing, and post-production) for serious game design. The iterative cycle of Salen and Zimmerman's design process (2003) was incorporated in the design, production, and testing phases. Furthermore, they identified components during the design phase, such as scenarios, characters, educational competencies, and challenges, using a theater metaphor (acts, scenes, actions, dialogues). Their methodology clarified the tasks of various roles in the design process, but it still required more specificity in translating learning content into the game. Pesántez et al. (2017) systematically reviewed serious game design approaches, identifying eleven methodologies. They structured the design process into four phases: analysis, design, development, and evaluation. Each phase is identified with factors, with emphasis on pedagogical and didactic aspects important to serious game design. However, it lacked detailed guidance on integrating these aspects into a game's design. Spyridon and Refanidis (2019) outlined a conceptual methodology based on a task repository that defined task dependencies and skill requirements. Their approach featured an adaptive schema using artificial intelligence to adjust learning tasks based on the player's prior knowledge. Rather than being a design methodology, this framework focused on creating an adaptive learning process for serious games. Continuing the goal of facilitating the design of serious games for learning, several authors have introduced libraries, models, and frameworks for serious games for learning, such as Arnab et al. (2015); Roungas & Dalpiaz (2015); Lope et al. (2017); Moya et al. (2016); Robson et al. (2015). These efforts aim to offer more structured approaches to designing serious games; however, there remains a need for clearer methodologies that effectively integrate educational content.

In conclusion, while numerous frameworks and models for serious game design exist, there is a general need for clearer methodologies that explicitly detail how educational content should be integrated into the game design. Each of the frameworks and models contributes unique insights into the analysis and structure of serious games, yet they often fall short of providing comprehensive design processes. For this reason, there is a need for means and models that bridge the gap between theoretical frameworks and technical designs. This bridging is necessary to alleviate the cost of developing serious games for learning by providing tools that facilitate the design process

easier and quicker, producing high-quality designs, to making the benefits of game-based learning available to a wide audience.

3. The Conceptual Framework

In the process of this research, and as part of my PhD work, an investigation is conducted to address the functional requirements for developing serious games for learning. The aim is to identify common requirements across serious games of various genres and topics to enhance reusability and leverage their potential applicability across different learning domains. This identification aims to derive components that contribute to both the effectiveness of serious games in learning and their potential for reuse in similar game genres based on these identified requirements. The criteria for identifying requirements are (i) relevance to the learning effectiveness and (ii) reusability across various games and learning domains, at least within the same genre of the game. The investigation resulted in a list of functional requirements for serious games that directly or indirectly affect players' motivation and learning success.

Table 1: The List of Functional Requirements

Category	The functional requirements	References
Pedagogy/Learning	FR1: A serious game should provide interaction mechanisms focused on objects, feature task-centered goals, and offer the opportunity for learning or playing within social groups. FR2: A serious game should provide the ability to present learning objectives through repetitive tasks. FR 3: To incorporate learning objectives, a serious game should offer interaction mechanisms. FR 4: A serious game should be designed in a way that supports the progressive introduction of new skills during the play.	Carvalho et al. 2015; Kazimoglu et al. 2010; Annetta 2010; Riedel et al. 2015.
Rules	FR 5: The design of a serious game must adhere to a set of game rules.	Carvalho et al. 2015; Batko 2016.
Interaction & Communication	FR 6: A serious game should enable communication and interaction with other components and/or players.	Carvalho et al. 2015.
Assessment	FR7: In a serious game, there should be the capability to offer feedback on the user's behavior. FR8: A serious game should offer the ability to display information. FR9: A serious game must have an assessment component	Arnab et al. 2015; Annetta 2010; Boyle et al. 2016; Shoukry et al. 2014; Bellotti et al. 2013; Gardner 2012.
Goal	FR10: A serious game has to include tasks that can be solved. FR 11: A serious game should have to be clear and understandable goals.	Bellotti et al. 2013; Gardner 2012; Paraskeva & Mysirlaki2010; Kickmeier-Rust & Albert 2012.
Adaptation	FR12: A serious game must have an adaptive component to measure the performance of players' learning progress, thus adapting the game to the ability and the current skill level of players. FR13: A serious game should have various levels of difficulty in solving tasks.	Silva 2019; Chandler 2020; Prensky 2001; Kickmeier-Rust et al. 2008; Soflano & Connolly 2015; Cox et al. 2012; Lomas et al. 2013.
Representation	FR14: A serious game should have the ability to display at least videos or to play audio. FR15: A serious game should have a user profile component to identify the player in the game. FR16: In a serious game, there should be both objects and characters, allowing players to interact with them.	Lainema & Henriksen 2015; Kazimoglu et al. 2010;

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These requirements serve as the foundation for designing the conceptual framework, which is organized into clusters of components within seven functional categories: pedagogy/learning, rules, interaction and communication, assessment, goals, adaptation, and representation. These categories have been analyzed, resulting in the extraction of 16 functional requirements for developing serious games. Table 1 presents the complete list of derived functional requirements.

These functional requirements are used as the foundation for constructing components within the models of a conceptual framework. Consequently, each requirement has been analyzed individually, and hence, model components supporting the fulfilment of these requirements have been derived.

The outcome of this process is a conceptual framework of serious games for learning. It allows the design of the structure and the behavior of a serious game. Table 2 presents the components of the framework and the corresponding requirements, from which the component has been derived.

Table 2: The Framework Components of Serious Games

Model Components			Derived from requirements #
The Game-Root			No derivation needed
Serious Game	Instructional Content		FR2, FR4, FR5, FR10, FR11.
	Player Profile		FR14, FR15
	Learning Motivation		FR9
	Repetition		FR2
Game Content	UI Manager	GUI Manager	FR8
		Media Manager	FR14
	Objects& Character		FR15, FR3
Game Design	Reward Manager		FR9
	Feedback		FR7
	Game Mechanics		FR1, FR6
	Challenge, Level, Learning Outcomes		FR2, FR12
State			No derivation needed
Activity (Actions)			FR3, FR10
Event			No derivation needed
Assessment (Task)			FR7, FR9

3.1 The Conceptual Model of Serious Games Structure

The first model in our framework is a conceptual model, describing the primary structure of a serious game for learning. The model identifies the roles of all components and achieves the desired educational goals. This structure describes how a serious game is constructed, detailing the layout of the game world, the inclusion of objects and characters, and the dynamics of player interaction. Figure 1 offers an overview of the serious game structure model, illustrating the components and their relationships. This model adheres to the familiar concept seen in UML class diagrams.

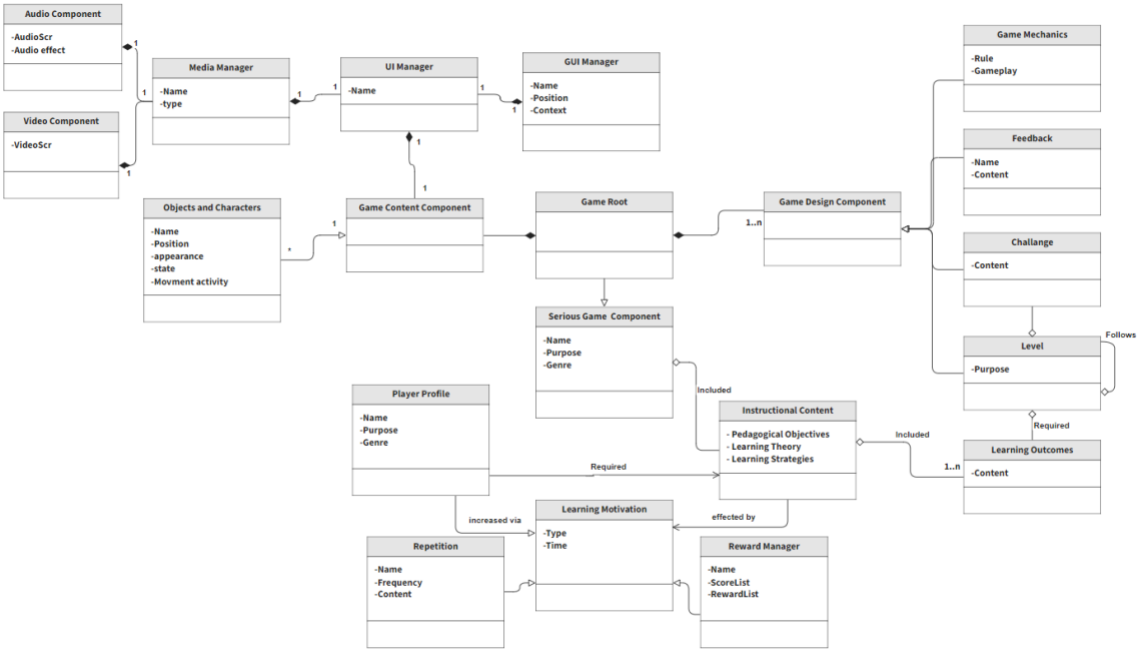


Figure 1: Structure Model of Serious Games for Learning

The Game Root is the central point for all other components. It includes the Game Design Component, representing development decisions regarding game mechanics and feedback; the Game Content Component encapsulates the structural elements. A serious game, considered a sub-component, inherits one or more characteristics from computer games but it is designed for educational purposes. Learning objectives are achieved through instructional content defined in terms of learning outcomes, outlining the knowledge players are expected to gain.

The Game Design Component includes objects and characters to represent interactive or decorative elements within the game. The UI Manager, which has two subcomponents, GUI Manager and Media Manager, controls the display of information for players. Game design identified the necessary to coordinate components into games: mechanics that dictate behavior, challenges that keep engagement of players during the gameplay, levels that break goals into tasks, and feedback that responds to player actions. A serious game component specifies the components that affect the learning process, such as player profile and instructional content defined in terms of learning outcomes. Learning objectives, strategies, and curriculum are critical aspects of learning structure. The Learning Motivation, Repetition, and Reward Manager components manage player motivation, repetition to reinforce learning, and rewards for successful behavior.

3.2 The Behaviour Model of Serious Game

The second model in our framework describes the behavioral dynamic of serious games. Behavioral dynamics refer to the interaction between game components, outlining the expected functionality of a game. This model describes the interaction design, thereby facilitating the analysis, design, and development of software interfaces. This, in turn, enhances the productivity and effectiveness of the serious game and simplifies the design process. Figure 2 illustrates the dynamic model of a serious game.

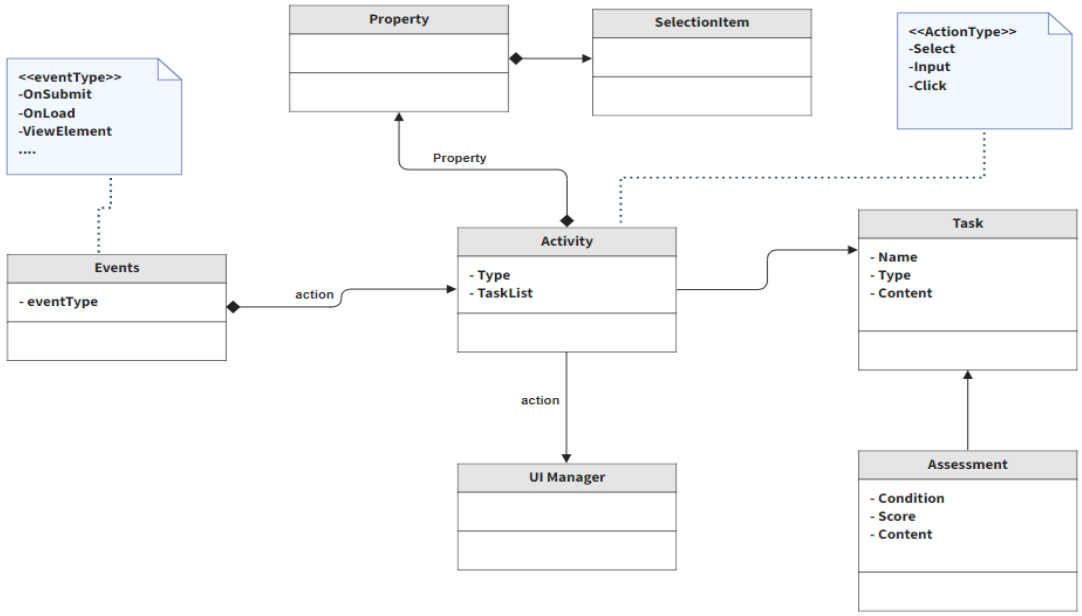


Figure 2: The Serious Game Behavioral Model

The dynamic model captures the structure of the serious game, describing the user interface (UI) and its components. The UI Manager includes all elements of the game's main functionality. Activity representing user actions such as input, selection, and interaction. Each activity has an Action-Listener that triggers events based on user actions. Events are used to express the interaction between Activity and the GUI. Task elements, like multiple-choice questions, are linked to assessment elements that evaluate results and provide feedback or rewards.

The adaptation method in the game monitors players' learning progress and adjusts content and difficulty accordingly. Players can initially choose their desired difficulty level, with predetermined game content tailored accordingly. Alternatively, the game can offer tasks of varying difficulty, dynamically selecting the appropriate task based on the player's previous performance.

3.3 User Experience of Serious Games

User experience (UX) is a psychological concept focused on users' emotions, thoughts, and reactions when interacting with a system (Hassenzahl, 2018). In serious games, UX is crucial as it deals with players' immediate responses and helps developers create more effective games.

Several models provide insights into UX for serious games. Sin et al. (2014) conducted a study on the UX of serious games, highlighting five motivating factors that encourage players to engage with these games: control type, updates, challenge, content, and fun. Similarly, Engl and Nacke (2013) proposed a three-layer abstraction game experience model, including the game system's playability, the player experience that emerges from interaction with the system, and the gameplay experience formed by external and internal factors. Law and Sun (2012) introduced a framework with four key dimensions-gaming experience, learning experience, adaptivity, and usability- characterizing the essential attributes of UX in adaptive serious games.

For describing a UX of serious games, it is important to identify the elements that shape the effective design according to players' motivation. Therefore, the game should be fast, adjustable and provide rich affect-based interactions that enhance the connection between the game context and player input (Yannakakis & Togelius, 2015). To obtain a positive effect on the learning process, the game should consider three design aspects: learning, entertainment, and motivation; by aspects stated in our work.

- Firstly, the learning aspects are based on the learning mechanics. For example, questions and answers, action/task, repetition and reflection, and (self)-assessment.
- Secondly, the entertainment aspect (gaming) should be designed to entertain and amuse players with the game mechanics while learning (goals, rules, and challenges).
- Finally, the motivation aspect includes the elements that take players to play the game, like rewards and feedback.

4. Evaluation of The Conceptual Framework as A Design Tool

4.1 Application of the Conceptual Framework

To provide an initial assessment of the conceptual model, it is applied in the design and development process of a game for teaching children how to read the clock ‘learning Clock game'. The conceptual model can be utilized independently and contribute to the creation of a serious game using any programming language. Consequently, individuals can reuse the conceptual model to develop their serious games. The game developed as a mobile app using Flutter, it could also be implemented as a web application. Figure 3 shows screenshots of the Learning Clock game.



(a) The main screen (b) The learning task

Figure 3: Learning Clock Game

To gain a better understanding of how the learning aspect takes place in the game with the conceptual framework models, we identify steps that guide the development team in applying the model for game design. These steps involve moving from a high-level understanding of concepts (concepts of what needs to be done) to the concrete components that implement those concepts.

- The first step is describing the game concepts: the multidisciplinary team development discusses the main aspects of the game and their subjects, such as the general objective of the game, the target group, and the learning aspect of the game. This step helps to highlight the main concepts of the game and allows to observe the game from different and complementary aspects. For our game 'Learning

Clock Game', is a mini-game designed for children aged 5-10 years to learn how to read and tell the time.

- The second step represents the game sequence: to help in the identification of the game components. The purpose of this step is to establish a reference point that helps uncover how the components of the game are connected throughout the game. The game sequence representation adheres to the UML activity diagrams notation, employing shapes connected by arrows to represent the flow of game aspects. The outcome of this step is a blueprint of the game structure that reflects the essential form of the game components, figure 4 presents the game sequence of the learning clock game.

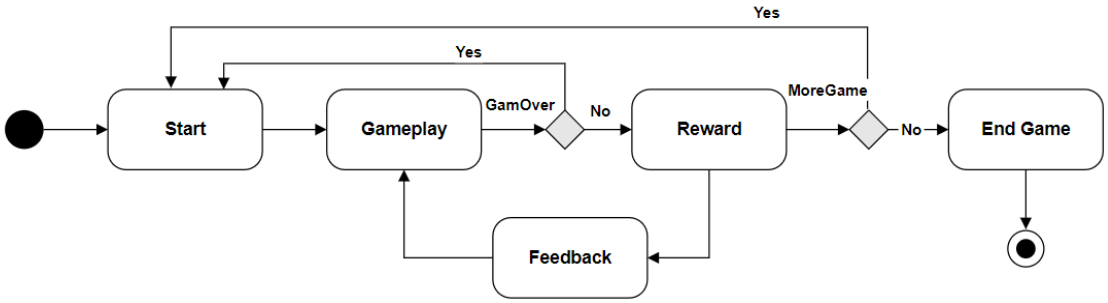


Figure 4: The game sequence of the learning clock game.

- Third step, description of the implementation: this step groups each set of actions and goals that belong to the same type of aspects and are related to the same components of the game sequence. It provides a more detailed description of the implementation of each block or component and explains what occurs at that point in the game, table 3.

Table 3: The Learning Clock Game Components

Components	Description
Mechanics	Rules: Multi choices
Challenge	The player should select the correct answer.
Level	Task: Gameplay screen
Feedback	Check the player's answer and provide information about their answer whether it is correct or not.
Reward Manager	To Calculate and update the player score after every corrected answer, and also update the game state
Object and Characters	To represent the objects within the game.
UI Manager	View: Levels and tasks (scene), display the feedback
Activity (action)	Interaction: Mouse, Keyboard Control: select the answer, button

Figure 5 demonstrates a screenshot of this game as a mobile app, a) represents the gameplay screen (Level), and b) shows the feedback that is given to the player when he chooses the correct answer.



a) The gameplay b) Feedback

Figure 5: The Gameplay and Feedback of the Learning Clock Game

Combining these steps offers a comprehensive view of the structure of the game, from its high-level purposes and general characteristics to its concrete implementation. Furthermore, they provide insights into the level of integration between gaming and learning components, thus highlighting possible weak points in the design.

4.2 The Conceptual Framework Evaluation

We performed an evaluation study in which investigating the users' perception of the framework's usability and usefulness. In this study, participants used the framework model and its design approach to design the “Senior PM Game”, a simple simulation game aimed at teaching project management to university students. Using an online survey tool with a proper set of questions, the experience of the participant in using the framework to develop the serious game is thoroughly evaluated and reported.

4.2.1 Participants

Participants of this evaluation totaled 17, aged 23-36 years (M = 28.76, SD = 4.024). The participants are master students of software engineering at the University of Babylon, Iraq. The participants are asked to use the conceptual framework model to design the 'Senior PM Game' and based on their practical experience, they evaluate the framework by answering the questionnaire. Participants first received an explanation of the framework, and then asked to apply the framework to design the game, using either templates or paper. After completing the game design, they are asked if the conceptual framework contributes to improving their perception of the game and if they have any suggestions to enhance the framework. They were also asked whether the framework was easy to apply and understand, and if it provided them with a better understanding of the game characteristics.

Furthermore, they were asked about their experience with the framework using an adapted version of the System Usability Scale (SUS) questionnaire (Brooke 1996). SUS is a simple, ten-item Likert scale that provides a global view of subjective assessments of usability, which yields a single usability score on a scale of 0-100 (100 is the best achievable score).

4.2.2 Qualitative Data Processing

In addition to the usability scores, we also collected qualitative data on the participant's experiences with the framework through open-ended questions on how the model affected their perception of the game if it was easy to apply and understand, and if it gave a better understanding of the game characteristics. To process the comments of participants, we coded answers to identify general statements about the framework. Each answer could contain one or more general statements. These general statements were grouped, and the results were presented subsequently.

4.2.3 Results

In general, participants considered that using the framework helped them better understand the characteristics of the game. It was positively evaluated by a large number of participants: among the 17 participants, 16 (94%) mentioned that the framework was helpful for them. It was considered simpler and easy to apply by ten participants, four of them non-gamers. The framework perception noted in qualitative data in the SUS usability scores was apparent. For the non-gamers group (N = 10), the average usability score was 71.25, and for the gamers group (N = 7), it was 68.93. While the average usability score for both groups of participants (N=17) was 70.29.

5. Conclusion

A conceptual framework is presented to facilitate the design and development of serious games for learning in a flexible and easy-to-use way. It identifies the main components for learning that could be incorporated into the game to aid the design process of an effective serious game. It links the mechanics that serve as learning mechanisms and those solely associated with gameplay to maintain the game's entertainment value. This linking provides the development team with a "dictionary" for adjusting the game mechanics to the learning objectives of the game. Additionally, the conceptual framework is easily understood and used because it employs vocabulary derived from the serious game domain itself, hence supporting the collaborative work among multidisciplinary development teams. Since it is possible to reuse design components of its model, it can serve as a guide throughout the development process, potentially reducing the time and effort required to complete the development compared to designing and developing serious games from scratch.

Finally, we demonstrated the feasibility and applicability of the conceptual framework by developing a serious game as a web application according to our proposed models. While this confirms the contributions of our conceptual framework, further evaluations are needed to demonstrate its utility in terms of productivity improvement. This could involve developing design methods and tools based on the model that can be compared with other design approaches. Additionally, further research could explore the conceptual model to identify any missing core components of serious games for learning.

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VR Simulation: Advancing Practical Skills in Computer Science Education

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Abstract: This study presents the successful integration of Virtual Reality (VR) tools as an element in computer science curriculum at German University of Technology, Oman. The research study investigates the use of MyScore, a VR application developed by RWTH Aachen University - Teaching & Research Field Engineering Hydrology as an environment for computer hardware assembly and troubleshooting exercises. The VR simulation utilized in this study acts as a gamified environment, incorporating elements like scorekeeping and interactive challenges to enhance practical learning in computer science, akin to game-based strategies that engage and motivate students. Over of some weeks, the project involved seven students and one tutor in immersive learning sessions to develop applied skills computer hardware assembly with VR technology over conventional teaching methods. Structured surveys and direct observations were used for data collection through students' interactions with the VR sessions. We also evaluated the students learning experiences as well as the usability of technology. The results showed that the user-friendliness of the VR interface and its ability to accurately simulate real-world tasks associated with computer assembly received both positive and negative reactions. While some students praised the technology for being pretty cutting-edge, some criticized it as unrealistic or non-interactive. We also received complaints that ranged from actually moving around in the virtual space to navigating only through teleportation spark points. Specifically, two students gotten motion sickness which is a well-known obstacle associated with VR environments and consequently left the sessions prematurely. The feedback of the instructor pointed towards that setting up the VR equipment is straightforward and described some potentials methods. Still, a call for more reliability in simulations and better interfaces began to surface as nevertheless less controversial agenda items. However, the instructor saw how VR has the potential to revolutionize educational practices. Providing interactive views between the VR device and students that can act as new learning methods. The present study extends the discussion on educational technology by providing empirical evidence of benefits and challenges experienced in deploying VR for technical education implementation. These findings thus support the continued development and validation of VR technologies in pursuit of improved commitment, cost-effectiveness, immersion, environment quality that may maximize learning outcomes in future educational applications.

Keywords: Virtual Reality, Computer Assembly, Educational Technology, Immersive Learning, Student Engagement, Motion Sickness, Technical Education, Usability, VR Simulation, Learning Outcomes

1. Introduction

To develop and evolve learning processes and outcomes, technology is evolving at a smart accelerated pace which keeps on revolutionizing educational horizons (Tang et al., 2022). Virtual Reality (VR) is one of the growing educational technologies to generate an immersive, interactive and multi-sensory experience which simulates real world environments (Luo et al. 2021; Frontiers in Psychology, 2018). This is invaluable for subjects such as computer science, where practical experience can sometimes be the most important part of understanding an idea.

But the broader deployment of VR in education still faces obstacles, such as the realism and fidelity of simulations on one hand, defy health and comfort concerns for its users. Studies have emphasized the ability of VR to increase student engagement and skill mastery, problems including motion sickness (LaViola 2000; Luo et al. 2021; Talespin, 2023).

As we directly address the trend of virtual learning environments in this project, particularly in relation to technical education using technology, it has become increasingly important for us to understand how VR technologies are changing conventional teaching methods. Perhaps this discovery is more about exploring new technology trends, but in this project we asked ourselves how the use of this technology would contribute to the learning experiences of our students at GUTech. This paper presents a research on "MyScore VR Simulation" adopted by the German University of Technology in Oman (GUtech) for computer science education using the MyScoreVR application. This project leverages VR technology to teach computer hardware assembly and troubleshooting, utilizing virtual components to minimize resource dependency and enhance scalability and

interactivity. While VR is an established method, recent advancements have made it more affordable and realistic, expanding its practical applications in educational settings.

To investigate how VR impacts educational outcomes in computer science - specifically around engagement, learning performance and system usability, this study qualitatively captures the experiences of seven students and one instructor during their use of the VR sessions. Their findings are part of a conversation about the role and scalability of VR in education more broadly, which helps to inform just what makes it worth adopting, if comparisons with traditional learning experiences weren't enough.

2. Literature Review

Virtual Reality (VR) is being widely acknowledged for its capabilities in computer science education and even the larger perspective of technical training. In fact, recent research has shown that VR can have comparable outcomes to traditional apprenticeship methods (such as in laparoscopic surgery) while providing a safer and more standardized training environment (Portelli et al., 2020). Moreover, VR has indeed been shown to enhance gait in individuals with cerebral palsy (Ghai & Ghai 2019) such that its applications can meet medical rehabilitative purposes. There are also claims that VR may improve college education, and particularly the effectiveness of vocational skill training (Simonova et al., 2021).

In the case of military training, VR is used succeeding on some fronts based upon 4th industrial revolution innovations. al, 2021). Moreover, due to the potential benefits of VR for sectors including surgical training (Palter & Grantcharov, 2010), and procedural skills that demand exact technical proficiency within surgery, (Bjerrum et al., 2013) a risk-free opportunity can be offered in these areas. Similarly, the enhanced VR environment have been also proven to be effective in rehabilitation where they accelerated executions on mental representations of actions and motor functions (Rodrigues-Baroni et al., 2014).

VR has also been used in sports. It was evaluated in a research on soccer skills (Fuller et al., 2019). VR has also been used in various training programs such as navigation training ("Using VR Virtual Reality in Navigation Training", 2018) in firefighting instructions and stress management module, which is an idea that is applicable worldwide (Zhang & Tsai, 2021).

Not only has virtual reality been considered to be a safe and affordable training environment (Jones et al., 2013), it also enables more interactive communication between trainees and instructors, offering improved learning outcomes for both groups of different study cases (Ahmed et al., 2012; Balistreri & Casile, 2019). Additionally, being able to use them in a pedagogical scenario and with intelligent tutoring systems only adds its ability to bring about changes that improve the efficiency of training by fostering knowledge transfer virtually (Corre et al., 2014) .These great benefits and similar studies have made interest in working in the field of virtual reality in the GUTech sector. However, the need to study and carry out similar and ongoing projects are needed in order to better adapt VR programs to individual educational. We strive to create a deeply interactive learning environment despite challenges such as motion in this project. We hope to continue to use these learnings and improve our use of VR in education as a benchmark for future considerations. In addition to these applications, simulation games in VR have become a significant component of game-based learning, providing immersive environments that enhance educational experiences. These simulation games offer dynamic and interactive learning opportunities, allowing students to develop critical thinking and problem-solving skills in a virtual setting, thus complementing traditional educational methods.

3. Methodology and Implementation

3.1 Study Design

The study used a case-study method to assess the incorporation in the computer-science curriculum at GUtech of Virtual Reality (VR) technology using MyScore application. This approach was selected because traditional case study provides a detailed holistic analysis of how VR experiences influences education in real classroom settings (Yin, 2014). For several weeks, students participated in both VR-enhanced and traditional hands-on activities during computer science courses allowing for a direct comparison of student engagement and skills development through the two different educational methods (Clark et al., 2016).

The primary aims were to evaluate whether VR employed in this manner would facilitate educational performance and potentially identify barriers (e.g. technological problems, user discomfort such as motion

sickness) (LaViola 2000). This data was collected through surveys and observations for usability, student experience(s)and general educational values [Bailenson, 2018]

These comparative experiment findings are meant to contribute to the continued intellectual dialogue on VR-specific pedagogy use-cases and indicate where improvements must be made if we want VR as an entity inside educational scaffolds in entirety.

3.2 Participants

Nine undergraduate students and one instructor from a computer science course (using Virtual Reality) were enrolled in the research. Seven students (4 male, 3 female ages between 19 and 24) took part at the VR sessions during that day that made a variety of experiences in relation to perspective on VR.

The instructor served as the facilitator of the VR sessions, and she had a background in computer science and an interest in innovative teaching methods. Her direction was instrumental in managing the VR learning curve and administering & collecting of survey data, which added to a better yield as well.

Full participation was voluntary and all participants provided written informed consent before and after being fully briefed on the aims of the study and their rights, including that at any time they could withdraw from this protocol without penalties.

Having participants with different levels of experience, and diversity in their demographics helped us to assess differential effects if any across a wide range of users within an educational setting.

3.3 Setup of the VR System

For this study the researchers employed an open-source tool named MyScore from RWTH Aachen University's Teaching & Research Field Engineering Hydrology Department of Virtual Reality (VR) application, intended for avatar-based education. In a number of instructional scenarios, the learners work through avatars in different types adopting various educational modules in virtual environment. The system was supplied with VR headsets and controllers, to ensure high performance of the 3D educational experience shown in Figure 1.

Prior to the start of this research, VR systems were thoroughly tested and calibrated for reliability and ease-of-use. The classroom, too, was rearranged to accommodate how students would be seated using the VR setup so that an announce of floor space could permit their bodies to freely engage.

MyScore goes beyond the constraints of traditional or hybrid approaches, which have been further underscored by recent teaching modality changes. Compared to video teaching tools that provide 2D only interactions, MyScore allows for a more engaging and enriched three-dimensional teacher-student interaction. However, this functionality is important when it comes to simulating and displaying real-world complex tasks like computer assembly so the learning experience would be richer.



Figure 1: Inside the MyScore app: A virtual workspace where students assemble and diagnose computer components.

MyScore application boosts engagement between participants, provides gamification elements with more interactive learning moments and also saving extra travel cost and environmental impact. VR settings were

modified over the course of study based on feedback to optimize performance while providing comfortable experiences for users that would fit smoothly into educational workflows.

For the project, a dedicated learning space environment was designed to provide an immersive VR setup. The setup introduced two central VR stations, labeled as VR Rack 1 and VR Rack 2, loaded with VR headsets and necessary equipment. These stations were supported by computer 1 and computer 2 support the stations, acting as control centers for the VR software running.



Figure 2: Displaying the VR setup for the activity, featuring VR racks, main and backup computers, and a spacious area ensuring at least 2 to 3 meters of distance between each student workstation.

In addition to the primary computers, two backup computers were kept on standby. Such redundancy was a necessity in order to handle any disruptions that might undermine the learning process. Strategic positioning are necessary to reduce interruptions and improve the functioning of the learning architecture, strengthening them against student engagement (Dodevska & Mihic, 2018).

3.4 Data Collection Methods

We mobilized information about the performance of VR configuration and utilization results achieved by MyScore app in facilitating computer science learning using a dual-method technique. The primary ways data was collected were through structured surveys and on-the-ground observations.

The surveys aimed to collect feedback on the general process through engaging in VR, its effectiveness as an educational tool, how user-friendly and intuitive was it interact with the interface of VR. Finally, any points need improvement could have been gathered. The aim of using the above approach was to evaluate subjective educational results and track student satisfaction with VR learning.

Observational data was recorded by the instructor in all VR sessions, specifically focusing on how students engaged with VR technology and their behaviors during each task. The instructor also noted any challenges or issues that arose. These observations were vital for understanding how students navigated and deployed knowledge in the VR-based setting. The instructor also recorded any incidents of motion sickness and how it affected student engagement. The instructor actively supported the students during the survey process and VR sessions and make sure that students understood the questions

3.5 Procedure

The study process was designed meticulously to measure the efficiency of VR technology in educational settings. A detailed illustrating the steps that were taken along with a comprehensive and systematic evaluation was performed in this study.

The classroom, shown in Figure 3 below was initially set up to accommodate the VR hardware so that students could move freely within the virtual space. The MyScore software was installed on the central computers and all equipment tested to confirm full operation.

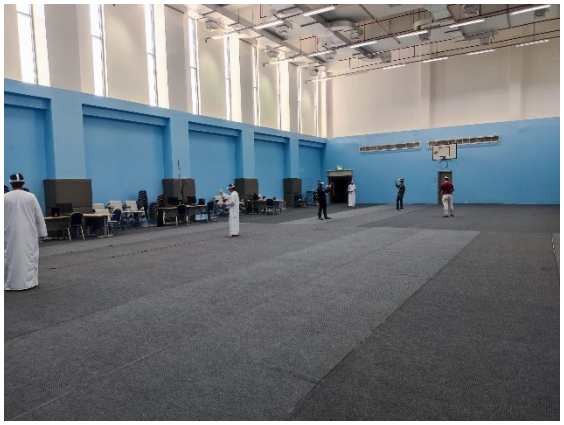


Figure 3: displays students engaging in the VR activity, spaced safely apart to ensure a secure and interactive environment.

The orientation session for the students familiarized them with both equipment and application (MyScore). The instructor spoke the goals of VR activities, showed how to use controls and answered any possible doubts from participants in order for them be able to understand very clearly what tools they would have at their disposal.

Students endeavored to perform emulation tasks corresponding to everyday examples in computer hardware assembly and diagnostics essentially giving them a hands-on experience within a safe virtual environment.

After the VR activities, students were provided with structured surveys by their instructor. These were aimed at capturing the more specific feedback factors such as experiences.

The instructor took notes and assessed the students' engagement with VR technology during each session. The instructor documented how the students strategically navigated, paid attention and adapted to their new tasks, as well as any difficulties they encountered like motion sickness.

Students were then brought together to discuss their experiences in a concluding open feedback session. Such a debate provided additional perspective from students and complement the quantitative data collected.

The last step is to compile and organize all the data collected (survey responses, observational notes, feedback from a discussion). In addition to human notes, any technical issues experienced during the sessions were recorded by the instructor and used for future planning of refinements within VR.

4. Data Analysis

Data from the structured surveys were quantitatively analyzed to identify trends in students' experiences with the VR system. Basic descriptive statistics were utilized to summarize the data.

The qualitative data from observational notes and open responses in surveys were reviewed to extract common themes regarding the VR learning process, technical issues, and the overall user experience.

Special attention was given to the feedback concerning motion sickness, with the aim of understanding its prevalence and impact on student participation. These insights were crucial for assessing the practicality of VR in classroom settings.

5. Results

5.1 Detailed User Feedback

Opinions about the VR experience itself amongst the students were divided, with both excitement and criticism overall. In particular, five of the seven students were impressed by the engaging interactivity and immersion facilitated through the VR environment; they believed that experiencing computer hardware components in 3D had greatly enhanced their learning on how to troubleshoot equipment. 3D-immersive experiences resonated particularly well with these students, allowing them to more easily grasp abstract concepts.

But there were some challenges too. One limitation they identified was that the VR simulations could be unrealistic at times, which may detract from their authenticity if not comprehensive or advanced enough to represent real-life tasks as realistic (as reported by four students). Three students encountered issues in VR

navigation that impaired their learning as well. Two additional students had ongoing system connectivity issues that impacted their participation and engagement with the VR tasks.

5.2 Instructors Note

Indeed, comments from the instructor were aligned with this feedback stating that it was easy to get VR up and running in session for both students as well as how much more engaged they found their class became. Though, she noted that more accurate simulations would need to simulate how physical hardware interacts. One of the students also faced miseries with motion sickness which was an issue that brought down the functioning and comfort level during VR usability.

5.3 Motion Sickness Concerns

Among the issues flagged up were intense motion sickness, which affected two students. A student described the sensation as being like motion sickness to an intense and extreme degree. This feedback does point that possibly before beginning the experiences themselves, there may need to be more preparatory sessions and even setting adjustments for those new going into VR due to individual sensitivities.

Unfortunately, this experience drove both students to leave the VR sessions midway. It underlines the increasing significance of introducing more robust user orientation and safety nets for beginners to adverse impacts as well privilege ease-of-use.

Despite initial testing sessions aimed at student preparation, the persistence of motion sickness represents an area that requires further research. This brought the idea that the future research should focus on developing more personalized VR experiences that are adjusted to individual thresholds for motion sickness and examine comprehensive pre-use orientations.

6. Performance Metrics

The data revealed that students using VR notably improved their understanding and retention of computer hardware concepts compared to those engaged in conventional learning settings.

6.1 Learning Outcomes Comparison

Quantitative assessment: Students who used the VR app learned academic theories quicker and applied them through practical exercises with more confidence. Pre-and post-test comparisons revealed a dramatic increase in test scores, with the average score regarding hardware assembly and troubleshooting tasks improving by 20% for students using VR. Indeed, it indicates that being in a VR environment drives better comprehension for challenging topics - leading to increased cognitive retention and applicability.

6.2 Skill Acquisition

5 Students out of 7 indicated an increased confidence in recognizing, installing and troubleshooting computer parts within the VR environment. The VR system offers hands-on computer assembly and real-time feedback which is much harder to ghost in the classroom than it is on VR. Using the VR, students could practice their skills multiple times in a safe environment with less errors and gain better understanding of standard operating procedures when building computers.

The conclusion is well supported by the data that VR can indeed make education far more interesting and informative which simply means a hands-on learning experience. They can learn by doing, which enhances skills and increases readiness for performing real-world job functions in contrast to other passive learning methodologies.

7. Comparative Analysis

This project highlights distinct advantages and challenges associated with each methodology.

7.1 VR vs. Traditional Methods

The major advantage of using VR in education is that it can provide an immersive, interactive learning experience where students are able to interact with 3D content as opposed to reading about these subjects on paper. This

allowed students to interact with computer components as if they were putting components together in person, demonstrating how such an assembly process works. The novelty and high-tech factor of VR made it fun for students to use, leading to better engagement and more motivation.

At the same time, it raised some issues with VR too. The single most important challenge was the high cost of initial investment and ongoing support for stably functioning VR equipment. A potential barrier to entry in deployment within institutions. Furthermore, the learning curve to learn how to use VR technology comfortably was high. For a few students, the new interface did not suit them and would only hinder their learning if it was not solved through proper orientation and training.

7.2 Instructor Observations

While VR can mimic many of the steps in the computer assembly process, the instructor noted that the process was not perfect and had limitations. Traditional methods, in contrast, are about hands-on experiences with hardware and are still important to many educators when deeper learning is crucial. However, instructors reported that students made the most of their class time and were not afraid to venture into an unproductive VR environment.

Comparative analysis shows that VR is suitable for basic learning and practice, but weak against more advanced skills, where traditional methods are better. Therefore, like the similar research of Cai et al. (2022), we think that combining both VR and traditional learning in one approach provides the best learning environment and allows students to benefit from the immersive experience of VR and the hands-on practice of traditional methods. This combination increases the overall learning results by using the strengths of each method together.

8. Challenges and Improvements

Overall, a number of key concerns emerged from the student and instructor feedback that may improve upon both VR platform learnability as well effectiveness.

One of the many problems identified were that some VR simulations lacked a sense of realism. Students however remarked that the simulations were not true to life when it came to computer assembly and lacked complexity while also lacking tactile feedback which is very important in learning hardware assemblies. Several students had direct difficulties even just getting around within the VR space itself, and others experienced system crashes that booted them out of the experience. On top of all that, we found the motion sickness for two students who were unable to continue through a full session.

To address these challenges, several improvements are suggested:

- **Enhance Simulation Realism:** Improving the VR to have higher resolution and more complex simulation scenarios especially in real-world conditions would make a significant difference. For example, this could integrate tactile feedback mechanisms that give a physical sensation of the virtual actions.
- **Improve User Interface and Stability:** Making the VR interface more user-friendly could allow students to navigate easier, which in turn minimizes learning curves for users. This could be with application support such as frequent software updates and bug updates that can improve stability, performance, which in turn make the VR experience smoother and more reliable.
- **Address Motion Sickness:** Some students may develop motion sickness when using VR, so the introduction of pre-session orientation and acclimatization tasks would allow students to adapt themselves. Furthermore, these staple VR experiences should at least introduce adjustable settings within the system that would allow users to tailor their experience based not only on what input paradigms they prefer but how likely they are to endure motion sickness in a given application.
- **Feedback Mechanisms:** Enabling feedback mechanisms that can alert instructors to student difficulties during VR sessions in real-time to provide immediate intervention and support for a better learning experience.

9. Future Prospects

The current study lays the groundwork for significant advancements and broader applications of VR in education and beyond. Here are some key future prospects:

- **Scalability and Future Applications:** The early success of the VR application in computer hardware assembly teaching can be a template for similar difficult subjects. The project is not limited to covering

only computer-science-related topics, as the VR curriculum could be expanded upon different kinds of simulations (e.g. networking setups or software engineering processes), addressing a wider variety of disciplines making it even more useful and accessible for other courses hours per week. Additionally, testing whether VR training could be further scaled to fields of study (e.g. medical students/architects/industrial engineers) would take advantage of its immersive and hands-on learning environment.

- **Research and Development:** Obviously, more R&D is needed to improve the VR learning experience. This can be the incorporation of technology to enhance how realistic and interactive VR simulations feel. Research can also centre around the pedagogical issues of VR learning, such as creating curriculum-specific content in VR for effective teaching and way to teach using a 360-degree game. Further research into the long-term impacts of VR learning on student outcomes will provide a more complete overview of its efficacy and potential areas for growth.
- **Integration of Advanced Technologies:** The integration with other advanced technologies could make the learning environment more efficient and effective through VR. For example, integrating artificial intelligence (AI) will enable adaptive learning environments more able to personalize an individualized experience of the same simulations according to different student needs. Hybrid models that combine AR & VR further extend the virtual simulations with interactive elements and contextual information.
- User Accessibility and Comfort: Future projects should look to the user-accessibility and comfort of VR technologies as well. This includes solutions for motion sickness, and better VR design so that equipment is more ergonomic. Being able to adjust VR setups for different physical needs and preferences will make the technology more inclusive, making it appealing on a larger scale.

10. Conclusion

The research conducted on the integration of Virtual Reality (VR) technology into the computer science curriculum at GUtech has provided valuable insights about VR as an educational tool. The results illustrate how VR can enhance the teaching of activities like computer hardware assembly and troubleshooting by providing immersive simulations that actively engage students in intricate subjects; for instance, 5 out of 7 participants reported that VR significantly improved their understanding and engagement. But the study also highlights where further improvements are necessary, including in simulation realism; user interface design and usability; and user comfort - health issues around VR such as motion sickness.

Encouraging results for VR, being engaging and motivating hardly surprising that this is a successful approach when it comes to teaching complex technical content. However, increase realism and stability of VR environments for learning purposes have been suggested. Also we discussed that virtual reality situated as a means to aid in traditional forms of practice but not replace them. This is why educators suggested to combine the power of VR with conventional teaching methods to deliver a more holistic learning experience that works.

Collectively, this research contributes to wider discourse in educational technology by demonstrating that VR can enhance learning. This underscores the importance of ongoing efforts to better design and optimize VR learning environments. Further endeavours could be featured on advancing VR technology for educational uses in terms of accessibility and usability as well effectivity located in different scholastic surroundings. Furthermore, a limitation of this study is the relatively small sample size, which may affect the generalizability of the findings; future research should involve a larger and more diverse group of participants to validate and expand upon these results.

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A Preliminary Study of Context Integration as A Determinant in The Effectiveness of Digital Mathematics Games

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Abstract: Contexts in the digital learning environment are one of the crucial components regarding students' motivation and positive attitude development toward content. Although there is not enough guiding information in the literature about how contexts should be, previous research has shown that even digital game contexts are effective in developing students' environmental awareness. To reveal the impact of contexts in the digital learning environment, it is necessary to consider the variables regarding the socio-economic and cultural status of the students. Therefore, it can be envisaged that the effect of digital game contexts may differ depending on students' experiences and social environments. For this purpose, digital games were designed in two different contexts in this research. In these digital games, two opposite contexts were selected. The first context was focused on saving nature and green energy. This context includes different levels of digital games on topics such as solar energy, reforestation, and clean water sources. The second context was focused on unregulated industrial development that negatively affects nature by ignoring it. This context includes different levels of digital games such as building thermal power plants, building chemical factories, and turning forests into fields. Apart from the contexts, the other variables in both games (i.e., gameplay, artistic structure, levels of problem parameters) are the same. At each game level, students were asked to solve mathematical problems regarding ratio-proportion. In this study, the preliminary findings, which were derived from a large experimental study, were presented. The participants of this study were 15 gifted eighth-grade students from Turkey. Among the participants, eight students played the digital game regarding the context of green energy, and the remaining seven students played the digital game regarding the context of unregulated industrial development. Preliminary findings showed that students were more interested in the digital game regarding the context of unregulated industrial development as it included interesting and beneficial topics such as energy generation and economic development. The resident perception of the citizens regarding the acute need for energy generation and economic development rather than saving nature and green energy since Turkey represents a developing country may explain this finding.

Keywords: Digital Game, Mathematics, Context, Problems, Environment Awareness

1. Introduction

Story (i.e., context) is presented in brief intervals to ensure that players understand essential concepts as the game progresses (Lim et. al., 2013). It is known that contexts (i.e. stories) are important in the learning process and have a positive effect on students' motivation and academic achievement (Hao, 2023). Moreover, contexts in the digital learning environment are one of the crucial components regarding students' motivation and positive attitude development toward content. Although there is not enough guiding information in the literature about how contexts should be, previous research has shown that even digital game contexts are effective in developing students' environmental awareness. To reveal the impact of contexts in the digital learning environment, it is necessary to consider the variables regarding the socio-economic and cultural status of the students. Therefore, it can be envisaged that the effect of digital game contexts may differ depending on students' experiences and social environments.

It is crucial to evaluate the effect of contexts on learning outcomes in terms of cultural differences in the digital game-based learning environment (DGLE). Previous research has shown that contexts related to environmental education have a positive effect on learning outcomes such as environmental awareness and attitude (Van Harskamp et al., 2023). Moreover, it was seen that the past studies conducted on environmental education positively and significantly improved students' awareness of the environment. (Ardoin et. al., 2018). It is also known that digital games related to environmental education are effective in developing positive attitudes in students (Janakiraman et. al., 2021). However, the most basic feature of digital games in these past studies (Ardoin et. al., 2018; Janakiraman et. al., 2021; Van Harskamp et al., 2023) is that the researchers focused on providing environmental awareness education rather than investigating the effect of contexts on learning outputs. While it can be argued that previous research underestimates the impact of digital game contexts on

learning outcomes, it may be useful to focus on the impact of digital game contexts on learning outcomes in terms of socio-economic and cultural norms through the country example.

In this study, Turkey has been selected as a country example. Turkey is a developing country and represents more Asian culture. Asian countries (e.g. Turkey) have a collectivist culture in which the decisions and value judgments of society are more important than those of individuals, whereas in European cultures individuality is at the forefront and individuals can make decisions on their own, their opinions are considered, and their self-constructs can be continuously developed. At this point, while Asian culture is resistant to change, European culture is change-oriented. (Klassen, 2004). Moreover, it is known that the environmental awareness of students in Turkey is not at the desired level (Savaşçı, 2020). Many researchers emphasize (Buldur et. al., 2018; Vural & Yılmaz, 2016) that Turkish national education is insufficient in terms of environmental education (Buldur et. al., 2018; Vural & Yılmaz, 2016). With the increasing need for energy in Turkey, citizens are concerned about foreign dependency on energy and the quality of life is decreasing due to expensive electricity bills (Ekşi et al., 2019; Clean Energy Foundation, 2022). As Turkey is a developing country, the resident perception of the citizens regarding the acute need for energy generation and economic development rather than saving nature and green energy is dominant (Clean Energy Foundation, 2022). It is also emphasized that there is an urgent need to ensure the information and active participation of citizens in Turkey in terms of social acceptance, especially regarding renewable energies (Demir & Ataöv, 2021). Therefore, exploring students' learning outcomes by focusing on environmental contexts (i.e., green/clean environment versus industrial environment) may reveal authentic, different, and in-depth findings, as Turkey represents a developing country with acute and resident perceptions of energy needs. At this point, it is thought that it would be useful to examine the effect of different contexts under GBLE within the scope of environmental education on learning outcomes in terms of socio-economic and cultural norms through the case of Turkey.

For this purpose, digital games were designed in two different contexts in this research through the case of Turkey. In these digital games, two opposite contexts were selected. The first context was focused on saving nature and green energy. This context includes different levels of digital games on topics such as solar energy, reforestation, and clean water sources. The second context was focused on unregulated industrial development that negatively affects nature by ignoring it. This context includes different levels of digital games such as building thermal power plants, building chemical factories, and turning forests into fields. Apart from the contexts, the other variables in both games (i.e., gameplay, artistic structure, levels of problem parameters) are the same. At each game level, students were asked to solve mathematical problems regarding ratio-proportion. Moreover, the digital games used in this study indirectly focused on environmental pollution through different contexts while teaching mathematical concepts.

In this study, the preliminary findings, which were derived from a large experimental study, were presented and it was aimed to reveal students' thoughts about different contexts within the scope of DGBLE. Moreover, the educational aspect of digital games was also examined. Therefore, the cognitive process of students while solving problems was observed.

2. Method

Since it was aimed to reveal the students' thoughts about different contexts in detail within the scope of DGBLE, the case study was chosen as the research design from qualitative research methods for this study. The case study design was chosen as it provides more in-depth analysis and findings from its natural environment through a situation or a case without any intervention (Yin, 2009). This research, which constitutes part of a larger experimental study, was conducted during the spring semester of the 2023-2024 academic year.

2.1 Participants

The participants of this study were 15 gifted eighth-grade students from Turkey. The age range of the students varies between 12 and 14. Eight of the students are boys and seven of them are girls. Participant students classified as gifted exhibit elevated scores on cognitive assessments, demonstrating superior intellectual capabilities in comparison to their age-matched peers. Consequently, these gifted students tend to display exceptional aptitude in domains such as visual arts, music, and academic pursuits (Bıçakçı & Bakırcı, 2021). The National Association of Gifted Children posits that subjects scoring within the top decile of the standard cognitive distribution are typically designated as "gifted". However, this threshold may fluctuate between the 1st and 25th percentiles, contingent upon the adopted theoretical framework or model of intelligence. A gifted student is characterized as one whose capacities in intellect, artistic expression, creativity, leadership, or general and/or

specialized abilities have been empirically determined by experts to significantly surpass those of their cohort (Ministry of National Education [MoNE], 2016).

For the purposes of this research, giftedness was operationalized as achieving a score exceeding 130 on the Anadolu Sak Intelligence Scale (ASIS), an instrument employed by the Turkish Ministry of National Education. The ASIS is an individually administered cognitive assessment comprising seven subtests, designed for children aged 4-12 years. Its verbal and visual components evaluate comprehensive cognitive functions, including reasoning, perceptual abilities, and working memory. The ASIS is regarded as one of the most robust individual intelligence measures globally, boasting internationally recognized psychometric properties (Sak et al., 2016; Sak et al., 2019; Tamul et al., 2020). The rationale for selecting participants from the 8th-grade level is that these students are in the formal operational stage and possess the necessary mathematical readiness in terms of the required learning outcomes related to proportional reasoning skills. Moreover, the participating students have previously taken many courses related to new-generation technology on Industry 4.0, augmented, virtual reality, and digital game design. Given the potential of gifted students to significantly influence future technological advancements and next-generation industrial developments, this study deliberately focused on 8th-grade gifted students as participants. The selection criteria were based on two primary factors: voluntary participation and the ability to articulate thoughts clearly. This deliberate sampling strategy was employed to ensure that the study population comprised individuals who are not only at a crucial stage of cognitive development but also possess the capacity to contribute meaningfully to the research objectives. The choice of 8th-grade students aligns with the developmental hypothesis that this age group has reached a level of cognitive maturity conducive to engaging with complex concepts and expressing sophisticated ideas, which is paramount for the study's investigative aims.

3. Data Collection Tools

3.1 Digital Games

In line with the purpose of the study, the digital games in this research were designed by the researchers. To explain the research environment in more detail, one of the contexts in digital games was the environmental context. In the environmental context, students were asked to organize the city by saving the city from environmental problems. In the industrial context, students were asked to develop the economy of the city and industrial development by damaging nature. In this respect, two different contexts were defined as opposite to each other. At the same time, in both contexts, students can visually observe the changes in the city. The problems presented in each context in GBLE, and the problems used in the game at each level were identical. To explain in more detail, the objects, animations, and mathematical problems used in both studies were the same. Only the context of the games was different.

This study focused on the possible advantages for gifted-students when utilizing a game-based learning environment for mathematics concepts and skills (i.e., rate/ratio and proportional reasoning). To select the problems used in the digital games in this study, past studies were analyzed to evaluate the concept of ratio-proportion from all aspects. In this study, the digital game was designed by considering the ratio-proportion problem types defined by Lamon et. al. (1993) and Van Dooren et. al. (2005). The problems at each level correspond to the problem types defined in these studies.

Gifted students played the digital games in the study individually or in groups of two or three. Among the participants, eight students played the digital game regarding the context of green energy, and the remaining seven students played the digital game regarding the context of unregulated industrial development. Eight of the students played the digital game individually (see Figure 1). The remaining seven students played the game in groups of two-two-three (see Figure 2 and Figure 3). In this way, both individual and group play of the game were evaluated. These digital games, each of which consisted of five levels developed for two different contexts (i.e., green/clean environment and industrial environment) varied between 15 and 45 minutes for each level. Meanwhile, the researchers were able to observe the behaviors and errors of the game-students interaction in detail. The digital gameplay was also recorded using Movavi Screen Recorder software. Then, focus group and individual clinical interviews were conducted with the students about the digital games they played.

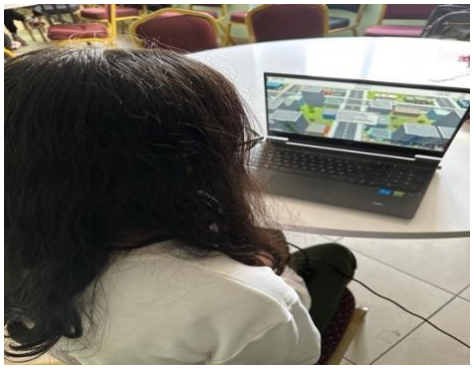


Figure 1: Individual digital game playing



Figure 2: Playing digital games with a group of three students



Figure 3: Playing digital games with a group of three students

3.2 Researchers' Observation

Researchers' observation was made under the recordings of student digital game-playing videos with two main purposes. The first one is to examine the digital game from an educational point of view and to observe the effectiveness of the game. In other words, the difficulties experienced by students while solving problems and the strategies they use were examined. In this respect, the educational effectiveness of the educational digital

game was examined in terms of educational effectiveness. Moreover, researchers' observation was made to determine the missing and faulty parts of the digital game design. Since this research is part of a large study, researcher observation is crucial in determining the gameplay and in-game errors of the digital game at the design stage. However, the design phase of the digital game was planned to be discussed in another study.

3.3 Clinical Interviews

The purpose of the focus group and individual clinical interviews was to evaluate the students' views on the contexts (Koichu & Harel, 2007). In these interviews, students were asked about the shortcomings of digital games and the aspects of digital games that they like or dislike. The questions asked to the students during the clinical interviews are as follows:

1. Can you explain what are your general thoughts and first impressions about these digital games you played?
2. What do you find interesting about these digital games you play?
3. Can you list what are the most important features of these digital games?
4. What are your thoughts on the shortcomings of these digital games you play?
5. What are your criticisms, if any, about these digital games you have played?
6. Can you explain in detail how you solved the problem in this digital game you played?

In order not to guide the students, direct questions about the digital game context were not asked. In this way, students were asked to express their views on the digital game context themselves.

4. Data Analysis

During the research, the data collected was analyzed simultaneously. To do this, the transcripts were processed by selecting which of the collected data would be used, open, axial, and selective coding were performed, and appropriate themes were interpreted (Strauss & Corbin, 1990). In this study, a thematic analysis of the qualitative data was conducted. During the analysis process, the transcripts containing the raw data were read several times, and the data were divided into conceptual categories. Themes were reached by establishing relationships between the codes. Open coding was used as the first step of the thematization effort. Themes at a low level of abstraction were reached through open coding based on the research questions, concepts in the literature, terms used by students, and their thoughts on the environmental contexts. Axial coding was carried out by making a second pass over the superficial abstractions obtained through open coding. In this second pass, all the initial codes were related to each other. Thus, many closely related concepts were combined under a more general concept. Therefore, with axial coding, the codes were organized and related to discover the basic analytical categories. With the final coding, selective coding, the data were gone through for the last time and certain themes identified during the previous coding were reorganized. Thus, the main themes of the research were reached (Strauss & Corbin, 1990).

Preliminary findings

In the clinical interviews, the students were asked to identify the most important feature that interested them about digital games. The students tried to describe the most interesting aspects of digital games according to their features (see Table 1).

Table 1: Student views on the most interesting features of digital games

Student's view	*f*
Power plant building industrial factory	5
Training for a budget economically	3
Gamifying mathematics	3
Contains mathematical problems	3
Tree planting	1

Based on Table 1, it was revealed that student's views on the most interesting features of digital games were related to the industrial context. The students emphasized that in the game regarding the industrial context, power plant building regarding industrial factory and training for a budget economically were given. In this respect, gifted students stated that the digital game associated with the industrial context was more interesting

and valuable as it provided energy generation and budget management training economically. Gifted students also indicated that the digital games in both contexts were interesting and enjoyable since they included mathematical problems and gamified mathematics. On the other hand, only one gifted student mentioned that planting a tree was the best part of the digital game in the context of a green environment.

When asked about the missing parts of the digital games used in the research, it was observed that the students made critical comments on the gameplay of the digital games. In these digital games, especially the inability to determine the position of the tasks on the map and the lack of information on how to move the camera were emphasized by the students. However, only one student stated that since digital games are interesting, it would be better to have more levels in digital games and thus, they could try to complete these games for a longer time. In addition to all the findings, it was observed that these game levels were challenging even for gifted students and that the game was compatible and suitable even for group work. It was also observed that these digital games can be played with groups of one, two, and three players.

It was observed that most of the gifted students were able to determine the task related to the digital game, such as finding the type of solar panel, without performing mathematical operations. Although these students focused on the relationship between two different variables (i.e., money and energy), they stated in the interviews that they only chose the type of solar panel according to the dependent variable, namely energy. This situation reveals that students focus more on the dependent variable instead of the quantitative relationship. The following sample excerpt demonstrates the aforementioned situation.

> S1: *"Since the C solar panel produces the most energy in this problem, we should choose this panel."*

On the other hand, it was observed that a few students initially ignored the data in the questions and the relationships between variables and chose solar panels randomly. These students tried to reach the answer by using a trial-and-error strategy among the options. These students used trial and error strategy only in the first digital game. In the other digital games, they were able to complete the tasks successfully by focusing on the problem situation and the relationships between quantities. Moreover, it was seen that almost all the gifted students used the proportional relationship while solving the mathematical problems in the digital games and they were able to use proportional reasoning easily. The example excerpt below shows the mentioned situation.

> Researcher: *"Do you comprehend the problem?"*
>
> S2: *"Yes, I try to find the answer by choosing randomly. Let me choose solar panel B and see what happens." "Oh, it didn't work, then I chose solar panel A. That didn't work either, so the answer is solar panel C (laughing)."*
>
> S3: *"We aim to increase our money and, in this way, to do other tasks. Therefore, I should choose the panel that allows me to spend the least amount of money." I have to focus on the relationship between money and energy."*

5. Discussion and Conclusion

This study showed that the adaptation of the digital game environment based on mathematical problems regarding the concept of ratio-proportion in the literature drew the attention of gifted students and that they played this game with enjoyment and motivation. In these digital games, gifted students were able to determine the parameters as in mathematical activities and solve the problems based on these parameters. However, at the beginning of the game, some students tried to reach the result by just clicking the buttons without thinking deeply about the questions. It can be inferred from this that these students did not perceive the game environment as a mathematical problem at the beginning of the game. In their study, Alkan and Ada (2023) observed that in digital educational games, students did not read the instructions at the beginning and guessed the answers. From this point, it can be revealed that these students are not familiar with this kind of digital educational game environment. At this point, it can be deduced that these students generalize their usage habits related to digital games focused only on entertainment to educational digital games.

Preliminary findings showed that students were more interested in the digital game regarding the context of unregulated industrial development as it included interesting and beneficial topics such as energy generation and economic development. The students highlighted that the digital game related to the industrial context was particularly useful for learning how to build power plants regarding industrial factories and manage budgets efficiently. Gifted students found the game even more interesting and valuable as it provided training on energy generation and budget management economically. However, only one gifted student mentioned that planting

a tree was the best part of the digital game in the context of a green environment. Therefore, it can be claimed that gifted students are not very interested in the digital game related to the green environmental context and their attitudes towards this context are low. The reason why digital games related to the environmental context are of little interest to students may be associated with the lack of sufficient level of green environmental education in Turkey (Savaşçı, 2020). However, it is known that digital educational games are important in raising environmental awareness (Janakiraman et. al., 2021). However, both contexts aimed to develop environmental awareness in students. Even in the industrial context, the negative impact of unregulated industrial development on the environment can be observed. Similarly, the problems in the environmental context are related to rehabilitating the environment. However, it was observed that both digital game contexts caused students to focus more on energy production and energy needs instead of environmental awareness. At this point, it can be argued that both digital game contexts regarding the green/clean environment and industrial environment remain neutral in terms of encouraging students in terms of environmental awareness.

Based on these preliminary findings, it was revealed that the student characteristics of Turkey, which represents a developing country, were dominated by the view that contexts such as the economy and industrial development, that was, the industrial context are more interesting and useful than the green/clean environmental context. Moreover, the resident perception of the citizens regarding the acute need for energy generation and economic development rather than saving nature and green energy since Turkey represents a developing country may explain this finding (Clean Energy Foundation, 2022). The findings of a recent survey indicated that adolescents aged 15-17 in Turkey consider the high cost of energy and dependence on imported energy resources as the two biggest problems. This survey also showed that among Turkish citizens, adolescents are the cluster that is most concerned about energy external dependence and the cluster with the highest tendency to see oil as the main source of Turkey's energy external dependence (Clean Energy Foundation, 2022). On the other hand, the adoption of renewable energies is crucial for a sustainable future, and Turkey is no exception. To achieve this, it is imperative to ensure that citizens are well-informed about the benefits of renewable energy and actively participate in its social acceptance. As highlighted by Demir and Ataöv (2021), urgent action is needed to make this a reality in Turkey. Therefore, it is recommended that future studies on both environmental and academic learning outcomes of students at all educational levels through digital educational games focusing on mathematical concepts regarding various environmental contexts (i.e., green/clean environment versus industrial environment) be conducted especially in developing countries such as Turkey.

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Games in Mathematics Education: Trends and Methodological Approaches in the Context of the Congress of European Research in Mathematics Education (CERME) Review

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Abstract: This study aimed to examine the studies on digital games presented in The Congress of European Research in Mathematics Education (CERME) using a systematic analysis approach in terms of research method, data collection tool, and how they define digital games. Sixteen studies related to games were selected from the proceedings. The findings of the research revealed that the number of studies on games has increased in recent years, and the interest of the mathematics education community in this subject has gradually increased. It was seen that qualitative research approaches were used in most of these studies. As a data collection tool, a semi-structured or clinical interview form was mainly used. To reach more comprehensive results, it is necessary to give importance to quantitative research approaches and even to prefer the use of both approaches together. It was indicated that the tendency towards mathematical reasoning and puzzle games has continued predominantly in recent years. Although it was seen that the number of studies on digital games has increased in the last five years, only six studies in total were presented at the CERME. Moreover, three digital games developed by using the tools in the context of dynamic geometry environments were found. Another significant finding was that most of these studies did not define games. Only a few studies that defined the game considered the game as a tool used to acquire a mathematical concept or knowledge. Based on the findings, it can be argued that digital games are not among the interests of the mathematics education community. Finally, it was observed that mathematical theorems and approaches were central to the studies reviewed. Games were generally defined as tools within these studies. Therefore, future research should particularly consider fundamental game features such as game mechanics to create more integrated research environments with mathematics education.

Keywords: CERME, Digital Game, Non-digital Game, Mathematics Education

1. Introduction

Games have long been a subject of research in mathematics education. Non-digital games are known to have a positive impact on students' academic achievement, communication, and critical thinking skills (Russo et al., 2024). Similarly, digital games are also known to develop students' cognitive skills such as creative thinking, critical thinking, and problem-solving, as well as their affective skills such as attitude and motivation (Rodriguez-Aflecht et al., 2018; Lin and Hou, 2016; Brezovszky et al., 2019). These studies demonstrate that games have an important place in mathematics education and will continue to be used in the future. In this light, it is important to present a framework for how mathematics educators approach games as a research topic.

In recent years, rapid adoption of educational games in classroom settings for diverse purposes has been observed, emphasizing their potential to enhance learning and instruction. During this period, several literature reviews have addressed a broad spectrum of disciplines, including science, technology, engineering, and social studies (Cheng et al., 2015; Peterson et al., 2022), as well as focusing on mathematics education (Byun & Joung, 2018; Hussein et al., 2021; Joung & Byun, 2021; Pan et al., 2022). Since mathematics education often requires different skill sets compared to other disciplines, games intended for teaching mathematics may necessitate specific attributes (Pan et al., 2022). Furthermore, a crucial step towards effectively utilizing games in educational settings is understanding their potential and evaluating learning outcomes. This enables educators to conscientiously select games that align with their pedagogical goals and contribute effectively to learning environments. Therefore, it is imperative to analyse the findings of these reviews, as this analysis facilitates a comprehensive understanding of the potential benefits of educational games and their impact on learning outcomes in educational settings.

In this study, the papers presented at the Congress of the European Society for Research in Mathematics Education (CERME) were examined. CERME is a conference that has been ongoing for over twenty-five years, sharing significant research in mathematics education. The knowledge accumulated during this time has reached

a level that can be analysed in different review research (Herfort et al., 2023; Donevska-Todorova and Trgalova, 2017). Therefore, we believe that examining the papers from this conference and presenting the studies within a framework of various perspectives over 25 years will provide valuable insights into the role of games in mathematics education.

2. Method

This study employed a systematic review method. To achieve this, all full-text articles published in the CERME symposium were examined, including those presented at 12 CERME conferences held since 1999. The full texts of CERME papers were accessed through the website http://erme.site/cerme-conferences/. Initially, papers related to games were identified by scanning for the keyword "game" in their titles. These texts were then examined in greater detail. An initial review of the abstracts and titles identified 32 full-text papers. During the subsequent detailed examination, several key criteria were considered. Studies that were not available as full texts were excluded from the list. Additionally, papers that were not research articles and did not involve the use of a game were excluded from the study. Furthermore, only studies that investigated the impact of a game on a specific variable were selected. After applying these criteria, 16 out of the 32 studies were excluded from the list, leaving 16 studies for detailed analysis. The criteria for excluding full-text papers in this study are summarized in Table 1 below.

Table 1: Criteria for excluding studies

Criterion	Frequency
The study is not related to games.	6
The game is not central to the study.	3
Not a research study.	2
Related to game design instruction.	5

The remaining 18 studies were examined according to specific criteria. The year of the study, its purpose, target audience, research method, assessment tool, mathematical subject area, name and type of the game, the purpose of using the game, theoretical framework used, and how the game was defined were all analysed. The details of these studies are listed in Table 2 below.

Table 2: Details of the examined studies

No	Reference
1	Sensevy, G., Mercier, A., & Schubauer-Leoni, M. L. (2001, February). A model for examining Teacher's didactic action in mathematics, the case of the game" race to 20". In *CERME 2 Proceedings*.
2	Vankúš, P. (2007). Influence of didactical games on pupil's attitudes towards mathematics and process of its teaching. In *European Research in Mathematics Education: Proceedings of the Fifth Congress of the European Society for Research in Mathematics Education* (pp. 369-378).
3	Jančařík (2007). Creatıng a mental image of dice blackjack game. *Proceedings of the Fifth Congress of the European Society for Research in Mathematics Education*, (pp. 446).
4	Vighi, P. (2013). Game promoting early generalization and abstraction. *Proceedings of the Eighth Congress of the European Society for Research in Mathematics Education* (pp. 2238-2247).
5	Avraamidou, A. (2015, February). Instances of mathematical thinking through collaborative gameplay. In *CERME 9-Ninth Congress of the European Society for Research in Mathematics Education* (pp. 2453-2459).
6	Soldano, C., Arzarello, F., & Robutti, O. (2015). Game approach with the use of technology: A possible way to enhance mathematical thinking. In *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education* (pp. 2552-2558).
7	Soldano, C., & Arzarello, F. (2017). Learning with the logic of inquiry: game-activities inside Dynamic Geometry Environments. In *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education* (pp. 267-274).
8	Moomaw, S. (2017). Teddy Bear Preschool Mathematics Assessment: Validation of a constructivist game-and story-based measure. In *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education*.
9	Cramer, J. C. (2019, February). Games as a means of motivating more students to participate in argumentation. In *Eleventh Congress of the European Society for Research in Mathematics Education*.
10	Meletiou-Mavrotheris, M., Paparistodemou, E., & Tsouccas, L. (2019, February). A case study of teacher professional development on game-enhanced statistics learning in the early years of schooling. In *Eleventh Congress of the European Society for Research in Mathematics Education (CERME11)* (No. 27).

No	Reference
11	Soldano, C., & Sabena, C. (2019, February). Exploring non-prototypical configurations of equivalent areas through inquiring-game activities within DGE. In *Eleventh Congress of the European Society for Research in Mathematics Education* (No. 30).
12	Thoma, G., & Biza, I. (2019, February). Problem-solving techniques in the context of an educational video game: the Mudwall puzzle in Zoombinis. In *Eleventh Congress of the European Society for Research in Mathematics Education* (No. 35).
13	Misailidou, C., & Keijzer, R. (2019, February). Making Mathematics fun: The 'Fear Room'game. In *Eleventh Congress of the European Society for Research in Mathematics Education* (No. 19).
14	Nilsson, P. (2022, February). Game-variation to support probabilistic reasoning. In *Twelfth Congress of the European Society for Research in Mathematics Education (CERME12)* (No. 18).
15	Vilchez, C. S. U., & Lemmo, A. (2022, February). A videogame for supporting teachers' scaffolding in whole-class discussions. In *Twelfth Congress of the European Society for Research in Mathematics Education (CERME12)* (No. 17).
16	Baccaro, S., & Cusi, A. (2022). A teaching methodology focused on the use of a videogame: analysis of the engagement of students with special educational needs. In *Proceedings of the Twelfth Congress of the European Society for Research in Mathematics Education (CERME12)* (pp. 1-8).

3. Findings

Initially, the years of the conducted studies were examined. Table 3 lists the years in which the studies were conducted.

Table 3: Year of the studies

Year	Frequency
2002	1
2007	2
2013	1
2015	2
2017	3
2020	6
2022	3

Upon examining Table 3 above, it can be observed that research involving games has remained relatively stable over the years. However, a notable increase in game-related studies occurred in 2020. In other periods, the number of studies remained balanced. This surge in 2020 can be attributed to the post-COVID era, during which interest in tools like games, especially digital games used by individuals or small groups, increased significantly.

Table 4: Target groups

Target Group	Frequency
Teachers	2
Ages 7-10	1
Prospective Mathematics Teachers	1
Kindergarten Students	3
Ages 11-14	7
Ages 15-18	3
disabled student (Middle School)	1

When the studies are examined, it is seen that the majority of the studies are aimed at secondary school students (see Table 4). There are no studies regarding university education. However, apart from this, there are studies for all target groups.

Table 5: Objectives of the studies

Objective	Frequency
Cognitive development	8
Emotional development	5
Teacher development	3
Assessment	1

Upon examining the objectives of the studies, it is evident that cognitive development takes precedence (see Table 5). Cognitive development encompasses areas such as knowledge, reasoning, geometric reasoning,

strategic thinking, mathematical thinking, and mental tools. Emotional development focuses on aspects like attitudes and motivation. The remaining topics include teacher development and the investigation of games as an assessment tool.

Tablo 6: Methods

Research method	Frequency	Research design	Frequency
Qualitative	13	Case Study	4
		The teaching experiment	2
		The teaching intervention	1
		Discourse Analysis	1
Quantitative	4	Experimental	1
		Descriptive	3

The analysis of Table 6 reveals a dominance of qualitative research methods, employed in (13) of the studies, compared to a smaller number of quantitative studies (4) employed. Furthermore, a closer examination of the qualitative methods suggests a preference for case studies (4).

Table 7: Data collection tools

Data collection tool	Frequency
Observation and Interview	6
Observation	3
Survey	3
Scale and Survey	1
Think-Aloud	1
Observation and Game Score	3

Upon reviewing Table 7, it is observed that the combination of observation and interview is the most frequently used data collection method. Additionally, observation, survey, and observation-game score studies are equally the least used, whereas think-aloud and scale-survey approaches are used to a lesser extent.

Table 8: Subject areas

Subject area	Frequency
Numbers	5
Geometry	4
Measurement	3
Algebra	3
Probability and Statistics	2

Upon examination of Table 8, it is observed that the most studied subject area is numbers. Within the realm of numbers, the topic most frequently explored is number sense (in four studies). Only one study pertains to problem-solving. There are four studies related to geometry. Regarding measurement, two studies focus on the concept of area, while one study addresses the topic of money.

Table 9: Game types

Game Type	Frequency
Didactic Games	2
Puzzle Game	5
Dynamic Mathematical Software	3
Board Game	2
2d Platformer	1
(Non-Digital) Puzzle	1
Sandbox Game	10
Chance Game	1

Game Type	Frequency
Life Simulation	1
Combinatorial Game	1

Table 9 demonstrates that digital puzzle games are the most favoured choice for research. Additionally, didactic games are prominent, especially in the early 2000s. Over time, while the usage of digital games increases, the number of non-digital games decreases. Only one entertainment digital game, Sims 3, is utilized in the studies.

Table 10: Theoretical framework

Theoretical framework	Frequency
Didactic Situation Theory	2
Constructivism	3
Jaakko Hintikka Theory	3
Polya's Problem-Solving Steps; Downs and Mamona-Downs (2007) Mathematical Problem	1
Realistic Mathematics Education' ('RME') and 'Inquiry Based Learning' ('IBL')	1
Deci & Ryan's (1993) Self-Determination Theory	1
Dörfler's Theory Meaning, Hejny's Theory the "Motivation"	1
Deci & Ryan's (1993) Self-Determination Theory	1
TPACK	1
Combinatorial Game Theory	1

Upon examination of the theoretical frameworks in the studies, three theories stand out: didactic situation theory, constructivism, and Jaakko Hintikka's theory (see Table 10). Particularly, games hold significant importance in the didactic situation theory. However, this theory has been predominantly utilized only in the 2000s. Hintikka's theory, on the other hand, has been employed within the framework of dynamic mathematical software. Overall, theories of mathematics education take precedence in the theoretical framework.

Table 11: Definition of games

Game Definition	Frequency
Research that does not define games	13
Research that defines games	1

It is observed that most of the research does not provide a definition of the term "game" (see Table 11). However, among those that do, games are defined as follows:

"Epistemic games are about knowledge, but they are about knowledge in action - about making knowledge, applying knowledge, and sharing knowledge." (Shaffer & Gee, 2005, p. 16).

In another paper: *"Strategic games within Dynamic Geometry Environments (DGEs): these are games in which players have to make strategic choices meant for setting up and coordinating actions aimed at the achievement of a goal"* (Soldano & Arzarello, 2017).

From these two studies, it is evident that action is central to the definition. In another study, a distinction between games and didactic games is emphasized in defining games:

"The main differences between the normal meaning of children's game and between the didactical game are:

1. *Children's game is totally free, in didactical game all pupils have to participate.*
2. *Didactical game is used to realize chosen educational goals; the main aim of children's game is just fun and pleasure.*
3. *The didactical game has its external management (teacher)."*

In this definition, as in the others, the focus is on the objective.

4. Discussion and Conclusion

It was observed that the interest in the game was particularly high in the studies conducted in 2020, but then decreased in the last conference. One of the main reasons could be attributed to the increased interest in digital tools during the COVID-19 pandemic (Vargo et al., 2021). Additionally, while non-digital games were

predominant in the initial symposiums, there has been an increase in the number of digital games over time. This can be attributed to the rise of independent digital game development, leading to an increase in the number and variety of games produced by various independent institutions (Josef et al., 2022). Consequently, the number of educational digital games may have increased as a result.

The research predominantly employs qualitative research methods, reflecting a broader trend in mathematics education research (Maamin, et al., 2020). This preference is also notable in research concerning games. Contrary to the findings, studies related to games predominantly focus on quasi-experimental designs (Hussein et al., 2021). Another significant finding pertains to the types of games utilized. While non-digital games were prevalent in the early 2000s, digital games have been increasingly employed in recent years. This can be attributed to the accessibility of Dynamic Geometry Software and various digital games, particularly those developed by independent developers or companies, with puzzle games being prominent. The dynamic geometry approach has become popular in mathematics education, especially since the 2010s (Ondes, 2021). This situation can be observed in these academic congresses. Among all the studies, only a single entertainment digital game (The Sims 3) was utilized, indicating that entertainment digital games are not widely perceived as valuable from a mathematical perspective by researchers. Dynamic Geometry Software (DGY) games constitute the second most utilized type of game. However, games developed using DGY may have certain mechanical limitations, making it challenging to classify them as digital games. Studies utilizing DGY tend to prioritize action in their definition of games, emphasising the active engagement of students with the tools (Zengin, 2022). The absence of purely dynamic action and fundamental mechanics such as rewards or penalties in DGY complicates its classification as a game (Arnab et al., 2015). In the context of games within mathematics education, importance is also placed on the roles of teachers (Alkan & Ada, 2023; Fujita et al., 2018). This emphasis is particularly evident in non-digital didactic games. Therefore, it can be argued that studies made by mathematics educators, especially within the framework of mathematical theories and tools, differ from educational digital games or game-based instructional theories.

5. Implications

Upon analysis, the primary objective of the studies was to utilize theorems and approaches related to mathematics education within a game environment. Consequently, future research should aim for greater integration of these theories and approaches with game-based methodologies. Specifically, studies that examine the impact of fundamental game features, such as game mechanics, on mathematical development should be prioritized. This focus on transferring mathematical theories and approaches to the game environment is expected to enhance the effectiveness of educational games. Additionally, it has been observed that mathematics educators often interpret games differently, sometimes categorizing activities using software like GeoGebra as games. However, GeoGebra and similar software are not inherently designed for game development as they lack many essential game mechanics. Therefore, conducting a theoretical investigation to delineate when an activity qualifies as a game versus an educational activity could significantly benefit future research in educational games.

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Cultural Game Jam Model: A Quadruple Helix Intervention

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Abstract: The EPIC-WE Cultural Game Jam: Óbidos UNESCO City of Literature (CGJ) was a purposeful game jam, and part of the EPIC-WE Horizon-Europe project. CGJ empowers youth to participate through ideating cultural worlds, by creating and exchanging cultural values and heritage through game-making (game jams experience), within the Quadruple Helix (QH) Cultural Innovation Ecosystem. The study is focused on the specific presence of jammers at the game jam venue, within the cultural spaces and cultural agents. Describing the development of unique Game Jams applying the QH model, linking a municipality region, a games company, university researchers, and a youth focus group to foster the production of games for culture and games through culture. With extensive experience in organising game jams since 2014, the researchers confronted the literature review study focused on youth empowerment and cultural game jams (Costa, *et al.*, 2024), ensuring the project research protocols to define a model for 4 game jams to be held from 2024 to 2025. The ongoing research demonstrates the creation of a research protocol for the 1st CGJ model: student recruitment; Pre-Game Jam with the theme reveal and ideation; Game Jam activities and conditions; Reflection Day; Data collection; Post-Mortem analysis; CCIs games evaluation; and future outcomes. 8 games produced on the 1st CGJ demonstrated the effectiveness of the CGJ model for cultural purposes. Besides the cultural theme limitation, participants (N=26) evidenced a high level of satisfaction evidenced in the final survey. Several recommendations for improvement were given (survey reflection 2) and outlined so that future CGJs can produce games that delve more deeply into the topics covered.

Keywords: Game Jams, Cultural Games, Quadruple Helix, Cultural Game Jam

1. Introduction

Game Jams have gained a lot of prominence in recent years, being events where the gamedev community and other enthusiasts from a wide variety of fields come together in a playful environment to create games. It's an experimental space for ideas and rapid prototyping where people participate freely under a specific theme within a predefined time frame (Kaitila, 2012).

Jam sessions are a spontaneous, unrehearsed gathering of musicians who don't have prior history as band members, often having very diverse backgrounds, value systems, and musical ability but nonetheless being able to come together as a unit capable of achieving a successful music performance (Katz & Longden, 1983). Similarly, in a game jam, people with know-how from diverse disciplines, traditionally programming, game design, art, and sound, convene to collaborate (Grace, 2016) and playfully develop games, adhering to a predetermined theme and time limit, commonly set at 48 hours (Kultima, 2015; Goddard, 2014).

These types of events have officially existed for over 20 years, starting in March 2002 with the Indie Game Jam, closely followed by Ludum Dare, in April 2002 (Lai *et al.*, 2021). The latter event remains popular and active to this day. According to Lai *et al.* (2021) we can categorise the earlier game jams in different waves in order to better understand the evolution of the format: 1st generation - events were mostly held online with a technical focus and games being developed by a single programmer; 2nd generation - began in 2006, events were in-person and the focus shifted to games created by a team with varied skill sets. Another important highlight from this generation is the appearance of the Nordic Game Jam, responsible for introducing the game jam model most commonly used today; 3rd generation - started in 2009 with the advent of the most popular game jam to this day, Global Game Jam (GGJ), an internationally synched game jam that takes place worldwide at the same time, across different countries and locations such as schools, universities and companies that welcome professionals, amateurs, students and everyone who might want to participate (Kultima, 2021). Since it began, the growth of locations, participants and games resulting from the GGJ has been exponential (Fowler *et al.,* 2015), with the trend continuing. What began with 23 countries and 370 games, has since expanded to 131 different participating countries and more than 79182 games created just in 2024 (Global Game Jam, n.d.); lastly, 4th generation - introduces the concepts of moving game jams, such as the Train Jam (hosted on a moving train), and unique locations such as castles or more remote locations. These new formats introduce additional constraints, such as limited internet access or power sources just to name a few, and offer singular experiences to participants.

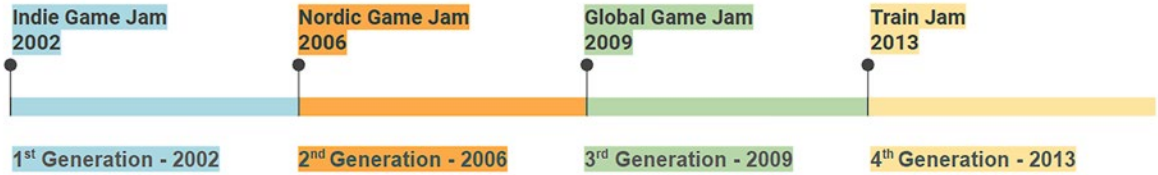


Figure 1: Game jam generations timeline.

Today, multiple game jams are taking place around the world at any given time, as can be attested through Itch.io, the most popular platform used to host and track many of these events.

Nordic Game Jam's model, first designed and applied in 2006, remains to this day the most widely used game jam format. The Global Game Jam, as the biggest and most popular game jam in the world, contributed significantly to the popularity of this model.

According to Lai et al. (2021) the most common agenda for this type of event is defined by: (1) a 48-hour duration; (2) starting with an Ice-breaker activity to involve all participants and jam organisers; (3) being followed by a Theme reveal; (4) a Pitch session, (5) Group forming and (6) Game presentations. Between steps 5 and 6, the games are developed during the event and disseminated on the game jam's website page at the last minute.

1.1 Meaningful Game Jams

Given the success, proliferation and recognised creative potential of game jams in creating and testing speculative ideas on specific themes, various game jams have been created for specific purposes. Goddard *et al.* (2014) propose guidelines to facilitate the design of game jams, providing means to balance between playfulness and gamefulness in relation to desired outcomes such as innovation in games or participant experience. Game jams oriented towards inclusion, the dissemination of meaningful themes, cultural themes and others, are today a very useful tool for participants to express themselves culturally through games (Wirman & Rhys, 2019) while at the same time being challenged to reflect on particular themes (Kultima, 2015).

In this context, when a game jam is developed in a specific environment, with a presentation of the Jam's theme and ongoing support by facilitators, the participants become fully involved and free to express themselves artistically (Kultima, 2018; Park et.al, 2023). When jammers are challenged with meaningful themes, the empathy generated and understanding of others' perspectives, such as different cultures, cultural heritages, people's feelings, climate change, health and others, are evident (Preston, 2014; Goddard, Byrne & Mueller, 2014), and the results of the games developed by teams of facilitators (educators), game designers, programmers, artists and sound designers, demonstrate the additional value of these "Serious" Game Jams (Ramzan & Reid, 2016; Abbot et al., 2023).

The present research is the culmination of a recent experience organising a cultural game jam, supplemented by prior involvement in numerous game jams dating back to 2014. Noteworthy among these are game jams focusing on neuroscience (Neuro Game Jam 2018), understanding the Sustainable Development Goals (SDG Game Jam 2021), and social impact (Games for Good 2017, 2018, 2019). These past experiences highlighted the extreme relevance of having facilitators in the game jams, both to guarantee an enriching approach to the topics covered and to ensure openness and a playful jamming experience (Goddard, Byrne & Mueller, 2014). This study introduced a fresh perspective to the team responsible for orchestrating an event that involves various stakeholders, including government officials, representatives from cultural and educational institutions, and industry professionals, all coming together to host a cultural game jam.

2. EPIC-WE Cultural Game Jam: Óbidos UNESCO City of Literature (CGJ)

The CGJ is one of the first outputs of the Horizon Europe EPIC-WE project, which aims to empower young people with social and cultural values through the development of games in cultural Game Jams. The project is being carried out by 13 European institutions from different fields of intervention (research/education, cultural heritage/museums, governance/citizenship/public, and game/creative industries), and presents a participatory framework based on the Quadruple Helix (QH) model which involves omnidirectional interactions of knowledge and technology (Aggarwal and Sindakis, 2022), for creating methods and a specific format for cultural game jams for culture and value-sensitive game-making. Since EPIC-WE engages in CGJs to create games through and for culture inspired by cultural heritage, the present project demonstrates how the QH empowers three EPIC-WE

partners, namely the Óbidos' Municipality, the Battlesheep games company, and Lusófona University, to converge in cultural research and innovation.

Regarding previous experiences where research included societal-based innovation through the QH, identifying key themes and future agendas requires a proper integration between different stakeholders (Wilson, 2012). This process will intensify existing challenges but also promote new ones (Miller, McAdam & McAdam, 2016). The QH interventions are an innovation-push model through the interaction of local and regional stakeholders into economic and technological development (McAdam, *et al.*, 2012; Bercovitz and Feldman, 2006). This collaboration enhanced the movement between stakeholders toward the most valuable societal aspects (Höglund & Linton, 2017). Thus, EPIC-WE's QH model fostered these diluted borders between public authorities and organisations, industry, academia, and citizens (Nørgård & Holfold, 2024).

The EPIC-WE project has three cultural Hubs: (1) Aarhus - contributing to societal challenges of young people feeling foreign to, disempowered in, or excluded from game-making and culture; (2) Hilversum - centred on societal issues like the impact of colonial legacies and online anti-democratic threats; and (3) Óbidos - exploring the cultural heritage awareness of young people within European Union values of inclusive quality education and sustainable economic growth.

In the context of this research, EPIC-WE Game Jam was the initial result of applying QH to create games with cultural significance. The Municipality of Óbidos suggested the theme of Óbidos Literary Village, due to the fact that Óbidos is a UNESCO-certified mediaeval literary village, and therefore, it is on the political agenda to disseminate this cultural mission. Battlesheep, the company from the creative sector with the role of providing inputs from the games industry, suggested that the game jam be oriented mostly to digital games, to foster this games' sector within the Portuguese game ecosystem.

Focused on research activities, Lusófona University contributed to the organisation of the event throughout the introduction of meaningful themes in the games to be developed. Thus, this educational perspective aims to raise the students awareness and reflection on the impact of their work as a form of artistic expression, as a form of design activism, and as game development educational empowerment. Finally, the participants were able to choose what game they wanted to develop within the scope of digital games through culture, giving them a voice to reflect on the particularities of the game jam's location site and express themselves artistically through digital games.

3. Game Jam Methodology and Procedure

This study adopted different methodologies and processes to: (1) produce games that relate to the culture of Óbidos; (2) guarantee the involvement of students in the creative process; and (3) analyse the games developed and student questionnaires. Quantitative methods were used with individual questionnaires being conducted before and after the game jam. For qualitative methods, face-to-face interviews during the game jam, and a final post-mortem at a round table with all participants and facilitators. These processes guarantee different levels of evaluation, whether it's recording the participants' perception of the game jam or using conceptual models to formally analyse the games created (Lankoski & Björk, 2015).

Thus, the CGJ methodology and procedure are summarised as follows: (1) student recruitment; (2) Pre-Game Jam; and (3) Game Jam, discussed below. Since the EPIC-WE project requires the qualitative evaluation of the games created, the researchers disseminate to students with experience in game development, namely at Lusófona's Master studies in Game Design and Playable Media and at the Videogames undergraduate studies. To recruit those students (1), sessions were held to present the EPIC-WE project and the CGJ in face-to-face informative sessions with the Videogames classes at Lusófona University. Registration forms (Google Form), a digital booklet with information about the project, the themes of the CGJ and the Game Jam Discord channel, were made available.

Held at Lusófona University site, the Pre-game Jam (2) happened three weeks before the actual EPIC-WE CGJ in the main University's campus, with the duration of four hours. The jam's theme was presented by a facilitator from the Municipality of Óbidos, and an ideation process model was carried out by two facilitators from the university while five observers assessed the effectiveness of the activities and classified the ideas generated. 27 participants (aged between 18 and 25) individually filled in informed consents and an individual survey with demographic and theme evaluation questions.

The EPIC-WE game jam (3) was attended by 26 students (one withdrew for health reasons), counting four observers and seven facilitators. As the aim was to make games through culture for culture, all students were

transported to the environment of the mediaeval village of Óbidos. Installed in four houses inside the castle, they could be among peers, experiencing the local atmosphere, and accidentally discover creative elements for their games. Because traditional 48-hour game jams require more intense game development activity, which is usually conducive to crunch time, the team of researchers decided to expand the development phase of the jam by one additional day (56 hours) to provide a cosier atmosphere and give the students the opportunity to also experience the village of Óbidos. Thus, a fourth day was dedicated to research activities, namely to the necessary "serious" load of the EPIC-WE research project (completing questionnaires, pitch evaluations, and post-mortem sessions). As illustrated by figure 2, the colour cells highlight those 'serious' moments (observation/research activities).

	Jam First Day:	Jam Second Day:	Jam Third Day:	Jam Forth Day:
10:00 AM	Visit to Cultural Institutions	Morning Pitch Session and Jamming	Day 3 Team Check In and Jamming Status report	Game delivery and submission
12:30 AM	Lunch	Lunch	Lunch	Lunch
3:00 PM	Jamming	Jamming	Jamming	Round Table Post-Mortem Survey
7:00 PM	Day 1 Team Check In Game Ideas Pitch	Day 2 Team Check In Participant Interviews	Showcase Game Presentations	
8:00 PM	Dinner	Dinner	Dinner	
9:00 PM	Jamming (Optional)	Jamming (Optional)		

Figure 2: Game Jam (activities and conditions).

4. Results

A qualitative analysis targeted participants' answers to the pre-jam questionnaire, along with their opinions regarding the jam's ability to meet their expectations and additional comments made about different aspects of the jam. A quantitative analysis was also conducted to assess the participants' grading of several aspects of the game jam. All the participants of the game jam (N=26) answered the questionnaires.

4.1 Pre-Game Jam Survey (Vox-Popping)

Before conducting the game jam, participants were given a survey with two open questions where they were asked about their motivations and expectations for the game jam.

4.2 Motivations

The participants' main motivations could be separated into three main categories. One of these was to learn more about how to develop digital games. 14 participants stated their ambition to create a project they could add to their portfolio and gain experience while developing games as part of a team with their classmates and friends. Another common motivation for participants (n=15) was their stated interest in 'new experiences', referring both to the uncommon plan of the game jam, involving the visit to the village of Óbidos (see section 3), and to the opportunity to participate in a game jam in general - as several of the participants (n=16) were first-year students who had little to no experience with game jams. Lastly, 10 participants specifically highlighted the possibility of visiting and learning about the village and exploring it with their classmates and friends while experiencing the local culture. A frequent comment about the visit to the village was its direct connection to the theme of the game jam ("*I want to learn about Óbidos culture and get new experiences*", participant n.14) as it allowed them to encounter a "*unique cultural experience that actually relates to the theme*" (participant n. 18) of the game jam.

4.3 Expectations

Regarding expectations for the game jam, participants shared similar ambitions for a playful experience and a learning environment. While there was a small number of participants that highlighted the possibility of improving their soft-skills and creating new contacts (n= 4), a large group of participants (n= 14) stated their expectations for a fun, and entertaining time developing games with other people. Comments such as "To learn and have fun. Also leave with a cool game for the portfolio." (Participant n.6) were common answers; Participant 11 mentioned a similar answer and specified that they were interested in the possibility of making a "functional" game, indicating that they might have been one of the first-year students for whom the game jam was their first game-development experience. The third popular answer was that participants were excited to learn more

about game development (n= 9). These three elements - learning how to (better) make a game, making a game, and having fun doing it - are common for participants in game jams (Meriläinen & Aurava, 2018; Reng, Schoenau-Fog & Kofoed, 2013) and can also be observed in these results. Lastly, while these were the majority of the answers, there was still a minority of participants that stated expectations directly related to the specific program of the game jam, including the opportunity to explore the village of Óbidos, having fun and learning while doing so, and then making a game about the culture surrounding it.

4.4 Did the Game Jam Meet the Participants' Expectations?

Participants were asked to answer whether the game jam underperformed, met, or surpassed their expectations, also having an open-text space to further explain their answers. The answers provided by the participants reveal that the game jam appears to have generally matched or exceeded participants' expectations. Specifically, 12 participants (46%) felt that the game jam exceeded their expectations, while another group of 12 participants felt that the jam successfully delivered on their expectations. Two participants answered that the jam's experience underachieved, considering their expectations, although one of them explained it was because most of the work they did was not included in their group's game. Participants who felt their expectations were matched by the event, mainly highlighted the learning opportunity that the game jam provided. Some of these, being first-year students, stated that they were not expecting to complete a functional game but instead learn how they might make one in the future. On the other side, this group also featured comments regarding the residences where the participants were housed - which may have tempered their overall assessment of the game jam. For the 12 participants for whom the game jam exceeded their expectations, the main highlights they gave were the possibility to have fun while making - or learning how to make - games. Some also specifically referenced the possibility of visiting the village of Óbidos and learning about its culture: *"Initially, I wasn't really captivated with the idea of basing our project in Óbidos' culture and thought it would be limiting in the ways we could develop this project, but after this experience I not only got to know new cultures and get new experiences but also I found my initial thoughts to be wrong." (Participant n.9)*

4.5 Participants' Assessment of the Game Jam

Having been given the opportunity to grade the game jam on a variety of factors from 1 to 7, the results indicate that the participants regarded the game jam and the program surrounding it as highly positive. The average score given to their overall experience at the game jam was 6.12 (*SD = 0.71*). Similarly, the venue of the event (*SD = 0.63*) and its conditions (*SD = 1.23*) were graded at 6.35 and 5.65, respectively. The lowest grade was given to the residences where participants were allocated: 3.81 (*SD = 1.55*), as participants complained that the homes were not fully prepared to host the number of participants allocated to them and that there was a lack of proper internet connection. Regarding the meals afforded by the event for the participants, similar positive evaluations were given for lunch (6.27, *SD = 0.72*) and dinner (5.54, *SD = 1.30)*. Participants scored the overall organisation of the event at 6.19 (*SD = 0.63*). Lastly, participants were asked through a 5-point Likert scale how likely they were to recommend the game jam to friends and classmates, and the result was 4.77 (*SD = 0.51*).

4.6 The Developed Games

Participants developed a total of eight games as part of the game jam. As most participants consisted of first-year students in the Videogames BA, they generally had little experience developing digital games. In some groups, this meant that successfully developing any game at all was the main priority, attempting to deliver a playable product by the end of the game jam - with the topic of the jam applied on top of it, as was the case with "Literature Defense: Guardian of Óbidos".

Table 1: Games developed at EPIC-WE Game Jam.

	Name of Game	Genre	Game Engine
1	Literature Defense: Guardian of Óbidos	2D TopDown Tower Defense	*Unity*
2	Lost in Words	3D First-Person Adventure	*Unreal*
3	Tsundoku	2D Sliding Puzzle	*Game Maker*
4	storyteller	2D TopDown Stealth	*Game Maker*
5	In Search for Words	2D Puzzle Platformer	*Unity*
6	BookDweller	2D TopDown Roguelike	*Unity*

	Name of Game	Genre	Game Engine
7	Puss in Book	2D Puzzle Platformer with Typed Commands	*Unity*
8	Paredes de Cor	2D Arcade	*Unity*

One aspect some groups of participants highlighted was how the theme of their games was directly inspired by their stay at the village of Óbidos. “In Search for Words” revolves around a typography workshop, being inspired by one such workshop that they visited as part of the jam’s program. “Puss in Book” stems from its developers' own observations that there was an uncommonly high number of cats living in the village. Lastly, “Paredes de Cor” references a highly specific and local concern surrounding tourists finger-painting on the outside walls of the houses in Óbidos by using the specific paint that coats them. These games are direct results of the participants’ stay at the CGJ’s location, and had it been hosted at the university campus, it would have been highly unlikely that such specific - authentic - topics could have emerged. The immersive experience of being there was undoubtedly an essential element for the creative trigger.

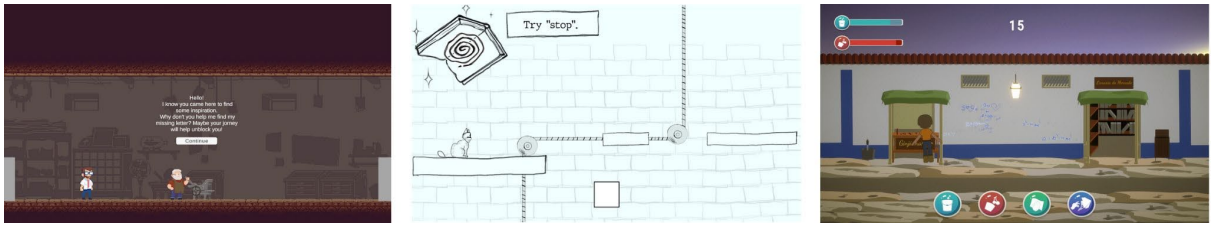


Figure 3: Games “In Search for Words”, “Puss in Book”, and “Paredes de Cor”.

5. Conclusions

The EPIC-WE Game Jam was a cultural game jam (CGJ) that utilised the cooperation of the Quadruple Helix (QH) model with the aim of providing a jamming experience that allowed participants to improve their skills and develop games immersed in the cultural setting of a mediaeval village. The results showed that the collaboration between the relevant parties (QH cooperation) allowed for a game jam where participants were able to fulfil their learning and playful goals of making their games while being in contact with the source of the jam’s theme (cultural topic). This effort allowed for the creation of culturally specific games that reflect and emulate the cultural village of Óbidos, leading to results that would not have been possible without the program of the jam and the collaborations behind it.

The game jam successfully provided a standard jamming experience while integrating the cultural goals it set out to support, with the participants’ projects reflecting the culture of the village and participants being satisfied with the overall experience.

During the CGJ, a group of facilitators (n=7) from Lusófona University provided constant game dev support, which ensured the event's goal of producing 6-8 games. Besides in the pitching sessions, the facilitators were not featured in the participants' answers to the questionnaires. However, participants were only supported with regards to the jam’s main theme - Óbidos City of Literature - during the first day, which inevitably led to the games not focusing on the subject matter. The developed games featured a more superficial approach to the topic, which should be more closely monitored in the future to incentivize greater engagement with the theme of the jam. The role of cultural facilitators, among the Game Jam facilitators, should always be reinforced when a game jam targets games with a specific cultural or meaningful impact.

6. Future Research

The discussion introduced here, based on the experience of the 1st CGJ that integrates various agents through the QH model, serves as a reflection for the planning of three more game jams expected in this project (scheduled for May 2024, December 2025, and May 2025), which could allow for evaluation in the medium term. Regarding the fact that some of the participants will be taking part in the next game jams, a lot of information will be gathered about the students' involvement in the process of designing these games, how they reflect on the cultural themes of each Game Jam, and how the various QH agents perceive the games created. The valuable data that will be collected will allow researchers to evaluate the perspectives generated by these cultural game jams through active participation with the QH model.

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The Influence of Social Competition and Maths Anxiety on Game Performance

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Abstract: Digital Game-Based Learning (DGBL) uses serious games to deliver educational content. DGBL has the potential to aid children's development of maths skills, providing educators with alternatives to traditional mathematics teaching. However, the efficacy of serious games can be affected by their attributes, including whether they are single or multi-player. While competition in a multi-player environment may enhance players' interest and motivation, potential social pressure may lead to anxiety and affect performance. In maths education, there are additional challenges. Mathematics Anxiety (MA), the negative emotional response to mathematics, may interact with game features and impact players' experience. This study assesses players' performance in a digital maths game called 'Seven Spells' across two different game modes (*vs. Human* and *vs. CPU*), and it also investigates whether MA levels impacted players' performance. 43 children from two classes in an Irish primary school participated in this study. Each class played a different game mode of the 'Seven Spells' game, one group playing against computer-controlled characters (*vs. CPU*) and the other playing against their classmates (*vs. Human*). The game mechanics were identical between the two competition game modes. The children completed the modified Abbreviated Mathematics Anxiety Scale (mAMAS) and a mathematics questionnaire before participating in the intervention, which included 4 sessions. They also participated in a focus group session at the end of the intervention. Data on their gameplay were collected throughout the first three sessions and analysed through multiple linear regression models to investigate possible connections between MA, maths knowledge, game modes and game performance. The results of the multiple linear regressions indicate that game performance was positively influenced by the duration of gameplay and the complexity of moves — measured by the number of moves and cards used — while being negatively affected by MA. However, a significant interaction between MA and the competition game mode was observed, suggesting that MA had a more pronounced negative impact on players in the *vs. Human* game mode compared to the *vs. CPU* game mode.

Keywords: Digital Game-based Learning, Primary School, Mathematics Anxiety, Competition.

1. Introduction

Digital Game-Based Learning (DGBL) is an active, student-centred problem-based learning approach in which digital games are used as tools for teaching and learning (Theofylaktos et al., 2018; Vanbecelaere et al., 2020). DGBL has been shown to optimise learning, positively influencing concentration, information assimilation and retention (Moyer-Packenham et al., 2019; Vanbecelaere et al., 2020). Additionally, DGBL mathematics interventions are perceived as more enjoyable than traditional paper-based mathematics exercises and typically show positive effects on arithmetic performance (Castellar et al., 2015, Vanbecelaere et al., 2020).

Games have several design elements that may influence learning (Moyer-Packenham et al., 2019), including whether they are single or multi-player. Playing against a human opponent or against a computer can affect immersion, flow, enjoyment and presence, all of which are relevant for digital learning and player motivation (Weibel et al., 2008). Among other factors, competition is indeed experienced in different ways when a player is facing a human opponent or a computerised one (Cagiltay et al., 2015). Even though competition can enhance a player's motivation and lead to better learning outcomes (Cagiltay et al., 2015), this game element can also reduce performance and increase anxiety (Cagiltay et al., 2015). In the context of mathematics, Mathematics Anxiety (MA), which is defined as a set of negative feelings such as nervousness and dread associated with mathematics learning, could indeed negatively affect mathematics performance (Buratta et al., 2019, Carey et al., 2017, Krinzinger et al., 2009). To investigate the relationship between different game modes, MA levels and game performance, this research investigates the connections between gameplay characteristics, maths knowledge, MA levels and player performance within a digital maths game ('Seven Spells') in two competition modes: *vs. Human* and *vs Computer-Controlled Characters (vs. CPU)*. The research questions for this study are:

1. What factors influence player performance in the digital maths game 'Seven Spells'?
2. Do specific factors affect player performance differently depending on the competition game mode?

Given the negative effects that MA might have on mathematics performance, we hypothesised that MA would be a significant factor negatively associated with game performance, while the complexity of the moves executed by players would significantly increase game performance. Moreover, due to the potential difference in the way competition is perceived in the two different game modes, we expect that the effect of MA could vary according to the game mode played.

2. Methods

2.1 Research Design

This study recruited two 3rd classes from a primary school based in Dublin, Ireland, comprising students aged 9 to 10 years old. Only students whose guardians/parents permitted participation in the study were included. Classes were visited in four sessions; twice per week, during school hours. Each session lasted one hour. Table 1 details the experimental design, displaying the activities performed in each session.

Table 1: Experimental design

	Session 1	Session 2	Session 3	Session 4
Activities	Questionnaires	Game review	Game review	Focus group
	Game tutorial	Game session	Game session	
	Game session			

In Session 1, the students completed the modified Abbreviated Mathematics Anxiety Scale (mAMAS) (Carey et al., 2017) and a maths fluency test. Students were then introduced to the 'Seven Spells' game, which they played on tablet devices provided by the research team. The research team also delivered an in-person tutorial explaining the game and advising the students during their first gameplay. The two 3rd classes played the same game, but in different competition modes: one group competed against CPU (*vs. CPU* group) whilst the other group competed against their classmates (*vs. Human* group). During Sessions 2 and 3, the researchers reminded students of the game's rules through a guided game match and students played again. During Session 4, the students were invited to attend a focus group discussion on their overall game experience.

2.2 Participants and Data Collection

The total sample for this study comprised 43 3rd class students. Data on the students' MA levels and maths performance before playing the DGBL intervention were gathered and inputted into an anonymised dataset, in compliance with the General Data Protection Regulations (GDPR). Students played the 'Seven Spells' game using randomly generated usernames. Data cleaning was necessary to remove students who did not participate in all four sessions and/or did not answer questions on the mAMAS scale (incomplete data). The final number of students whose data was included in the analyses is shown in Table 2.

Table 2: Number of students included in the analyses of each variable (complete data).

Variable	vs. CPU	vs. Human	Total
Mathematics test	21	22	43
MA levels	21	20	41

Data was analysed to investigate possible correlations between the game's distinct competition modes, player performance, and MA levels. Data was password-protected, and only participant researchers could access it.

Maths fluency. The students' maths fluency was identified through a short mathematics test aligned with the content covered both by the 'Seven Spells' game and the Irish Mathematics curriculum for 3rd class. They were given ten minutes to complete the questionnaire. In the data analysis, the number of mathematics errors (ME) was captured with omissions (i.e. questions not answered) being counted as errors.

Mathematics Anxiety (MA). The modified Abbreviated Mathematics Anxiety Scale (mAMAS) (Carey et al., 2017) was used to measure the students' MA. In this questionnaire, the students answered nine questions about

situations involving mathematics learning. using a 5-point Likert scale to indicate their feelings: 1: 'Low anxiety'; 2: 'Some anxiety'; 3: 'Moderate anxiety'; 4: 'Quite a bit of anxiety'; 5: 'High anxiety'), along with a simple emoji to better illustrate that feeling. The minimum possible score for the mAMAS questionnaire is 9, which would indicate low MA. The maximum possible score of 45 points would indicate high levels of MA.

Focus groups. Students from each group were recruited to participate in 2 focus groups (one per group) in Session 4. These focus groups aimed to elicit the students' points of view, motivations and perceptions regarding 'Seven Spells'. To achieve this in a non-directive way, the moderator created a set of open-ended questions (Gibson, 2007). To make better use of the students' potential to generate rich debate, only five to six students were included in each focus group due to their age (9-10 years old). Gibson, 2007 recommends using small focus group numbers when working with younger children (6-10 years). The following questions were asked to both groups: "What did you think about the game?"; "What maths concepts did you learn while playing Seven Spells?"; "Did the game make you feel less anxious about maths?". One question differed depending on the group: the *vs. CPU* group was asked: "How do you feel about playing against the computer characters?", while the *vs. Human* group was asked: "How do you feel about playing against your classmates?".

2.3 The 'Seven Spells' Game

The digital maths game 'Seven Spells' was used to deliver the DGBL intervention. To play, the students needed to understand the concept of even and odd numbers, prime numbers, multiples, intervals, symbols (such as less-than and greater-than ("<", ">")) and intervals. The aim of the game is to capture the opponents' cards by using the players' own cards. Cards can be classified as 'number cards' (the blue and red cards in Figure 1) or 'spell cards' (the yellow cards in Figure 1). Spell cards are used to capture or modify number cards displayed on the board. To capture a card, a player must match cards that carry the same number. There are also 'special' number cards: the 'Total' card (capable of capturing multiple opponent cards, as long as they sum up to the number shown on the 'Total' card) and the 'Max' card (which captures any card whose number is equal or lower than the number shown on the 'Max' card). During their turn, players can use as many cards as they want, combining numbers, arithmetic operations, and number properties to capture the highest amount of cards. After completing their moves, players press the 'GO' button to earn points for their actions. It is then the opponent's turn to play next.

To win, players must reach or surpass 100 points. If the player who started the match achieves or exceeds 100 points first, their opponent has one more turn. If the opponent surpasses the starting player's score, they win; if not, the first player wins.

Although the rules and gameplay are similar, there are some differences between the two competition game modes. When playing *vs. CPU*, a storyline element is connected to a reward system. In the story, the player is part of a fictional martial arts academy where they learn the art of number fighting. They must face distinct characters to advance through different-coloured belts, with characters from the next belt being stronger than those having a belt of a lower rank. It is only when the players defeat an opponent that they can face the next opponent. After defeating all opponents in a particular level, the player is rewarded with a belt matching that level's colour. When playing the *vs. Human* mode, players have to choose an opponent within their class and create a match in an online lobby. The invited classmate can then join this match.



Figure 1: "Seven Spells" gameplay - *vs. CPU*.

2.4 In-game Variables Considered in the Study

By collecting and processing game logs, we computed various indicators of game performance. The variables were computed for each move that a player executed. The move-level in-game variables include:

- **Number of opponent cards -** The number of opponent cards that can be captured by the player in that turn.
- **Maximum achievable points -** The maximum number of points that the player can achieve in that turn. It is a theoretical number of points that the player can be awarded through the 'best' possible combination of moves.
- **Stack size -** The number of the player's own cards used to execute a move. A higher number of cards being used suggests a higher complexity of moves in that turn.
- **Total cards available -** The total number of cards available for the player to use in their moves in a turn.
- **Incremental move -** An incremental number for the moves of each player. The variable is introduced to control for a learning effect, where players execute more complex and precise moves as they play more.
- **Optimality score.** This score measures the quality of each player's moves performance and is equal to the number of actual points scored by the player in a turn, divided by the maximum achievable points. This measure ranges from 0 to 1, with 1 being perfect optimality, meaning that the player scored the maximum amount of points possible for that turn. Optimality represents a measure of game performance and it is used as the target outcome variable in our regression models.

$$Optimality = \frac{Number\ of\ points}{Maximum\ achievable\ points}$$

We also collected the game mode being played: *vs. CPU* or *vs. Human.*

2.5 Quantitative Data Analysis

Data analysis was carried out using R. Descriptive and inferential statistics were used to draw conclusions about the effect of MA and other variables on the players' performance in the 'Seven Spells' game in distinct game modes. Regarding the inferential statistics tests, a set of multiple linear regression models was carried out considering the optimality of each move as the target variable; as predictors, this study considered the players' level of MA and the in-game variables described in section 2.4, including the number of opponent cards, maximum achievable points, stack size, total cards available and incremental moves.

3. Results

3.1 Descriptive Statistics for Mathematics Anxiety & Mathematics Errors

MA values collected before the DGBL intervention were considered for both the *vs. CPU* (MA_{CPU}) and the *vs. Human* (MA_H) groups. The values of both groups together are referred to as MA_{CPU+H} (Table 3).

Table 3: Descriptive statistics of MA.

Variable	Description	N	Mean	SD
MA_{CPU}	MA in the *vs CPU* group	21	17.14	7.95
MA_H	MA in the *vs Human* group	20	21.75	7.09
MA_{CPU+H}	MA in both groups	41	19.39	7.80

Mathematics Errors (ME) collected before the intervention were considered for both the *vs. CPU* (ME_{CPU}) and the *vs. Human* (ME_H) groups. The values of both groups together are referred to as ME_{CPU+H} (Table 4).

Table 4: Descriptive statistics of ME.

Variable	Description	N	Mean	SD
ME_{CPU}	ME in the *vs CPU* group	21	12.43	9.38
ME_H	ME in the *vs Human* group	22	11.68	7.97
ME_{CPU+H}	ME in both groups	43	12.05	8.59

3.2 Multiple Linear Regression

A multiple linear regression analysis was conducted to identify the relationship between game performance (measured by optimality of moves) and a set of predictors represented by MA, the set of in-game variables described in section 2.4 and the game mode, represented by a categorical variable with two possible levels: *vs. Human* or *vs. CPU*. A total of 3875 moves were collected from the game logs.

Table 5 shows the results obtained. *MA* was a significantly negative factor, showing how a higher level of MA decreased the optimality of a player's moves. The variable *incremental move* was significant and positive, suggesting that players were getting better the more they played. *Stack size* was also significant and positively associated, meaning that larger and more complex moves increased game performance. Finally, the control in-game variable, *maximum number of achievable points,* was significant, suggesting how the optimality of a move increased when there were more points available to capture. The R-squared value for the model was 0.2406, suggesting a moderate level of fit for the model. The variable *game mode* was not significant, showing how there were no significant differences in optimality across the two game modes.

Table 5: Linear regression coefficients (both game modes).

Coefficients				
	Estimate	**Standard Error**	**t-value**	**Pr(>|t|)**
Intercept	0.5750435	0.0613538	9.373	< 2e-16 ***
ME	-0.0002430	0.0011195	-0.217	0.82817
Incremental move	0.0015602	0.0002552	6.113	1.21e-09 ***
MA level	-0.0036764	0.0012461	-2.950	0.00322 **
Game mode = Human	-0.0252745	0.0187479	-1.348	0.17780
Maximum achievable points	-0.0061532	0.0006561	-9.379	< 2e-16 ***
Stack size	0.0826504	0.0049369	16.741	< 2e-16 ***
Total cards available	-0.0060673	0.0038093	-1.593	0.11141
Number of opponent cards	-0.0014115	0.0071558	-0.197	0.84366

We then fitted the same model for the *vs. CPU* and *vs. Human* game mode data separately. In the *vs. CPU* game mode, MA ceased to be a significant factor, whereas the in-game variables - incremental move, stack size, and maximum number of points - remained significant, consistent with the model fitted using data from both game modes (see Table 6). The multiple R-squared was 0.1981, lower than that of the model fitted on all the data.

Table 6: Linear regression coefficients *(vs CPU* mode).

Coefficients				
	Estimate	**Standard Error**	**t-value**	**Pr(>|t|)**
Intercept	0.4520127	0.0896796	5.040	5.48e-07 ***
ME	-0.0002351	0.0013084	-0.180	0.857
Incremental moves	0.0014337	0.0002810	5.103	3.97e-07 ***
MA level	-0.0023759	0.0015327	-1.550	0.121
Maximum achievable points	-0.0066158	0.0008738	-7.571	8.14e-14 ***
Stack size	0.0857383	0.0067286	12.742	< 2e-16 ***
Total cards available	-0.0007567	0.0051220	-0.148	0.883
Number of opponent cards	0.0096095	0.0117563	0.817	0.414

In contrast, a model fitted only using game data from the *vs Human* game mode (Table 7) showed how MA was strongly significant, with a coefficient of $\beta_{MA} = -6.61 * 10^{-3}$, almost twice the size of the coefficient computed using the data from both game modes ($\beta_{MA} = -3.67 * 10^{-3}$, see Table 6). Once more, *incremental moves, maximum achievable points* and *stack size* were significant factors. The multiple R-squared was 0.2747, exceeding the values observed in the two preceding models.

Table 7: Linear regression coefficients (*vs. Human* game mode).

Coefficients				
	Estimate	**Standard Error**	**t-value**	**Pr(>|t|)**
Intercept	0.7195637	0.0903635	7.963	8.45e-15 ***
ME	-0.0009067	0.0022966	-0.395	0.693122
Incremental moves	0.0025835	0.0007225	3.576	0.000377***
MA	-0.0061942	0.0022159	-2.795	0.005350 **
Maximum achievable points	-0.0050291	0.0009919	-5.070	5.30e-07 ***
Stack size	0.0771627	0.0072745	10.607	< 2e-16 ***
Total cards available	-0.0143471	0.0056819	-2.525	0.011824 *
Number of opponent cards	-0.0122425	0.0094350	-1.298	0.194935

As MA showed significance in the *vs. Human* mode but not in the *vs. CPU* mode, we explored the possibility of a significant interaction between MA and game mode by performing a multiple linear regression to assess the interaction effect between these two variables. The results in Table 8 show a significant interaction between MA and game mode at a 0.05 confidence level. The direction of the interaction is shown in Figure 2, suggesting that MA had a stronger negative impact on performance in the *vs. Human* game mode. The multiple R-squared value was 0.2426, slightly higher than the model without interaction (Table 6).

Table 8: Linear regression coefficients (MA and game mode).

Coefficients				
	Estimate	**Standard Error**	**t-value**	**Pr(>|t|)**
Intercept	0.5308061	0.0615147	8.629	< 2e-16 ***
Incremental moves	0.0016373	0.0002493	6.566	6.83e-11 ***
MA	-0.0023753	0.0011311	-2.100	0.0359 *
Game mode = Human	0.0669650	0.0454827	1.472	0.1411
Maximum achievable points	-0.0060389	0.0006459	-9.350	< 2e-16 ***
Number of opponent cards	-0.0008633	0.0070940	-0.122	0.9032
Stack size	0.0833005	0.0048711	17.101	< 2e-16 ***
Total cards available	-0.0057731	0.0037237	-1.550	0.1212
*MA * Game Mode = Human*	-0.0044325	0.0021444	-2.067	0.0389 *

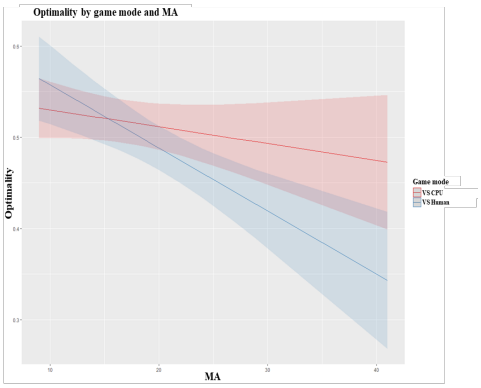


Figure 2: Optimality by game mode and MA.

3.3 Focus Groups

A review of the focus group feedback showed that the students provided positive remarks regarding their experience, describing it as fun and beneficial to their learning. They also mentioned various mathematics topics they practised during gameplay, such as multiplication, addition, prime numbers, and symbols.

In the *vs. CPU* group, the students expressed appreciation for the fantasy martial arts setting, particularly noting the progressive levels marked by different coloured belts: One student remarked; “I like the way there's a bunch of different belts, so it's like you are doing jiu-jutsu and you're fighting people and the more people you fight and win, the more you get a higher belt”. Another mentioned, “You started with an easy-peasy belt, and you got upper belts and it got harder”. Overall, students enjoyed this game mode, commenting: “I liked the way that people were robots, but they act like real people”.

Meanwhile, students in the *vs. Human* group emphasised the competitive aspect against their classmates. One student said; “I like the fact that I've been beating everybody whenever playing the game. I am really good at the game and I really like it”. Another student mentioned: “You are able to go against people and beat them because you are good at maths”. However, they also acknowledged a negative social aspect, with one student expressing: “but it’s also bad, because you don’t want to see them getting upset, but then you can cheer them up by helping them win against someone else”.

4. Discussion and Conclusions

This study investigated the relationship between different playing modes, psychological factors and students’ performance in ‘Seven Spells’, a digital maths game. The results of a linear regression analysis showed several in-game variables as significant predictors of game performance and indicated a distinction in how MA levels impact performance based on the game mode (*vs. Human* or *vs. CPU*) being played.

When considering both game modes as one group, the linear regression identified MA, incremental moves and stack size as significant coefficients for the target variable (optimality). Whilst MA had a negative effect on optimality, incremental moves and stack size affected optimality positively. Considering MA, this suggests that students who feel anxious about maths have lower performance in the ‘Seven Spells’ game. Regarding incremental moves, this result indicates that as the students played ‘Seven Spells’ for longer durations, their performance in the game improved. Finally, the positive correlation between stack size and optimality points out that players who use more cards in their moves have a better performance. In this analysis, game mode was not significant after controlling for all other factors.

When considering just the *vs. CPU* game mode, the linear regression produced similar results: incremental moves and stack size remained statistically significant and positively influenced optimality. However, MA was not a significant coefficient. When repeating the linear regression for the *vs. Human* mode, the results for incremental moves and stack size did not change, while MA showed a significant and negative effect on optimality, the strongest effect among the models considered. This difference suggests that MA had a different effect on players’ performance depending on the game mode, with a higher negative impact when students compete against one another (*vs. Human*), as opposed to playing against the computer (*vs. CPU*).

To further investigate the potential link between MA and the different competition game modes, we fitted a linear regression to examine the interaction between MA and game mode. The interaction was found to be significant, confirming that MA had a negative impact solely in the *vs. Human* competition game mode.

Given that MA encompasses the social experience of doing maths (Rooney, 2014), this study offers additional insights into serious games focused on maths. The presence of a competitive element, especially in scenarios involving two human players, may trigger anxiety, particularly related to MA within its social context, thereby negatively affecting performance (Cagiltay et al., 2015; Rooney, 2014). This highlights the need for maths games to consider MA and the experience of maths-anxious players (Dondio, Gusev and Rocha, 2023).

In the *vs. Human* focus group discussion, some players mentioned concern over potentially upsetting their classmates if they were to win a match. This hints at a possible increase in anxiety due to the competitive component/aspect of the game (Cagiltay et al., 2015).

Concerns about potentially irritating other players did not arise during the focus group discussion in the *vs. CPU* group, as these players were solely competing against computer-controlled characters. These results may suggest that players of the *vs. Human* competition game mode potentially experienced some attributes of social

anxiety, characterised by fear/apprehension of social interactions and negative social outcomes (Belzer et al., 2005). Since social anxiety can also impact students' concentration and academic performance (Leigh et al., 2021), this raises the possibility of an interaction between social anxiety and MA, with one potentially influencing the other and both negatively impacting students' performance.

This study has several limitations, mainly the low number of students involved in the experiment and the differences between game modes. The small sample - due to the number of available classes and students missing sessions and/or not answering all questionnaire questions - had an impact on data significance. A further issue with the present dataset is that students from the *vs. Human* group had a higher baseline MA than those in the *vs. CPU* group. Moreover, the two competition game modes evaluated in this study have additional differences other than having human or computer-controlled opponents. The *vs. CPU* mode incorporates a storyline element and a reward system. The inclusion of a reward mechanism, serving as a motivational tool, could potentially introduce a confounding factor. Furthermore, the two competition game modes have a fundamental difference in terms of the ease with which students could start a match. The v*s. CPU* players could start a match against the computer at any time, while the *vs. Human* players needed to set up a match with another human player. As a result, students assigned to the *vs. CPU* group engaged in more gameplay sessions. Additionally, games against human players tended to be longer as players took more time to execute their moves, and communication between the two players during the match was infrequent.

Further research should include larger sample sizes to better investigate how MA and different competition game modes, in addition to their potential interactions, influence students' performance in 'Seven Spells'. The current study establishes links between the aforementioned factors and highlights shortcomings in the existing experimental design, mainly regarding students' playtime. These limitations will be addressed in a redesigned version, informed by the findings of this study.

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Game at School? Italian Teachers' Perceptions of the Introduction of Games in the Classroom

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Abstract: The growing awareness that games can be a very valuable training support, both as a resource to engage and motivate and to promote acquisition of disciplinary knowledge and skills, has not been accompanied by an effective diffusion of games in Italian schools. From primary school to university, an ambivalent behaviour is manifested: a widespread appreciation of games as a learning environment is contrasted with a limited application, often reduced to the use of games or online software of a behavioural matrix. An analysis of research on the use and diffusion of games in Italian schools and universities highlights the lack of recent studies on the basic didactic-pedagogical knowledge, level of acceptance and confidence of teachers regarding the introduction of games in the classroom. The goal of this contribution is to provide an updated understanding of Italian teachers' competencies related to the formative use of games. To this aim, we developed a survey adapting to the Italian context one of the most established competence frameworks for game-based learning (GBL): the Technological Pedagogical Content Knowledge-Games (TPACK-G), a variant of TPACK specifically modified for the analysis of games. This new tool extends to non-digital games and integrates the sections on aspects related to game-based instructional design, game scenarios, and the role of the teacher in the instructional activity. This research will not only provide an updated look at how the prevalence of play in the classroom is changing, beyond simple manifestations of interest and trends, but also reveal how the approach to games is changing in the design of educational activities and what is the degree of awareness of the game pedagogical-educational skills necessary for the introduction of games in education. This, in turn, is instrumental for the development of new and more focused teacher training programs to promote the use of games in classrooms.

Keyword: Game-Based Learning (GBL), Italian School, Quantitative Research, Teachers' Perceptions of Classroom Game; Teachers' Attitudes toward Classroom Games, Technological Pedagogical Content Knowledge-Games (TPACK-G).

1. Introduction

The relationship between gaming, teaching, and learning has developed over centuries. Just think of games such as Mancala, which has facilitated people in learning the best strategies for counting livestock and food for almost 4000 years, or Chess, which has challenged strategists for centuries (Laamarti et al., 2014; Parlett, 2018).

What has been witnessed in the last two decades is the increasing attention of educational research towards the characteristics and outcomes that play takes on in the educational setting. Games offer an engaging experience, providing essential features for effective learning (Marengo et al., 2018) and language acquisition (Quy, 2019); the integration of games as part of learning increases learner engagement when traditional teaching methods are used (Sanchez et al., 2011; Shute et al, 2017). Game-Based Learning (GBL) and its digital declination (DGBL) have become central to training programs targeting different sectors, such as education, military, transport, communications, and healthcare (Ongoro and Fanjiang, 2024; Ullah et al, 2022). GBL, in a narrow sense, is the use of games, analogue or digital, within the context of learning; in a broader definition, which is the one adopted in this study, it can also be understood as an approach in which learning goals and tasks are integrated into game activities with the aim of linking formative goals with playful objectives (Andreoletti and Tinterri, 2023), so that the pursuit of the latter promotes the achievement of the former.

Research has highlighted how within the school context games can be used to support learning (Beavis et al., 2014; Clark et al., 2016; Stufft, 2018; Stufft and von Gillern, 2021; von Gillern et al, 2022), to promote students' critical thinking and metacognition (von Gillern and Stufft, 2023), game analysis (Bacalja, 2018), multimodal composition (McClay et al., 2007) and collaborative problem solving and design work (Gerber et al, 2014). These different forms of implementation of play within the curriculum have been shown to have a positive impact on student learning (Nash and Brady, 2022): in all contexts, researchers have reported increased student engagement (Gerber et al., 2014), changes in approach to disciplines (Marlatt, 2018), complex analytical thinking (Beavis et al., 2015) and design thinking and multimodal composition (Nash and Brady, 2022, Nash, 2021; Stufft and von Gillern, 2021).

A second strand of investigation has focused on teachers' readiness, willingness and competence to introduce play within their instructional activities (Assaf et al., 2021; Bourgonjon et al., 2010; Chang and Tsai, 2014; Hamari and Nousiainen, 2015; Hayak and Avidov-Ungar, 2020; Hsu et al., 2013, 2017; Jesmin and Ley, 2020; Kaimara et al., 2021; Kenny and McDaniel, 2011; Koh et al., 2013; Lee and Tsai, 2010; Loperfido et al., 2019; Martín-del-Pozo et al., 2019; Matić et al., 2023; Palha and Matić, 2023; Rulyansah et al., 2023; Takeuchi and Vaala, 2014; Zhonggen, 2019). Teachers are the main agents of change in GBL (Bourgonjon et al., 2011; Li and Huang, 2016; Proctor and Marks, 2013). Therefore, their perceptions and beliefs have a crucial effect on their decisions on how, when and for what purpose to integrate GBL into their lessons (Andreoletti and Tinterri, 2023; Beavis et al., 2014; Ertmer, 2005; Ertmer and Ottenbreit-Leftwich, 2010). Several factors influence a teacher's predisposition to use GBL; for instance, when teachers perceive GBL as highly useful, their attitude towards digital games tends to be more positive (Sánchez-Mena et al., 2017). Other aspects include the level of play culture (game literacy), the presence of prejudices about the role and meaning of play in society and culture, the difficulty in translating curricular learning goals within the play activity and/or in the game, the difficulty in identifying and selecting the most appropriate game and integrating it effectively and efficiently within the educational activity, the difficulty in identifying the appropriate assessment methods for learning goals and play objectives (Andreoletti, 2023; Andreoletti and Tinterri, 2023; Hanghøj, 2013) and the limited availability of curriculum-aligned games is an obstacle that teachers identify as hindering the implementation of GBL in the classroom (Takeuchi and Vaala, 2014). Other factors that hinder the adoption of games are the rigidity of curricula, fixed class schedules and their short duration (An and Cao, 2017; Baek, 2008; Kaimara et al., 2021).

In general, what emerges is that:

- teachers' level of pedagogical experience in using games as a teaching resource seems to be a crucial factor in understanding their inclination towards game-based pedagogy (Andreoletti, 2023; Palha and Matić, 2023)
- teachers' attitudes towards new teaching methods such as GBL contribute to their subsequent implementation and influence students' learning motivation (Martín-del-Pozo et al., 2019);
- teachers use informal means to gain knowledge about ways of teaching with games, e.g. through trial and error, seeking ideas from colleagues (Takeuchi and Vaala, 2014) or suggestions, directions and online tutorials (Andreoletti and Tinterri, 2023);
- the chances of achieving educational goals and facilitating students' acquisition of any academic skills or knowledge increase if teachers consider games as legitimate teaching tools (Bonanno and Kommers, 2008; Kenny and McDaniel, 2011);
- games and GBL can only be effective in K-12 education if teachers and students regard them as valid teaching and learning tools (Andreoletti, 2023; Bourgonjon et al., 2010).

Overcoming these critical issues requires adequate training for future and in-service teachers (Andreoletti; 2023). However, there is a lack of professional development opportunities to guide teachers in the systematic use of games for teaching, learning and assessment (Matić et al., 2023; Martín-del-Pozo et al., 2019).

Equipping teachers with specific knowledge about the pedagogical activities involved in teaching with requires knowledge and skills that are not intuitive for most teachers (Nousiainen et al., 2018). Hébert and Jensen (2019) note that a comprehensive understanding of the barriers teachers face in implementing GBL is "important to ensure not only that the benefits of GBL are translated into practice, but also that teachers receive the support they need to make GBL a possibility within their classrooms" (p 308). It is thus essential to understand what these needs are to design meaningful play-based pedagogy curricula that meet the needs of (future) teachers.

I the Italian landscape, apart from the research by Alsop and Jessell (2015) and Loperfido et al. (2019), there is No. recent research investigating teachers' perceptions in relation to the introduction of GBL methods within their training practice.

2. Aims of the Research

The aim of this research is to understand in the Italian landscape the perception of GBL by teachers, both in training and in service, in relation to their teaching experience with GBL. Specifically, this study investigates teachers' perception of their competence in four key dimensions of GBL; to this aim, we developed and distributed a questionnaire aimed at in-service and in-training teachers at all school levels. The overarching hypothesis of this study is that teachers with less or more experience of play and GBL will view the implementation of GBL differently and have different concerns about aspects of the learning environment.

Understanding the concerns and the factors that encourage and hinder them can provide a valuable contribution to the development of a meaningful curriculum. Therefore, the following research questions were formulated:

RQ1: what are the perceived skills with GBL of Italian teachers?

RQ2: which demographic factors influence teachers perceived GBL skills?

3. Methods

The development of the survey started from the analysis of the literature, identifying the instruments that investigated the factors that influence the teacher in the adoption of GBL (Hsu et al., 2013, 2017, 2020; Loperfido et al, 2019); subsequently, on the basis of those identified, a new instrument was defined that integrated new areas and items to adapt them to the Italian context and, at the same time, extends the investigation also to non-digital gaming, aspects related to game-integrated instructional design, game scenarios and the role of teachers in teaching activities (Andreoletti and Tinterri, 2023).

3.1 Literature Analysis

Hsu, Liang, Chai and Tsai (2013), having focused on analysing pre-school teachers' experience with digital games and their attitudes towards game-based learning, derived the Technological Pedagogical Content Knowledge-Games (TPACK-G) from the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra and Koehler, 2006), which is structured into four factors:

1. *Game knowledge (GK)*: knowledge about the *general use of games*: knowing how to play and possessing technical skills to play games effectively, e.g. 'I can learn to use games easily'.
2. *Pedagogical Game Knowledge (GPK)*: knowledge on the *use of games with various pedagogical features for teaching without specific reference to content knowledge*: knowing how to use a game with collaborative features to promote player collaboration during play, e.g. 'I know how to use the features of games to support teaching'.
3. *Game Content Knowledge (GCK)*: knowledge *about how the content can be represented by the game without considering the implemented pedagogy*, it is the combination of game and content knowledge and excludes the pedagogical element: using games specifically created for learning a certain subject, e.g. "I can identify games to use in my class that fit with the topics covered in the discipline/subject I teach".
4. *Knowledge of the Pedagogical Content of the Game (GPCK)*: knowledge of the *use of games to implement teaching methods for any targeted content*: if you have sufficient GPCK, you can select appropriate games to improve what you teach, how you teach and what students learn in class; e.g., "I can select games to use in my class that improve what I teach, how I teach and what students learn".

3.2 The new Tool

The new survey integrated and expanded on previous studies, to better fit the entire game context, to integrate with the findings of more recent research (Andreoletti and Tinterri, 2023, p 37), and extend the topic of the survey to the entire analogue gaming sector (board games, exergames, etc.). To this aim, the survey was structured in three sections: the first included questions linked to participant demographic information (gender, age, school level, years of teaching experience, etc.), a second section with the ADGBL questionnaire (not included in this study) and a reworked version of the TPACK-G. For the latter, several items were rewritten and the GC dimension, which was removed from the work of Hsu et al. (2013), was reintroduced. The initial formulation for the new TPACK-G questionnaire included 4 questions for each dimension (GK, GPK, GCK, and GPCK), each answered through a 1-4 Likert scale (Joshi et al., 2015). The survey underwent a series of preliminary tests using Cronbach's Alpha, a commonly employed measure to test consistency of the items within the same category (Tavakol and Dennick, 2011); this led to several iterations of the questionnaire before the version that was ultimately submitted to participants, which included 15 items (three items for GCK and four each for the other factors). The survey was administered in CAWI format, using Google Modules, to teachers undergoing training to achieve teaching qualification (DPCM 4 agosto 2023). Data was collected via Google Modules and analysed using R (R Core Team, 2023).

4. Results

4.1 Characteristics of the Sample

From April 9 to April 16, 2024, 2752 participants (83.1% females, 18.4% males, 0.3% unspecified) were recruited for the study. Mean age of participants was 44.6 (s.d. 7.81, N=2236). 49.2% of participants were curricular teachers, 48.8% were special need teachers and 2% of participants played different roles within the school system (e.g. pedagogist, school psychologist, educators). Out of all participants, only 2.5% were not actively teaching and were therefore excluded from current analysis (Table 1).

Table 1: Distribution of participants according to school level

School Grade	Frequency	% of Total
Not teaching	68	2.5 %
Kindergarten	99	3.6 %
Primary school	601	21.8 %
Secondary School (I grade)	1067	38.8 %
Secondary School (II grade)	917	33.3 %
Total	2752	100%

The participants differed in their teaching experience, which ranged from less than a year to more than 20 years; Table 2 shows aggregated values that has been used for analysis.

Table 2: Teaching experience distribution of participants

Teaching Experience	Frequency	% of Total
Up to 2 years	353	13.2 %
3 to 5 years	614	22.9 %
6 to 15 years	1144	39.2 %
More than 16 years	662	24.7 %
Total	2683	100%

4.2 Analysis of the TPACK Questionnaire

To validate the factorial structure of the questionnaire, we ran a Confirmatory Factor Analysis (CFA) (Harrington, 2009). The first CFA returned values within the limits that are considered acceptable in the literature for the questionnaire ((X^2(84 df)=894, p<0.001); CFI (0.976), TLI (0.970), SRMR (0.0346), RMSEA (0.058)). Still, based on the analysis of factor loads and our interpretation of the constructs, we decided to modify the factorial structure of the questionnaire. We removed item GK4 (“I can recognize the differences between games and other media like books, films, photographs, graphic novels…”) and item GCK4 (“I can distinguish game content from game objectives”) from it, reducing the revised version to 13 items. The revised questionnaire shows a better factorial profile; all factor loads are moderate to strong and statistically significant (Table 3). The new version, despite retaining significant chi-square value (X^2(59 df)=362, p<0.001), indicating a less than ideal fit, has better values overall for CFI (0.989), TLI (0.986), SRMR (0.0216) e RMSEA (0.0437) indicating a good correspondence between the data and the factorial structure of the questionnaire.

Table 3: Confirmatory Factor Analysis of the TPACK-G questionnaire

Dimension	Item no.	Item	Estimate	SE	Z	p
GK	1	I know the main typologies of games (analogue versus digital and their categories) in the market	0.597	0.015	38.9	<0.001
GK	2	I know how to search for and setup board games and/or install digital games.	0.771	0.015	52.2	<0.001
GK	3	I can recognize game mechanics (e.g. roll dice and move, area control, point and click, etc.).	0.697	0.016	43.2	<0.001
GPK	4	I can tell the difference between Gamification, Game-Based Learning, Playful Learning.	0.680	0.015	44.9	<0.001
GPK	5	I can tell the difference between Serious Game, Educational Game, and commercial game.	0.776	0.015	51.2	<0.001
GPK	6	I can tell the differences in how board and video games promote learning.	0.740	0.015	48.8	<0.001
GCK	7	I can identify knowledge related to my discipline in games.	0.774	0.012	62.7	<0.001
GCK	8	I can identify skills related to my discipline in games.	0.795	0.012	68.4	<0.001
GCK	9	I can identify competencies related to my discipline in games.	0.786	0.012	66.1	<0.001
GPCK	10	I can design learning activities that integrate appropriately games with the subject matter.	0.755	0.014	55.2	<0.001

Dimension	Item no.	Item	Estimate	SE	Z	p
GPCK	11	I can choose games to use in the classroom to improve teaching and learning processes.	0.768	0.013	59.9	<0.001
CPCK	12	I can choose game to represent real world situations.	0.724	0.014	53.3	<0.001
GPCK	13	I can modify the game experience to better fit the individual needs of the students.	0.756	0.014	53.6	<0.001

4.3 TPACK-G Values and Demographic Factors

Once the factorial structure of the questionnaire has been verified, we pooled individual answers to obtain the aggregate values for the four dimensions of the TPACK-G (Table 4). Overall, the self-attributed competence levels were tilted towards the average, with game pedagogical competencies having the lower mean value and game content knowledge the highest.

Table 4: Aggregate values of for the TPACK-G dimensions

N=2684	GK	GPK	GCK	GPCK
Mean	2.56	2.14	2.98	2.67
Median	2.67	2.00	3.00	2.75
St. Dev	0.755	0.792	0.800	0.782
Minimum	1.00	1.00	1.00	1.00
Maximum	4.00	4.00	4.00	4.00

All four factors positively correlate with one another, with correlation indexes (Spearman's Rho) spanning from a minimum of 0.459 for GK and GCK to a maximum of 0.636 for GCK and GPCK. All correlations were statistically significant at the <0.01 level. Next, we sought to understand which demographic factors influenced self-attribution of TPACK-G competencies. To this aim, we analyzed the distribution of answers according to teacher gender, to school level, and teacher experience, using nonparametric rank-based tests. We found that gender was a factor, as males declared higher competence values for Game Knowledge and Game Pedagogical Knowledge compared to female; however, No. statistically significant difference was observed for Game Content Knowledge and Game Content Pedagogical Knowledge (Table 5).

Table 5: Values of TPACK-G by gender

	Group	N	Mean	SD	U	p-value
GK	Female	2183	2.52	0.741	459591	< .001
	Male	493	2.72	0.796		
GPK	Female	2183	2.11	0.779	477088	< .001
	Male	493	2.27	0.834		
GCK	Female	2183	2.97	0.798	527469	0.475
	Male	493	3.00	0.810		
GPCK	Female	2183	2.68	0.781	521177	0.270
	Male	493	2.63	0.785		

We also observed that TPACK-G competencies tend to decrease with the increase of school level, indicating that, on average, teachers that operate with younger students tend to report higher GBL skills than their colleagues working with older students (Table 6). Nonparametric Kruskal-Wallis test reported significant effect of school grade for all dimensions (GK X^2(3 df)=22.0, p<0.001; GPK X^2(3 df)=15.1, p=0.002; GCK X^2(3df)=52.3, p<0.001; GPCK X^2(3 df)=87.4, p<0.001).

Table 6: Values of TPACK-G by school grade

School grade	GK		GPK		GCK		GPCK	
	Mean	St. dev	Mean	St. dev	Mean	St. dev	Mean	St. dev
Kindergarten	2.69	0.789	2.33	0.823	3.10	0.783	3.01	0.794
Primary	2.60	0.722	2.18	0.782	3.05	0.812	2.84	0.758
Secondary I grade	2.60	0.738	2.16	0.800	3.06	0.762	2.70	0.753
Secondary II grade	2.47	0.785	2.06	0.779	2.82	0.816	2.50	0.789

There is also a small, albeit significant, difference in TPACK-G competencies according to teaching experience of the participants for Game Knowledge (GK X^2(3 df)=12.32, p=0.006, Game Content Knowledge (GCK X^2(3 df)=8.97, p=0.03), and Game Pedagogical Knowledge (GPK X^2(3 df)=8.97, p=0.03; the significant pairwise comparisons (Dwass-Steel-Critchlow-Fligner test) are between group 2 (From 3 to 5 years) and group 4 (more than 16 years) for GK (W=-4.69, p=0.005) and GPK (W=-3.979, p=0.025), and between group 1 (Up to 2 years) and group 3 (from 6 to 15 years) for GCK (W=4.240, p=0.014). Overall, it seems that teacher with very little experience and those

with longer experience are those that report lower values for TPACK-G values compared to colleagues, with the notable exception of GPCK values (Table 7).

Table 7: Values of TPACK-G by teacher experience.

School grade	GK		GPK		GCK		GPCK	
	Mean	St. dev	Mean	St. dev	Mean	St. dev	Mean	St. dev
Up to 2 years	2.53	0.724	2.16	0.774	2.86	0.820	2.59	0.784
From 3 to 5 years	2.62	0.746	2.19	0.782	2.99	0.800	2.70	0.757
From 6 to 15 years	2.58	0.775	2.14	0.800	3.01	0.774	2.68	0.763
More than 16 years	2.48	0.744	2.07	0.795	2.97	0.826	2.68	0.830

5. Discussion

In this study, we developed and analyzed a new survey using the TPACK-G framework to explore the perception of competence concerning GBL by Italian in-service teachers at all school levels. The first research question concerned the perceived levels of skills in GBL by Italian teachers. We found that our version of the TPACK-G effectively captures the four key dimensions of the framework. On average, participants report average knowledge of games (GK), relatively low knowledge of pedagogical concepts related to games (GPK), while at the same time reporting good ability to identify learning content in games (GCK) and higher than average skills in incorporating games in their teaching activity (GPCK). The evolutionary structure of the TPACK-G framework suggests that a lower element (GK) is more general and fundamental and that the more specific knowledge factors (GPK, GCK and GPCK) build on this (GK). In other words, to develop a specific GPCK, one should first possess an adequate knowledge of the game in general (GK) and, subsequently, a pedagogical knowledge of the game (GPK) and the content of the game (GCK). Conversely, if one has no knowledge of games (GK), one might not have adequate pedagogical knowledge of games (GPK), let alone adequate knowledge of the pedagogical content of the game (GPCK). Hsu et al. (2013, p. 464) research also pointed out that, when it comes to using games to represent content (GCK), teachers might automatically incorporate this knowledge into teaching activities and might not have a clear idea of what (GCK) it is. Thus, these results suggest that participants might overestimate their ability to identify learning opportunities in games and incorporate them in their teaching practice despite lacking fundamental knowledge related to games, possibly due to a high and generalized belief in games' effectiveness as learning environments (Cantoia, Clegg and Tinterri, 2023). The second research question investigated whether perception of competence with GBL might be related to demographic factors. In this study, we observed that gender has an impact, as male teachers report significantly higher values for GK and GPK. Further analysis is required to understand whether this difference is linked to different gaming habits for male and female teachers, as a largely confuted but persisting social stigma in Italy sees games, and video games in particular, as primarily male occupation. Furthermore, we observed that all TPACK-G levels decrease with the progression of school level, i.e. teachers working with younger students tend to perceive themselves as more competent with GBL than teachers working with older students. Again, further investigation is required to verify whether there is a link between this perception and actual implementation of game activities. Finally, we observed a rather complex distribution of TPACK-G values according to teacher experience. For instance, the teachers that report lower game knowledge are the less experienced (less than 2 years of experience) and the most experienced (more than 16 years); it is plausible that the reasons might be different for the two categories, but a more in-depth analysis is required to identify potential explanations for the data observed. Currently, the study has a few limitations: First, despite the good sample size, which makes it the most extensive study on GBL in Italy to date, participants have been recruited from a specific subset (teachers training to change discipline or special need teachers switching to curricular teaching), which might not reflect the general population of teachers at large. Second, the survey only concerns self-reported attributions by teachers which might not accurately represent actual GBL skills. Taken together, this study presents a new tool to investigate teachers' perceptions of their GBL skills, built according to a well-established frameworks (TPACK) and starts to shed light on the perception of Italian teachers concerning the use of games in their teaching and learning activity, a crucial first step towards the building of evidence-informed teacher training programs to effectively (re)introduce games as proper learning environment in formal education.

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From Designing Houses to Studying Architecture: Did Those Who Study Design Share Any Similarities in Playing the Sims Game?

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Abstract: Wright's famous game The Sims, and its sequels; The Sims2 (2004), The Sims3 (2009), and The Sims4 (2014) are computer based digital games that provide digital settings to simulate virtual dollhouses (Martey and Stromer-Galley, 2007). They are one of the most played games of all time, which is why it has been the focus of academic studies since its first release. Within the scope of this research, a comprehensive survey was conducted. The first phase of the survey was conducted with 54 participants and the participants who graduated from different departments were asked whether there is a relationship between The Sims game experiences, interest in playing SIMS and choosing a profession. The following phase was conducted with the focus of architects, interior architects and industrial design graduates and students, who are called design faculty members. In this study, the effects of playing The Sims on the profession and their professional achievements were questioned.

Keywords: The SIMS, Playing Computer Games, Game-based Learning, Effect of Playing The Sims, Design Education

1. Introduction

Computer games are a significant component of most children's spare time, and they are also becoming an increasingly vital part of everyone's life. Adults frequently marvel as youngsters devote hours to playing different types of games. In the past, computer and video games were criticized as a distraction from more "useful" activities, often leading educators to overlook their potential. When teachers have discussed games, they have mostly concentrated on the social consequences of playing games, disregarding major educational possibilities (Squire, 2003). However, the perception of computer games has begun to shift as the educational potential of this medium becomes increasingly recognized. A growing body of research and scholarly articles explores how games enhance learning outcomes, cognitive skills, and engagement (Dale et al., 2020; Rebetez and Betrancourt, 2007; De Freitas and Liarokapis, 2011).

Combining the words "education" with "entertainment," the term "edutainment" first appeared in the 1970s to describe media that was intended to be both educational and entertaining. Walt Disney, whose early educational films and television shows sought to make learning fun for youngsters, has been linked with creating the idea. The phrase gained popularity in the 1980s, and companies began to create educational software and video games that combined gameplay, puzzles, and storytelling with learning objectives. With the introduction of CD-ROMs and personal computers in the 1990s, edutainment gained popularity as a means of distributing instructional materials both at home and in schools. The 2000s experienced a shift in internet and digital media that resulted in the growth of several online learning platforms and applications, expanding the possibilities and audience for edutainment (Aksakal, 2015; Mukherjee, 2019).

The importance of computer-based learning is further underscored by the rapid technological advancements that have transformed education. From the 1970s onwards, researchers like Papert (1973), Perlman (1976), Malone (1980), and White (1981) began investigating how computer-based technology could enhance education. Their work laid the foundation for what we now recognize as educational technology, where digital tools and platforms are integral to the learning process. With the advent of sophisticated computer games that incorporate educational content, students can now engage with material in a way that is interactive and tailored to their individual learning pace. This not only increases motivation and engagement but also helps in developing critical thinking and cognitive skills.

From the 1990s onward, academics, teachers, and learning resource designers began to explore how digital games and interactive media could be used to promote learning. Research studies were conducted to examine the cognitive and social benefits of these tools, and many educational institutions began incorporating computer-based learning modules and educational software into their curricula. By the 2000s, with increasing access to technology, there was a growing interest in harnessing the motivational aspects of games to support learning in formal and informal settings. This exploration has continued to evolve, leading to the development of game-based learning environments, simulations, and interactive digital content that are now widely used in classrooms and online learning platforms.

Educational researchers and teachers have begun to recognize the value of games like The Sims in fostering critical thinking, creativity, and strategic planning. By engaging with these virtual environments, players can develop skills that are transferable to real-life situations.

It's critical to emphasize how some video games, even those that aren't specifically made for educational purposes, may still provide an extensive amount of learning opportunities in order to connect the conversation about computer-based learning with the particular example of The Sims. The shift from a broad discussion of educational technology to the particular instance of The Sims entails realizing that many games have intrinsic educational value because of their design features, which promote problem-solving, investigation, and judgment.

While educational technology has historically concentrated on products specifically designed for learning, it is becoming increasingly clear that engaging students with games like The Sims may be done in a novel and efficient way. These games mimic actual events and give players a risk-free setting in which to try out various tactics and results. Even while these games' main objective is amusement, their open-ended design encourages creativity and critical thinking, making them useful educational resources. Among the games that best illustrate how a game meant for amusement may be adapted to promote educational objectives is The Sims. The Sims offers players the chance to hone skills in areas like resource management, design, and interpersonal relationships—all of which have real-world applications—through its simulation of daily living.

The Sims, a life simulation video game series, is an excellent example of how computer games can be harnessed for educational purposes, though it was not originally designed with education in mind. The game allows players to create and manage virtual people, known as "Sims," and guide them through various aspects of life, including building and designing homes, managing finances, developing careers, and navigating social relationships. The game emphasizes creativity, open-ended gameplay, and personal expression, allowing players to shape the lives of their Sims in various ways, from mundane day-to-day routines to more fantastical and extraordinary scenarios.

The game's appeal lies in its sandbox nature, where there are no strict goals or endings. Instead, players have the freedom to create and experiment within the virtual world, making choices that affect the lives of their Sims. This flexibility, combined with the ability to mod the game and add custom content, has made The Sims a popular and enduring franchise since its debut in 2000.

The Sims game has managed to attract attention since the first day it was released. Like any game that sells in huge numbers, it has been the focus of research. Despite its popularity, no academic studies have been published on the future career choices of Sims players when they were younger. There are limited studies on the game itself (Martey and Stromer-Galley, 2007, Sihvonen, 2009), gender differences in players' motivations and patterns (Jansz, Avis, Vosmeer, 2010), the simulation games genre (Lenhart et al., 2008; Nutt and Railton, 2003), and ideological and cultural features (Consalvo, 2003; Frasca, 2003).

In this study, which started from a personal inquiry, the past propensities of design faculty students in The SIMS game and professional acquisitions retrieved from The Sims were questioned. As part of this research, a comprehensive survey was undertaken. The initial phase of the survey involved 54 participants, who had graduated from various academic disciplines, and they were asked to explore whether there was a connection between their experiences with The Sims, their interest in playing the game, and their choice of profession. The subsequent phase of the survey specifically targeted graduates and students from architecture, interior architecture, and industrial design programs—collectively referred to as design faculty members. This phase focused on examining the impact of playing The Sims on their professional development and achievements. Individual experiences are included. Research questions are defined as: How does the practice of playing The Sims differ between those who are from design school and those who are not? How does engagement with The Sims game influence individuals' career aspirations and academic choices in design-related fields? What kind of practices do those from the design faculty demonstrate during the house design phase in The Sims game?

2. The Sims Game

William Wright is an American video game designer who founded Maxis and part of Electronic Arts (URL-1). Electronic Arts' The Sims is a series of life simulation video games. During the Oakland-Berkeley Firestorm, his house was one of the first to burn down. Wright became interested in the worth of belongings and the possibility of satisfaction when reviewing his losses and material demands after his home burnt down. Having always been

interested in architecture, he proceeded to create a concept for a game in which players would simulate everyday routines in a rural neighborhood, including the design of a home from the roots up: The Sims was born.

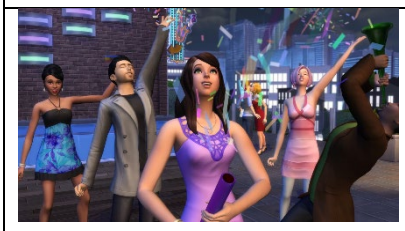
> "I started to wonder about all the things we have and how we purchased them for a reason. Why do we need x or y or z? Why do we think something will make me happier? It almost came down to Maslow's pyramid of needs," Wright says (URL-2).

The Sims and its sequels' gameplay The Sims 2 (2004), The Sims 3 (2009), and The Sims 4 (2014) include maintaining a digital setting simulating a virtual dolls' dollhouse (Martey and Stromer-Galley, 2007). According to Jeff Braun who founded Maxis with Wright, when Wright presented his proposal to the Maxis board of directors, "the board looked at The Sims and exclaimed, 'What is this?" Is he proposing an interactive doll house? 'This guy is insane.'" Girls didn't play video games, and doll homes were for girls (URL-3). All this time, The Sims has been called many things: a sandbox, a toy, a dollhouse, a story engine, and a virtual world, as well as a game (Gee and Hayes, 2010). The Sims game has been continued to grow rapidly.

As of August 2024, *The Sims 4* has released 13 expansion packs, 12 game packs, 19 stuff packs, and 15 kits. With the latest updates, more detailed basements, pools, modular staircases have been added to the game, such as never before. The Sims games sold more than 200 million copies in gaming platforms as of 2019 (URL-4).

Along with playing, The Sims needs a great deal of design (Hayes, 2008). The player can establish a life for virtual persons known as "Sims," by pre-built homes or create their own, interiors, and outfits, as well as controlling them in overall. They direct their characters to satisfy their emotions and demands. The goal of the game is to keep your Sim characters happy, fed, clean, and nurtured (Flanagan, 2003). Wright created a method for "measuring" the happiness of the characters in his doll home based on their status, popularity, and skill, but also the environmental quality provided by the player— Characters are happier when they are in a pleasant home. After purchasing the game, most new Sims players spend hours (and usually days) in non-stop manipulation of the simulated house (Flanagan, 2003).

Table 1: Stages of playing The Sims (URL-5)

Stages		Definition
	Create Unique Sims	A variety of Sims are yours to personalize, each with distinct appearances, dynamic personalities, and inspiring aspirations. Create yourself, your favorite celebrities, your fantasy, or your friends!
	Build the Perfect Home	Effortlessly build and design ideal homes for your Sims using Build Mode. Construct the home of your – and their – dreams by planning its layout, choosing furnishings, and altering the landscape and terrain.
	Explore Vibrant Worlds	Travel between locations, discover amazing and distinctive neighborhoods, and encounter captivating venues. Your Sims can visit new communities, hang out with friends, or throw unforgettable parties.
	Add New Experiences	Use the Gallery to find inspiration from a community of players just like you, where you can add content to your game or share your own creations. Download, like, and comment on your favorite Sims, homes, and fully-designed rooms. Join the community, join the fun!

The SIMS describe the game on their website (URL-5) as follows: Unleash your imagination and create a world of Sims that's wholly unique. Explore and customize every detail from Sims to homes–and much more. According to the game manufacturer itself, the game has 4 stages; Create Unique Sims, Build the perfect home, Explore Vibrant Worlds and Add new experiences (Table 1).

The first stage, "Create Unique Sims," emphasizes the customization of Sims, where players can personalize their virtual characters with distinct appearances, dynamic personalities, and individual aspirations. This stage allows for a high degree of creativity, enabling players to design Sims that represent themselves, celebrities, or fictional characters.

In the second stage, "Build the Perfect Home," players can design and construct homes for their Sims. Using the game's Build Mode, players can effortlessly plan and create dream homes, choosing layouts, furnishings, and even altering the surrounding landscape and terrain. This stage focuses on architectural creativity and home design. "Build. Buy. Live." is the tagline of the game, and building is, accordingly, its first priority. Once the property deal is finalized, the player has the option to either construct a new home for their Sims or modify the existing one to better match their preferences and the needs of their Sims. Although building a new house is more expensive, it offers greater creative flexibility. The game's "build" mode provides an extensive and remarkably intuitive architectural toolkit, allowing players to easily manipulate and place everything from landscaping elements to window treatments using a simple, icon-based interface. If a room requires a door, the player can simply drag and drop it into place. The main challenge the player faces at this stage, aside from budget constraints, is the overwhelming number of design choices available. As the player browses through these options, it becomes clear why Celia Pearce (2002) referred to The Sims as "the IKEA game." Furniture is presented in a catalogue-style menu, each item accompanied by a perfectly crafted description highlighting its advantages (Paulk, 2006).



Figure 1: Build mode in The Sims 4 (URL-6)

The third stage, "Explore Vibrant Worlds," involves Sims traveling between various locations and exploring different neighborhoods. This stage allows players to immerse their Sims in diverse environments, meet new people, and engage in activities such as attending parties or visiting new communities.

Finally, the "Add New Experiences" stage encourages players to engage with the broader Sims community through the Gallery. Here, players can find inspiration, download, share, and comment on user-created content, such as Sims, homes, and rooms.

This stage fosters a sense of community, allowing players to enhance their game with content created by others and share their creations with the world. Together, these stages represent the core experiences of The Sims, combining personal expression, creativity, exploration, and community interaction.

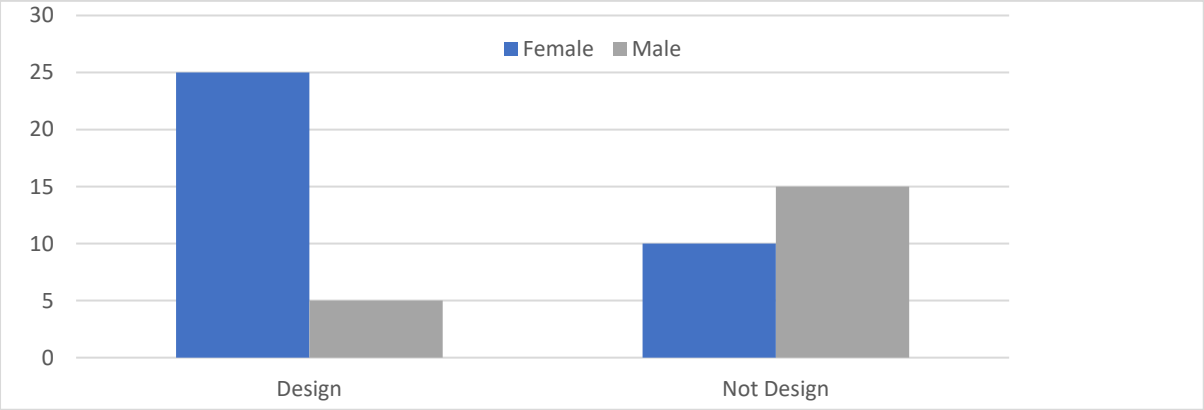
3. Researching 'The Sims'

Survey studies are mostly used to understand the differences of players in various contexts (Jansz, Avis and Vosmeer, 2010; Steen, et al., 2006; Cotton, et al., 2001). In a study compares the gender differences in players' motivations and patterns of play in Sims by Jansz, Avis and Vosmeer (2010), and online study with 760 participants was conducted. Participants were attracted by placing an advertisement on the official Dutch The Sims 2 website (www.desims2.nl). The hyperlink forwarded them to an online questionnaire that consisted of two parts. The first part inquired about the demographic background of the participants, such as age, gender,

education, profession, and so on, and continued by asking about the participants' favorite games, access to computers and/or gaming devices, and the time spent playing games. Part 2 included 27 graded phrases or items aimed at detecting the various motivations for playing The Sims 2.

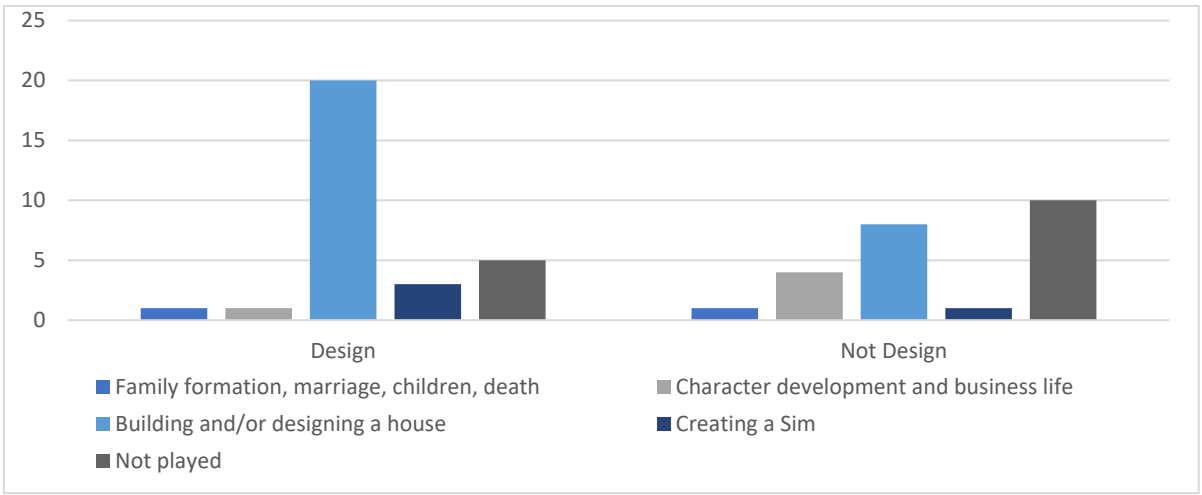
For this study, a survey with two phases was conducted, first with 54 participants and then with 40 participants, who were recruited through a hyperlink shared for a day on Instagram. In the first survey, 10 questions were asked to the participants. Of the participants, 19 were male and 35 were female. Among them, 25 female and 5 male participants were from a design profession, while 14 female and 10 male participants were not from a design profession (Table 2). In total, there were 30 participants from architecture, interior architecture, landscape architecture, and industrial design, which will be collectively referred to as "design professions" in this research. The remaining 24 participants were not from a design profession and came from fields such as engineering, medicine, law, communication, etc.

Table 2: Gender by Profession



During the game, players are first creating a character and a family if they want. Then they need to find a house, modify it or design from scratch. After that, they establish a family (marriage, kids, death), while developing their character, fullfiling their needs and advancing their careers. Participants are asked by doing which, they spent most of their time (Table 3). 71.8% of the participants spent most of their time by designing a new house and/or modifying an existing one. If the faculties are analyzed separately, these rates are 80% for those who come from design faculties and 57.1% for those who come from other faculties among those who play Sims.

Table 3: The part that participants spend the most time



The last question of the survey is an open-ended question and asks; Were you interested in designing and/or modifying houses in The Sims game? Can you explain this process? The advantage of open-ended questions can be seen in this question. From the answers given, it is seen that the participants are very interested in designing a house while playing the game. Those who have both studied at the design faculty and are interested in home design, state that they are influenced by this game in their choice of profession.

> “Yes. Before I chose the department I was reading, I realized that I was interested in this subject with games like sims.” (Male, 1996, Interior architect)
>
> “Yes, it was interesting to me, even I would play sims only for the house part. I can't say that I enjoyed playing with the next people.” (Male, 1993, Industrial Designer)
>
> “Yes, I spent the most time and the most enjoyable part was designing the house. My purpose in playing the game was mostly to design houses.” (Female, 1990, Architect)
>
> “Yes. I was designing the house and playing the game in five minutes and closing it.” (Female, 1992, Architect)
>
> “I chose the interior architecture and environmental design department because I love and enjoy playing Sims a lot. In cases where the items in the base game and additional packages were not enough, I would download cc and decorate for hours. I witnessed the development process of the game and I played it from Sims1 to Sims4. I'm still playing. Since I did not know how to model in the first years of my undergraduate education, I did a similar modeling on Sims4 and obtained 3d visuals from the game. In short, I still play this game, which has greatly affected my professional life, and I learned many basic information (decoration, design, structure, English, etc.) thanks to this game.” (Female, 2000, Interior Designer)

Thematic analysis was used to analyze the open-ended responses. First, the responses were read carefully to understand the overall content. Important phrases and ideas related to designing houses were then identified and coded. These codes were grouped into main themes, such as "Career Influence" and "Design Skills." The themes were reviewed and refined to ensure they accurately reflected the participants' experiences. Finally, the findings were interpreted to reveal how The Sims influenced participants' career choices and design interests, clarifying the game's impact on their professional paths.

The analysis of responses to the open-ended question about participants' interest in designing or modifying houses in The Sims game reveals a significant connection between gameplay and professional aspirations in the field of design. The responses indicate that The Sims game has not only been a source of enjoyment but also a pivotal influence in shaping the career paths of those who later pursued studies in design-related disciplines.

Participants who have studied in design faculties, such as interior architecture, industrial design, and architecture, consistently noted that their engagement with The Sims played a critical role in developing their interest in these fields. The game served as an early platform for exploring their creativity and honing their design skills, which later translated into their academic and professional choices. For many, the act of designing virtual homes was not merely a part of the game but the primary reason for their continued engagement with it.

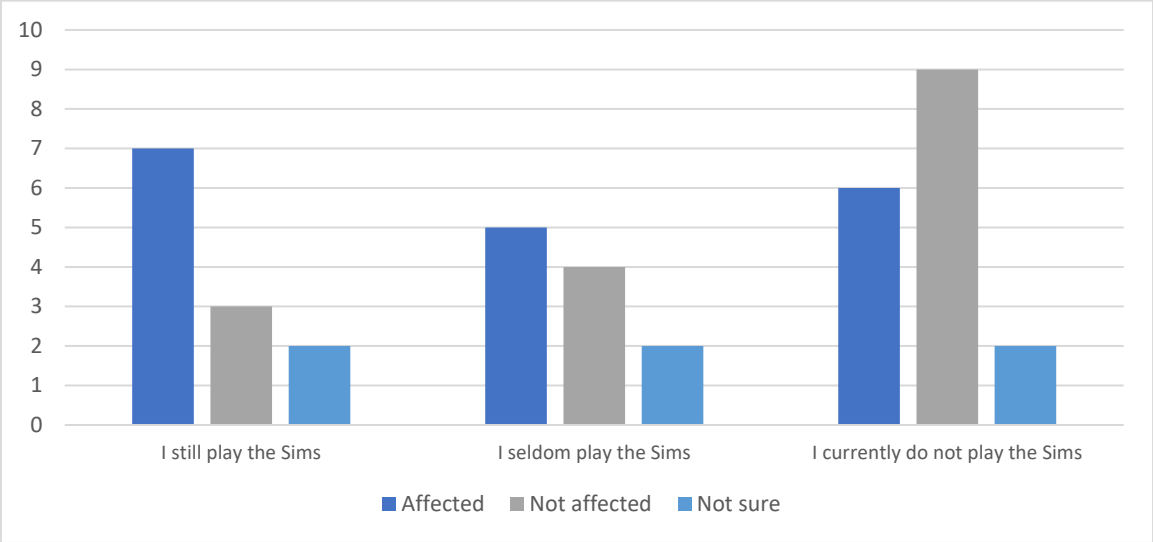
14 of the 24 participants who did not study at the design faculty stated that they played sims. 8 of these participants said "designing a house" for the part they spent the most time with. Here are some of the answers that are worth mentioning.

> “I would play with the enthusiasm of creating an order similar to the one seen at home.” -Male, 1994, Engineer
>
> “Yes. Because my dream was to become an architect or interior designer. But I didn't want to read it because I don't have drawing skills. I suppressed my dream of designing a house a little bit with this game. I was more into decoration.” -Female, 1990, International relations specialist “
>
> Designing the house according to myself and decorating it as if I was really going to live in that house was the process that interested me the most.” -Male, 1996, Medical Promotion Representative

It can be seen from here that these participants tend to design like their own houses and/or environments. however, those studying at the design faculty mostly refer to their professions.

Participants from design faculty were asked whether they still play The Sims or not. 30% of the participants still play The Sims, 27,5% seldom play The Sims, and 42,5% currently do not play The Sims. 18 out of 40 (45%) participants state that playing The Sims effected their choice of profession. When looked at the participants who still play The Sims, the rate increases to 59%. In contrary, participants currently do not play The Sims state playing The Sims didn't affect their choice of profession (Table 4).

Table 4: Playing preferences vs choice of profession



In conclusion, the survey's results and the open-ended questions highlight the strong correlation between The Sims participation and goals for design-related careers. The data shows that The Sims was not simply a source of enjoyment but also a formative platform for the development of design abilities and interests for many players, especially those with academic backgrounds connected to design. The impact of the game on career choices is especially noticeable among those who keep playing, since a significant portion of them credit their professional journeys to their gaming experiences. On the other hand, the perceived influence on their professional decisions decreases for those who stop using The Sims. This contradiction draws attention to how the game's impact changes depending on how much time is spent playing it, and it implies that creative, interactive platforms such as The Sims may have a significant impact on how people develop their careers in design fields.

4. Conclusion

The strong connection between gaming and career development, as evidenced by the responses from the surveys, underscores the educational potential of simulation games like The Sims. These games can inspire and nurture an interest in design from a young age, providing a practical and enjoyable introduction to concepts that are foundational in professional design education. The fact that some participants continued to use The Sims as a tool for modeling and visualizing designs during their studies further emphasizes its value as a learning resource, highlighting its profound and lasting impact on individuals interested in design. This influence extends to their educational and career trajectories, suggesting that video games can serve as both an inspiration and a practical tool in the development of professional skills, particularly in creative fields like design and architecture.

Wright's assertion that the design and organization of a player's [Sim] house can provide significant insights into their personality and character traits aligns with the survey findings. Many players create in-game representations that closely mirror their real lives, replicating their own identities, homes, and even their neighbors within the virtual environment (Breznican, 2004). This behavior further demonstrates the deep engagement and personal connection that players develop with the game, reinforcing its potential as a tool for exploring and refining design skills.

However, it is important to note the limitations of this study, which was conducted in Turkey with a limited timeframe and participant pool. The cultural and geographical focus may affect the generalizability of the findings. To validate these results, similar studies should be conducted in different countries and cultural contexts. Understanding how players from diverse backgrounds engage with The Sims could provide a broader perspective on its educational impact.

Video games vary widely in their social and complexity dimensions, as noted by Granic, Lobel, and Engels (2014). For example, games like puzzles and Tetris are simple and non-social, while Guitar Hero and Need for Speed are simple but social. On the more complex end, games like The Sims and SimCity are non-social, while Among Us and Minecraft are both complex and social. Interestingly, the upcoming release of The Sims 5, which EA revealed to be in development in 2020, is expected to introduce multiplayer online features. This addition would elevate

The Sims from a complex, non-social game to a complex, social one, potentially enhancing its educational value by enabling collaborative, online interactions among players.

With these anticipated developments, The Sims 5 is likely to attract renewed interest from researchers, particularly in terms of its educational applications. The game's evolution to include social and collaborative features may further solidify its role as a tool for developing professional skills in design and other creative fields. As the game evolves, it will also be important to consider how generational differences and the changing technological landscape influence player engagement and the game's educational potential.

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From Consoles to Classrooms: Preliminary Insights About Pre-Service Teachers and Video Games

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Abstract: Integrating video games into the classroom is a promising way to enhance learning experiences, as the market of serious games is expanding. European schools are investing in digital equipment, and the use of educational video games is technologically viable. Nonetheless, actual experiences of video games in class are still rare. A key gap to be explored is understanding how pre-service secondary teachers perceive and are prepared to use digital games in their future classrooms. Do they think it would enhance their teaching and their students' learning? Do they feel prepared for it? To answer these questions, and possibly address future challenges, we conducted a comprehensive study with students at Zurich University of Teacher Education (PHZH). The research process began with the development and testing of a detailed questionnaire that focused on participants' personal gaming behaviour, preferences, and perceptions of the educational potential of video games. Key areas such as serious games, game design, gamification, game-based learning, and game culture were explored to assess the relevance and understanding of these concepts in an educational context. This paper explains the development and structure of the questionnaire as a measurement instrument as well as the underlying literature and methodological considerations. The first implementation and the preliminary survey with 48 PHZH students are presented, and the practicability and reliability of the questionnaire are evaluated. The result of the survey suggests pre-service teachers are generally positive about integrating video games and game design into the classroom, yet enthusiasm is not enough without additional support.

Keywords: Game Studies, Video Games, Primary and Secondary Education, Pre-Service Teachers, Game-based Learning

1. Introduction

In recent years, integrating digital technologies into education has become increasingly important as students must be equipped with the necessary skills to succeed in a digitally oriented world (Digital Competence Framework, 2021). This trend is particularly evident in expanding the market for serious games - video games developed explicitly for educational purposes (Statista, 2021). Video games have shown significant potential to increase student engagement, promote critical thinking and improve learning outcomes in various subjects. Research indicates that serious games can boost students' motivation and engagement, making the learning process more interactive and enjoyable. For example, the study by Arias-Calderón, Castro, and Gayol (2022) showed that 90.8% of students found serious games to be effective in improving their learning experience, while 87.9% stated that these games increased their motivation to study theoretical content. In addition, the literature review by Videnovik et al. (2023) has shown that game-based learning promotes critical thinking and collaboration by allowing students to apply their knowledge in practical, real-world contexts.

Despite the technological advancement and availability of educational games, their actual use in the classroom is still relatively limited. A systematic review of empirical studies by Oyelere et al. (2020) showed that this is partly due to the challenges associated with aligning game content with educational objectives and the need for more comprehensive integration strategies. Another critical evaluation of smart classrooms and the use of new technologies by Dimitriadou and Lanitis (2023) reveals that while many tools exist to improve student engagement, the actual implementation of these technologies faces several hurdles. These include inadequate teacher training, lack of resources and the complexity of integrating new technologies into existing curricula.

This discrepancy highlights the need to explore the factors that influence the use of digital games in the classroom. One crucial aspect is understanding the perceptions and readiness of pre-service teachers who will soon be at the forefront of educational innovation. Their attitudes towards digital games and their willingness to incorporate these tools into their teaching practices are critical to the successful integration of game-based learning (Meccawy, 2023). To find out more about this target group, this paper will tackle the following research question: "How do Swiss pre-service teachers perceive the opportunity to use video games in the classroom?"

This paper details the questionnaire's development and structure as a measurement tool, including the underlying literature and methodological considerations in Section 2. The selection and formulation of the questions as well as the theoretical framework on which the development of the questionnaire was based are discussed in Section 3. Following this detailed explanation, the first implementation and preliminary survey with a group of 48 PHZH students is presented in Section 4 and discussed in Section 5. This first test phase serves to evaluate the practicability and reliability of the questionnaire.

2. Literature Review

The origins of video games date back to the 1950s, with the first commercially successful video game, “Pong”, being released in 1972 (Kent, 2001). Since then, video games have evolved from simple arcade machines to complex interactive media encompassing a wide range of genres and game mechanics. In parallel with content innovation, technological advances have led to smaller and more powerful devices, making video games more accessible. In particular, the development of mobile tablets and affordable laptops has significantly lowered the physical and economic barrier to accessing video games. This accessibility increasingly allows schools to integrate video games as a teaching tool without having to rely on a computer lab, for example, which often has limited use and can be a major administrative burden.

Scientific studies show that the use of video games in an educational context can have a positive impact on students' learning and motivation. A meta-analysis examining the effects of digital games in STEM (Science, Technology, Engineering, Mathematics) showed significant learning effects in students who used digital games as a learning aid compared to those who used traditional teaching methods (Wang et al. 2022). Another study suggests that integrating games into the classroom can lead to increased student engagement and improved understanding of complex topics. In particular, games that emphasise active participation and problem orientation were found to be particularly effective in enhancing the learning process (Vlachopoulos and Makri 2017). However, results vary depending on the design of the game, the way it is integrated into the curriculum and the role of the teacher in using the games as a pedagogical tool. Games that are well integrated into the course and actively accompanied by teachers show the best learning effects. It is also important that the games are tailored to the specific learning objectives and educational level of the students (Vlachopoulos and Makri 2017; Smiderle et al. 2020). Overall, research confirms the potential of video games as effective teaching tools that, when used correctly, can increase motivation to learn and support the achievement of learning objectives.

Video games in the classroom can help to develop the subject-specific and interdisciplinary skills required by the curriculum. They promote critical thinking, problem-solving skills and collaboration. According to Curriculum 21 (D-EDK 2016), which is used in most parts of Switzerland, students should, for example, use games for research and learning support. The application competence, which is valid for all three school cycles (ages 7 - 16), reads as follows: “Pupils can use given media to learn and obtain information on a given topic (e.g. book, magazine, educational game, story, website).”.

The cross-references to the subjects German, media education, and informatics and STEM indicate that games can and should also be used in a wide variety of subject areas. A second application goal appeals to students' independence in selecting media for learning. “Pupils can independently select and use media for their own learning process (e.g. non-fiction book, magazine, RSS feed, social networks, e-book, subject-related software)”[1].

In today's world, where video games often play a central role in young people's everyday lives, it is obvious that schools should consider them as a learning medium and demonstrate the possibilities and limitations.

The Dagstuhl Triangle (Brinda et al. 1985), a framework for evaluating and designing educational technologies, emphasises the interplay of three critical perspectives: a technical, a socio-cultural, and an application-oriented perspective. When applying the Dagstuhl Triangle to the use of games in the classroom, it is important to ensure that each of these components is carefully balanced and integrated, see Figure 1.

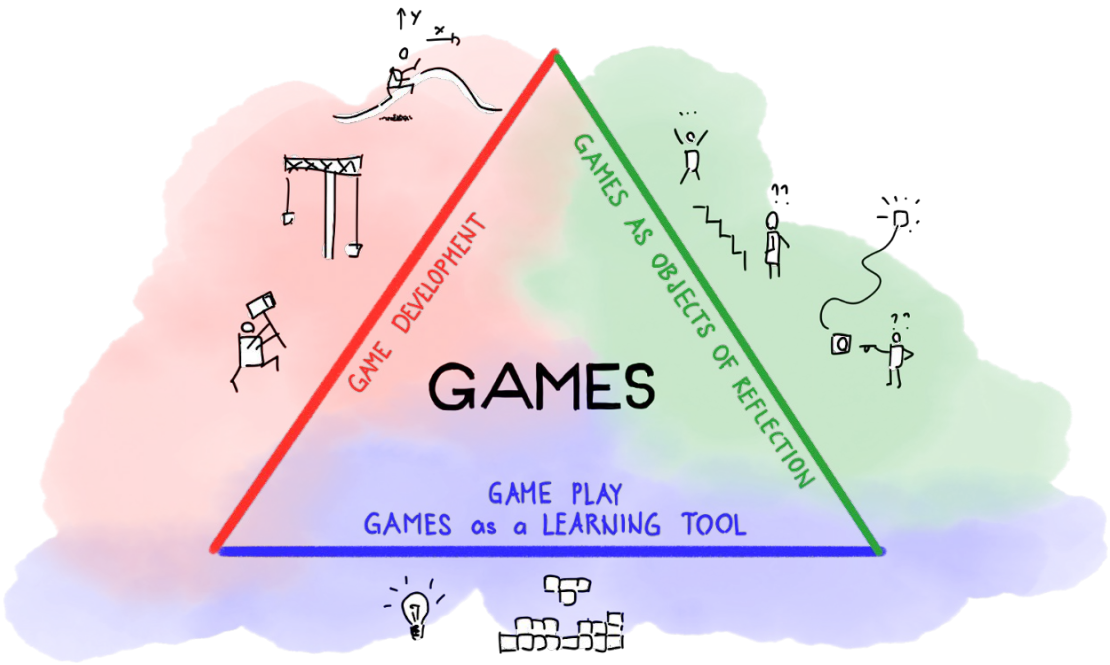


Figure 1: The Dagstuhl triangle can be used to combine games in education with different perspectives. Own illustration.

Game Development: This perspective involves students creating games, enhancing their skills in programming, design, and critical thinking (Clark et al., 2016)

Games as Objects of Reflection: Here, games are used to stimulate discussion and analysis, fostering critical thinking and deeper understanding (Boyle et al., 2016). This could include the media-psychological effects of games on young people, trends, and new developments that influence us as a society.

Games as Learning Tools: This involves using games to directly teach specific content, promoting engagement and retention (Plass et al. 2015).
Numerous research findings support the assumption that early exposure to digital games is associated with more positive attitudes towards these games in an educational setting. For example, research shows that teachers who played digital games in their childhood not only have a more positive attitude towards games today, but also have greater knowledge in this area. This positive correlation was highlighted in the work of Pozo et al. (2021).

Furthermore, this extensive knowledge of games often leads to a more nuanced understanding of their potential learning benefits, which is not readily apparent to those with less gaming experience. Studies by Sánchez-Mena et al. (2017, 2019) support this idea by showing a positive correlation between the frequency of game use by teachers and their positive assessment of the educational value of games.

Studies by Bourgonjon et al. (2013) and de Grove et al. (2012) also agree with these findings and show similar trends in teachers' intentions to use digital games educationally. The accessibility and thematic relevance of games are cited as the main reasons for their use in educational contexts, as a study by Belda-Medina and Calvo-Ferrer (2022) shows. They found that a wide range of games are used by teachers, suggesting that the choice of games does not necessarily depend on specific pedagogical skills, but rather on perceived ease of use and thematic fit with curricular objectives. This is also supported by Alberola-Mulet et al. (2021), who points out that while teachers see the potential of using digital games for learning, they also recognize significant challenges in effectively integrating these tools into the curriculum.

Our past research revealed several important findings about in-service primary teachers' perceptions and use of digital games in the classroom (Spieler and Degonda, 2022). Teachers associated both positive and negative aspects with games. On the positive side, they noted the usefulness of games for practising learning content, individualising lessons and introducing fun and innovative elements. Gamification and competitive aspects were seen as motivating factors. However, negative perceptions included the effort required to use games, the risk of

them being seen as time wasters and the potential to isolate students. Teachers also reported that games are a pervasive topic at break times and during free time. These findings suggest that targeted teacher training is needed to better integrate digital games into the educational environment and eliminate existing stereotypes and misconceptions.

3. Study Design

To understand the perception of pre-service teachers regarding the use of video games in the classroom, whether they believe it would improve their teaching and their students' learning, as well as if they feel prepared for it during their future classes, we designed and administered a questionnaire during the Spring Semester 2024.

We designed the questionnaire in a digital format with Survalyzer[1] to be completed online, ensuring accessibility and ease of data collection. The questionnaire presented a set of close-ended questions, with the exception of a final open-ended space for comments on the survey and was divided into three categories. The first category presented an introductory set of questions regarding data about the participants, such as gender and age. The following two categories presented Likert-scale questions to assess students' perceptions on a five-point scale from "strongly disagree" to "strongly agree". In particular, the second category of questions regarded the perception of participants on the possibility to learn while playing, while the third category focused on game design in the classroom. The questionnaire was designed to be anonymous, with no personal identifiers collected to maintain participants' confidentiality. Participation was voluntary.

The design of the questionnaire was based on the survey presented in Rüth et al. (2022), where multiple regression analyses were applied to investigate how the individual traits of pre-service teachers influence their plans to incorporate digital games in educational settings. The questionnaire identifies perceived usefulness and curriculum relatedness of video games as important factors for pre-service teachers' intention to teach with them. We applied the same multiple regression analyses approach used in Rüth et al., while adapting their questionnaire for the Swiss educational context and shortening it from the original 23 questions with 87 items to 12 questions with 46 items.

In the Swiss Curriculum 21 (D-EDK 2016), active media work, i.e., creating digital products and exploring programming skills, is becoming increasingly important. For this reason, it makes sense not only to use games as a learning tool and occasion for reflection, but also to create games on your own. Our questionnaire was thus supplemented with three questions of three items each on attitudes to game design at school. These were based on the content of the previous questions and collected data on the following topics:

- Perceived usefulness of game design in the classroom
- Perceived user-friendliness of game design for teachers
- Perceived user-friendliness for pupils

The questionnaire was pre-tested in advance with three students from the PHZH. In addition to minor shortcomings, it was also pointed out during this test that negatively worded items could be confusing. The two items to which this applied were reformulated. It was also noted that video games in the school context may only be understood as software that has been developed for teaching. For this reason, a brief definition of what is meant by and considered as video games was included in the introduction.

The students at PHZH who completed the survey are in their 8th semester and usually complete their studies in the following semester. The students surveyed have selected media education and informatics (MI) as an elective area and must obtain 18 ECTS credits in this area. Particularly noteworthy is the 7th semester, in which the Scratch programming language, and game design approaches were addressed in several module courses. These included a course dedicated to (paper) prototyping and several inputs on typical mechanics that are used in games and can be recreated with Scratch. As proof of performance, the students had to develop and implement a game idea with individual students within two double lessons. The topic of games was thus examined intensively from the perspective of game design. The perspective of using games as a learning tool in

[1] https://survalyzer.com/

the classroom was not actively addressed. We gathered 48 answers out of a total administration of 55 students during a self-organised phase of a module as a task.

4. Findings

Part 1 of the survey gathered general data about the population sampled and their experience with video games. The sampled population had an average of 28 years old, with 17 participants describing themselves as female, and 31 as male. On average, the surveyed population plays video games for 3-4 hours a week, while they used to play 11-12 hours a week when they were 15 years old. About 71% of the sampled population does not describe themselves as gamers, 61% does not think they play more video games than other people, about 45% mention they play different kinds of video games, 52% admits they don't play video games often, while 68% admits they like to play video games.

Part 2 of the survey was focused on their perception of the possibilities to learn by playing video games. The following tables presented in this Section show internal consistency, mean (standard deviation) and results of the one sample t-tests for the scales of the regression models' dependent variables. The one-sample t-tests were always computed to examine whether means differ from the scale's midpoint of 3.

Scale	α	M (SD)	t	p	d
Perceived benefits of games in the classroom ("By using games in the classroom, I can teach better.", "By using games in the classroom, I can teach students more.", "Using games in the classroom improves my effectiveness as a teacher.", "I find the use of games in lessons useful.")	0.84	3.24 (0.65)	t(44) 2.52	0.015	0.37
Perceived ease of use of video games for teachers ("The use of games in the classroom is clear and understandable to me.", "For me, interacting with games in class doesn't require much mental effort.", "I find it easy to use games in the classroom.", "I find it easy to use games in the classroom the way I intend to.")	0.83	2.84 (0.74)	t(37) -1.13	0.202	-0.21
Perceived user-friendliness of the use of video games for students ("The use of games in the classroom is clear and understandable for students.", "Interacting with games in class doesn't require much mental effort for students.", "Students find it easy to use games in class.", "Students find it easy to use games in class the way they intend.")	0.60	3.03 (0.58)	t(37) 0.41	0.68	0.067

Table 1: Perceived benefits and ease of use for teachers, perceived user-friendliness for students.

Table 1 shows the perceived benefits, perceived ease of use for teachers, and perceived user friendliness for students of video games. The degrees of freedom for the t-statistic varies from scale to scale, as not all the participants answered all the questions. Table 2 shows the results for the scale related to reputation.

Scale	α	M (SD)	t	p	d
Assumptions about the reputation of other people through the use of video games in the classroom ("People who have an influence on my behaviour think that I should use games in class.", "People who are important to me think that I should use games in the classroom.", "I think that the school management would support me in using games in the classroom.", "I think that the school management would generally support the use of games in lessons.")	0.76	3.13 (0.63)	t(28) 1.08	0.28	0.20
Reputation of teachers who use games in the classroom ("Teachers who use games in lessons are more highly regarded at school than teachers who do not use games in lessons.", "Teachers who use games in the classroom are well known.", "Using games in the classroom is a status symbol for teachers.")	0.45	2.92 (0.58)	t(34) -0.77	0.44	-0.13

Table 2: Teachers' assumptions about their reputation, or other teachers' reputation, in using video games in class.

Table 3 shows the results for the scale related to relevance for teachers to use video games in the classroom, their belief regarding the results of using video games in the classroom, and their subjective perception on the use of video games in class.

Scale	α	M (SD)	t	p	d
Relevance of video games for teachers in the classroom ("The use of games in the classroom is important in the teaching profession.", "The use of games in the classroom is relevant in the teaching profession.", "The use of games in the classroom is relevant for the various tasks in the teaching profession.")	0.78	3.17 (0.66)	t(43) 1.73	0.089	0.26
Conviction of results ("I have no difficulty telling other people about the results of using games in the classroom.", "I think I could teach other people about the effects of using games in the classroom.", "The results of using games in the classroom are obvious to me.")	0.76	3.30 (0.73)	t(42) 2.67	0.010	0.40
Subjective perception of using video games in the classroom ("I find it entertaining to use games in the classroom.", "The actual process of using games in the classroom is gratifying.", "I enjoy using games in the classroom.")	0.83	3.89 (0.51)	t(40) 11.15	< 0.001	1.74

Table 3: Relevance of video games in class for teachers, their belief on the results achieved, and subjective perception of the use of video games in class.

Figure 2 and Figure 3 show how in-training teachers replied to items of the questionnaire related to what opportunities video games offer, and how they could use a video game in class.

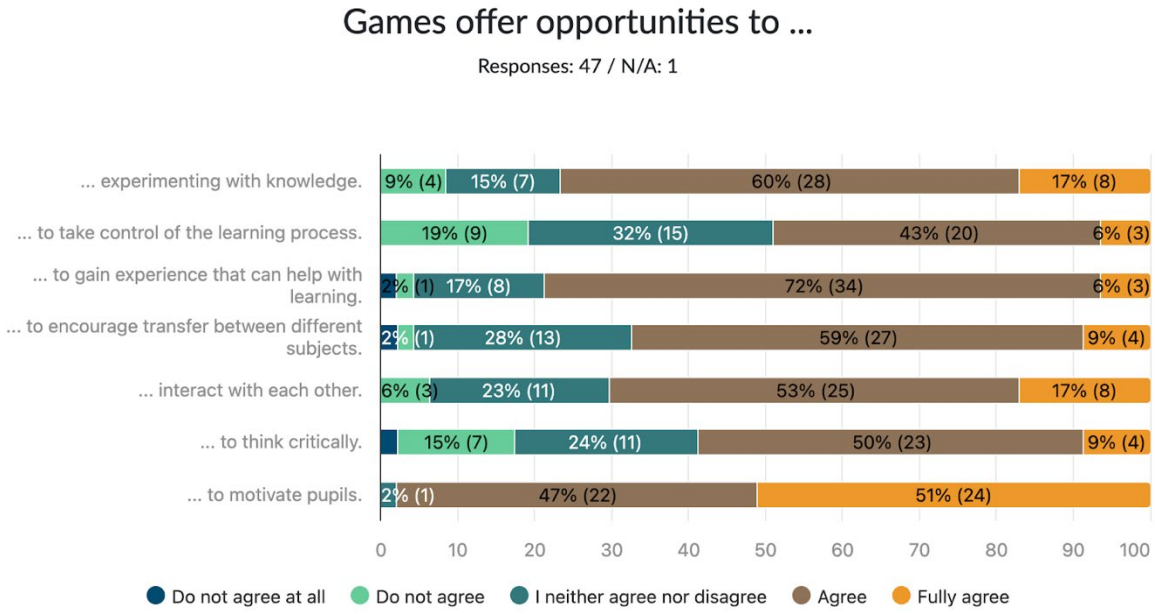


Figure 2: Visual representation of the results of the question on opportunities offered by video games.

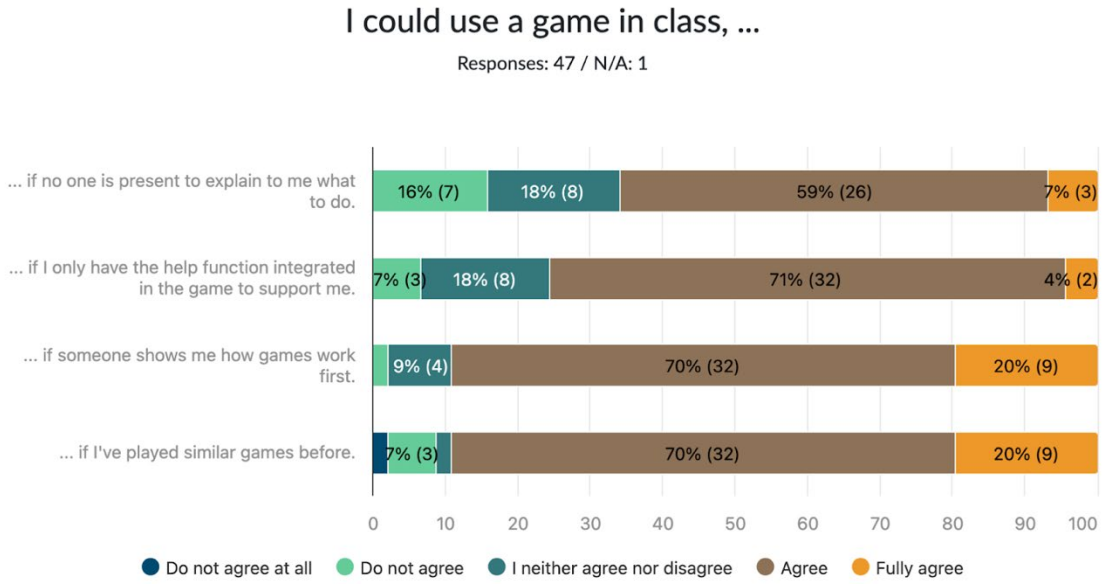


Figure 3: Visual representation of the results of the question on how pre-service teachers think they could use video games in class.

Part 3 was focused on the intention and perception of using game design in the classroom. Table 4 shows the results of the one sample t-test carried over the intention of using game design in the classroom.

Scale	α	M (SD)	t(44)	p	d
Intention to use game design in the classroom ("I intend to use games as a tool in the classroom as soon as I start working as a teacher.", "I can already think of specific game design content that I will implement with the students.")	0.65	3.33 (0.13)	2.45	0.018	0.36

Table 4: Teachers' intention to use game design in class.

Table 5 shows the results of the one sample t-test carried over the perception of usefulness and user-friendliness for both teachers and students of game design in the classroom.

Scale	α	M (SD)	t(42)	p	d
Perceived usefulness of game design in the classroom ("Game design is suitable for implementing the objectives of the curriculum.", "During the use of game design, the students' skills increase.", "Game design can be used to create productive lessons.")	0.8	3.93 (0.53)	11.47	< 0.001	1.75
Perceived user-friendliness of game design for teachers ("I have the confidence to do game design with my future classes.", "I can support my students profitably with questions about game design.", "I know a tool or a programming environment that can be used to develop games in the classroom.")	0.81	3.65 (0.90)	4.96	< 0.001	0.78
Perceived user-friendliness for students ("The students will be able to develop games without much help.", "There are tools and instruments that are suitable for game design at school.", "We will develop exciting games in the classroom without any major effort.")	0.66	3.19 (0.72)	1.74	0.08	0.26

Table 5. Perceived usefulness and user-friendliness from teachers' perspective on the use of game design in class, and perceived user-friendliness for students.

5. Discussion

The analysis of the survey results among pre-service teachers provides interesting insights into the perception and acceptance of video games as a teaching tool. Despite widespread recognition in the literature as an effective teaching tool, see Section 2, the data reveals a complex mix of agreement and reservations that merit critical examination.

5.1 Teachers' Perceptions of the Benefits, Ease of Use, and User-Friendliness of Video Games in Classroom

The perceived benefits of games in classroom showed a significant result (p=0.015), indicating a positive attitude towards the integration of games in the classroom. This suggests that teachers in education see the value of video games, which is consistent with existing literature highlighting the motivational and pedagogical benefits. However, this optimism must be viewed critically as the moderate effect size suggests that the perceived benefits may not be convincing enough to encourage widespread adoption without additional support.

Teachers' perceived ease of use (p=0.202, not significant) suggests that there is a need for targeted teacher training and resources. The moderate perception of usefulness compared to difficulty of use suggests that it may be difficult for teachers to effectively incorporate games into their teaching practice without adequate training.

The perceived ease of use for students (p=0.68, not significant) suggests that while teachers believe that students could potentially benefit from using video games, their confidence in this belief is not very strong. This highlights the need for better support structures and institutional readiness to facilitate the integration of video games into the classroom.

5.2 Teachers' Perceptions of the Reputation of using Video Games in the Classroom

The assumptions about the reputation of others through the use of video games in the classroom indicate that pre-service teachers believe that the use of games in the classroom is moderately supported by others. The mean of 3.13 (SD=0.63) with a p-value of 0.28 and a small effect size (d=0.20) indicate that although there is a slight tendency towards the perception of support, it is not strong enough to be considered statistically significant. This moderate perception may reflect cautious optimism among teachers about the acceptance and promotion of video games by colleagues and administrators, suggesting that further efforts to communicate the benefits and secure institutional support are needed to strengthen this perception.

The prestige of teachers using games in the classroom shows a mean of 2.92 (SD=0.58) with a p-value of 0.44 (not significant) and a negative effect size (d=-0.13). These results suggest that teachers generally do not perceive a significant improvement in their reputation through the use of video games in their teaching practice. The lack of a perceived reputational benefit suggests that the use of video games in the classroom is not currently viewed by teachers as a prestigious or noteworthy endeavour. This finding highlights the importance of fostering a culture that values and rewards pedagogical innovation, thereby encouraging more teachers to experiment with and adopt video games strategies.

5.3 Teachers' Perceptions on the Relevance, Effectiveness, and Enjoyment of Using Video Games in the Classroom

The relevance of video games to teachers in the classroom shows a mean of 3.17 (SD=0.66), with a p-value of 0.089, which is not statistically significant. These results suggest that while there is a general perception among teachers that video games are relevant to their profession, many teachers are still unsure of the importance of video games to their teaching practice.

The results regarding the use of video games in the classroom shows a mean of 3.30 (SD=0.73), with a p-value of 0.010, which is statistically significant. This significant result suggests that teachers feel quite confident discussing and teaching the outcomes of using video games in the classroom with others. Furthermore, the figures show that those who have used games see tangible benefits and are willing to advocate for their use.

The subjective perception of the use of video games in the classroom has the highest mean of 3.89 (SD=0.51), with a p-value of less than 0.001, which is highly statistically significant. These results show that teachers have a very positive attitude towards the fun and satisfaction of using video games in the classroom. The high mean score indicates that teachers find the use of video games highly engaging and satisfying, suggesting that personal and professional enjoyment of these tools can significantly motivate their integration into classroom practice.

This strong positive perception is crucial as it can foster intrinsic motivation to adopt and consistently use game-based learning approaches and contribute to a more dynamic and interactive educational environment.

The results of the questions on the opportunities of games (see Figure 2) and an overwhelming agreement in almost all areas (> 50% agreement, except for “take control of the learning process”-option) also show the positive attitude of teachers towards games in the classroom. The same picture can be seen in Figure 3 where a wide range of applications of games in the classroom is seen and here an agreement of almost 60% is recorded for all items.

5.4 Teachers' Intention and Perception of using Game Design in the Classroom

The intention to use game design approaches in the classroom is recorded with a mean value of 3.33 (SD=0.13) and a p-value of 0.018. These results indicate that the intention of prospective teachers to use game design as a teaching tool is statistically significant. This result emphasises the importance of continuously encouraging and supporting teachers to put their intentions into practice.

The perceived usefulness of game design approaches in the classroom has a mean of 3.93 (SD=0.53) and a p-value of less than 0.001. These results indicate a strong and statistically significant perception among teachers that game design can be effective in achieving curriculum goals, improving students' skills, and creating productive lessons which suggests a solid basis for further promotion of game design approaches as an integral part of the curriculum.

The perceived ease of use of game design for teachers is captured with a mean of 3.65 (SD=0.90) and a p-value of less than 0.001, showing that teachers feel confident in their ability to use game design in their future teaching and to support their students effectively. This positive perception of ease of use is crucial as it indicates that teachers are likely to adopt game design methods, provided they have access to the necessary resources and training.

Perceived ease of use for students has a mean of 3.19 (SD=0.72) and a p-value of 0.08 (not statistically significant). Although teachers believe that students can manage game development with minimal help, confidence in this belief is relatively low.

In general the practicability and reliability of the questionnaire showed good values, as evidenced by the successful implementation and high internal consistency for most scales (e.g. $\alpha = 0.84$ for perceived usefulness). However, some scales, such as the reputation of teachers who use games ($\alpha = 0.45$), need to be refined to improve reliability.

6. Conclusion and Outlook

To answer our research question, this study shows that pre-service teachers are generally positive about integrating video games and game design into the classroom. Teachers recognize the significant benefits of using video games in the classroom, particularly in promoting student engagement and achieving curriculum objectives. However, the moderate effect sizes and lack of statistical significance in some areas suggest that while enthusiasm exists, it may not be sufficient to achieve widespread adoption without additional support.

In conjunction with the literature, the discussion section illustrates that the integration of video games in the classroom is not only a question of the availability of the technology or the effectiveness of the games, but also of pedagogical attitude, institutional support, and practical implementation.

This study has several limitations that must be considered. The sample is relatively small and consists exclusively of pre-service teachers from a single institution, which limits the generalizability of the results. Therefore, future studies will include students from the Italian-speaking part of Switzerland (University of Applied Sciences and Arts of Southern Switzerland) and consider students from primary and secondary level and in various stages of their studies.

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HeritageRoots: Developing Interconnected Immersive Experiences for Cultural Preservation and Education

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Abstract: In this paper, we present technical implementation details, describe the virtual world procedural generation pipeline, and discuss potential uses in cultural preservation, museum exhibits, and education of *HeritageRoots*, an innovative software infrastructure designed for preserving indigenous narratives and oral histories. *HeritageRoots* consists of two interconnected systems - (1) a web-based knowledge graph (KG) data collection and management system which stores, connects, and presents indigenous traditional knowledge (ITK) in the form of narratives, myths, and testimonies from multiple cultures and languages; (2) a virtual environment rendering pipeline which utilizes large language models (LLM), Unity3D, and Meta Quest software development kit (SDK) to procedurally generate virtual worlds from the KG data. Preliminary system evaluation with Ecuadorian Kichwa narratives showed promising results in (1) academic community interest and support, (2) the possibility of developing an infrastructure capable of connecting indigenous narratives with modern scientific knowledge via KGs and (3) procedurally generating virtual worlds from KG.

1. Introduction

Around the world, the traditional knowledge of Indigenous communities (Indigenous Traditional Knowledge, or ITK) is threatened by migration and the profound changes associated with globalization. Cultures that do not have a strong written tradition are especially threatened – as younger generations move away in search of education and jobs, and as globalization forces linguistic shifts to more "global" languages such as English and Spanish, rich oral traditions either disappear completely or become artifacts in university or library archives, accessible only to small groups of academics.

Indigenous communities, with relatively small populations concentrated in rural areas, are particularly vulnerable to the loss of traditional knowledge because globalization fosters mobility to jobs and increasingly requires that these jobs and the higher education needed to obtain them be carried out in international languages. The vulnerable native languages encode the indigenous populations' long and complex relationships with the land in ways that make each population unique. Their stories embody traditional knowledge of spirits, places, land uses, and ecology (Cajete and Williams, 2020; Corntassel, 2020; Lewis and Sheppard, 2005). Although indigenous populations value their traditions and strive to preserve them, the challenges they face are often overwhelming. There is thus a need for a virtual resource that helps preserve indigenous cultures not as artifacts in a museum but as living traditions of the populations who can transmit ITK to future generations.

One of the main problems for the transmission of oral (and even written) traditions is that native language-dominant elders often become disconnected from younger speakers who must move to cities for education and jobs. Like young people everywhere, their identities are increasingly complex, influenced by global currents from broader Latin America, Asia, Europe, and the US. Indigenous students who have to move away from their home communities to attend schools are more likely to lose their heritage language and identity (HUANG, 2024; Little, 2020). Typically, these more mobile members are able to spend some time in their territories with elders but often not enough time to really learn the traditions. We intend for *HeritageRoots* to be used as both a cultural preservation and an educational tool that could bridge time in school or in an urban setting with periods of time in the territories with elders.

Specific to our project's pilot, Amazonian Kichwa communities treasure their traditional knowledge, values, and beliefs that have been passed from generations through oral communication and shared experiences. This traditional knowledge establishes spiritual and cultural relationships with the land, the animals, and the plants. Those relationships are reflected in expressions, words, gestures, and practices specific to the Kichwa traditions. Characters in Kichwa narratives have complex similarities and differences across versions from neighboring cultures that cannot be easily captured by static documents or textbooks. Individual narratives connect to each other in complex ways, forming a network of interacting plots, characters, humans, animals, plants,

environments, and languages. While oral myth cycles have sometimes been linked to each other in master plots by the scholars who reduce them to writing, this imposed order is often too rigid to capture the fluid and multivalent way in which their characters evoke, presuppose, or relate back to each other. Furthermore, these collections almost never capture the ways in which stories of one language borrow from, adapt, or even playfully mock the stories of neighboring languages.

Many initiatives have been activated to preserve and revitalize indigenous cultures, traditions, and languages (Adlam et al., 2022; Ajani et al., 2024; Meighan, 2022; Peterson et al., 2021; Yeh et al., 2021). While a number of these initiatives involve the use of computational technologies and multimedia to document and archive indigenous languages and knowledge, much of what has been created to date is primarily designed to serve academic communities and does not provide access to either the broader public (e.g., anyone who wishes to learn about a particular culture) or to the indigenous communities struggling to maintain continuity of their ancestral knowledge across generations. Moreover, existing systems and frameworks tend to focus on a single corpus of narratives and do not provide possibilities to connect and map stories, characters, and concepts across neighboring cultures and languages.

Over the past few decades, a tremendous amount of work has been done on representing knowledge using graph structures. Knowledge graphs have been used to represent provider expertise in healthcare (Zhang et al., 2020), extend transparency of black-box models in machine learning (Gaur et al., 2021), map concept knowledge in adaptive learning systems (Shi et al., 2020), identify fake news (Hu et al., 2021) and represent linguistics constructs (Liu et al., 2020). There is, however, a surprising lack of both academic research and digital humanities projects that leverage graph-based concept representation in the area of ITK and cultural preservation. While Native communities would certainly not characterize their traditional knowledge as "folklore", the technical challenges in presenting ITK resemble those encountered by existing digital Humanities projects in that field. Two digital folklore projects at Tennessee State University (Bacon, 2011) and Utah State University (McNeill, n.d.) focus on tracking oral traditions on the Internet by creating collections of trending memes, hashtags, and urban legends, and analyzing and studying their prevalence in society. While their respective projects provide a tremendous amount of insight into modern folkloric trends, they do not show how these trends relate to or influence each other, nor do they allow for the exploration of the collected digital folkloric artifacts. Several prominent research projects used knowledge graphs to represent relationships between stories, characters, and concepts in corpora of Greek (Pastor-Sánchez et al., 2021), Kurdish (Ahmadi et al., 2020), Finish (Janicki et al., 2023; Kallio et al., 2020), and Danish (Davis et al., 2021) folklore, as well as provide insight into relationships between stories, political complexity, high gods, trade, cultural traits, gender roles, attitudes towards risk, and trust (Michalopoulos and Xue, 2019). However, none of these projects provide a user interface that would allow researchers or general users to interact with the graph data. James, Broadwell, and Tangherlini propose, implement, and describe a graph-based approach in the context of "computational folkloristics" (Abello et al., 2012; "Big folklore: a special issue on computational folkloristics," 2016), but their knowledge graph search and exploration tools are desktop application-based and are not available to broader audiences.

In the education and learning technologies domains, on the other hand, graph-based concept representation has received a lot of attention, and much work has been done in the areas of concept mapping (Tergan, 2005) and supporting cognitive behaviors in concept map-based learning environments (Wang et al., 2019). A number of companies have developed commercial products to support concept mapping for business purposes (most notably Mural ("Mural," n.d.), Obsidian ("Obsidian," n.d.), Figma ("Figma," n.d.), and Tinderbox ("Tinderbox: The Tool For Notes," n.d.)), and much research has been done in various areas of human-computer interaction (HCI) and natural language processing (NLP) to develop intuitive user interfaces to generate knowledge maps from text corpora (Krause, 2019; Zuo et al., 2021) and to manually map concepts identified in text notes or in domain-specific use cases (Huang et al., 2021; Tergan, 2005; Xiao et al., 2019).

And finally, we get to games. Serious games, or more specifically, educational games, usually focus on a single topic (or at best, a set of similar topics), such as algebra, physics, or second language acquisition (e.g., DuoLingo). These types of games rarely focus on creating immersive environments and usually put the majority of their development efforts into designing learner models (Emerson et al., 2020; Khenissi et al., 2015, 2014) and creating educational content. In the world of entertainment games, AAA game franchises such as Assassin's Creed invested tremendous resources to create immersive and reasonably historically accurate virtual worlds (Burgess and Jones, 2022). However, building such meticulously designed worlds involves a large investment of time and money, the latter being a rather scarce resource when it comes to academic institutions and, more importantly, indigenous communities.

Smaller indie game developers have done amazing work in creating serious games for cultural preservation. Never Alone (Kisima Ingitchuna) is a puzzle adventure game made in partnership between the Cook Inlet Tribal Council and E-Line Media is based on the traditional Iñupiaq tale, "Kunuuksaayuka" (“Never Alone - Homepage,” n.d.; “Never Alone - The Story of Kunuuksaayuka (Part One),” 2014; Parkinson, 2014). Mulaka, a 3D adventure game developed by Lienzo (“Lienzo,” n.d.) is based on the narratives and traditions of the indigenous culture of northern Mexico’s Tarahumara (Gonzalez, 2021; Horton, 2019). These are just two examples of a growing number of efforts to create collaborations between indigenous communities, designers, and developers to produce high quality immersive and engaging experiences that tell indigenous narratives and help preserve ITK.

However, even without the AAA-game-level graphics and assets, game development is a costly endeavor. According to a 2023 LinkedIn report, 43% of game development projects are halted during the development phase, and 38% of developers who actually publish their games do not release regular content or updates (“Report: 83% of mobile games fail in the three years after launch | LinkedIn,” 2023). One possible way to alleviate the high costs associated with creating high-fidelity virtual worlds is to procedurally (i.e., algorithmically) generate the environment and the content from existing assets. In recent years, a tremendous amount of work has been done, both in academia and in the game industry, to create pipelines and develop algorithms for procedural content and world generation (Balint and Bidarra, 2022; Grabska-Gradzińska et al., 2021; Liu et al., 2021; Raistrick et al., 2023; Smith et al., 2011; Yannakakis and Togelius, 2011). However, to the best of our knowledge, none of these approaches utilize large data stores and/or KGs to procedurally generate content and environments for serious or entertainment games.

To address some of the aforementioned shortcomings of existing systems, we have developed *HeritageRoots*, an open-access system for collecting, storing, connecting, and presenting ITK in the form of narratives, stories, myths, and multimedia from multiple cultures and languages. Moreover, *HeritageRoots* allows users to connect ITK narratives based on topics, characters, environments, storylines, and other criteria (e.g., a particular animal appears in X stories from X cultures and acts as a positive character in X of the stories and as a negative character in the remaining X stories). Lastly, *HeritageRoots* can leverage the knowledge graph data to partially procedurally generate immersive 3D virtual worlds using Large Language Models (LLM), the Unity3D game engine, and Meta Quest 2/Quest 3 headsets. These virtual environments provide immersive interactive representations of the environments, flora, fauna, characters, and interactions described in indigenous narratives.

The preservation and revitalization of ITK holds immense importance for Indigenous communities, the Indigenous diaspora, museums, and educational institutions worldwide. With globalization and migration trends, traditional knowledge faces significant threats, particularly in cultures reliant on oral traditions and languages. Indigenous communities, often residing in rural areas, are vulnerable as younger generations move away for education and job opportunities, leading to a disconnect between elders and youth. This disconnect risks the loss of rich oral traditions and spiritual connections to the land, animals, and plants unique to each Indigenous population. Museums and educational institutions recognize the urgency of preserving these living traditions, not merely as artifacts but as ongoing sources of knowledge and identity for future generations. We firmly believe that the development of platforms like *HeritageRoots*, focusing on narrative connections, knowledge mapping, and immersive experiences, bridges the gap between modern challenges and the knowledge embedded in Indigenous cultures, fostering understanding across diverse communities and audiences.

2. System Design

2.1 Knowledge Graph

A graph database is a specialized type of database where instead of storing data in the form of spreadsheet-like tables, the data is stored as a collection of nodes where each node represents an object (e.g., story, character, animal). These nodes are linked by edges - connections that represent physical or semantic relationships between pairs or groups of nodes (Figure 1). The example in Figure 1 illustrates that a nodes of type “Animals” (spider monkey and peccary) are connected to the “First mother…” narrative via “APPEARS_IN” relationship, indicating that both of these animals are mentioned in the narrative.

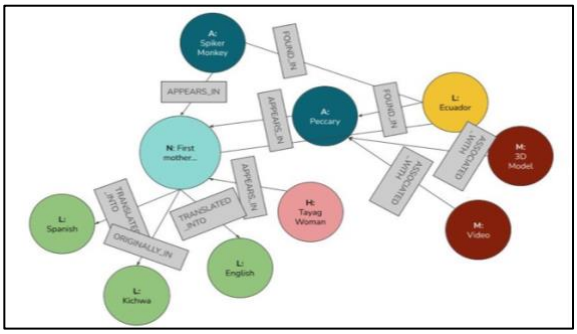


Figure 1: Example of representing semantic relationships with a graph.

This data representation allows a meaningful mapping of stories to concepts, physical objects, locations, characters, and to each other. To store the KG, we are using Neo4J, an open-source graph database. The current version of the knowledge graph represents concepts, objects, and relationships related to narratives, animals, plants, languages, geographic locations, physical objects, and multimedia objects (e.g., 3D models, 360 photographs, images, and videos).

2.2 Web-Based Data Management Module

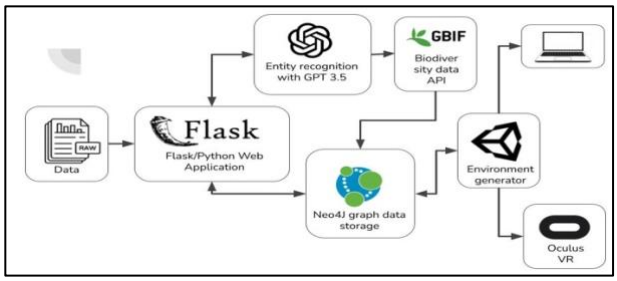


Figure 2: *HeritageRoots* system diagram.

HeritageRoots system consists of two primary modules - a web-based data processing, storage, and visualization module (Module 1), and a stand-alone virtual world Unity3D-based generation module (Module 2).

We developed Module 1 in Python using the Flask web server. The graph data is stored in a Neo4j database, and the graphs are visualized using the D3js Javascript data visualization library. There are two modalities for importing data into the system - a web-based user interface and a data import pipeline from comma-separated values (CSV) files.

To add a narrative to *HeritageRoots*, the user can either copy and paste the narrative's text into a web-based form or upload a file in text, PDF, or Microsoft Word formats. *HeritageRoots* uses OpenAI's Generative Pre-Trained Transformer (GPT) 4 application programming interface (API) to analyze the provided text to recognize the entities, activities, and dialogues described in Table 1.

Table 1: Entities, concepts, activities, and dialogues extracted from text via ChatGPT API.

Recognized Entity	Description
Semantic concept	A semantic concept refers to an ideas and inherent meanings of a word, phrase, or symbol as understood by individuals within a linguistic or cultural framework. Examples of concepts may include words like "mother", "queen", "leader"
Animal	Animals mentioned in a given narrative, including their Linnaean taxonomy
Plant	Plants mentioned in a given narrative, including their Linnaean taxonomy
Named entities	Proper nouns, names of people or places
Physical objects	Ex: house, bowl, blowpipe
Action Verbs	Action verbs represent actions that a character performs within a narrative. For example, a toucan [sits on a branch], [flies], [speaks], [complains]. *HeritageRoots* uses these action verbs to generate animation state machines for Unity3D to represent behaviors of corresponding NPCs.
Utterances	Utterances, monologues, speeches, and dialogues produced by characters within a narrative

Once *HeritageRoots* saves the uploaded narrative in the Neo4j database, the system redirects the user to an interface where identified entities, actions, and dialogs are highlighted and color-coded (Figure 3). The user interface (UI) allows users to make changes to connections, identify entities that were missed by GPT 4, and create additional entities and connections.

The current version of *HeritageRoots* also supports a search functionality that allows users to search by animal, plant, narrative, or geographic location. The result is displayed as an interactive graph (Figure 3) where users can explore connections between nodes, as well as to view the details of each node by and connections associated with each node by clicking on a node of interest.

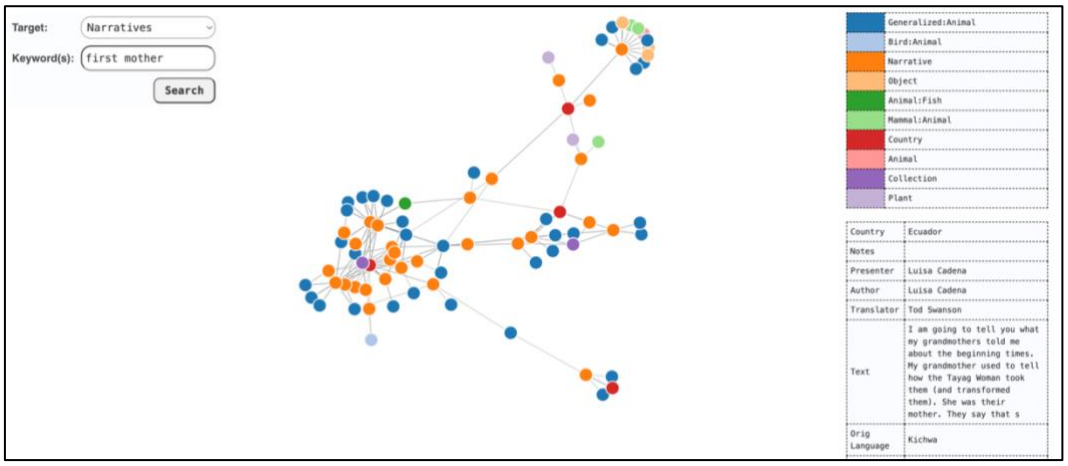


Figure 3: HeritageRoots search results as an interactive graph.

2.3 World Generator Module

The World Generator Module (Module 2) is a set of Unity3D editor tools designed to allow users to procedurally generate terrains, place vegetation and objects, and create animator state machines for NPC animation.

The web-based data management module (Module 1) provides users with the option to generate an API key for every narrative available in the system. The data can be accessed via a RESTful API endpoint, which returns narrative data as a JavaScript Object Notation (JSON) document. That JSON document includes all information available not just for a given narrative, but also on all animals, plants, objects, and media that are linked to it via the KG edges.

In Unity3D, the user can enter the API URL into the desired editor tool (Figure 4). The tool will download all relevant assets linked in the KG, generate a pattern of Perlin noise over the terrain (Burch et al., 2020; Emmanuel et al., 2019; Pop et al., n.d.), and place the assets (e.g. trees, plants, houses) onto the terrain according to user-specified parameters. In the current implementation, we download relevant assets using a standard HTTP request.

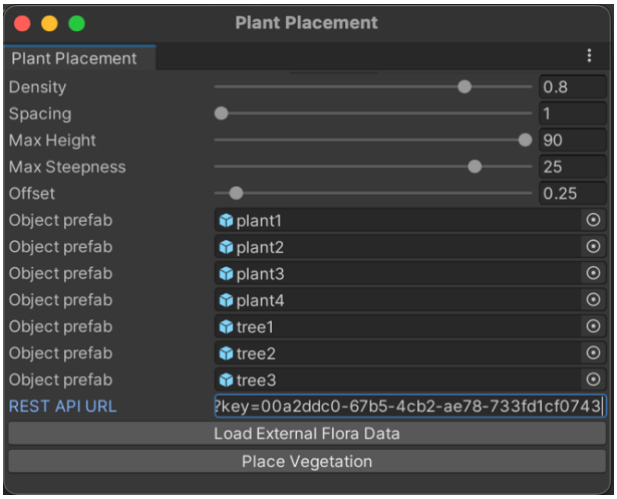


Figure 4: Unity3D module/tool for procedurally placing flora from KG / RESTful API data.

Let us consider the following example. A user (a VR developer) starts with a Unity scene that contains a blank terrain (Figure 9). In the "Plant Placement" editor tool, users can specify vegetation density, minimum required spacing between plants, maximum altitude and maximum steepness at which plants are allowed to be placed on the terrain, and an offset value to make the plan placement appear more random.

A narrative associated with the provided API key (in the REST API URL field, Figure 7) mentions six plants and is subsequently linked to each of these plants in the KG via a graph edge. Each of these plants, in turn, is linked in the KG to a media node containing a 3D model of that plant.

When the user clicks "Load External Data", the system will (1) read data from the *HeritageRoots* RESTful API, (2) download plant assets associated with the specified narrative, (3) generate a pattern of Perlin noise over the terrain, and (4) place plant assets onto the terrain according to the Perlin noise pattern (Emmanuel et al., 2019) and user-provided placement specifications (Figure 7). Perlin noise is a type of mathematical function that creates natural-looking patterns of randomness and is often used in computer graphics to generate realistic textures like clouds, terrain, or marble. Imagine looking at a bumpy surface where the bumps are smooth and gradual, not too sharp or jagged. Perlin noise is like a recipe for creating such surfaces, blending different frequencies of noise to produce a smooth, flowing pattern that mimics natural variations in the real world.

Lastly, the current iteration of Module 2 is capable of generating Unity3D animation state machines from the KG data. The current pipeline uses ChatGPT 4 API to identify animals in narrative texts, as well as to extract all action verbs associated with the animal's activities/actions within the narrative's context. Consider the following text: "*The **toucan** flew from branch to branch. After sitting for a few minutes, it flapped its wings and hopped to a lower branch and spoke.*" *HeritageRoots* will identify characters' actions and after stemming and lemmatization, return a JSON document accessible via *HeritageRoots'* RESTful API (Table 2). Our Unity3D editor tool parses the document and creates an animator state machine (Figure 8c) that can be used with any appropriately rigged 3D model.


```
{
    "label": "Animal",
    "name": "toucan",
    "states": ["idle","hop","fly","flapwings","speak","sit"],
    "transitions": [
        [ "idle", "hop" ],
        [ "idle", "fly" ],
        [ "idle", "flapwings" ],
        [ "idle", "speak" ],
        [ "idle", "sit" ]
    ]
}
```


Figure 5: Example of JSON generated from the identified entities and action verbs after stemming and lemmatization

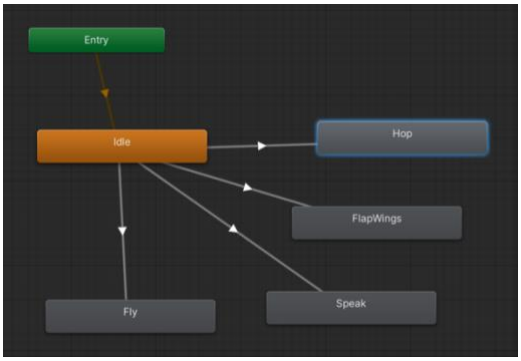


Figure 6: Animator state machine created in Unity3D from JSON shown in Figure 5

3. Technical/Feasibility Evaluation

Our team has evaluated the *HeritageRoots* data pipeline and world generation framework by building a KG with data from three different sources. First, we scraped Wikipedia data related to plants, mammals, birds, insects, and mollusks native to Brazil and Ecuador using a custom Python script. Once we imported flora and fauna data into the *HeritageRoots* KG, we imported narratives from a collection of Amazonian Kichwa language material recorded over the years by Dr. Tod Swanson in collaboration with the Iyarina Center for Learning run by

Fundación Cotococha, an indigenous-led foundation in Napo Province of Ecuador. An experienced team of Kichwa staff members from the Center worked in tandem with Native elders to translate and annotate narratives. A team of undergraduate students imported 12 translated and transcribed Kichwa narratives into *HeritageRoots'* KG. Lastly, our team has downloaded two publicly available Brazilian folklore collections (Albuquerque et al., 2007; Eells, 2008) from the Project Gutenberg website and imported a total of 15 Brazilian narratives into the KG. With all narratives, we verified that the system created appropriate edges and that ChatGPT correctly recognized appropriate entities (e.g., animals, plants, objects) in the narratives' text. This process created a total of 14,418 nodes and 29,452 edges. We checked the validity of relationships (edges) with a Python script to ensure that correct taxonomy had been created for all animals and plants. We manually checked the validity of relationships between narratives and other objects in the KG. The validation showed that 52 edges were not created (an animal or a plant did not get connected to an appropriate taxonomy) and ChatGPT did not recognize 7 animals and 13 plants in the uploaded narratives.

To evaluate procedural plant placement, we uploaded 3D models of three generic tropical plants and three trees (purchased from the Unity Asset Store) as "Media" nodes into the KG and connected them to a Kichwa narrative titled "The First Mother Turns Her Children into Animals.". In Unity, we created a blank scene with a standard first-person controller (FPC) and a simple terrain (Figure 7). We asked seven undergraduate university students with no game development experience in Unity or other game engines to use the *HeritageRoots* world generation tools to populate the blank terrain with flora linked to "The First Mother…" narrative (Figure 8). Every participant was able to populate the scene with flora without any instruction; the maximum time it took one of the participants to navigate the system was 1 minute and 45 seconds (mean time of 1 minute and 3 seconds).

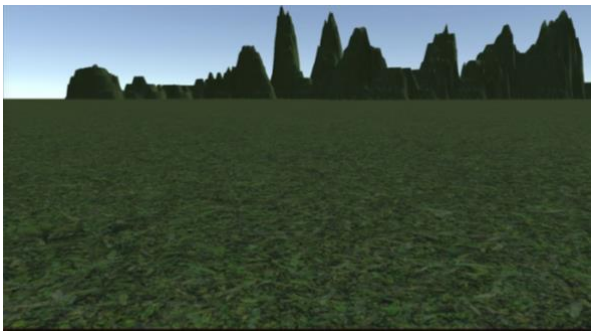


Figure 7: FPC view of a blank terrain in Unity3D, Game view.



Figure 8: FPC view of a terrain populated with flora using *HeritageRoots* world generation tools, Unity3D, Game view.

4. Limitations

In presenting this work, it is important to acknowledge its limitations. We would like to reiterate that this was not meant to be a research paper but rather a technical paper presenting and assessing the feasibility of an idea for a data pipeline that would allow procedural generation of immersive virtual worlds for cultural preservation and education.

One of the major potential limitations of this work is accessibility - the current iteration of *HeritageRoots* does not address potential barriers to access for indigenous communities, such as limited internet connectivity, lack of digital literacy, or availability of necessary devices like computers or VR headsets. To alleviate the impact of

this particular limitation, we ensured that the web-based part of *HeritageRoots* is accessible with 3G internet connectivity and works on older mobile device and desktop browsers, with Google Chrome version 52 (2016) and Apple Safari version 9.1.2 (2016). In addition to creating immersive environments builds for Meta Quest III, we are also working on MacOS and Microsoft Windows builds to ensure wider access.

Another limitation lies on the fine line between cultural preservation and cultural appropriation, especially when using advanced technologies like AI, machine learning, and VR. We acknowledge that in this paper we have not discussed or addressed ethical considerations and strategies to ensure respectful representation and collaboration with indigenous communities throughout the development and use of *HeritageRoots*. Lastly, given the sensitive nature of indigenous cultural knowledge, we have not yet developed robust protocols for data privacy, ownership, and consent.

5. Discussion and Future Work

The *HeritageRoots* system has the potential to address a critical need for the preservation and transmission of Indigenous Traditional Knowledge (ITK) in the face of globalization and cultural erosion. By leveraging advanced technologies such as KG, natural language processing, and procedural content generation, *HeritageRoots* aims to bridge the gap between traditional oral knowledge and modern digital tools. The system's design encompasses a web-based data management module for narrative processing and visualization, as well as a Unity3D-based world generator module for creating immersive virtual environments.

While our evaluation was admittedly shallow and only focused on assessing technical feasibility of the system, we were able to establish that the data pipeline in its current form is capable of representing complex relationships between narratives, characters, environments, and physical objects. This interconnectedness allows users to explore the rich tapestry of ITK in a holistic and interactive manner. Furthermore, the Unity world generation module in combination with HeritageRoots' RESTful API is capable of generating "starter" environments based on indigenous narratives for users with little to no game/VR development experience.

Moving forward, we plan on establishing collaborative partnerships with indigenous communities for co-designing and co-developing the *HeritageRoots*. Incorporating community feedback, cultural protocols, and traditional knowledge systems into the system's design and governance structures is paramount. We will also work on enhancing language support for indigenous languages. We plan on seeking partnerships with non-profit organizations such as *WikiTongues* to integrate tools for language revitalization, transcription, and translation within the platform to empower communities to preserve and promote their linguistic heritage.

Furthermore, we will work on establishing a robust ethical framework for data governance, consent management, cultural sensitivity, and respectful representation, as well as implement Implementing protocols for community-driven data ownership, access control, and data sovereignty to build trust and transparency.

Lastly, we have already begun working on conducting research and evaluation studies on the platform's effectiveness, user experience, learning outcomes, and cultural impact.

6. Conclusion

Based on preliminary evaluation, we believe that *HeritageRoots* has the potential to serve as a transformative tool for safeguarding indigenous cultures, promoting intergenerational knowledge transfer, and fostering global appreciation for cultural diversity. By embracing a participatory and ethical approach, the platform can contribute to the broader goals of cultural sustainability, social justice, and inclusive technology development.

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Developing Graduate Attributes Through Competitive Gameplay and Learning Theories

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Abstract: The term competitive gameplay or gaming is predominantly associated with esports. Esports, a synonym, or abbreviation for electronic sports is an industry that has a global outreach with a lucrative market. This is accentuated by the event driven, business model focus and organised competitive events, often involving sponsorship. These additional characteristics associated with esports is what distinguishes it from traditional or casual gaming. Though esports games can be played individually, they are predominantly viewed as a team activity. Beyond the debate as to whether esports can be classified as a sport, it is an area that has attracted a significant amount of academic research. Research areas have often included esports psychology, esports player health and nutrition and esports management. Some research studies have also reviewed how esports have the potential to e.0quip esports players with relevant 21st century skills such as critical and lateral thinking. One area where esports appears to be under researched is in the relationship between competitive gameplay and learning theories. It can be argued that this is an important consideration when delivering esports from an educational perspective. The aim of this paper is to provide a scoping review of the esports literature identifying empirical research associated with competitive gaming and graduate attributes. Esports game genres will be explored from a gameplay perspective demonstrating via learning theory examples how these games can facilitate graduate attributes in players. Exploring the domain of esports game genres, learning theories and meta-skills, the paper presents a conceptual model illustrating the interrelationship between these areas. The paper also has practical value to educators, who may be as yet unfamiliar with esports, informing them of the subject's educational benefits from a graduate attribute and employability perspective.

Keywords: Esports, Game Genres, Competitive Gaming, Gameplay, Learning Theories, Graduate Attributes.

1. Introduction

Esports is a global phenomenon that attracts wide ranging audience. It is estimated that by 2025, the esports market in terms of people engaged in esports events and competitions will be over 318 million worldwide. It has also been stated that 322.7 million people will become viewers of esports by 2025 (statista, n.d.). Esports, as a concept, has proved difficult to define as it is a discipline that emits multiple perceptions dependent upon perspective. In comparison to traditional or casual gaming, esports is sometimes perceived as competitive multi-player gaming. Whilst it can be argued that most games are competitive and provide a sense of challenge to the player, it is the organised, event and business model driven nature of esports that distinguishes it from traditional gaming. Regardless of their genre and application, the immersive qualities and engagement factor of video games are supported by the concepts of gameplay and game mechanics.

Whilst a game may be unique in terms of gameplay, game genres have certain universal game mechanics that define and distinguish them. There are various perspectives regarding what constitutes gameplay. Gregory, (2014, p. 847) defines the concept as *"the overall experience of playing a game"*. According to Adams (2014, p. 9) gameplay consists of *"The challenges that a player must face to arrive at the object of the game"* and *"The actions that the player is permitted to take to address those challenges"*. In contrast to gameplay, de Byl (2012, p. 206) states that the term *"game mechanic" refers to "designed game/player relationships that facilitate and define the game's challenges"*. The learning potential of video games and how they can prepare adolescents for learning relevant 21st century skills for employability success has been documented in the academic literature (Yanes et al., 2023). The work of Prensky (2006) articulates the concept of the "Digital Native" referring to someone who has grown up with digital technology. It has often been argued that video games have the potential to positively enhance learning through gameplay (Gee, 2007).

In the context of education and how digital natives learn, empirical research has shown that the application of game-based learning (GBL) and serious games have the potential to inform and educate students on a wide range of topics (Baxter et al., 2021, Yallihep and Kutlu, 2020). According to Videnovik et al., (2023, p.2) *"Game-based learning involves designing and incorporating educational content within a game format, where players actively participate and interact with the game mechanics to acquire knowledge or develop skills"*. For example, empirical research related to games-based learning has focused on how it can be applied to provide students

with critical thinking and problem-solving skills (Qian and Clark, 2016). GBL has also been used as an educational approach to inform students about skills required for undertaking academic research (Abbott, 2019), enhance communication skills (Bodnar and Clark, 2017) and the development of generic graduate attributes (Barr, 2020). Dörner et al., (2016, p.3), define serious games as *"…a digital game created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health). These additional goals are named characterizing goals".* Research has also indicated that serious games can support the development of higher order thinking skills (Van Voorhis and Paris, 2019) and future skills (Gurbuz and Celik, 2022). It appears evident that educational games have the potential to assist students in learning relevant 21st century meta-skills for the world of work. The salient aim of this paper is to explore the applicability of esports in the context of competitive gameplay towards enhancing graduate attributes for employability purposes.

2. Defining eSports

Various definitions and perspectives of esports exist in the academic literature. According to Wagner (2006, p.3) *"eSports" is an area of sport activities in which people develop and train mental or physical abilities in the use of information and communication technologies"*. When defining esports, debates appear to be articulated around the use of the letter "e" in esports and whether esports can be considered a sport (Hamari, and Sjöblom, 2017). Various perspectives abound regarding this debate with esports considered to be a *"… manifestation of sportification"* (Heere, 2018, p. 21). The phrase esports emits different meanings to stakeholders associated with the industry. It is sometimes seen as a "polymorphic domain" defined by some as an "*intellectual exercise"*, as a *"physical activity"* or as a *"business activity"* (Chap et al., 2022). Esports is viewed as a multi-faceted activity also requiring a wide-ranging degree of skill sets in the context of competitive gaming. According to Zhouxiang (2022, p.1), when compared to traditional sports, competitive gaming necessitates *"…skill, strategy, tactics, concentration, communication, coordination, teamwork and intensive training".* The socio-cultural dynamics of esports in the area of competitive gaming are related to the structured approach of the discipline where competitions are organised in leagues and tournaments allowing for the engagement of individual and team competitions (Werder, 2022).

3. Competitive Gameplay and eSports Genres

Similarly to traditional gaming or when engaging with social, casual, and mobile games, esports games also encompass various game genres. In the domain of competitive gaming several popular esports genres exist that consist of differing elements of gameplay and mechanics. It has been articulated in the literature that when engaging in the playing of esports, there are various performance indicators that are taken into account. Examples include cognitive, sensorimotor, and physiological that may vary dependent upon different game genres (Toth et al., 2021). Esports titles, when played competitively, are divided by "tiers" where tier-level esports are associated with prize pool amounts, hours watched and impact of viewings via social media (Migliore, 2021). Hence the perception that esports are viewed as *"organized video game competitions"* (Jenny et al., 2016, p.4). It has been argued that what drives esports players are the gaming motivations of interactivity and competition. Interactivity is defined as *"… the opportunity to communicate and cooperate with other gamers in the online environment, and competition is the mechanism by which gamers can compare themselves to each other"* (Bányai et al., 2019). Esports game genres are predominantly classified into five types played globally in events running online and offline: fighting games, first person shooter games (FPS), real time strategy games (RTS), sport video games (SVGs) and multiplayer online battle arena games (MOBA), (Qian et al., 2020).

Table 1: Provides an overview of the some of the salient esports' genres and characteristics (table by authors).

Esports Game Genre	Definition/Description	Characteristics of Genre	Game Examples
Fighting Games	"… a fighting game is usually a one-on-one combat game, often themed with two humanoid characters punching and kicking each other, and usually seen from a side view" (Burgun, 2013, p. 117).	Player-controlled characters engage in combat in fixed-space, close-quarters setting, sideways, 2D viewpoint (Migliore, 2021).	Street Fighter 6, Tekken 8, Mortal Kombat 1
First Person Shooter Games (FPS)	"FPS games are played from the first-person (egocentric) perspective of a single protagonist who is generally charged with combating enemies while navigating through a three-	Played from subjective experience, camera becomes avatar, emphasises presence,	Counter-Strike 2, Tom Clancy's Rainbow Six Siege

Esports Game Genre	Definition/Description	Characteristics of Genre	Game Examples
	dimensional environment" (Dobrowolski et al., 2014, p. 60).	sensorially immediate, very immersive (Rehak, 2008).	
Real Time Strategy Games (RTS)	"… viewed as simplified military simulations. Several players struggle over resources scattered over a 2D terrain by setting up an economy, building armies, and guiding them into battle in real-time" (Buro, 2003, p. 1).	RTS' based on strategy, tactical decision making. Play can be turn-based or real-time, use of multiple avatars, resources collected to develop units and structures (Migliore, 2021).	StarCraft II, Warcraft III, Age of Empires II
Sport Video Games (SVGs)	Sometimes referred to as sports simulation games though viewed as "Games which are adaptations of existing sports or variations of them" (Wolf, 2008, p. 272)	Usually have various roles player can engage in (e.g., acting as a player, coach, manager over period of years), (Adams, 1999).	NBA2K, EA Sports FC, NHL
Multiplayer Online Battle Arena Games (MOBA)	"… MOBA games are a subgenre of real-time strategy games in which two teams, typically consisting of five players each, compete against each other with each player controlling a single character" (Mora-Cantallops and Sicilia, 2018, p. 128).	Focus on combat tactics, involves metagaming, individual character development, combat, cooperative team play ((Mora-Cantallops and Sicilia, 2018).	Defense of the Ancients (Dota), League of Legends (LoL)

4. eSports Genres and Graduate Attributes

There are various research studies that have been associated with esports as an activity that relate to developing learning and skills enhancement (Rusk and Ståhl, 2022, Zhong et al., 2022). Similar to traditional gaming, there are commonalities with competitive gaming in terms how game mechanics can facilitate esports players' skill sets for employability purposes and the world of work. Game mechanics such as game spaces, the aspect of time (e.g., turn-based or racing games), decision making through the use of objects in a game (e.g., characters, props, tokens), the embedding of basic and strategic actions, the rules of the game, the aspect of skill (e.g., physical, mental, social), (Burgun, 2013, Schell, 2020, Fullerton, 2019) are prevalent mechanics esports players engage in through gameplay. It can be argued that esports as discipline has a correlation to the graduate attribute and employability literature. Though there are differing definitions regarding the concept of employability within higher education, it can be perceived as *"… the development of a range of attributes and skills at university that can be transferred into situations beyond university study"* (Gunn, Bell and Kafmann, 2010, p.1). Despite at times being programme specific, graduate attributes can be transferable and generic (Green, Hammer and Star, 2009). Figure 1 provides a conceptual overview of some of the salient graduate attributes obtained through competitive gameplay and the engagement of game mechanics.

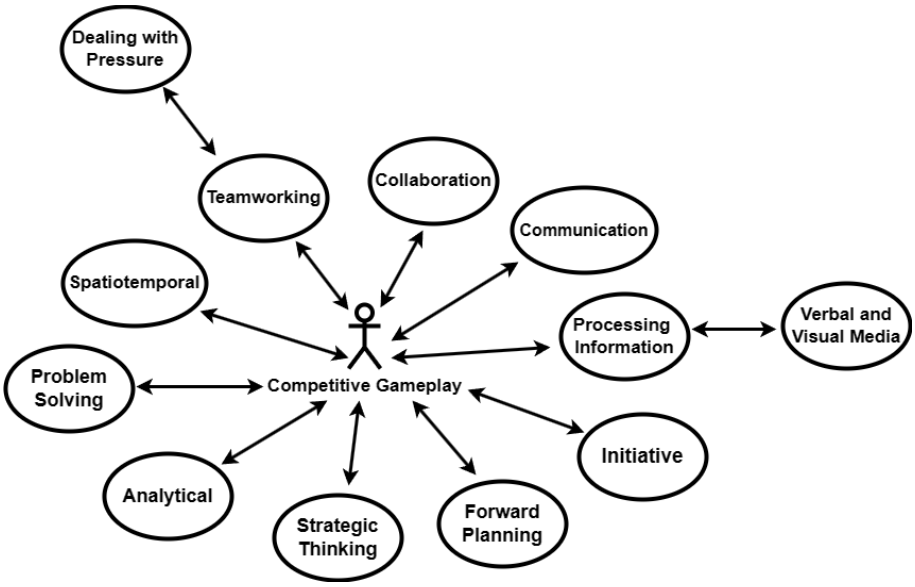


Figure 1: Graduate attributes examples gained through competitive gameplay (figure by authors).

According to Smithies et al., (2020, p.2), esports players possess a range of *"specialized skills and experiences*" with attributes that include: digital intelligence, experience in computer human interaction, communication and enriched cognitive capabilities. Success within an esports team is often dependent upon team members having proficient communication and teamworking skills. Esports players, in certain game genres, have predefined team roles. This is prevalent in MOBAs where teams are formed of five players with differing roles, sometimes consisting of a champion, with the intention of optimising team performance (Buchan and Taylor, 2016). FPS games can, through their unique gameplay, accommodate and support the ability to adapt and learn, metacognition and reflective practice in addition to skills such as *"… attention, visual short-term memory, spatial cognition, and decision-making"* (Neri et al., 2021). Tactical and strategical skills are also important in addition to the skill of sensory-motor control (Toth et al., 2021) such as skills of movement resulting in enhancement of player performance and actions. A study by Reynaldo et al., (2021) found that RTS players outperformed FPS players in relation to cognitive flexibility. RTS players often require skills associated with problem solving, decision making, tactical and reactive control which relates to macro and micromanagement. Marco management refers to *"…long term planning, like strategies conducted in the early game, technology upgrading, and scouting"*. Micromanagement, on the other hand, is associated with the player's ability to *"…control a group of units in combat or other skirmish scenarios to minimize unit loss and maximise damage to opponents"* (Liu et al., 2014, p. 1). From an employability and graduate attributes perspective, competitive gaming can provide students with a platform to learn, develop and enhance meta skills for the world of work.

5. eSports Genres and Learning Theories

Within the domain of esports, research into the area of learning appears to be *"…an immature research field"* (Ye et al., 2021, p. 363). Academic research has evidenced how esports can facilitate and support the development of meta-skills among esports players (Zhong et al., 2022). However, there appears to be little published research relating to how esports game genres and gameplay can accommodate different learning theories. Meta-cognitive experiential learning is one learning theory that has applicability regarding how esports players learn towards improving their abilities. Experiential learning theory (ELT) identifies learning as *"the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience"* (Kolb, 1984, p.41). For example, the immediate or concrete experiences from having played a game can allow esports players and teams to reflect upon their experiences, conceptualise these and test the implications of these reflections to improve performance in future gaming scenarios.

Social learning theory (SLT), is associated with observational learning, learning from others and also from the direct experience of an individual's environment (Hong and Craig, 2023). The concept of social learning theory supports learning in esports teams especially when reviewing gameplay from prior tournaments, analysing their performance, collectively providing feedback and advice on how to enhance performance. The theory of social learning also involves cognitive processes where *"… learners internalise and make sense of what they see in order to reproduce the behaviour themselves"* (Horsburgh and Ippolito, 2018, p. 2). The learning theories of constructivism, cognitive and social, are also both directly relevant to aiding learning and enhancing meta-skills from an esports gameplay perspective. Constructivism is associated with the premise that learners devise or construct new knowledge or understanding by engaging through experience or social discourse. It can be argued that constructivism can be related to solving real-world problems through active learning in context. Constructivism also involves learners applying new knowledge to improve upon new or current scenarios with feedback and self-reflection part of the learning activity (Yoders, 2014). New knowledge acquired in mastering various techniques or roles in a game (e.g., a MOBA) through active learning can aid an esports players self-determination and self-efficacy.

Connectivism, a learning theory based on distributive knowledge, also has the potential to facilitate learning in an esports setting. In the context of connectivism, *"Connective knowledge is created by interactions with people who are linked to various networks and thus is distributed across a web of individuals"* (Jung, 2019, p.50). When engaged in MOBA games, esports teams, through network connectivity, can share new knowledge they have learnt through prior matches, this can sharpen decision making in real-time play and allow networked learning to collectively develop and enhance both player and team performance. Table 2 provides an example of five learning theories that can support the learning of meta skills in an esports concept.

Table 2: Examples of learning theories and how they facilitate meta skills through competitive gameplay (table by authors).

Learning Theory	Main Characteristics	Relation to Graduate Attributes and eSports
Experiential Learning (Kolb, 1984)	Learning through experience, learning can occur in any context, process of learning begins in a four-step experiential learning cycle: experiencing (concrete experience), reflecting (reflective observation), thinking (abstract conceptualisation) and acting (active experimentation).	Esports players or teams can learn something new when engaged in a particular game (e.g., a new technique that enhances performance), reflect upon this experience , make sense of it with a plan of action for improvement in addition to testing new ideas.
Social Learning Theory (Bandura, 1977)	Learning viewed as a cognitive process, occurs in social contexts through an observational learning process leading to imitation and enhanced self-efficacy.	Esports players or teams can observe and analyse their performance individually or collectively, learn and reinforce their learning from the behaviours of team members through positive feedback.
Constructivism (Piaget, 1964)	Learners actively construct new knowledge based on their previous experiences and interactions, individuals build a repository of experiences from which they learn.	Massively Multiplayer Online Games (MMOGs), via their design principles can provide scope for a constructivist learning environment (Muñoz Rosario and Widmeyer, (2009), Bonk and Denner, (2005).
Social Constructivism (Vygotsky, 1978)	Learning and knowledge is formed via social interaction through communication, dialogue with peers when engaged in real life tasks. Associated with 'Zone of Proximal Development', 'Intersubjectivity', and 'Enculturation' (Woo and Reeves, 2007).	Enhancement of player performance can be achieved through interaction with coaches, esports team members through collective peer and teacher inquiry, providing guidance through dialogue and feedback.
Connectivism (Siemens, 2005)	Learning viewed as a "network phenomenon", adheres to concept of distributed knowledge, impacted by technology and socialisation (Goldie, 2016).	Esports players can communicate and coordinate strategies through a network of knowledge and expertise, share instructions and enable quick strategic decision making.

6. Conceptual Model: eSports, Learning Theories, Meta Skills

The conceptual model presented provides a theoretical overview of the integration of learning theories deemed applicable to supporting the development and enhancement of meta-skills through the engagement of competitive gameplay. The model commences with the concept of self-determination theory (SDT) (Deci and Ryan, 1985) which encompasses two associated theoretical principles of intrinsic and extrinsic motivation. Intrinsic motivation results in the overall satisfaction and enjoyment of a particular task where the psychological requirements of competence (having the knowledge or skill to perform the task), relatedness (sense of belonging to others), and autonomy (ownership of one's behaviour and decisions), (Mills et al., 2018). Extrinsic motivation relates to when an activity is undertaken to obtain an outcome that is external to the activity being performed. In the context of competitive gaming, esports players can be intrinsically motivated to gameplay concepts such as immersion, challenge, improvement of skill, competing against other players, online engagement whereas extrinsic motivation relates more to entering tournaments to gain notoriety among players or for the aspect of tournament prize money. Via the five esports game genres exemplified in the model, some of the salient skill sets esports players can acquire through competitive gameplay are outlined. How learning is supported through competitive gameplay via salient learning theories applicable to esports leading to the acquirement of meta-skills and graduate attributes are shown as being interrelated.

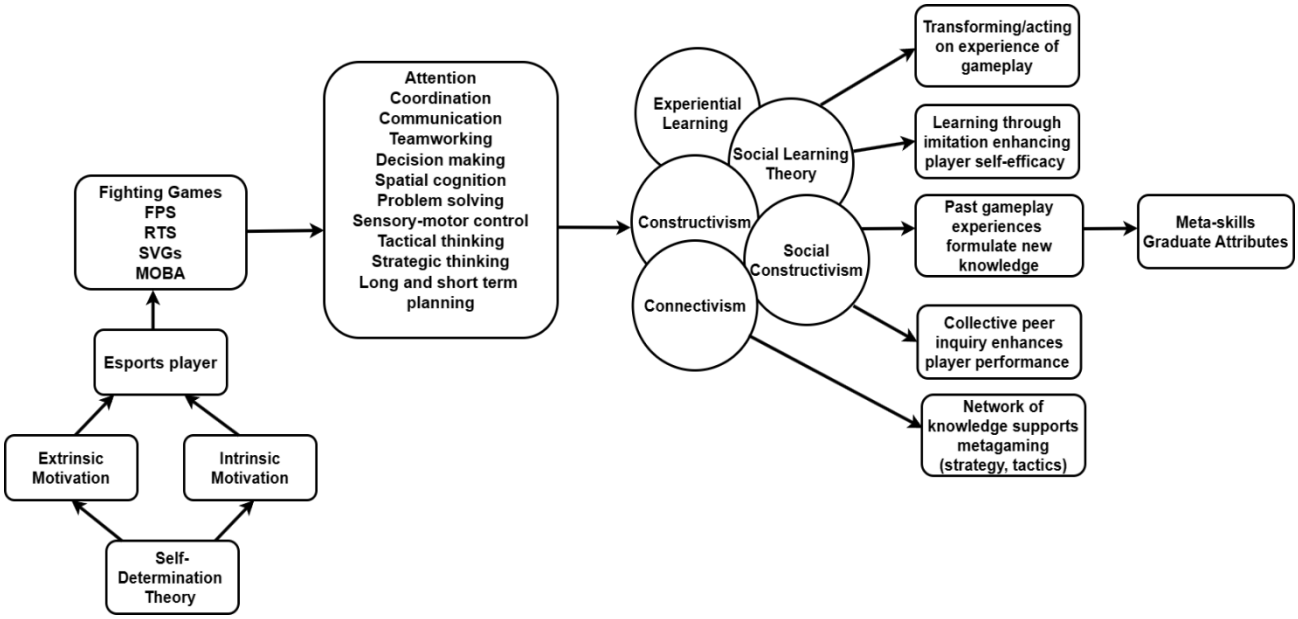


Figure 2: Interrelationship between esports, learning theories and meta-skills (figure by authors).

7. Limitations and Future Directions

The aim of this paper was to provide a preliminary scoping review of esports from a competitive gameplay perspective with a view to articulating how the underpinning of learning theories are naturally inherent in esports game genres. From a theoretical and conceptual standpoint, it has been argued that when utilised constructively and strategically, the learning and accumulation of knowledge that coincides with competitive gameplay can lead to the attainment of meta-skills, preparing graduates for the world of work. The theoretical foundations of the research are still at an early stage with more work required from an empirical standpoint to substantiate the ideas articulated in this paper. It is acknowledged that additional esports game genres in relation to additional learning theories accommodate competitive gaming require to be explored. Moving the research forward, a systematic literature review will be performed searching relevant academic databases that the authors have subscription to via their academic library. Preliminary search terms will include: ("esports" OR "electronic sports" OR "competitive gaming" OR "online gaming" OR "FPS" OR "RTS" OR "MOBAs" OR "MMORPG" OR "fighting games" OR "SVGs" OR "genres") which will be refined and expanded to include additional esports game genres. Terms impacting and influencing the acquirement of graduate attributes through gameplay will include: AND ("skills" OR "graduate" OR "meta-skills" OR "attributes" OR "learning" OR "education" OR "outcomes" OR "enhancement" OR "motivation" or "engagement").

At present, the primary limitation of the of the research is the lack of empirical evidence to substantiate the theoretical propositions proposed in the paper. Though still in the preliminary stages of the research design, it is intended that the research will adopt a parallel mixed methods design (Tashakkori et al. 2021) utilising data gathering techniques that will include questionnaires, semi-structured interviews and focus groups. The aim in doing so will be to obtain a breadth of opinion and perspective from various esports stakeholders (e.g., educationalists, esports players) to assess and evaluate viewpoints about the learning potential of esports as an academic discipline and if it can equip graduates with meta-skills. It is intended that the research will benefit the wider esports community and educators considering whether to introduce an esports programme within their academic institutions. The proposed conceptual model, which is in a very rudimentary stage of development, will also need to be refined. The dilemma is whether to focus on one specific learning theory as an amalgamation of several may be too wide ranging in academic scope.

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A Systematic Review of Examples and the Effectiveness of Game-Based Learning Used To Teach History in K-12 Education

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Abstract: This systematic review is intended to assess the examples and effectiveness of game-based learning (GBL) in teaching history in K-12 education. The review also aims to identify gaps in the current GBL literature and provide future research and development guidelines to improve learning outcomes when incorporating GBL in teaching history. This systematic literature search was conducted using Scopus, focusing on studies that utilized games to address historical teaching in K-12 education. The PRISMA methodology procedure was followed. A total of 688 studies were initially identified, and after the first screening, 360 studies remained. Twelve studies fulfilled the inclusion criteria. The systematic review concludes that games used to teach history in K-12 education vary considerably in content, users, contexts, teacher approaches, and technology. Most of the included studies reveal positive motivational factors when GBL is used. However, only very few studies can provide significant results on the learning outcomes. Most evaluations are based on self-reporting, primarily questionnaires and knowledge tests. Specific learning objectives are rarely included in the games. Future studies could include more participants and other methods to measure the learning effectiveness of GBL.

Keywords: Game-based Learning, History, Systematic Literature Review, K-12 Education, Evaluation, Learning Effectiveness

1. Introduction

Around the world, schools place a high value on teaching pupils and students about history. Through knowledge of countries' histories, pupils can understand their own and other societies. Reading history is a skill with many graduations of proficiency, and learning history is more than names and dates (Wineberg 2001), as it entails inquiry or historical thinking, which calls for using abilities such as perspective-taking, historical analysis, historical comprehension, and argument creation (Craig 2017). However, many pupils have difficulties in history, mainly because the subject can be rather text-heavy and based on the utilization of a teacher-centered teaching approach (Koutromanos et al, 2020).

The PISA 2022 results revealed that, on average, across OECD countries, 26% of students were low performers in reading (OECD 2023). One approach to supplementing the traditional analog reading in history is incorporating game-based learning (GBL). The aim of including GBL is often to improve pupils' engagement and learning about various historical subjects (Baxter et al, 2021; Oceja et al, 2022), making it easier to memorize and understand facts, concepts, time, and historical events. Using games to learn history subjects can also increase interest, make history seem alive, and use technologies such as VR and AR (Rammos and Bratitsis 2019; Ventoulis and Xinogalos 2023). However, history education suffers because the past needs to be demonstrated and experienced directly. Many aspects of games must be suited to history teaching. Games are very good at providing narratives, going back in time to show—and, not least, include—users in historical settings with various interactive elements, with the potential for enhanced experiences with personalized and immersive elements.

GBL can be seen as a teaching supplement to provide continuous motivation for learning, as opposed to motivation loss due to repetitive teaching formats. GBL can complement history teaching, in addition to a range of other established materials such as YouTube clips, film/cinema, documentaries, museum visits, field trips, and festivals. Most literature indicates that GBL can be used to engage and motivate pupils and students in the learning process (Al-Azawi et al, 2016; Bjørner et al, 2022; Bjørner et al, 2023; Chen and Chang 2020; Clark et al, 2016; Karakoç et al, 2022; Lampropoulos et al, 2022), making learning more fun and enjoyable. However, the effects of GBL on specific learning outcomes are diverse and inconclusive (Connolly et al, 2012; Fendt and Ames 2019; Roozeboom et al, 2015; Ventoulis and Xinogalos 2023).

There seem to be significant challenges in measuring the learning outcomes of GBL (Roozeboom et al., 2015). This systemic review will provide an overview of examples and the effectiveness of GBL in teaching history in K-12 education. The research questions are as follows:

1. Which methods are used to evaluate the learning outcomes of implementing GBL to teach history in K-12 education?
2. How effective is GBL for improved learning in teaching history in K-12 education?

Most previous literature revealed that pupils playing historical games are more engaged than pupils receiving traditional instruction. However, it is also important to emphasize that studies on using GBL to teach history have taken place in various contexts, including diverse user groups, school/teaching settings, cultural and geographic contexts, gaming technologies, and use cases, with a wide variety of historical content. This systematic review is intended to assess the examples and effectiveness of GBL in teaching history in K-12 education. The review also aims to identify gaps in the current GBL literature and provide future research and development guidelines to improve learning outcomes when incorporating GBL in teaching history.

The definition of learning outcomes also varies across the literature. For this review, learning outcomes are defined similarly to how Adam (2006 p. 2) describes it: "statements of what a learner is expected to know, understand and/or be able to demonstrate at the end of a period of learning." Learning outcomes are often valued in curriculum development. However, the definition also faces some challenges in defining the end of a learning period. Further complexity is involved in learning at various levels, including interpretations of what a learner is, what is expected, and what it means to understand and/or demonstrate.

2. Methods

2.1 Literature Search Strategy and Exclusions

The electronic bibliographic database Scopus was used for conducting this literature search. The search strategy was based on the following keywords: TITLE-ABS-KEY (game* OR serious game OR game-based learning), AND TITLE-ABS-KEY (history* or cultural heritage) AND TITLE-ABS-KEY (teach*) OR (learn) OR (learning outcomes). To collect the latest studies, each study's publication time was restricted to range from January 2009 to February 2024. The search filter was restricted to history and cultural heritage (by click boxes in Scopus). Further, the identification included that the search included only articles, conference papers, book chapters, and books in English. The search excluded reviews and notes. In case they were not identified during the whole search process, references from Google Scholar, reviews, and systematic reviews were also checked manually for further screening. The PRISMA methodology procedure was followed, with the overview in Figure 1.

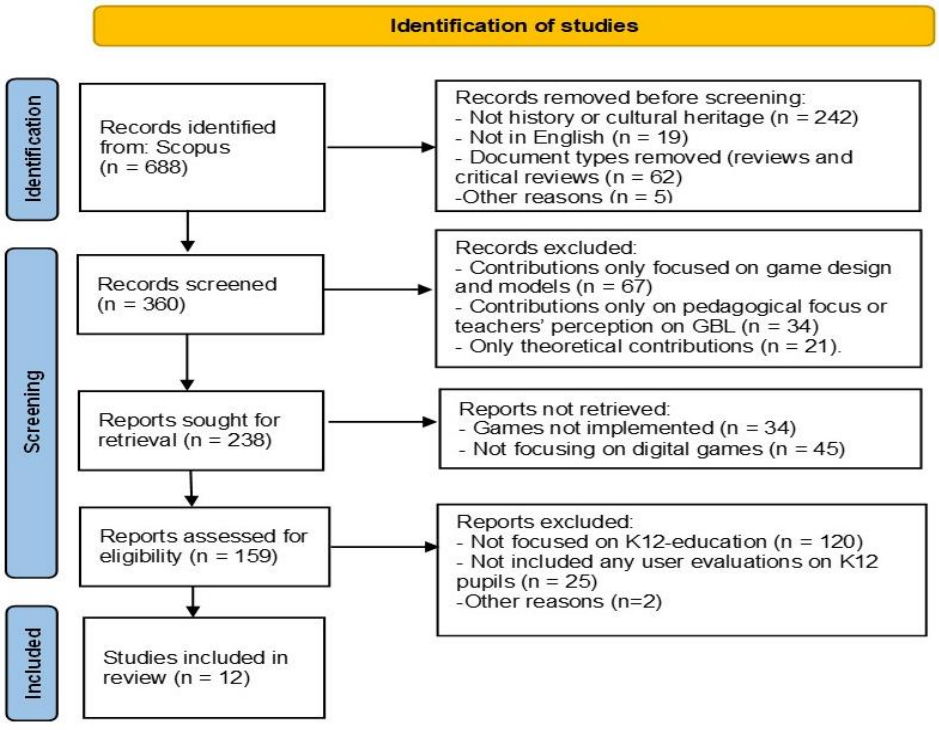


Figure 1: Literature Screening and Selection flowchart

360 records were screened but excluded in the further filtering because the contributions were only focused on game design and models (n = 67), pedagogical focus, or teachers' perceptions (n = 34); for example, the contribution from Andersen (2019), or only theoretical contributions (n = 21). By this filtering, most remaining records provided evaluations of games used in history teaching. However, it is interesting that a substantial

number of contributions (n = 67) include general game design aspects for teaching history but do not include focus on the evaluation. This included, for example, excluded studies such as Azzahra et al, 2023; Ghulamani et al, 2017; Hutson and Fulcher 2023; Ohyama et al, 2020).

For further screening, the educational games need to be implemented, excluding, e.g., contributions with only early-stage low-fi prototype testing (n = 34). This review focuses on digital games, and by that, board games (e.g., Humpire et al, 2022) or other playful learning (for example, roleplaying) were excluded (n = 45). Excluded are studies using simulations (e.g., VR and AR) without game elements, including e.g., the contribution from Efstathiou et al (2017).

The included studies had to be within games used for history teaching in K-12 education. K–12 education is a term that indicates the range of years of supported primary and secondary education, typically ranging from kindergarten to 12th grade. This means that some of the many studies within a high school or university context for teaching history are excluded (n = 120). This includes studies like Ekonomou and Vosinakis 2018. However, an essential aspect of this review was to focus on K-12 education and, within this, also the cognitive abilities for performing various evaluations within this group. Few studies are excluded (n = 25) for being tested at another target group than the game was developed for; this is e.g., the case with the study from Fernes et al, (2023).

2.2 Data Analysis

A predetermined grid was adopted to perform data extraction, including the following information: author, publication year, topic (historical content of the game), game technology (e.g., PC, VR AR), number of participants (sample size), grade and age, setting/ location (context), evaluation methods, and main outcomes. These categories in the grid are like other studies (Oceja et al, 2022), but this study follows more detailed and structured information. The extracted contributions for inclusion were quality assessed by a second reviewer. Because of the high heterogeneity of the studies' measures and the limited articles (n = 12), a narrative synthesis was performed. Meta-analysis was unfeasible to run as the measurement units of each study were not comparable. Therefore, a narrative synthesis was conducted, concentrating on the general characteristics of the included studies.

3. Results

3.1 Overview

As with many other studies in GBL, the number of contributions has increased dramatically (Figure 2). In the literature search for this review (before the screening, n = 688), there were 20 contributions in 2009 - but more than 60 in 2023.

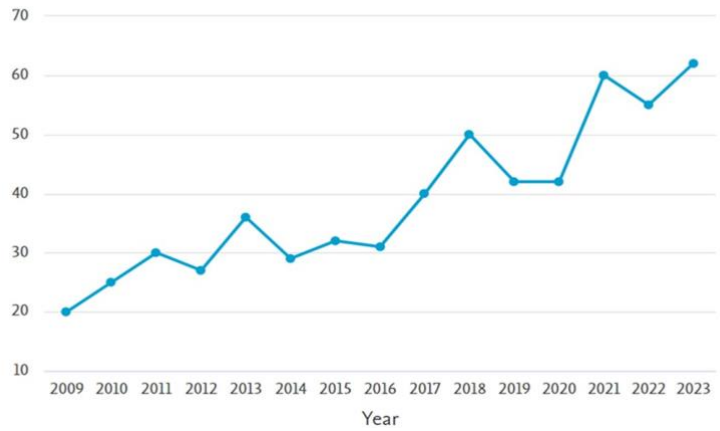


Figure 2: Identified numbers of contributions.

The studies cover various fields, perspectives, and game technologies. Interestingly, most of the contributions are from computer science (29.5%) and social science (24.5%), whereas the contributions from art and humanities are less present (9.5%). Most contributions (92 %) are from conference papers or journal articles.

3.2 The Included Studies

The studies included in this review are listed in Table 1 below.

Table 1: Studies included in the review (n = 12)

Study and Topic	Topic and Game Technology	Participants and Location	Evaluation Methods	Main Outcomes
Huizenga et al, 2009	Historical knowledge of medieval Amsterdam Mobile city game	458 pupils from 20 classes from five schools, Netherlands.	• A quasi-experimental design and grounded theory approach • A/B test, game vs. regular lesson. 10 classes played the game/ 10 classes regular lessons. • Oral reports provided by guides • 110 Observation forms • - 1550 game days were transcribed.	• Pupils who played the game gained significantly • more knowledge about medieval Amsterdam than those with regular instruction. • - No significant differences in the motivation for the history between the A/B group.
Sedano et al,, 2013	Local Finish history Hypercontextualized Game/ Storytelling game	101 pupils, Grade 7 pupils, aged aged 13 and 14, Finland.	• Questionnaires, including • multiple choice and composition questions measuring cognitive and affective engagement.	• significant correlation between (a) fantasy and (b) affective and cognitive engage-ment. • - affective and cognitive engage-ment, through the fundamental ele-ment of fantasy, in the game narrative is essential.
Tegos et al, 2014	The Balkan Wars, World War I, and World War II PC game	34 5th grade pupils. Aged 11 to 12 years old, Greece.	• -Pre/post test design. • Pre-questionnaire followed by (one week later) gameplay. • - Collaboration in dyads to compose a story based on cards from the game.	• Positive opinions about the game.
Chintiadis et al, 2018	Greek Mythology/ Trials of the Acropolis VR game	28 pupils, Greek Schools, Greece	• -Questionnaire, 23 items on a 7-point Likert scale, 3 items on perceived learning. • -Focus group	• Positive opinions about the game. • Making the learning environ-ment natural is essential. • self-reported faster learn
Drosos et al, 2018	El Greco's Travels and Artwork 3D game	20 pupils. Aged 6-15, primary and secondary school, Greece.	• - Questionnaire with 11 items - knowledge quiz for "El Greco" of 7 questions.	• - self-reported increased learning about El Greco – increased

Study and Topic	Topic and Game Technology	Participants and Location	Evaluation Methods	Main Outcomes
				subject interest.

Rammos and Bratitsis 2019	12 Olympic gods
	
	3D game, AR
		24 pupils, 4th grade, Greece.	• Small-scale, qualitative ethnographical study
			• Observations
			  • - Pupils' performance comparison after playing.
				• Pupil performance: 15 improved, 8 the same, 1 worse.
				  • - Positive feedback on using AR that inspired them in creating their narratives.

Fendt and Ames 2019	Battles of Galveston, Texas Civil War
	
	PC game
		33 pupils, 8th grade history Class.
		
		Public middle school, USA
			• A/B test, Game vs. regular lesson (text)
			• pre/post test.
			• 17 pupils played the game, and 16 read the packet
			  • - one-tailed t-test, one-tailed Mann Whitney U test; 5-point Likert scale.
				• No increased learning/ No difference between the game and the text read.
				  • - Increased interest in learning about history and the Civil War through the game.

Koutromanos et al, 2020	The Castle in Naxos, local history.
	
	AR game
		26 pupils, 5th grade, living close to the Castle in Naxos, Greece.	• Qualitative participant evaluation.
			• Interviews with experts
			  • - Evaluation of the pupils' feelings by using work sheets and observation
				• The experts evaluated
				  • the game positively
				• Problems with games in the field.
				• The game was an experiential tool

Remolar, et al, 2021	Ancient Rome
	
	AR game
		75 pupils, se-condary school. ? Spain ?
		
		Experiment 1: 25 pupils aged 12 years old. Experiment 2: 50 pupils, 25 pupils in both the experi-menttal group and the control group.
			• A quasi-experimental design.
			• Experimental group/ Control group.
			• Questionnaire, 5-point Likert scale
			  • - Knowledge test/ no. Of correct answers.
				• Increased interest in studying history
				• greater fixation on
				  • different concepts

Ventoulis and Xinogalos 2023	Greek Mythology.
	
	AR Mini games
		31 pupils, primary school. Greece	• Pre-/post-test design
			• Knowledge test
			• The game experience questionnaire was adopted using the MEEGA+ model.
			  • - Qualitative note-taking and think aloud during gameplay
				• improved perform-ance after playing the game, but no statistical significance.
				• Positively perceived the AR mini-game.
				  • A perceived "learn while playing".

Petersen et al, 2023	Bombardment of Copenhagen in 1807 PC game	22 pupils, aged 13 or 14. Elementary school, Denmark.	• A/B test, Game vs. regular lesson (text), • Experimental group (11 pupils)/ control group (11 pupils). • knowledge test • Questionnaire with engagement items • Semi-structured interviews • - No significance test	• Higher under-standing of specific learning objectives in the experimental gaming group compared to the control group • High perceived perceived intuitiveness and

Study and Topic	Topic and Game Technology	Participants and Location	Evaluation Methods	Main Outcomes
				clarity for the game. • - positive per-ceptions of clarity in the game's narrative.
Carrascosa et al, 2024	Historical events in relation to BC and AD AR game/ gamification	76 pupils. Intervention 1: 19 pupils, 5th grade. Intervention 2: 57 pupils, 2nd and 3rd year, secondary school, Spain.	• Intervention 1: Quasi-experimental pre-post design. Single treatment • group. • Intervention 2: Experimental pre-post design, with a control group and experimental group. Experimental group (29 pupils)/ Control group (28 pupils). • -Knowledge test pre/post • -Motivation and usability, 16 items, 5-point Likert scale. • - No significance test	• AR with gamification improves learning outcomes • - Positive impact on motivation and emotions.

Despite the relatively strict screening, the results from the 12 included studies are rather heterogeneous. The included contributions range from 2009 to 2024, during which there has been considerable technology development, with more recent (from 2018) included VR and AR studies. Notably, the contributions rarely do not include the novelty effect – with the potential that the pupils have the most robust response the first (or second) time they play the game, and by that, the studies can face potential bias for both the learning effectiveness and engagement.

Some studies involve games played at school, whereas others are outdoors on site (Huizenga et al, 2009; Koutromanos et al, 2020). Outdoor games can be affected by weather conditions, making them difficult or impossible to play at certain times of the year. There can also be problems with Wi-Fi connections, as already highlighted in the study by Koutromanos et al. (2020).

The topics in the contributions are very different, though a majority (8 out of 12) of the studies include ancient or medieval history. Most of the participants included in the contributions are between the ages of 11 and 14. Like other GBL research, the studies have very different numbers of participants. The highest number of included participants is 458 pupils (Huizenga et al, 2009), followed by 101 students (Sedano et al, 2013). 8 out of 12 studies are included with 20-35 participants.

Several studies are within an A/B test set up for measuring the differences in the game use and regular lessons with analog text read (e.g., Huizenga et al, 2009; Fendt and Ames 2019; Petersen et al, 2023). Six studies are included as a quasi-experimental study and have included both an experimental and control group. Questionnaires are often combined with qualitative methods (interviews, focus groups, observations, note-taking, think-aloud). Two studies are found with an only qualitative approach (Rammos and Bratitsis 2019; Koutromanos et al, 2020).

Interestingly, almost all studies found increased motivation and/or engagement by using GBL in historical teaching, except for Huizenga et al, 2019. Most of the studies also found positive effects on learning, but there were considerable differences in how learning is defined and how the teachers were involved in the learning. Only very few studies can provide significant results (Huizenga et al, 2009; Sedano et al, 2013) on the learning outcomes. Few studies also reported no difference in learning by using GBL (e.g., Fendt and Ames 2019).

4. Conclusion

As with many other studies in game-based learning, most of the studies included in this systematic review reveal positive perceptions about the included games used and an increased motivational factor for learning history. The novelty of this systematic review is a specific focus on game-based learning for teaching history in K-12 education and a focus on the methods used to evaluate the learning outcomes. The most common methods

used to evaluate learning outcomes of GBL in history for K-12 education are self-reported questionnaires and knowledge tests, often as pre-/post-tests. The knowledge test questions are often direct questions related to the learning content provided by the game, thus putting more emphasis on these exact questions. Most studies include rather few participants. Within the included studies for this systematic review, only two studies have more than 100 participants included. Longitudinal studies are absent.

The included studies highlight educational and learning objectives very differently. Analyzing the complex relations between topic, context of use, user groups, technological solutions, and number of participants is still a significant challenge for providing profound results in learning effectiveness via GBL in history teaching in K-12 education. Some studies reveal that pupils who used game-based learning gained significantly more knowledge about history than those with regular instruction. Other studies showed no increased learning effect by using game-based learning. However, it is complicated to compare these studies, and one should be careful not to conclude too quickly regarding learning outcomes across studies. Notably, specific learning objectives are rarely included in the games. The topics and the settings are also very different across studies, and even within the same studies, settings vary between the included experimental groups, making it difficult to repeat the studies.

For future works, it would be very beneficial if more studies included more participants to provide statistically profound results. It could also benefit if more studies used randomization, meaning that the participants are grouped by chance—either being randomly assigned to the intervention (game-based learning) or the control group (traditional teaching). It is also worth highlighting that studies should always be transparent in the research design and sampling methods.

When evaluating GBL for pupils in K-12 education, it is essential not to neglect the challenges of finding the right match between participants' cognitive abilities and a solid methodological approach. We need to challenge and reflect more on the methods used. For example, it is worth discussing if the suitable method is to use a 5- or 7-point Likert scale for kids aged, e.g., 11-12 years old, in terms of motivation and understanding the questions and scaling. Future studies could include more advanced and novel methods for incorporating improved methods to measure the learning effectiveness of GBL. Future studies could include more participants and variables such as gender, genre motivation, text expectations, and specific reading differences between analog and digital text.

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Cthink.It. A Board-game for Computational Thinking in Early Years

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Abstract: Computational Thinking (CT) refers to a specific set of mental skills used to formulate solutions to problems by converting given inputs to produce appropriate outputs while following detailed algorithms to perform this process. Essentially, CT is broadly defined as a combination of thinking processes which include abstraction, algorithm design, decomposition, pattern recognition and data representation.

Board-games can be used in the educational process as a learning tool while creating an attractive and authentic learning environment, providing an educational approach which is transdisciplinary, developing and utilizing multiple skills. Using board-games in Early Childhood Education (ECE) cultivates students' social skills, 21st century skills and cognitive skills, while helping them to increase their motivation and achieve the objectives of the curriculum framework.

In this paper, the aforementioned areas are combined through the presentation of a board-game that was designed within the CThink.it Erasmus+ project (2022-1-MT01-KA220-SCH-000086903) for cultivating CT competency in the early years. The backstory is a toy, lost in a museum and through a series of activities, it is to be returned to the child-owner. Prior to designing the game, a systematic literature review was conducted so as to provide foundation for the game itself and a set of associated lesson plans.

The produced materials were pilot tested in schools. The paper aims to provide preliminary data for the game evaluation, focusing on the issues of playability, age appropriateness, connection to curricula and the teachers' perspective on the usability of the game as teaching resource for ECE. For that, the research methodology will be presented, along with preliminary findings.

Keywords: Computational Thinking, Board Games, Early Years, Cards

1. Introduction

Computational Thinking (CT) refers to a set of mental skills, related to problem solving. According to Denning (2009), such skills are used to convert provided inputs for producing appropriate outputs through designing and following detailed algorithms for realizing this process, thus formulating solutions to the initial problematic state. Wing (2006) described it as a combination of thinking processes which include abstraction, algorithm design, decomposition, pattern recognition and data representation.

With the increased integration of technology in everyday life, the discussion about the so called 21st century skills emerged (Wing, 2006), bringing CT as an educational topic to the forefront (Grover & Pea, 2013). Holding CT competency provides an individual with the ability to deal with complex problems (Tang et al., 2020), allowing the characterization of CT being "a universally applicable attitude and skill set" which can be cultivated from young ages (Wing, 2006). Thus, CT is not only a skill-set but mainly a mentality.

Early Childhood Education (ECE) is a fundamental stage for a child's development during which acquired skills pertaining to the cognitive, social and emotional domain take place. For many researchers ECE is an ideal initiation point for cultivating CT and early exposure to CT is important to ensure young children master ideas and habits of mind to shape their learning (Su & Yang, 2023). In this age group, children transition between concrete and abstract processes and develop higher-order thinking processes. Active experiences provision to provoke thinking appears to support this transition. CT, often through programming, allows children to acknowledge the process of automation and understand that it results in a set of a clearly defined instructions which drive a device. This process may lead children to start solving real world problems through systemic steps, ultimately becoming technology designers rather than passive users.

Another pilar of the approach is educational board-games which can create a learning environment which is attractive for the children and is authentic (Ali et al., 2019), allowing the implementation of transdisciplinary approaches for the development of multiple competences (Strode, 2019). Moreover, board-games' utiliation in ECE fosters the development of social (Eriksson et al., 2021; Tsapara & Bratitsis, 2021) and 21st century skills (Ambarita et al., 2020; Bratitsis et al., 2021), positively impacts learning motivation and facilitates the achievement of curriculum objectives.

In this paper, a board-game called CTHINK.IT is described (Busuttil et al., 2023). It aims at introducing CT to ECE children (4-8 years old). The paper is structured as follows: first, the main outcomes of a conducted literature review is briefly presented. Then the board-game is described and some preliminary findings from its pilot testing are presented.

2. Theoretical Framework

Two main pillars guide the idea behind the project; CT and board-games in ECE. First a systematic literature review on both areas was conducted.

The literature reveals many divergent CT definitions (Haseski et al., 2018). They focus on problem-solving, technology, thinking, individual and social qualities or learning by doing, following Papert's (1980) approach of Constructionism. Although often CT development is supported by programming, Voogt et al. (2015) highlighted that it expands further than that. Wing (2006) first considered CT as a broader notion that involves problem solving, but also understanding and systematizing human behavior via computer science concepts, also involving systems design. In a revised CT definition Wing (2010) included thinking processes as a core constituent.

The review examined how CT is treated in ECE, also searching for classroom activity types (Bratitsis et al., 2024). Different approaches were followed. One major category is implementing unplugged activities separately or combined with a digital device (e.g. robot) or a programming platform, appropriate for these ages. Due to the connection of programming with Mathematics and Sciences, a connection between STEM and CT teaching can be noticed. Overall, the unplugged approach is portrayed as a good strategy for introducing CT to young students. This in fact emerged as an ideal pre-cursor to further programming and problem-solving tasks that include both robotics and programming, which both require complex thinking abilities to understand abstract concepts and solve problems. Unplugged activities have the potential to establish a foundation for educational methods based on problem-solving and constructive learning, which involve the learner's active engagement with the environment on both physical and mental level to construct and scaffold their understanding. Such activities include hands-on robot play (Storjak et al., 2020) or spatial movement (Sung et al., 2022), before moving to programming environments such as Scratch (Lee et al., 2020) or programmable devices (Metin, 2020).

Ultimately, unplugged approaches provide some sort of embodied cognition that allows the physical enactment of the CT concepts, which seems to be effective for children in understanding these abstract concepts. However, despite the perceived value of unplugged approaches to CT, there seems to be a dearth of unplugged resources which can be used for CT in early childhood education, and this calls for the need of further research in this area to create and develop more unplugged resources that can continue to help and support the acquisition of CT skills in early childhood education.

Several studies utilise coding in ECE. Games such as Kodable (Lennon et al., 2022) or game-like activities platform (Montuori et al., 2022) are utilized. Other studies utilize tangible programmable objects such as Osmo Coding Awbie (Liu & Iversen, 2022). Mainly, programming environments such as ScratchJr (Kyza et al., 2022) or Viscuit (Watanabe et al., 2019) have been utilized for coding-based CT approaches in the early years.

Another approach is using robotics. Overall, 51 papers were found, focusing on robotics CT approaches. Of them, 35 papers exclusively focus on robotics CT implementations, 11 combine robotics with unplugged activities, 3

combine robotics with programming, and only 2 papers explore the combination of all three methods. Several robotic devices have been utilised, including: KIBO (Bers et al., 2022), BeeBot (González & Muñoz-Repiso, 2017), Cubetto and Botley (Silvis et al., 2022).

The final conclusion of the review was that unplugged activities seem very effective in young ages as they allow some kind of embodied cognition, allowing CT concepts to be physically enacted and thus better acquired.

The second pillar of the review examined board-games utilization in ECE. Combining hands-on practice with complex knowledge, board-games seem to be a perfect fit for children's creativity, imagination, curiosity (Uribe & Cobos, 2014). For Tsai et al. (2021), board-games allow students to peer learn, focusing on interactivity and student-centered learning. Board-games have features such as rules, goals, tangible experience (e.g. through pawn movement or cards), turn-taking, interaction (also of a social nature), competition, collaboration and problem solving, to name a few of them. Thus, board-games within educational context can facilitate the cultivation of various competences (Tsapara & Bratitsis, 2024).

The review revealed that board-games are utilized for CT cultivation in ECE. Bratitsis et al. (2021) taught internet related issues through a board-game in Kindergarten. Machuqueiro & Piedade (2022) analysed several studies in which board-games acted as unplugged activities for CT teaching. Overall, 11 papers were found studying board-games utilization for CT in ECE (Bratitsis et al., 2023).

Finally, the official curricula of three EU countries were studied in order to identify existing approaches, both on theoretical and practical level, including proposed activities. This allowed the consortium to reach a conclusion about the CT model to be followed and consequently be treated through the board-game which was designed and is presented in the next section.

3. The CThink.It Board-game

The systematic literature review allowed to gain valuable insights on the current trends of CT approaches and board-game utilization in ECE. The conclusions derived from this study (Bratitsis et al. 2023, Busuttil et.al 2023) led to the decision to incorporate a 4-element approach to CT, including: abstraction, decomposition, pattern recognition and algorithms. This simplified model seemed to be a better fit for younger ages.

A board-game was designed, called "Mystery at the Museum". This game places the player in the role of a detective hired to solve a mystery. The player will have to use basic competencies of CT to: a) identify a lost item in the museum, b) discover its owner, and c) return it to its owner. It comprises 4 levels. The game is played collaboratively or competitively, with the facilitation of an adult (teacher/parent). Several combinations of collaborative vs competitive mode can be applied (e.g. pupil groups playing levels 1-3 in parallel and then come together to compete in level 4). The game includes variations that result in different experiences each time it is played.

Mystery at the museum was designed for children 4-8 years-old. Ii incorporates features that differentiate difficulty, according to game level and players' age. Depending on the players' ability only some levels might be completed, however for older players, all 4 levels with more difficult puzzles should be played.

The game starts with an invitation to the detective by the museum director to locate the owner of a lost item, a toy left behind by a child in the previous day. In level 1, a card is randomly selected from a deck, containing two images from a specific division of the Museum. One image depicts a time before the opening of the museum and one after the closing time, on the day the item was lost. By comparing the two images, the player should identify the lost item (Figure 1).

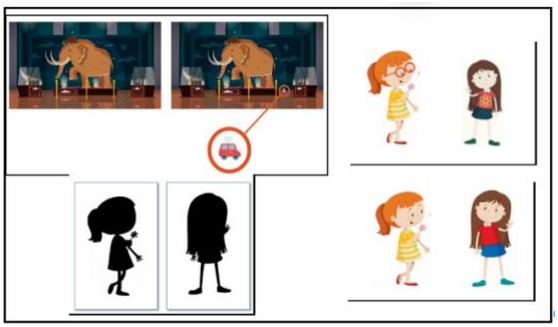


Figure 1: Level 1 and Level 2 image examples.

In level 2 (Figure 1), an introduction card explains that security camera footage is available for the player to identify the owner of the lost item. In the invitation it is noted that the lighting was not very good and shadows may appear in the footage. A card is selected from the Security Cam Deck, showing the shape/shadow of the toy owner. Having in mind the shadow in the card, the player has to look at other footage from the entrance camera with clear images to narrow down the possible toy owners. At this point, the player takes another card from the Testimonies Deck from people that were present at the Museum that day. This card provides new clues, such as whether owner wore spectacles, their hair colour, if they had a flower, etc. The player has then to identify the person from the deck based on these characteristics

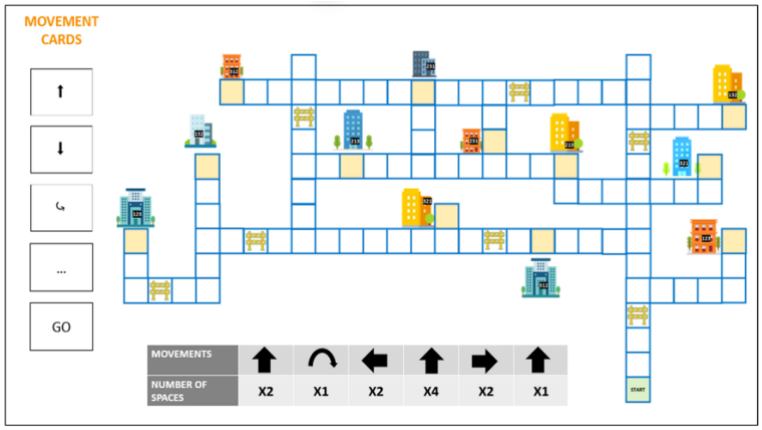


Figure 2: The city map and movement cards.

In level 3, the museum director provides a city plan to the detective who then has to identify the item owner's house and return it. The map includes 3 spots with a museum symbol which supplies clues for finding the owner's house. These cards are placed by the teacher in any space in the board (e.g. can make it to be closer to one another to make the difficulty level lower or make the game faster). The player also gets initial Movement Cards (Figure 2) which can be re-used in each turn. To move around the city, the player must compose algorithms representing the path they must take on the map. The algorithms created must be able to fit a pre-established grid, the Programming Bar (Figure 2 – bottom), representing a minimum of length. Player can create as many algorithms as needed to reach the final destination. The grid has 6 movements and it is not allowed to use less in each turn. There is also a jump card which can be used for jumping over obstacles, as an increased difficulty feature. For younger students, the algorithm can be designed on the city map directly.

The players must first visit all the spaces with the symbol "?". Upon landing on a space with the symbol "?" the player gets a Clue Card. There are two sets of Clue Cards, one with numbers and one with colours. The number cards form the door number and the order in which they are picked is the order by which the numbers are on the door. The teachers must take 2 cards from this set and place them on the board (museum cards). The colour cards represent the colour of the building – either Blue or Orange. One of these cards should be placed by the teacher on the board (museum cards). With the 3 clues gathered, the player must guess which is the correct building and visit it tolook for the owner's flat. This level can further be played/replicated in the classroom by utilizing robots (e.g. BeeBot) or by asking the students to move around a mat version of the map themselves.

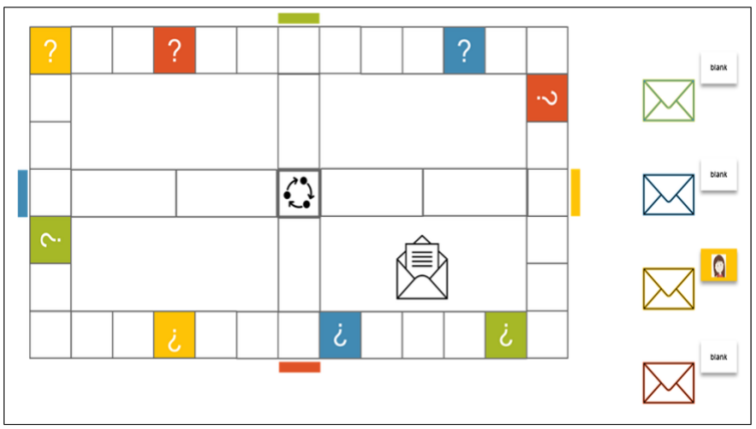


Figure 3: Level 4, inside the building.

In level 4, the player enters the building. There are 4 envelops with different colours (yellow, green, red and blue) representing the different doors/apartments in the building. Additionally, there are 4 character cards – 3 blank cards and one with a child. The teachers secretly puts one card in each envelope. The door with the envelope containing the character card leaads to the toy-owner (Figure 3). Then, players put their pawn in the centre of the board. Each player rolls a die in turns, moving around the board, in whatever direction chosen. This means that player can choose a new direction after rolling the die, but must follow it for that turn. If the player lands on "?" he/she picks a question from the respective colour pack. If it is answered correctly, the card is kept as a token, otherwise it is returned at the bottom of the pack. By rolling a "6" an additional die roll is earned. After collecting all 4 coloured tokens the player can "knock" at any door and reveal the corresponding envelope to try finding the toy owner. For that purpose, the player must go to that door, only after acquiring four tokens, one of each colour, by landing to the space in front of it. If the envelops reveals the child (character card), the payer wins. If not, the player loses the token of that door and needs to re-acquire a token set of 4 colours. To knock on any door, the player must always have the 4 coloured tokens. At any point in the game, the player may collect more than one card of the same colour, but to open a door they must have the 4 different colours. There is a special space at the centre which by landing on it the player is teleported to the door of their choosing.

The winner of the game is the player who finds the child and returns the lost item to them. A group of children may, of course, act as one single player and collaborate throughout the game. The questions in level 4 are all exercises directly connected to the 4-attribute model of CT and connected to the theme of the story (museums and toys).

A set of 11 lesson plans was designed to complement the game, serving as a foundational precursor to the board-game. These lesson plans are designed to introduce children to the major components and learning objectives addressed in the game, preparing them for gameplay by familiarizing them with essential concepts. Each lesson plan is structured to progressively introduce key computational thinking concepts in an engaging and interactive manner. The plans cover topics such as algorithmic thinking, problem-solving strategies, logical reasoning, decomposition and pattern recognition.

Through hands-on activities, group discussions, and guided exercises, students explore fundamental computational thinking skills. They learn to identify patterns, create step-by-step sequences, and analyse problems systematically. Moreover, the lesson plans emphasize the importance of collaboration and communication, encouraging students to work together to solve challenges and share their ideas.

By the end of the lesson series, students are equipped with the foundational knowledge and skills necessary to engage effectively with the board-game. They acquire a solid understanding of the core concepts and are ready to apply them in a game-based learning environment to further develop their computational thinking abilities.

4. Pilot Testing

The game is being pilot tested at the time this paper was written. Some preliminary data have already been analysed and discussed upon in the final section of the paper. It is to be noted that the game is being tested as a mock up and the final graphical design will be implemented after the completion of the pilots. The main aim of the pilot testing is to use the designed material (game and lesson plans) to collect feedback for improvements and refinement. The testing regards the following axes: a) The lesson plans, b) The game, and c) Learning assessment (optional).

The pilot studies are being conducted in three partner countries, namely Greece, Malta and Portugal. Prior to the pilots, teachers underwent training which focused on familiarizing themselves with the CT concepts and approaches, the game itself and the designed lesson plans. During the training sessions, the participating teachers actually played the game. Each of them is required to pilot test at least two lesson plans and collect feedback for the following aspects: a) Lesson plan clarity (steps, structure, guidelines), b) Goals (easy to meet, interdisciplinarity), c) Applicability in class (time required, class management, etc.), d) Perceived usefulness, and e) Perceived success (students learned – optional). For the game itself, it is to be tested with the students in order to collect two levels of feedback: student and teacher feedback. Regarding the students, the aspects for which data is collected are: a) Game concept and clarity, b) Game Mechanics, c) Game difficulty, d) Group playing and collaboration, e) Perceived Enjoyment (how much did the students like playing the game), and f) Positive & Negative aspects (1 thing they like or not). From the teachers' side, the requested feedback concerned is: a) Game concept and clarity, b) Game Mechanics, c) Applicability of the game in class (time required, class management, space required, ability to play in intervals, etc.), and d) Perceived usefulness. As an optional level

of feedback collection which is not examined in this paper, a learning assessment was proposed to be carried out.

For each set of data, appropriate templates were designed and distributed to the teachers. Regarding the process, at least 3 teachers from each country are required to test the game and material, implementing a different lesson plan with the participation of at least 10 children. A teacher's diary was proposed to be kept for keeping notes deriving from observations during the testing. The data collection templates are being filled in right after each pilot testing round has been completed.

5. Discussion and Future Plans

The initial findings from the pilot provided valuable insights. Notably, the study revealed that the collaborative version of the game was more effective than the competitive version in a classroom setting. In the competitive mode, students who completed their tasks quickly experienced extended waiting times compared to others. This led to challenges for some teachers in managing the class while ensuring everyone remained on task. Specifically, when played with larger groups, some teachers found it difficult to oversee each group's progress and provide necessary guidance while also progressing through the game explanation. Conversely, in the collaborative mode, where students worked together towards common goals, the game was more manageable, regardless of group size. In this mode, the teacher played a crucial role in monitoring group dynamics, ensuring everyone took turns and remained inclusive of one another.

Furthermore, subsequent runs of the game with the same students showed significant improvement, indicating that familiarity with the game mechanics led to increased focus on learning outcomes and enhanced computational thinking competencies. This suggests that repetition and practice are key factors in the effectiveness of using the game as an educational tool.

One noteworthy observation was the enthusiastic reception of the game by students, who exhibited high levels of motivation and engagement throughout gameplay. This positive response suggests the game's potential to effectively engage students in computational thinking activities.

However, several challenges and areas for improvement were identified during the pilot testing. Firstly, it was noted that the board and pieces were too small, indicating the need for size adjustments in the final design. Additionally, the introduction of a step-on mat as the game board was suggested to accommodate younger children and encourage physical engagement with the game.

The integration of a narrative backdrop was found to increase student engagement and provide context to the learning experience. Levels 1 and 2 progressed smoothly, emphasizing the importance of the teacher's questioning techniques in guiding students through the game and maximizing learning outcomes.

In contrast, Level 3 presented challenges, especially in competitive mode, where students struggled with the complexity of using the program bar to code actions. Some students had difficulty visualizing the outcomes of their actions and translating the code execution into movements on the board. This challenge was less pronounced in the collaborative version, as no program bar was necessary; instead, players directly placed the required sequence of commands on the board. After an initial adjustment period, students quickly adapted to effectively using commands in this mode.

Level 4, which involved chance elements with dice rolls, occasionally led to prolonged gameplay due to the requirement for specific combinations. In relation to game rules, for this final level, it was suggested that allowing movement both forward and backward in the same turn could be an improvement. Previously, the rules permitted movement in both directions but not within the same turn. This adjustment could lessen frustration, promote strategic thinking, and speed up gameplay.

In conclusion, the preliminary findings suggest that the board-game holds promise as an effective tool for teaching computational thinking skills. Addressing the identified challenges and implementing suggested improvements could further enhance the game's educational value and usability in classroom settings.

The pilot tests are still being carried out while writing this paper. More feedback from more countries will be received, including more structured analysis of observation journals and data collection instruments. The expected results will be utilized for improving game mechanics but also proceeding to the final graphical design of the game, addressing the recorded needs for size, colors, etc. Based on the teachers' feedback, the final version of guidelines for the lesson plans will be written.

Other future plans include quasi-experimental approaches for measuring the learning outcomes in order to assess the learning potential of the board-game further. Considering that there is limited availability of educational material for ECE, there is the intention of translating the material in more languages and further testing its connection to national ECE curricula which integrate CT.

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Play Your Way Into Production: Game-based Skills Development for the Screen Industries

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Abstract: Screen industry employers report they are unable to recruit graduates with the right skills for entry level roles in film and television (e.g. runners or production assistants), citing a lack of business awareness and various 'soft skills' as barriers to employment (Grugulis and Vincent 2009; Carey et al, 2017; Jones, Swords and Brereton, 2022). Traditionally such knowledge and skills are obtained through in-person work experience on set, but work experience is usually unpaid and therefore inaccessible to many students and graduates. However, research in the use of applied/serious games and extended reality technologies for training purposes has indicated that situational skills training can be facilitated using these approaches (Ebner and Holzinger 2007; Connolly et al, 2012). This paper presents an analysis of the design process behind a game-based learning intervention, developed to enable players to experience a day working on a film set and to allow educators to open up discussions about working practices and employability/progression within the screen industry. The simulation gives players the opportunity to take on a junior role in a film studio, respond to typical requests on set, interact with other crew members and observe proceedings. The study draws on interviews with educators and an ethnographic account of playing the game and using the complementary educational resources. We argue that a serious game can function as a meaningful intervention allowing potential new entrants to the screen industry to understand the tasks and duties of job roles in the industry. This approach also improves access to the development of skills and knowledge which are traditionally gained through (unpaid) work experience.

Keywords: Serious Games, Educational Games, Skills Gaps, Screen Industries

1. Introduction

1.1 Skills Gaps/Shortages in Film and TV

Skills training and work-readiness in the UK screen industries has been a topic of concern, debate and research for many years (Creative SkillSet, 2014; Carey et al, 2017). From retaining skilled workers as they age to the freelance nature of many roles, skills gaps and shortages pose real issues to the success of the UK screen sector (Van Loo et al, 2001; Allen and De Grip 2007; BFI 2023). As film and TV production continues to grow it is estimated that the UK screen industry will require between 15,130 and 20,770 additional full-time equivalent employees (FTEs) by 2025 (ScreenSkills/Nordicity/Saffery Champness 2022), meaning the question of skills development is a growing concern.

Despite the many practical further and higher education courses and training programmes available, employers and the workforce state that these do not always provide the skills required (BFI 2017; Animation UK 2018; ScreenSkills 2019). In particular, training was criticised for not providing the professional skills required in the workplace, including team-working, communication and confidence. However, there are often barriers to developing these skills for under-represented groups, compounded by the prevalence of 'on-the-job' training, which is often obtained through unpaid work experience or internships which are inaccessible to many (Jones, Swords and Brereton, 2022). Research into film/media qualifications in the UK indicates that even those registered on formal programmes of study face difficulties in securing work placements (Allen et al, 2013; Mayne, Zborowski and Macrae, 2024).

1.2 Use of Applied Games for Training

Connolly et al, (2012) provides strong evidence of the benefit of computer games on knowledge acquisition, understanding and affective/motivational outcomes, while Ebner and Holzinger argue that "games are often closer to simulating real life experiences than more traditional educational media" (2007: 875). Further, game-style simulations are often-used in training contexts where 'virtual' mistakes do not have the critical impact that errors in the real world would, especially in medical and health research (Shorey and Ng, 2021; Chen et al, 2020).

Given the issues around accessing work experience and training in the film and TV industry, an educational game – Play Your Way into Production (PYWIP)– was developed, primarily for use in further and higher education settings. PYWIP offers a gamification and simulation of the experience of working on a TV or film set, together with some gamified elements, and was designed to help develop a range of professional and situational skills which might otherwise be traditionally gained through work experience.

2. Co-Creating the PYWIP Game

2.1 The Collaboration

Play Your Way Into Production[1] is a collection of digital educational resources to support skills development and employability for new entrants to the screen industry workforce and comprises:

- A scenario-based educational game based around a virtual TV studio for PC or Mac,
- An additional virtual reality (VR) experience that allows users to explore the virtual studio, with detailed information about the studio equipment and roles of crew members,
- Downloadable 'character cards' outlining the crew members, their skill sets, roles and responsibilities,
- Short films of interviews with both film/TV students and recent graduates working in the industry,
- An Educational Resource Package (ERP)[2] with learning activities focussed on the skills developed in the game.

The Play Your Way Into Production game was co-created through an interdisciplinary collaboration between academic researchers and an independent production company under the auspices of the skills and training workstream of the Screen Industries Growth Network (SIGN)[3] The production company One to One Development Trust[4] is an independent charitable arts organisation who use film, game and XR to break down barriers and increase opportunities and aspiration.

2.2 Research-led Design

An academic advisory board of researchers from UK Higher Education Institutions steered the development and design of the materials to ensure that it was underpinned by research on a) previously identified skills gaps in the screen industry and b) the design of educational games and active-learning pedagogies.

2.2.1 Identified Skills Gaps

Research conducted by the Screen Industries Growth Network (SIGN) drew on 27 semi-structured interviews with a range of screen industry stakeholders, including training providers, production companies and employers and identified several themes relevant to new entrants in the screen industries (Jones, Swords and Brereton, 2022; Willment, et al, 2024). The most salient of these were:

- *Attitudes* – Some new entrants refused to accept criticism or suggestions for further improvement as they had obtained an undergraduate degree and felt they knew all they needed to.
- *Industry knowledge* – There was a perception among training providers that graduates knew how to write, edit or operate a camera but didn't understand the industry as a whole or how different roles worked together.

[1] https://playyourwayintoproduction.com/
[2] https://subjectguides.york.ac.uk/PYWIP-ERP/
[3] https://screen-network.org.uk/work/skills-training/
[4] https://onetoonedevelopment.org/

- *Mental health and wellbeing* – The industry can be demanding with long hours and high expectations. The report identified that it was important to know about these issues as well as how to maintain a work-life balance and be resilient.
- *Professional skills (a.k.a. soft skills)* – Knowledge, and specifically technical knowledge, was seen as less important than being able to work in a team, communicate effectively or be assertive.

The skills gap areas identified here echo those identified in recent industry focussed research (e.g. Carey et al, 2017; BFI 2023, BFI 2017; Animation UK 2018; ScreenSkills 2019) and form the framework of skills that the PYWIP game addresses.

2.2.2 Game Design Principles

Games design theories are closely associated with the design and rationale for game-based learning. Gee (2003, 2007) purports that good games incorporate good learning principles, which are supported by current research in cognitive science. The PYWIP game was developed around a selection of design principles chosen to support and underline the overall aim of situational learning and skills development, as follows:

- *Probing* (Gee, 2003) – players probe the world through exploration, experimentation, testing and selecting options and various scenarios. They then form a 'hypothesis' (an object, skill, event or action) before reprobing the world with that hypothesis in mind. Depending on the consequent action or reaction, they then rethink their original hypothesis.
- *Stored simulations* (Gee, 2003; Reeve, 2011) – in games players form mental associations and make connections between "stored simulations" of previous experiences and adapt and apply these to new experiences. In cognitive terms, this is pattern recognition — the process of forming associations between objects. This applies to experiences and situations within a single game, as well as developing experience that translates to subsequent game titles.
- *Agency* (Murray, 1997) – the process of self-discovery and player autonomy. In good games, players are in control; they seek out tasks and decide how best to achieve them, and, when faced with conflict and combat, learn how to overcome them.
- *Reflection* (Iacovides et al, 2022) – an important first step for addressing attitudes and supporting behaviour change, but often overlooked in game based learning. Providing players with an opportunity to role-play within a relevant context promotes reflection.
- *Situated Cognition* (Brown, Collins and Duguid, 1989) – argues that knowledge is fundamentally linked to the activity, context, and culture in which it is developed and used. Comparisons between simulation-based training and lecture-based education in teaching situational awareness have also shown that simulations are more effective, particularly in improving perception skills essential for time-sensitive, critical decision-making roles (Chang et al, 2017; Zarraondia et al, 2015).

2.3 The Play Your way Into Production Game

The Play Your Way Into Production game is set in a virtual film/TV studio where Pink Sprout Productions, a fictitious production company, are making a CGI-rich dinosaur documentary. The game includes a film studio that is populated by 17 crew members with varied backgrounds and experience, a green room containing a kitchen area and office equipment, and an outside area with a catering van. Small details have been intentionally included to enhance the realism of the studio context including real posters on the corridor walls, changes to the weather, and the in-game camera monitor playback screen reflecting the scene being filmed (*situated cognition*).

During game play all technical equipment and other items in the studio can be explored by selecting to bring up a 365-degree view mode with text-based info (*probing*). While exploring the set, players can eavesdrop on conversations between other characters/crewmembers about different aspects of working in the industry **(***industry knowledge***)**.

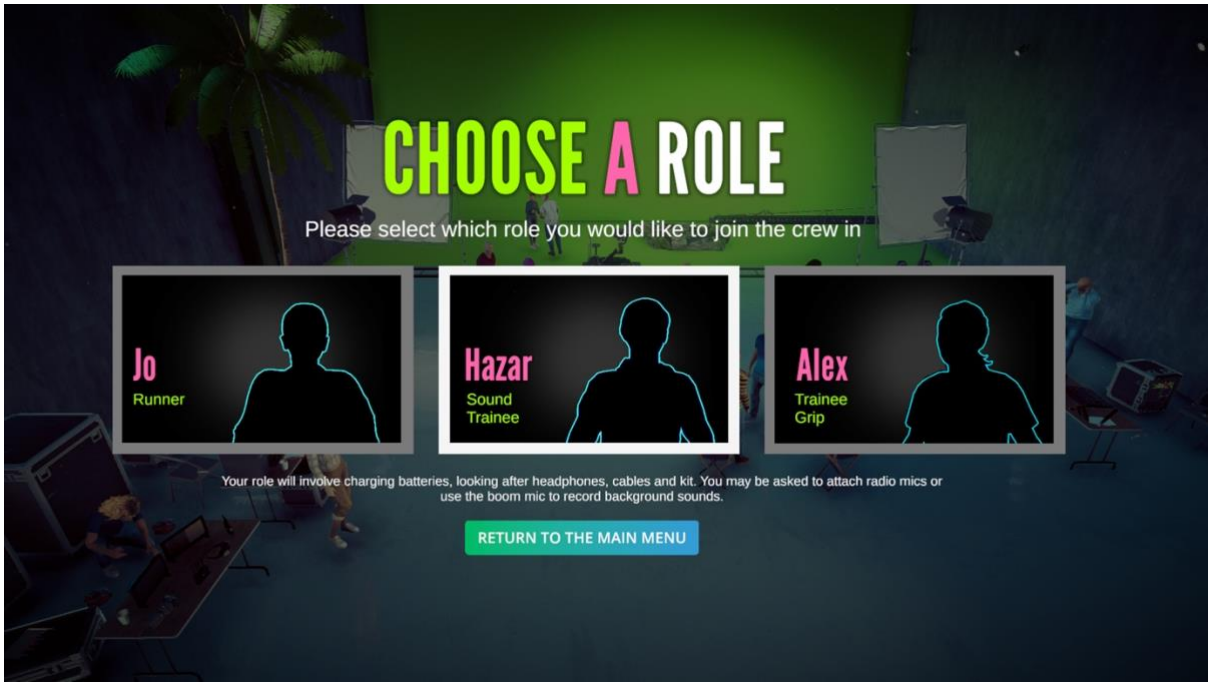


Figure 1: The three entry-level roles players can choose.

The game offers players a choice to play as one of three different entry-level roles – a runner, a sound trainee or a trainee grip (see Figure 1). Choosing a role encourages player *reflection* by a) providing relevant context for the role and the tasks they are likely to encounter and b) offering some distance from their own personal, subjective identity (Iacovides et al, 2022). Interactions with non-playable characters (NPCs) form the basis of scenarios in which the player is presented with a task and various options to choose from (*stored simulations*) – all scenarios are based on the lived experiences of people working in the industry. Some choices affect the story flow (see Figure 2) and trigger immediate feedback, whereas most result in gameplay continuing (*agency*). Feedback on player interactions, and their performance in all tasks and scenarios encountered are summarised in appraisal from their line-manager at the end of the game (*reflection, situated cognition*) (see Figure 3).

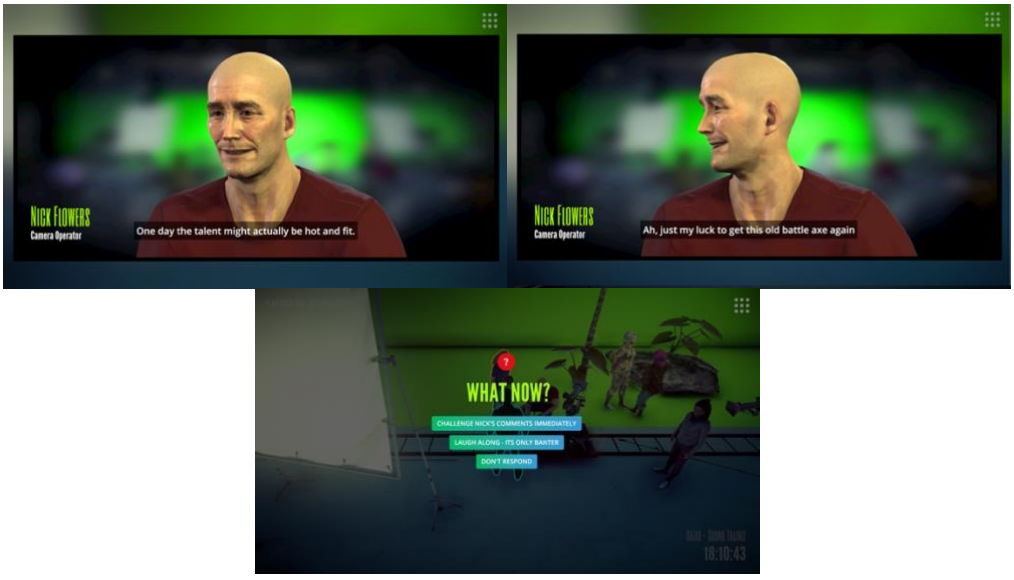


Figure 2: Example scenario players are faced with while playing as Hazar.

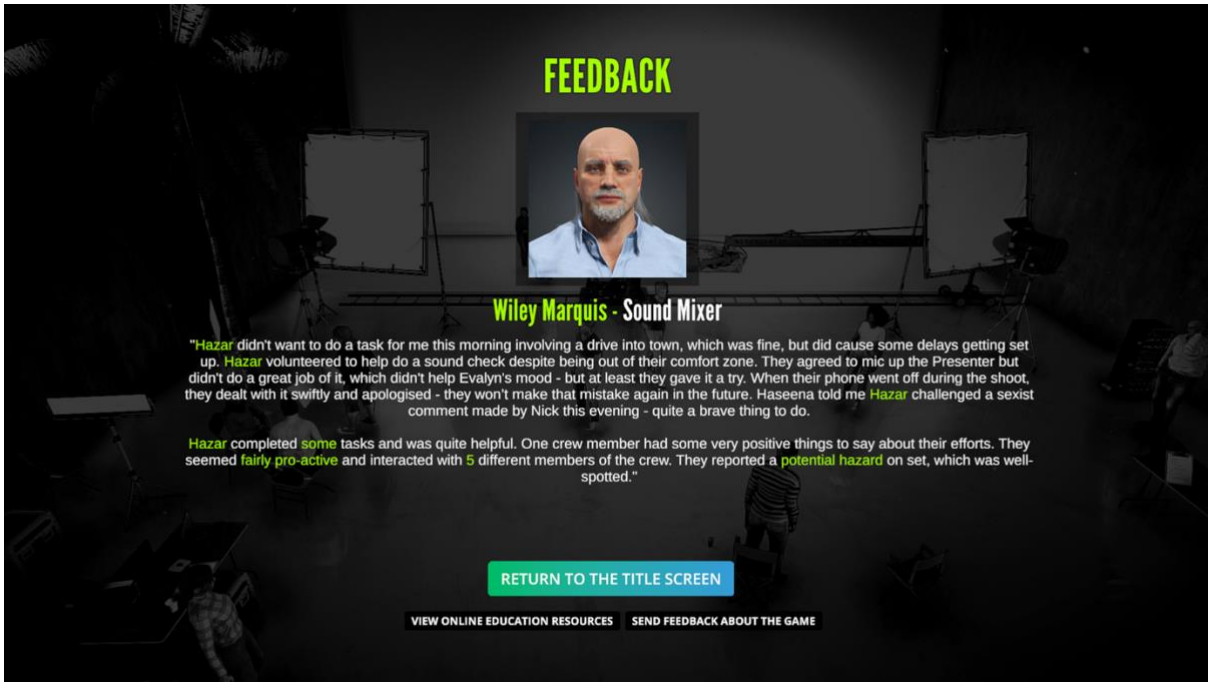


Figure 3: Feedback offered to players while playing as Hazar, dependent on scenario options selected.

3. Evaluation of the Play Your Way Into Production (PYWIP) game and Educational Resource Pack (ERP)

3.1 Methodology

The experience of students and tutors playing the PYWIP game on a PC and using material from the ERP in 2 UK higher education settings was evaluated, drawing on data from teaching observations, an auto-ethnographic account and interviews

Lecturers at two UK higher education institutions were asked to identify an existing module in which they could teach a 2-hour seminar based on the PYWIP resources as part of an existing undergraduate BA degree programme. Students were told they did not have to take part in the research, and if they did choose to participate there was no right or wrong feedback, or expectation that students would view the game and resources positively. Sixteen students took part in the study across 3 seminar groups, with the majority having had no previous work experience in the industry despite being enrolled on a media studies-related degree.

At the beginning of the taught seminar, the students were asked to complete an on-line skills audit [5]to provide each student with an opportunity to self-assess their own professional skills and knowledge of the Screen Industry. The PYWIP skills audit is based on the Worklink Skills and Values Assessment Tool (WLSVA) (Dershem, 2020), which is a validated tool designed to measure skills development among youth and young adults.

The lecturers were not given specific instructions on how to use the PYWIP game and ERP, and instead were told to use the resources however they felt best within their seminar.

3.1.1 Interviews

A week after one of the seminar sessions took place the lecturer who ran the session was interviewed (designated L1 below). Exploratory questions focussed on how they used the game, what they found useful, what ERP modules they used (if any), and if they thought the PYWIP game and ERP resources could help students who want to work in the industry.

[5] https://york.qualtrics.com/jfe/form/SV_78TLMCEcobjRdci

3.1.2 Analytic Autoethnography

Two of the three seminars were taught by the research associate involved in designing the game and ERP, and as such required an autoethnographic approach to data collection and analysis (designated AE below). Autoethnography, as Méndez notes, "can range from research about personal experiences of a research process to parallel exploration of the researcher's and the participants' experiences" (2013, 281).

As the researcher was both a member of the research team at the University of York and an hourly paid lecturer at one of the institutions taking part in the research, they were able to transcend "empirical data to gain insight into some broader set of social phenomena than those provided by the data themselves" (Anderson 2006, 387) – in this case the use of an educational game for teaching skills required by the screen industry. The researcher was also able to discuss the use of the game with the students during the seminar, making notes and recording comments made by those students who had agreed to take part in the research project.

3.2 Results and Discussion

The two data sets, interviews and autoethnographic, were analysed separately using an inductive/deductive hybrid thematic approach (Proudfoot, 2023) to identify themes. As a result, three broad inductive themes were identified: '*game efficacy', 'engagement with the ERP'* and '*contextualising the game'*. Deductive themes from the game design principles and skills gaps areas are highlighted in (*italics*).

3.2.1 Game Efficacy

Lecturers started the seminar by introducing the game and its development context to the students, who were then left to explore it on their own (*probing*). Both lecturers noted they gave no explicit instructions on how the game should be played, but both told students to play through the game as at least one of the entry-level roles. Once they had done that, the students were free to play as another character or explore other aspects of the game such as the crew profiles or interviews (*agency*). Students progressed at their own pace throughout the game, with the research assistant (AE) noting that the 3rd year students needed some more guidance due to the language barrier (the students who attended this seminar were solely international students). The other cohorts navigated the game with ease, although one third year student felt that a map should be included as it was difficult to find out where they needed to go to complete certain tasks (*agency*).

When asked how they used the ERP, the lecturer (L1) said:

> The short version is I went in and I picked the bits that I thought were the best and would work best with my cohorts. So I wanted something that would. That they would see was relevant but also was potentially kind of fun. So I was kind of going for balance and engagement and a bit of information. [L1]

Students appeared engaged with the game, with several 1st year students across both seminars viewing the additional resources after they had played the game once, and felt it was a valuable tool. L1 noted that "there wasn't any kind of cynicism towards the game or the scenario, you know, it seemed like people could genuinely see this is a good way of learning about the stuff that goes beyond the technical elements of a role" (*situated cognition, attitudes*) while AE highlighted feedback from a student who said "I like how even though I played it [the game] wrong I still learned stuff". This student deliberately chose scenario responses which were the least appropriate (*agency, reflection*), including refusing to get out of the presenter's chair, and ultimately being asked to leave the set. However, they still felt that the game was helpful in developing their knowledge (*industry knowledge*).

Feedback from students was broadly positive: the game was "useful", "interesting" and "good for seeing what it's like" (*stored simulations*), suggesting that the game could be an effective tool for addressing skills gaps identified by the research. Lecturers also felt that the scenarios in the game, coupled with the activities from the ERP could provide students with a bank of examples or scenarios that they could use in future job interviews (*industry knowledge*).

3.2.2 Engagement With ERP

Both lecturers chose elements from two different ERP modules, one covering communication and the other assertiveness, and adapted these for use in the sessions. As AE noted:

> I know the game really well and I had an idea of what scenarios might work in a session where I hadn't taught the students before and didn't know their depth of knowledge and experience. I went through the modules and decided I wanted to look at communication but I also really like the scenario between Hazar and Nick and used that to discuss different people you can communicate with if you're in that situation on set and don't feel comfortable about calling someone out. The communication and assertiveness modules had aspects I could choose to be able to include that scenario.

Students were able to highlight examples of good and bad communication (*reflection, attitudes*) within the game which were then used to facilitate discussion. Both lecturers used the "director's dilemma" exercise in which two lead actors have creative differences during filming an important scene. Students were asked to discuss how they would resolve this, what communication skills they might use and why. Students engaged with the activity, explaining why they might include the full cast and crew in the conversation, film two versions and decide which was best, or take the actors to a private room to discuss the scene, which for L1 led into a broader discussion about different management styles (*professional skills*).

Seminar tutors were also asked to reflect on their use of the ERP, particularly regarding whether they thought it was a useful resource to use alongside the game. L1 thought it was, not only because it was efficient and saved them time but because of the way it was structured, with high level practical skills and more in-depth scenarios (*industry knowledge*). L1 highlighted the reasons behind why they felt it was useful, saying:

> before the session it was actually quite useful, partly for, like, the hyperlinks for the consent, forms and stuff, I put them all on Canvas pages that they could navigate through. I copied and pasted sort of judiciously chosen bits of the text from the ERP pages, you know, that gives you sort of background and categories of different kinds of communication, and so on. And I put those on Canvas pages so that I didn't have to sort of go through it verbatim. But the students had it there and for sort of catering a little bit for neurodiversity, and so on. I wanted. I was sort of telling the students what we were doing, but also, if they needed it, they had it there on a page so they could go back and say, 'Okay, that's what we're supposed to be doing'. (*mental health and wellbeing*)

Both tutors felt the ERP was a useful resource which could smoothly be slotted into existing modules. L1, in particular, felt that the ERP was "a bit of a gift" because the resources "slide quite easily into sessions" while AE noted that having pre-written modules was helpful for teaching students they hadn't previously been engaged with.

Neither of the tutors used the additional resources – such as interviews or crew profiles – provided on the website in their seminars, however AE suggested them as a resource students could engage with if they finished playing the game as one character while L1 noted that some students watched the interviews without being prompted to (*agency*). AE suggested that time was a factor:

> I wanted the students to play at their own speed without rushing them. They've got the option to explore the set, pick up bits of kit and see what they're used for, as well as carrying out the tasks and while there is a timer in the game the point of it isn't to finish as quickly as possible (*probing*). Asking the students to look at the other resources once they'd finished playing one character meant they could do things at their own pace, especially because I was going to spend the second half of the session going through a module (or parts of two modules) that are suggested to take 50 minutes). Maybe I prioritised the module over what I thought could have been useful? But then the crew profiles and videos are more about getting into the industry and would work better with a module like getting your foot in the door or leadership (*industry knowledge*).

3.2.3 Contextualising the Game

Both lecturers discussed how they had contextualised the game in relation to the research carried out by SIGN, highlighting to students that they were testing the game and how useful it was. As AE wrote, reflecting on their session:

> It was important for me to make clear my role in the development of the game and to express that we were interested in their [students'] responses because we want to know if the game works. If not then that's a research finding in itself.

The background to the game is only briefly mentioned in the ERP introduction module, however, and isn't highlighted in any of the modules (*industry knowledge*). L1 suggested that including that either in the ERP or as a brief intro card as you enter the game could be valuable to highlight the game is grounded in what the industry needs rather than a generic skills exercise (*industry knowledge, professional skills*), making it more relatable to specific modules and to students' career plans.

Feedback from the first three seminars was therefore broadly positive from both the students and the lecturers who agreed that the game helped them address the skills gaps identified in the research. Indeed, L1 noted that was its major virtue:

> imagine if you've gone through your whole degree, and this is like your first working experience. And all of a sudden, like the ground would shift beneath you. It's like, okay, so I know all this stuff about editing and camera, but I don't understand the flow of working on a set. So yeah, I think, I think in that respect, that's kind of the game's USP for me in a way. (*industry knowledge, mental health and wellbeing*)

Further data collection is scheduled to take place with students, lecturers and industry professionals, but initial responses are positive.

4. Future Development of PYWIP

While the initial responses were positive, there are opportunities for improvement and further research. For instance, the underutilization of additional resources such as interviews and crew profiles suggest potential areas for enhancement in future sessions. Additionally, the integration of contextual information from other SIGN research into the ERP or game introduction could further enhance its relevance and application within industry settings.

Several areas of the game design have been identified for further development of the game such as: improving digital accessibility, producing similar games based on different working environments including live events, theatre or a Virtual Production studio.

Further data collection with students, lecturers, and industry professionals will provide valuable insights into the long-term impact and effectiveness of the game and ERP in addressing skills gaps within the screen industries.

5. Conclusion

A pedagogical approach to gamified simulation harnesses the cognitive benefits associated with gameplay situations. Play Your Way Into Production is designed to encourage users to probe and to store simulations that they can apply to future real-world situations requiring familiarity, confidence, agency, and choice-making. At the same time, a simulation environment encourages exploration and risk-taking that would be too costly in a real-world situation, potentially leading to loss of face, or even loss of earnings or future employment possibilities. Lowering the real-world stakes increases the space for reflexivity, and for learning.

Lecturers have played a pivotal role in framing the PYWIP game and ERP within the broader context of the screen industries and specific research objectives. The deliberate decision not to provide explicit instructions on gameplay allowed students to explore the game freely, promoting autonomy and curiosity. Despite language barriers faced by some students, the overall impact on student engagement was positive, with most cohorts navigating the game with ease.

Both lecturers demonstrated effective utilisation of the ERP by selecting relevant modules that underpinned a balanced approach that catered to various learning styles and the needs of their cohorts. This strategic selection process aimed to strike a balance between relevance, engagement, and the conveyance of essential information. The integration of ERP modules into the sessions facilitated meaningful discussions around communication and assertiveness, providing students with practical examples and scenarios to enhance their learning experience.

The combination of the PYWIP game and ERP modules proved to be an effective tool for addressing skills gaps identified by the research. Student feedback highlighted the game's value in providing insights beyond technical aspects of roles within the screen industries. The interactive nature of the game encouraged students to actively engage with scenarios and reflect on their experiences, contributing to a deeper understanding of industry practices and challenges. Lecturers also noted the positive impact on student learning, emphasizing the game's

unique selling proposition (USP) in bridging the gap between theoretical knowledge and practical industry experience.

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Integrating Agile Methodologies and Gamification for Student Engagement and Success

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Abstract: The article highlights a flexible and adaptable approach for the development of game like activities for higher education students from Politehnica University of Timisoara, Romania. The approach embraces agile methodologies to guide the iterative development process of educational games and consists of several key elements. First, it underlines the importance of defining clear learning objectives and aligning them with the game's design. Second, it encourages multidisciplinary collaboration between teachers and instructional designers to deliver relevant information to students, but also appropriate to their learning styles and needs. Regarding engineering problems and methods, students frequently encounter several difficulties. For this reason, the article attempts to provide an organized and engaging learning environment that encourages active participation and information retention. In industrial engineering, most of the students' exposure is to theoretical materials; nevertheless, there are several ways to give them practical experience with the topics they are studying. Using a comprehensive review of the literature, the article explores the pedagogical benefits, challenges, and practices associated with the use of agile methodologies in education. Agile methods are very based on collaboration, teamwork, flexibility, and participation, and help create a more relaxed learning environment to support students' increasing need for control over their learning path. Throughout regular communication and feedback cycles, students can iterate on content and pedagogical approaches, resulting in activities and games that are more engaging and effective for learning. In the end, the paper presents the conclusions of the authors on the current advantages and limitations of using this approach based on agility and game-based learning in higher education.

Keywords: Agile Education, Scrum, Game-Based Learning, Iterative Development, Sprints, Continuous Feedback

1. Introduction

This article presents an approach used by the authors to incorporate gamification into training exercises for 4th year students studying Economic Engineering within the Electric, Electronic, and Energetic field at the Faculty of Management in Production and Transportation, Politehnica University of Timisoara, specifically for the Computer-Assisted Manufacturing course. The syllabus of the Computer-Assisted Manufacturing course contains a range of topics including Manufacturing Systems, Manufacturing Planning, Models and Modelling in Manufacturing, Artificial Intelligence in Manufacturing, Agile Manufacturing, and Flexible Manufacturing Systems. Typically, when students engage in the study and analysis of manufacturing systems, their exposure is predominantly limited to theoretical aspects, as is commonly observed in many industrial engineering courses (Yiming, 2021). This article focuses on Scrum, an agile methodology widely used today, and explores its potential applications in game-based education. The significance of examining this subject lies in the mutual advantages that it offers both students and professors. When Scrum is implemented, regular feedback can be obtained, allowing for continuous adaptation between students and instructors. The degree of student dedication and the educators' flexibility or agility both have an impact on the continuing learning process (Buciuman, 2020). Furthermore, the article investigates how game-based activities might be used to incorporate concepts related to product development, including Agile and Scrum processes. Agile development concepts encourage students' problem-solving and collaborative abilities in addition to supporting their learning and work methods. The course activities' adaptable format allowed students greater autonomy and the chance to get continuous feedback on their progress.

2. Literature Review

Agile can be viewed as a philosophy that embraces flexibility, adaptability, and innovation that extend beyond its roots in software development. Over the years, agile methodologies have proven their value in various domains. Agile project management techniques, often known as flexible product development methodologies, use strategies that enable affordable modifications in contrast to traditional project management approaches that strictly follow original plans (Buciuman et al., 2012).

Due to the successful application of Agile methodologies in the management of software development teams and projects, researchers recognised the potential to adapt them to the educational context (Dewi & Muniandy,

2014; Salza et al., 2019). Initially, El-Abbasy et al. (2010) proposed a framework for applying agile methods in computer science education. He created an analogy between software development and the educational process. Subsequently, it was discovered that Agile methodologies were equally effective in teaching other subjects, such as mathematics (Duvall et al., 2017). Given that every student has different abilities and learning styles, not all students in a classroom will be able to grasp concepts at the same pace or using identical methods. Considering this diversity, teachers must be aware of these varying learning needs and be prepared to adapt their approach accordingly, rather than following rigidly to a predetermined plan (Buciuman, et.al., 2012). Translating Agile values into the classroom involves aligning the principles of Agile with the dynamics and requirements of an educational environment.

Several studies have demonstrated the effectiveness of implementing Agile methodologies also in online courses, as presented in (Salza et al., 2019). The findings revealed that the integration of Agile strategies within project-based learning facilitated effective team coordination and project management. With this approach, the instructor took on the responsibilities of a supervisor and a facilitator, assisting the students while they worked on the project and guiding them through an iterative learning process that improved their learning outcomes over time.

The directions in which agile can impact the learning process are described below:

1. Iterative and incremental Learning: agile promotes an environment where students learn and progress in small steps. Instead of focusing on long-term plans or a rigid curriculum, an agile education approach encourages continuous improvement and feedback loops.
2. Flexibility and adaptability: teachers can adjust their strategies and content, based on student feedback and emerging trends. This allows the creation of personalised learning experiences that support the needs and interests of the individual student.
3. Collaborative learning: in an agile education setting, students work together on projects, solving problems, and sharing knowledge. Collaborative learning fosters communication, critical thinking, and collaboration between students. Especially in the Romanian educational system, teamwork and collaborative work skills are not adequately supported throughout learning activities, and an agile approach can help minimize this weakness.
4. Student empowerment: agile empowers students by giving them more autonomy and ownership over their learning process. Students contribute by setting goals, planning their learning activities, and monitoring their progress.
5. Continuous feedback and improvement: agile encourages a culture of continuous feedback and improvement in which teachers and students provide regular feedback collaboratively shaping the educational experience.
6. Agile tools and techniques: agile offers a variety of tools and techniques that can be adapted to education. For example, Kanban or Scrum boards can be used to visualize and manage learning tasks, retrospective sessions can be held to reflect on learning experiences and make improvements.
7. Learning from failures: agile education aims to encourage a growth mindset by embracing mistakes as opportunities for learning and improvement. Students are encouraged to experiment and learn from their experiences, fostering resilience and a positive attitude toward challenges.

By adopting agile principles and practices in education, teachers and students can create a more dynamic, adaptive, and student-centered learning environment.

When measuring the impact of Agile practices in education, several Key Performance Indicators (KPIs) can be used to assess the effectiveness and success of the implementation. A list of KPIs used to measure the impact of Agile on education is listed as follows:

1. Student Engagement: measures the level of student engagement by monitoring attendance rates, participation in class discussions and activities, and completion rates of assignments. Higher participation indicates that Agile practices encourage active student participation in the learning process.
2. Learning Outcomes: this KPI assesses the extent to which students achieve the desired learning objectives and acquire the necessary knowledge and skills. It can be measured through tests, exams, projects, and other assessments that evaluate student understanding and application of the taught concepts.
3. Student Satisfaction: conduct surveys or gather feedback from students to assess their satisfaction with Agile teaching methods.

4. Time Management: assess students' ability to manage their time effectively by comparing their ability to meet deadlines and complete tasks within given time frames.
5. Collaboration and Teamwork: evaluates the extent to which agile practices promote collaboration, teamwork, and communication among students. It can be assessed through observations, self-assessments, or feedback from students.
6. Adaptability: monitors students' ability to adapt to changes and adjust their learning approach based on feedback and evolving requirements. The KPI can be calculated as a ratio between the number of task adjustments the student team completed during a predefined period and the total number of adjustments required for that interval.
7. Continuous Improvement: measures the number and impact of improvements made to the curriculum, teaching methodologies, and learning materials due to the adoption of agile practices. This could include the incorporation of student feedback, improvements to learning resources, or changes to instructional techniques.
8. Innovation and Creativity: assesses students' ability to think creatively, generate innovative solutions, and apply critical thinking skills. The KPI measures the ability of students to approach problems from different perspectives and to propose new ideas (Elizondo, et al., 2010).

It is important to note that the KPIs must be tailored to the specific objectives and context of the educational institution or program. The selection of KPIs should align with the course goals, data collection should be carried out consistently, and insights should be used to make informed decisions and improve the implementation of agile practices in education.

2.1 Serious Games to use Agile in Education

Game-like activities have been widely used in Agile Engineering Education to improve learning outcomes and engagement. By incorporating elements of gamification, educators can create a more immersive and interactive learning environment. These activities often simulate real-world scenarios and challenges that students may encounter in professional settings. Through these game-like experiences, students can apply Agile principles, such as collaboration, iteration, or problem-solving, dynamically and enjoyably. Ultimately, game-like activities in Agile Engineering Education offer a practical and engaging approach to prepare students for real-world Agile practices in the field (Buciuman, 2021). There is a growing shortage of specialists in the labour market, and students need new approaches to learning activities that incorporate ways of how the industry approach works and offer an experience closer to what happens in real life. Gamification can vary depending on the perspective, but certain elements commonly exist. These include the presence of rules, goals, players (either individual or team-based), and often the use of physical or virtual artifacts such as cards, dice, or whiteboards. Games are designed to provide entertainment and can involve elements of competition, although they can also promote cooperation through team-based gameplay (Parson, 2014). Figure 1 presents the use of game-like activities in education as a comprehensive system made up of three interrelated pillars: learning and teaching, gaming, and simulation.

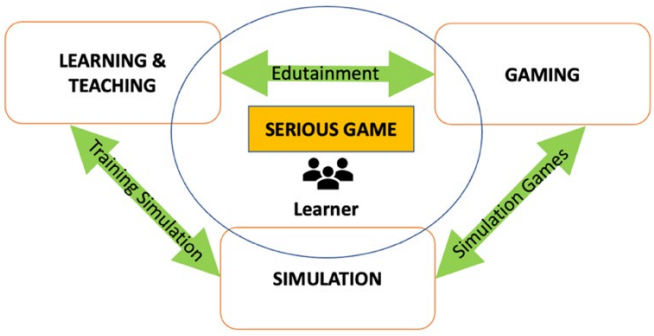


Figure 1: Serious game – a definition model (adapted from Buciuman, 2021)

In Figure 1 the focus is on the learner, highlighting the distinctiveness of training simulation, simulation games, and Edutainment as separate concepts. The Learning & Teaching component encompasses both the learner's perspective and the instructor's viewpoint, considering their respective roles and objectives (Buciuman, 2021).

Game-like activities in education are also known as Serious Games or Edutainment (Yiming, 2021; Laamarti et al., 2014). Edutainment is a term that refers to the combination of education and entertainment. It involves the

use of entertaining and engaging content and activities to facilitate learning and educational outcomes. The primary goal of education is to make the learning process enjoyable and engaging, thus increasing motivation and knowledge retention.

The model for defining and categorising serious games in Figure 1, provides a structured framework for defining and categorising serious games. It outlines key components and characteristics that contribute to the experience of serious games:

1. The Serious Purpose: Serious games have a clear educational or training objective beyond pure entertainment. They aim to deliver specific learning outcomes or impart practical skills.
2. The Game Element: Serious games incorporate interactive elements typical of traditional games, such as rules, challenges, and rewards. These elements engage the user and provide a pleasant experience.
3. Contextual Relevance: these games are designed to address real-world problems or simulate specific scenarios relevant to the learning or training context. The content and context are following the intended educational or training goals.
4. Active Participation: Serious games require active participation of the user, who makes decisions and solves problems.
5. Feedback and Assessment: Serious games provide immediate and constructive feedback on the user's actions and performance. Feedback helps learners track their progress, understand their strengths and weaknesses, and make improvements.
6. Progress and Challenge: Serious games offer a sense of progression and challenge by gradually increasing the difficulty level or complexity of the tasks.
7. Integration of Learning Content: Serious games can seamlessly integrate educational or training content into the gameplay. Instructional materials, simulations, and assessments can be included, providing a cohesive learning experience.
8. Learner-Centred Design: Serious games are designed with the learner's needs and preferences in mind. May include different learning styles and the ability to personalize the experience to meet specific learning requirements.

Serious games can be an effective tool to integrate agile principles and practices into education. They promote active learning, teamwork, problem-solving, and critical thinking skills. Additionally, serious games create a safe environment for students to experiment with agile practices and gain a deeper understanding of their benefits and challenges. Generation Z students are digital natives and focused on practical study methods with direct implications for real life (Iftode, 2019). By incorporating serious games into agile education, students can develop a practical understanding of agile methodologies and improve their ability to apply them in real-world scenarios.

3. Methodology

The main purpose of this research was to explore and describe the implementation of an agile approach using game-like activities for 4th year students from the Faculty of Management in Production and Transportation at Politehnica University of Timisoara.

The agile methodology used was Scrum, a project management technique that guided students through the planning, execution, and review stages of a manufacturing project. To comply with the curriculum, students should assimilate concepts related to planning, resource allocation, estimates, assigning tasks, manufacturing models, productivity, and problem-solving. Figure 2 shows the agile principles applied when using agile for engineering courses.



Figure 2: Agile principles embedded in engineering courses

Each of the steps in Figure 2 fosters the iterative and collaborative Scrum mindset, allowing students to develop their engineering projects efficiently and effectively, as follows:

1. Agile Project Planning:
    - Identify the engineering project or problem that students will work on throughout the semester;
    - Break down the project into smaller tasks or milestones that can be completed within shorter iterations (Sprints) and prioritize tasks based on their importance and dependencies;
2. Sprint Planning:
    - At the beginning of each Sprint, collaborate with the students to set goals for the duration of the Sprint (e.g., one week).
    - Assign tasks to students based on their skills and interests, considering the project requirements;
    - Discuss and estimate the effort required for each task using story points or other estimation techniques;
3. Daily Stand-Up:
    - Conduct short daily stand-up meetings in which each student briefly shares his progress, the challenges he faced, and the plans for the day;
    - Encourage students to communicate any obstacles or issues they encounter and collaborate to find solutions;
4. Iterative Design and Development:
    - Encourage students to apply iterative design and development processes, such as Agile Engineering Practices or Rapid Prototyping;
    - Break down larger engineering tasks into smaller subtasks that can be completed within a Sprint;
    - Regular review and evaluation of the progress and quality of the design;
5. Collaborative Teamwork:
    - Assign students to project teams, promoting collaboration, communication, and shared responsibilities;
    - Encourage regular team meetings to discuss progress, exchange ideas, and coordinate efforts;
6. Sprint Review and Feedback:
    - At the end of each sprint, conduct a review in which the students showcase their progress and outcomes;
    - Provide feedback on their work, highlighting strengths and areas for improvement;
7. Retrospectives and Process Improvement:
    - Conduct retrospectives at the end of each Sprint to reflect on engineering processes, teamwork, and project outcomes;
    - Discuss what worked well, and challenges faced, and identify areas for improvement;
8. Documentation and Reporting:
    - Encourage students to maintain documentation and progress reports, capturing their design decisions, challenges, and solutions;
    - Use project management tools or version control systems to track and manage project artifacts;

For the agile manufacturing project, students were asked to develop a solar power bank project, implemented in Autodesk Thinkercad, over a seven weeks period. Agile values and renewable energy scenarios were covered using the "Agile Penny Game" and the "Siemens Energy Island" game. This was an engaging and educational way to learn more about renewable energy and sustainable technologies used in manufacturing. The important aspects of the project were the game-like activities they had to carry out and the fact that the entire activity was developed based on agile principles. In line with agile principles, the project was developed iteratively, in Sprints of one week each. The first week was assigned to activities to learn about agile and renewable energy. Before the beginning of the first Sprint, the teacher explained the learning goals and how agile can help support the

achievement of these goals (Buciuman, 2020). For students, it was the first contact with agile methodologies, especially with Scrum. To facilitate understanding of the main concepts of Agile and Scrum, students played the "Agile Penny Game". The "Agile Penny Game" is a very popular agile game and is generally used to teach agile teams, the impact of large workloads on productivity, and the importance of self-organization. To play the game, the students used a Miro virtual board as the one in Figure 3.

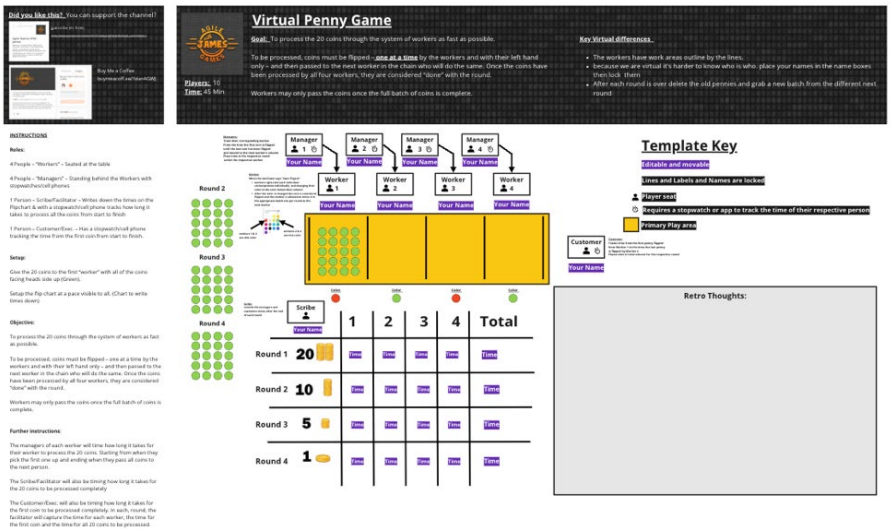


Figure 3: Virtual Agile Penny Game Miro board

Students were organized into teams of four members, with one of the members receiving the role of the Scrum Master. The teacher played the role of the Product Owner. She assumed multiple responsibilities in the agile framework, including defining learning objectives, specifying deliverables, and evaluating educational outcomes. The teacher was responsible for developing the list of tasks in the project. These tasks, also called user stories were used to organize the solar power bank features into a Product Backlog. Due to scheduling restrictions, each Sprint started with a planning meeting and included two daily meetings each week. To facilitate reflection at the end of each Sprint, Miro boards were utilized. Additionally, the teacher provided feedback and offered suggestions to improve the overall learning process.

To have a game-like approach when learning more about the context of the renewable energy sector, the students played the "Siemens Energy Island game". Students found it easy to understand the various ways of producing energy and their advantages and disadvantages. They were reminded that the game was intended to help them generate ideas to develop their solar bank project. It also explained how solar panels capture sunlight and convert it into electrical energy.

All the features of the solar power bank were organized in the Product Backlog, serving as a comprehensive list of requirements, enhancements, and bug fixes for the project. The items in the Product Backlog are typically described as user stories that capture the user's perspective and desired functionality. Each item in the backlog is assigned an estimate, often using story points, to indicate its relative complexity or the effort required. Some examples of tasks from the Product Backlog are shown in Figure 4.

PRODUCT BACKLOG						
User Story ID	User Story	Estimate (size)	Priority	Sprint	Task owner	Estimated effort
US001	As a user I need to be able to recharge wireless compatible electronical devices	Medium	5	2	Student 1	7
US002	A a user I need to be able to recharge the power bank with solar energy	Large	4	4	Student 2	21
US003	As a user I want to have a light and portable power bank	Medium	4	2	Student 3	13
US004	As a user I want to have a LED to report battery level	Small			Student 4	3
US005	As a user I want to have a USB port to connect other electronic devices	Small			Student 5	3

Figure 4: Solar power-bank sample Product Backlog

Each of the Sprints began with a Sprint Planning Meeting during which the students determined the amount of work they aimed to complete within the Sprint. The chosen educational tasks were converted into a Sprint

Backlog. Before the first Sprint, the teacher Product Owner instructed students on how to estimate work during a Sprint. Initially, students struggled with accurate task estimation, but this self-regulating process allowed them to gradually improve their ability to complete all learning activities in the Sprint Backlog after one or two Sprints. For task estimation, the students used the Planning Poker Game (Cohn, 2005) with a set of virtual cards.

During each one-week Sprint, students conducted two Daily Meetings. The decision to have only two such meetings and not every day was taken by mutual consent between the students and the teacher Product Owner. Everyone agreed that it was not feasible to have a meeting every day since the students had other subjects to deal with at the same time. Figure 5 shows a board based on a Miro template that the students used to run the retrospective meetings at the end of each Sprint.

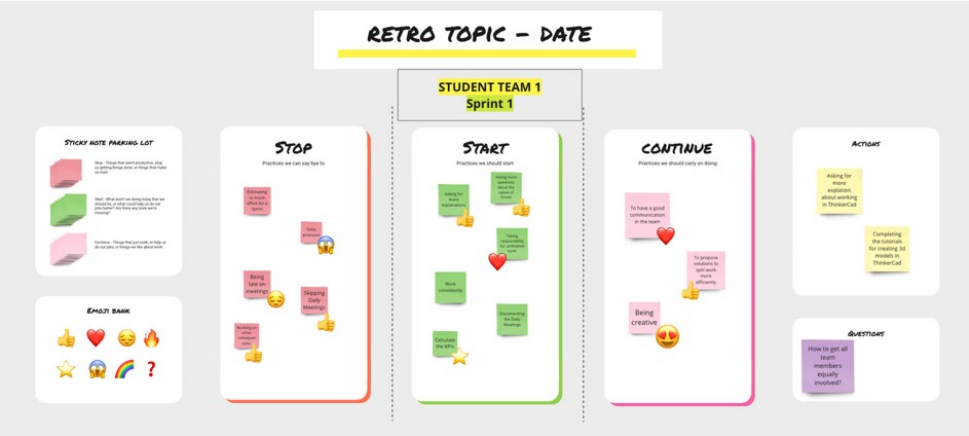


Figure 5: Miro Retrospective Meeting Board for Student Team 1

4. Results and Discussion

The activities described in the paper are intended to provide an overview of the experience of applying agile methods to an engineering course and to offer a perspective of using game-like activities to provide a more engaging learning experience for students. Following teacher observations and feedback received from students, the use of games such as “Planning Poker”, “Energy Island” or “Penny Game” allowed them to participate in the activities and embrace concepts more easily. It is important to mention that the balance between fun and education in serious games can be quite subjective and that the teacher is responsible for finding the right approach to fulfil the course learning objectives. There were quite significant differences between the teams' perceptions regarding the work they felt they could complete during a Sprint. Six out of eight teams failed in the first Sprint due to a lack of understanding of the fact that agile is based on an incremental approach and that every Sprint is relevant.

For the students, estimating the amount of work and organizing their approach for each Sprint represented their biggest obstacle. In the first two Sprints, the Scrum Master student struggled to keep the team respecting the principles of the Scrum methodology. They constantly needed to be reminded that the concept of “Done” for a task means that the project they were working on was not just a theoretical exercise to learn agile, but also had the goal of developing a possible viable product in a hands-on project in Autodesk Thinkercad. To provide a brief overview of the agile approach and to summarize the overall performance and engagement of students, the following KPIs were used:

1. The average task completion rate (%): measuring the average percentage of tasks completed by all student teams within each Sprint;
2. The average quality of deliverables (1-5): used to evaluate prototypes for each Sprint and the final product (solar power bank). Rated on a scale from 1 (poor) to 5 (excellent);
3. The average meeting participation rate (%): used to measure the average attendance at Daily Stand-ups, Sprint Planning, and Retrospective meetings by all student teams within each Sprint;
4. The average feedback incorporation rate (%): used to measure the ability to incorporate feedback from Sprint reviews and improve subsequent iterations for all the student teams within each Sprint;
5. The average team collaboration score (1-5)**:** used to measure the average level of teamwork and communication within teams, rated on a scale from 1 (poor) to 5 (excellent) for each Sprint;

6. The average learning outcomes (Quiz Scores %): measuring the average percentage of understanding of agile concepts and renewable energy principles, measured through quizzes for the students enrolled in the course within each Sprint.

Table 1 provides a clear numerical representation of the student performance and engagement over the seven weeks, showing how the student's work evolved over the seven Sprints.

Table 1: KPIs used to measure student performance during the Agile project

Sprint	The average task completion rate (%)	The average quality of deliverables (1-5)	The average meeting participation rate (%)	The average feedback incorporation rate (%)	The average team collaboration score (1-5)	The average learning outcomes (Quiz Scores %)
1	50	2.5	40	-	4	50
2	60	3	60	65	5	64
3	70	3.5	85	70	5	70
4	75	4	85	85	4	78
5	80	4	90	92	5	84
6	80	4.5	100	90	4.5	88
7	95	4.5	100	100	5	95

For the first Sprint, the average task completion rate was only 50%, as the students became accustomed to agile principles and did not realize in the first phase the importance of attending meetings and working constantly. The average quality of deliverables starts at 2.5, showing room for improvement. The average feedback incorporation rate could not be calculated in the first Sprint, because students received feedback only at the end of each Sprint. As the students understood their roles better, the average meeting participation rate and the average team collaboration score increased, which was reflected both in the quality of the tasks they completed in each sprint and the learning outcomes, reaching 95% at the end of Sprint 7. The steady increase in learning outcomes (Quiz scores) indicates a successful understanding and application of the concepts taught.

Agile methods are very based on collaboration, teamwork, flexibility, and participation. That was one of the main reasons why Student Teams with a good balance between creative thinking skills, communication, and organizational skills performed better than those with gaps in working as a team. It was a challenge that at the end of every Sprint they had to reflect on their participation during the Sprint, but also to offer consistent feedback on the activity of other team members. Another important aspect to mention is that Student Teams were randomly created, and students needed to work with colleagues with whom they had never worked before. It can be concluded that the agile approach was more easily assimilated by teams with well-developed soft skills, rather than teams with good technical knowledge. Keeping in mind that the project was developed using Scrum, the game-like activities that the students carried out implied a lot of decision-making, adaptability, and teamwork spirit. Based on student feedback, it was noticed that integrating gaming into their learning experience had a positive impact. They expressed that this approach made the learned concepts more tangible and accessible. However, some students faced initial challenges due to the limited time it took them to learn Agile and Scrum, which made them feel a bit overwhelmed, but this iterative approach ensured that the project path remained aligned with the needs and preferences of the target audience.

Furthermore, the agile gamified approach emphasized adaptability and responsiveness. Choosing this approach for the Computer-Assisted Manufacturing course enabled running regular retrospectives and feedback loops and incorporating new educational concepts or technological advancements from one Sprint to another.

However, even if agile methodologies offer numerous benefits, it is important to acknowledge that there are also some limitations and challenges associated with the implementation of an agile approach in education. There may be some limitations to the availability of some resources and curricula. Agile methodologies often require a significant investment of time and effort, and educators can face challenges in terms of training, access to technology, or availability of support systems. To enhance future experiences in using serious games for engineering courses, certain aspects will be considered to improve the measurement of student productivity and sustainability in developing manufacturing projects. These considerations aim to enhance the overall learning outcomes and assess student work. Nevertheless, it should be remembered that, for example, in manufacturing, teamwork skills and building strong work relationships with colleagues are extremely important,

and innovative teaching methods are no longer optional but rather a necessity for the development of students' professional skills. Engineering courses are still crucial for developing a technical education.

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Play with Purpose: A Heuristic Approach to Evaluating Tabletop Serious Games for Academic Integrity Education

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Abstract: This article introduces a heuristic evaluation of CiteSaga, a tabletop serious game designed to enhance skills in referencing and citation, crucial for academic writing in higher education. We detail the application and outcomes of a novel heuristic evaluation framework tailored for tabletop serious games, dubbed "Play with Purpose." This framework is distinguished by its focus on eight essential categories: Learning Experience, Utility, Game Features, Social Dynamics, Adaptability, Learning and Feedback, Play Experience, and Accessibility, marking a significant contribution to the evaluation of non-digital game-based learning tools. Furthermore, we delve into the insights gained from participatory design sessions with students, aimed at evaluating CiteSaga's component appeal and game mechanics. The paper culminates in a discussion on how student feedback has informed subsequent iterations of CiteSaga, underscoring the critical role of heuristic evaluations in refining game-based learning experiences. Our findings not only advance understanding of empirical evaluation methodologies for tabletop serious games but also provide a valuable framework for future research and development in educational game design.

Keywords: Heuristic Evaluation, Game Design, Tabletop Serious Games, Academic Integrity

1. Background

The tabletop gaming industry has grown in the recent past due to advancement in technology and changes in consumers' preferences. This sector includes board games, card games, role-playing games, and digital-tabletop games, which are intermeshed with physical games, and target different groups of consumers (Thammavongsy et al. , 2020; Bolesnikov et al. , 2022). Tablet games are popular due to their ability to create social interaction and co-operative gameplay with new technologies such as augmented reality improving the game play and the convenience (Yuan et al. , 2021; Koukia, 2018; Thévin et al. , 2021). These games have spread their audience beyond the typical gamers, and such institutions as schools, libraries, and even psychologists pay attention to them. They are now employed in the teaching of different disciplines and have been crafted to accommodate different groups of people including the elder people as well as the visually impaired persons (Triboni & Weber, 2018; Bolesnikov et al. , 2022).

Thus, such an interest in the application of SGs in educational environments has required a proper assessment of their impact on learning. Heuristic evaluations involve the assessment of the usability, accessibility, and general usability of SGs, with a view of determining the areas that require some changes and confirming its compliance with the educational objectives (Desurvire et al. , 2004; DiNardo & Broussard, 2019; Slyman et al. , 2022). Both these assessments employ principles to assess the interface, interaction design and gameplay experience hence helping the educators and developers to improve the educational value of SGs and to foster the learning achievement.

2. What are Tabletop Serious Games, Anyway?

Tabletop serious games are defined as the interactive games which are meant for achieving certain educational, training, or persuasive goals beyond the realm of entertainment (Noda et al. , 2019). These SGs are mainly done on a flat surface as physical board or card games and give a real feel and touch of board and cards to the players which makes the player involve in the game more effectively and increase the level of team work, participation and interaction (Bonnechère et al. , 2016). They usually incorporate physical objects and multimodal tools to create engaging educational situations to support learner-centered approaches and establish positive learning contexts (Zhang et al. , 2021). Furthermore, tabletop SGs enhance the physical interpersonal relationships and social interactions and are thus ideal for use in learning and entertainment settings (Mccallum & Boletsis, 2013). Designing these games is focused on the principles of usability and accessibility which make the games appealing and beneficial to many users (Abbott, 2019).

The CiteSaga concept implemented at the North-West University's Library is a good example of how the students' engagement and the academic integrity can be promoted within the higher learning institutions. As a result of understanding the difficulties that students encounter in the correct citation and referencing styles, CiteSaga has come up with an interactive way of teaching students these important academic skills through the use of games. This way, the initiative strengthens the concept of academic integrity since the various tasks involve the correct use of citations. Also, CiteSaga enables group learning and peer to peer interaction where students are able to solve citation problems and share great experiences. This social dimension is important in helping students to foster their interpersonal skills through collaborative and group work to identify the most appropriate method of referencing thereby improving on their knowledge and performance.

3. The Purpose of This Research

Traditional academic integrity education is usually done in writing courses, research tutorials or workshops where students are taught about citation laws in order to avoid plagiarism (Obeso, 2023; Ramdhany, 2023). Citation management tools and bibliographic instruction help the students to reference the sources used in the right manner; however, many students fail to use citations in the right way thereby limiting their engagement in academic discourse (Iskandar & Patak, 2019; Okeji et al. , 2020). These conventional techniques fail to capture the various citation formats thus creating mistakes that affect the quality of the work (Romanowski, 2022). Citation instruction is only offered in the first and the third year at North-West University, which means that there is a necessity to find new ways to enhance the students' citation skills and promote academic integrity through the usage of serious games (SGs).

The focus of this paper is to describe the heuristic evaluation of CiteSaga, a serious game in the context of citation and reference styles at a South African university. The research involved the students in the design of the game, and their feedback concerning the usability, accessibility of the game and the extent to which it helped in improving citation skills and academic integrity. The purpose of the study was to confirm that the game is useful to students, make suggestions for the game design and assess how the game affects students' ethical decision making and academic integrity (Ifenthaler & Yau, 2020).

4. Literature Review

4.1 Serious Games and Their Potential for Education

This paper also analyze several literatures on the application of serious games (SGs) in the educational context. Educational value of SGs was discussed by Breuer & Bente (2010) whereas Khaled & Vasalou (2014) explained the significance of participatory design in learning through domain expertise. Medema et al. (2016) explained how SGs promote social learning and stakeholder participation in environmental management and Ampatzidou & Gugerell (2018) explained the aspect of having content in SGs while making them fun. Verschueren et al. (2019) proved that SGs can be effective in the management of psychological and health problems in children. Furthermore, Sharifzadeh et al. (2020) also identified that SGs are useful in health education and Hainey et al. (2022) also showed that SGs are helpful in formative assessment. The effectiveness of SGs was demonstrated in the real world by Putra et al. (2022) through an example of a COVID-19 social distancing game. Altogether, these studies point to the potential of SGs for use in educational and health-related settings.

4.2 Heuristic Methods for Evaluating Serious Games

These studies collectively highlight the significance of heuristic methods in evaluating the accessibility, feasibility, and effectiveness of serious games (SGs) across various domains: All these works in combination depict the role of heuristic approaches in evaluating the applicability and effectiveness of serious games (SGs) in various fields:

1. Tong et al. (2016) have described how SGs can be utilized for identification of cognitive impairments in the healthcare setting which makes it possible to apply the presented cognitive screening in the clinical practice.
2. Lau et al. , (2017) also did a systematic review and meta-analysis of SGs and they also concluded that SGs have a moderate effect in the reduction of symptoms of mental health disorders is vital since SGs are easily accessible and useful.

3. As stated by Ghoman et al. (2019), neonatal HC professionals are trained by SGs; the best way for this is through board and computer-based games which are also the most effective method of knowledge enhancement.
4. Salvador-Ullauri et al. , (2020) described the SGs design as non-inclusive because the designed SGs are not for everybody and called for inclusive design in the SGs.
5. Olgers et al. (2021) stated that SGs are useful in improving skills in medicine, though more studies need to be done so as to determine if they are efficient as well as accessible.

Table 1: Overview of Methodologies and Key Elements in Serious Game Research

Reference	Methodology	Key Elements
Bellotti *et al.* (2010)	Effective Serious Games Design	Cognitive aspects, theoretical foundations
Yoon & Park (2013)	Quality Evaluation Standard	9 main elements and 31 sub-elements
Kato (2010)	Serious Game Evaluation	Interactivity, Learning, Scoring, Scenario, Enthusiasm, User's traces
Hannig *et al.* (2012)	Collaborative Serious Game, Web-Based Collaborative Serious Game	Stimulation of conceptual thinking, Optimal design of a medical practice
Roungas (2016)	Model-driven Framework, Model-Driven Framework	Educational and entertainment game elements (twice listed)
Gordon *et al.* (2016)	Heuristic Evaluation	User Interface (UI), User Experience (UX), Serious immersive games and M-instruction
Lameras *et al.* (2016)	Serious Games Design, Linking Learning Attributes to Game Mechanics	Learning attributes and game mechanics
Salvador-Ullauri *et al.* (2020)	Accessibility Evaluation, Heuristic Evaluation	Heuristic method for evaluating accessibility, Accessibility in serious games, Accessibility issues, usability, effectiveness
Couret *et al.* (2020)	Risk-taking Behaviour Modelling, Operationalization, Heuristics evaluation strategy	Operationalisation of the availability heuristic, Avalanche accident victims, availability heuristic, Mobile game-based learning

Table 1 captures the methodologies and focal shifts in SG studies, illustrating the evolution from foundational theories to practical applications. Starting with Bellotti *et al.* (2010), it traces the development of cognitive frameworks and theoretical underpinnings in SGs, moving towards the critical evaluation of game effectiveness and educational utility through interactivity and user engagement, as emphasised by Yoon & Park (2013) and Kato (2010). It further explores the application of SGs in educational and other settings through collaborative and model-driven frameworks discussed by Hannig *et al.* (2012) and Roungas (2016). Notably, Gordon *et al.* (2016) highlight the importance of usability, focusing on user interface and experience, while Salvador-Ullauri et al. (2020) and Couret *et al.* (2020) reflect ongoing advancements in accessibility and heuristic evaluations, underscoring the increasing emphasis on making SGs both accessible and instructional.

Table 2: Heuristic Evaluation Elements in Serious Game Research

Reference	Heuristic Evaluation Elements
Desurvire *et al.* (2004)	Playability, game mechanics, aesthetics, user experience
Desurvire & Wiberg (2009)	Game usability, design, better games
Gordon *et al.* (2016)	User Interface (UI), User Experience (UX), software reflection
Hermawati & Lawson (2016)	Domain-specific heuristics, identification of specific issues, consensus on domain-specific heuristics
Tondello *et al.* (2016)	Motivational affordances, gameful design, usability
Yáñez-Gómez *et al.* (2018)	Mobility, multiplayer interactions, enjoyability, playability
Ishaq *et al.* (2021)	Usability, playability, game-based language learning
Lima *et al.* (2022)	Content validity, Cronbach's alpha, heuristics
Muhanna *et al.* (2022)	Usability, playability, Arabic mobile games
Slyman *et al.* (2022)	Learning elements, usability, design
Paneva-Marinova & Pavlov (2018)	Student motivation, learning, curiosity, skill development
Zaibon & Shiratuddin (2010)	Applicability, modular playability heuristics, health-enhancing games
Suhonen & Väätäjä (2010)	Core game elements, usability, health-enhancing games

Table 2 explores heuristic evaluation elements in SG research, detailing the evolution of criteria used to assess their usability and effectiveness. It starts with the foundational contributions of Desurvire *et al.* (2004) and

Desurvire & Wiberg (2009), who emphasise playability, game mechanics, and user experience, key to engaging and educational games. The field has since seen the development of more specialized heuristics, such as those by Hermawati & Lawson (2016) and Tondello *et al.* (2016), focusing on domain-specific issues and motivational affordances, indicating a shift towards more nuanced evaluation strategies. Recent research, including studies by Ishaq *et al*. (2021) and Lima *et al*. (2022), continues to refine these criteria, aligning them with specific educational goals and broader learning scenarios, while researchers like Lee & Lee (2021) expand the definition and applications of SGs by incorporating narrative and multimedia elements.

Table 3: Specific approaches and methodologies for conducting heuristic evaluations of SGs

Approach	Description
The Fuzzy Analytic Hierarchy Process (FAHP)	A technique employed to assess SGs, specifically in educational settings. This approach involves the use of fuzzy logic to prioritise and evaluate various dimensions of SG, including pedagogical, technological, ludic, and behavioural aspects (Omari *et al.,* 2020).
Participatory Game Prototyping	Involving stakeholders, such as students and educators, in the process of designing and developing SGs. This approach prioritises significant player involvement and the integration of local context, guaranteeing that the game design is in line with educational goals and user preferences (Desurvire *et al.,* 2004).
Usability Heuristics	A systematic method for assessing serious games, specifically in the realm of mobile games. This approach entails the creation and implementation of usability heuristics specifically designed for assessing serious games, guaranteeing that the games adhere to usability and playability criteria (Soomro & Ahmad, 2014 and Muhanna *et al.,* 2022).
Serious Game Evaluation Framework	A methodology to evaluate the efficacy and educational value of SGs. This approach prioritises the evaluation of SGs by considering their theoretical, technical, empirical, and external aspects, thus ensuring a comprehensive assessment (Wilson *et al.,* 2016).
Heuristic Evaluation to Assess Immersive Games	This approach expands the application of heuristic evaluation to encompass complex immersive games and mobile instructional platforms. The process entails the use of established heuristic evaluation techniques to evaluate the usability and educational value of SGs, specifically in immersive and mobile settings (Gordon *et al.,* 2016).

Table 3 shows the variety and depth of heuristic assessment methods for SGs. Omari *et al.* (2020) analyse SGs using fuzzy logic to assess pedagogical, technical, ludic, and behavioural characteristics using the Fuzzy Analytic Hierarchy Process (FAHP). Participatory Game Prototyping involves students and educators in SG design to correspond with educational aims and user preferences, according to Desurvire *et al.* (2004). SGs, especially mobile games, need usability heuristics to ensure usability and playability, according to Soomro & Ahmad (2014) and Muhanna *et al*. (2022). Wilson *et al.* (2016) evaluate SGs theoretically, technically, empirically, and externally using the Serious Game Evaluation Framework. Finally, Gordon *et al*. (2016) applied heuristic assessments to sophisticated immersive games and mobile teaching platforms, focussing on usability and educational value. This table describes the methods used to improve and evaluate SGs across dimensions and platforms.

Evaluating SG heuristics involves not only the game's functionality and playability, but also its ability to effectively communicate its educational or training content. Below are several frequently assessed heuristics for both digital and analogue SGs. **Heuristics applicable to tabletop SGs are marked with a ✅ symbol:*

- Educational Value ✅ : Assess the game's efficacy in achieving its educational goals, encompassing the acquisition of knowledge and the development of skills.
- Engagement ✅ : Evaluate the game's ability to effectively captivate and sustain players' attention.
- Usability ✅ : Evaluate the user-friendliness of the game, encompassing factors such as the design of the user interface, ease of navigation, and the clarity of instructions and feedback.
- Accessibility ✅ : Assess the game's capacity to be utilised by individuals with varying abilities, including those with disabilities.
- Responsiveness ✅ : Assess the effectiveness in delivering informative responses to the player and modifying its difficulty level to enhance the process of learning and participation.
- Narrative ✅ : Evaluate the efficacy of the storyline or narrative in augmenting learning by offering context and significance to the game's goals.
- Interactivity ✅ : Evaluate the extent and quality of the interaction(s) within the game, encompassing the level of control given to the player and the game's ability to promptly respond to the player's actions.
- Learning Analytics ⚠ : Analyse the methods the game employs to measure the player's progress and advancement towards the game's educational goals.

- Social Interactions ✅ : Assess the extent to which a game promotes cooperation, competition, and communication among players in games that have multiplayer features.
- Fidelity ⚠ : Evaluate the degree to which the game faithfully replicates real-life situations—a crucial aspect for training and simulation games.
- Flexibility ⚠ : Assess the game's capacity to be expanded or modified to suit various situations, player counts, or degrees of difficulty.Ethical and Cultural Sensitivity ✅ : Evaluate the degree to which the game demonstrates respect for cultural uniqueness and whether or not it refrains from endorsing detrimental stereotypes or biases.

The selection of these heuristics may differ depending on the particular goals and intended audience of the serious game. They are frequently employed in conjunction with conventional game design principles to ensure that the game is both efficacious in achieving its serious objectives and captivating as a game.

5. Research Strategy

The “Play with Purpose” model (Figure 1) is a comprehensive model for analyzing serious games, especially tabletop games such as CiteSaga, on different aspects of Accessibility, Utility, Learning Experience, and Social Dynamics. Therefore, these aspects make the game easy to play by any person, the rules of the game are well defined, players are able to learn easily through the game and the game fosters social interaction. Other factors like Play Experience, Feedback, Adaptability and game Features are added to the evaluation process which is consistent with literature on pedagogical affordances of serious games.

In this study, this framework informed a survey completed among education and economics students at a South African university to assess CiteSaga. Thus, despite the limited number of participants and the alpha-phase of the game, the present study was able to offer a focused analysis of the game’s design and educational potential. Subsequent larger scale testing on more universities will determine the validity of CiteSaga in more universities and improve on the current glitches to make it more versatile.

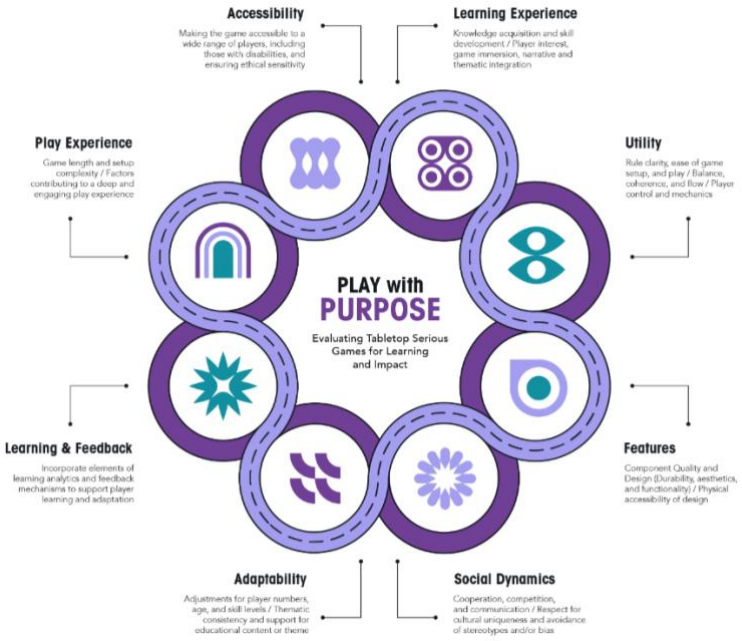


Figure 1: Play With Purpose framework for tabletop serious game evaluation (Source: Own conceptualisation)

5.1 Framing “Play With Purpose”

In the evaluation of the tabletop SG *CiteSaga* using the "Play with Purpose" (PWP) framework, the study strategically focused on four specific elements of the heuristic wheel: Learning Experience, Features, Play Experience, and Learning & Feedback. This targeted approach was designed to provide a solid empirical foundation for these aspects prior to more interactive play sessions with students. The following sections explain how this strategic focus integrates into the broader discussion of the game's development and future testing.

5.1.1 *Strategic Focus on Selected PWP Elements*

The choice to limit the initial empirical evaluation to Learning Experience, Features, Play Experience, and Learning & Feedback allowed for a concentrated analysis of these critical areas. Each of these dimensions plays a vital role in the overall educational effectiveness of the game:

- Learning Experience: By assessing how well the game facilitates knowledge acquisition and skill development, the study ensures that the main educational goals of *CiteSaga* are being met.
- Features: Evaluating the quality and design of the game components provides insights into the physical and aesthetic appeal of the game, which are crucial to maintaining engagement.
- Play Experience: Focusing on game length and setup complexity helped determine whether the game's structure was conducive to deep and engaging gameplay, which is essential for sustained interaction and learning.
- Learning & Feedback: This dimension was critical to assess how effectively the game incorporates feedback mechanisms and learning analytics, supporting adaptive learning and ongoing player development.

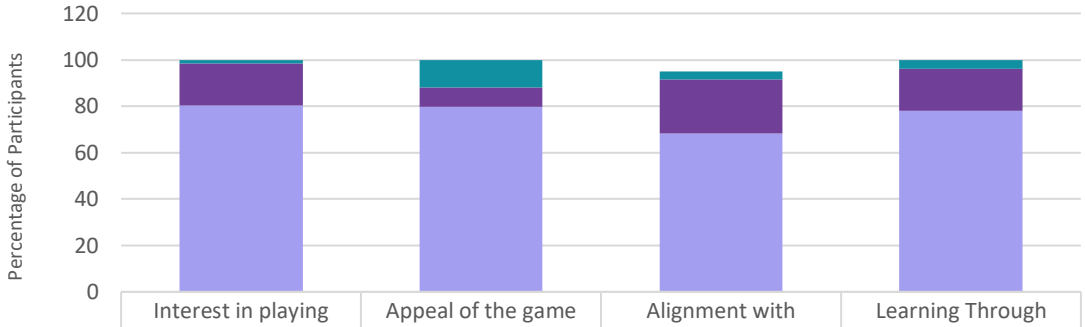
5.1.2 *Future Testing of Remaining Elements*

The remaining four elements of the PWP framework—Accessibility, Utility, Adaptability, and Social Dynamics—were not empirically tested in the initial phase reported here. The rationale for this was to allow these dimensions to be explored during actual play sessions with students. This approach aims to observe and measure these aspects in a dynamic, interactive environment where real-time data and feedback can provide a more genuine and comprehensive assessment.

- Accessibility: Future sessions will specifically look at how the game accommodates diverse player needs, including those with disabilities.
- Utility: Observations will focus on the game's rules, balance, and flow during play to assess its practical utility and ease of understanding in a live setting.
- Adaptability: Testing will evaluate the flexibility across different player demographics, skill levels, and group sizes of players.
- Social Dynamics: This will involve evaluating how the game fosters interaction among players, including aspects of cooperation, competition, and communication.

6. Findings and Recommendations

The survey received 151 responses over the course of a two-week period. Figure 2 highlights the positive reception of *CiteSaga* among participants, with convincing interest, appeal, and perceived educational value. Such insights are crucial for refining the game and enhancing its effectiveness as a learning tool. The data, moreover, suggests that *CiteSaga* has the potential to significantly impact students' understanding and application of citation styles and academic integrity practices.



	Interest in playing the game	Appeal of the game experience	Alignment with university experience	Learning Through Playing
No	1.72	12.02	3.43	3.86
Maybe	18.03	8.15	23.18	18.03
Yes	80.26	79.83	68.24	78.11

Figure 2: Reception of various elements of the *CiteSaga* game concept.

The results reveal a strong positive reception of *CiteSaga* among research participants. A significant majority (80.26%) expressed interest in playing *CiteSaga*, indicating a strong initial engagement with the game concept. Furthermore, 79.83% affirmed the appeal of the game experience, suggesting that the design and concept resonate well with the target audience. In terms of educational alignment, 68.24% of participants agreed that *CiteSaga's* objectives align with their university experience regarding the need to reference sources correctly, with another 23.18% somewhat agreeing. This demonstrates the effectiveness in addressing relevant academic integrity skills. Furthermore, 78.11% of the respondents believed that they would learn more about citation styles and academic integrity by playing *CiteSaga*, highlighting its potential as an edifying tool. The data also reveals areas for potential improvement, as 18.03% were uncertain about the game's appeal and educational value, and a small fraction (3.86%) did not think they would learn more, suggesting opportunities for enhancing engagement strategies.

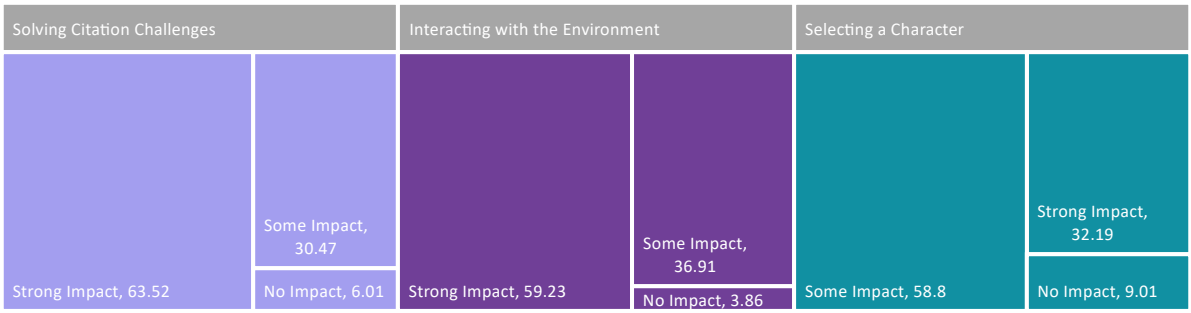


Figure 3: Reportage of various *CiteSaga* mechanics and their perceived impact on learning

The stages of gameplay in *CiteSaga* vary in their level of appeal. The most attractive aspect was the solution of citation challenges, which accounted for 26.45% of the overall experience. This was followed by interaction with the various environment cards at 21.76% and selecting a character at 20.66%. Understanding these preferences is crucial to optimising the design to improve player engagement and outcomes. The impact of these gameplay elements on learning is also significant. Solving citation challenges had the strongest impact, with 63.52% of participants indicating it as highly impactful, followed by interacting with the environment (59.23% strong impact) and selecting a character (32.19% strong impact). In terms of ease of the learning, 72.96% of participants found the *CiteSaga* game mechanics relatively straightforward to learn, while 13.30% found them extremely easy. However, a minority of participants (13.73%) encountered difficulties with the mechanics, indicating a need to streamline or clarify the game rules.

6.1 Learning Experience

The assessment of CiteSaga with regards to educational impact centred on the learning that it offered to the students. The survey questions (Q1-Q25) were about the level of participation, understanding of the learning objectives and the application of the in-game scenarios. As seen, relevance of content, goals, and learning as integral parts of the games were mentioned by the respondents, in accordance with the theory of good educational games (Gee, 2003; Plass, Homer, & Kimzer, 2015). Customer feedback pointed to the following primary goals of the game; citation (60%), integration (25%) and interactive learning (15%). However, some of the feedback feedback indicated that educational content should be integrated more deeply which is a problem recognised by Annetta (2010). Thus, the majority of respondents were inclined to think that playing CiteSaga would improve their knowledge about citation styles and academic integrity and thus recognized the potential of the game as a proper learning tool.

6.2 Features

Questions Q26-Q30 was related to the physical and aesthetic features of CiteSaga with regards to customizations (45%), gameplay (35%), and hardware (20%). Research-backed customisation and narrative-based engagement influence the level of player's commitment and willingness to replay the game (Salen & Zimmerman, 2004; Habgood & Ainsworth, 2011). The aspects which were important for 60% of students were high-quality components while 40% of students mentioned the character customization, which is in harmony with Adams (2014), who pointed out the significance of the esthetic aspects for educational games. According to 55% of the respondents, the storyline of the game had to be compelling and 50% said that the environment had to be well

developed, in line with Jenkins (2004) on the need for narrative integration. On the whole, the responses pointed out that CiteSaga is good in component quality and design, the aspects that are crucial to the game's appeal.

6.3 Play Experience

Questions Q31-Q44 asked to explore the participants' pre-play experience of *CiteSaga*, focusing on length of play, setup complexity, and structure of gameplay activities. Key issues were the high percentage of cooperative play (50%) and competitive aspects (30%), and scenario-based challenges (20%) that participants found yielded a high degree of educational value and required engagement. In this sense, the outcomes are consistent with Johnson *et al.* (2011): cooperative gameplay supports the development of collaboration and communication, while elements of competition might be engaging. They also value clear instructions (45%), balanced levels of difficulty (30%), and reward(s) for progression (25%), which were essential to ensure a certain degree of game engagement conducive to educational objectives (Gee, 2003). Character development (40%) and narrative contexts (35%) were also good indicators. The high rate of narrative-driven activities is explained by the fact that gameplay should be a challenge but also manageable, supporting the findings by Barab *et al.* (2009) that narrative contexts in games can promote deeper engagement and learning.

CiteSaga's length and complexity of the setup were seen as contributive factors to the learning experience, suggesting that these aspects provide a deep and engaging play experience as envisioned in the PWP framework.

6.4 Learning and Feedback

Questions Q45-Q49 were aimed at measuring the learning and feedback process applied in CiteSaga. While, 70% of the participants highlighted that they had access to self-assessment opportunities, 30% of them wanted to see some changes. Interestingly, 40% of the students wanted more frequent feedback, 35% wanted detailed explanations, and 25% wanted adaptive learning paths. These findings are in accord with Shute (2008) and Hattie and Timperley (2007) who stressed that feedback has to be formative and timely in order to promote self-regulated learning. The call for adaptive learning relates to literature for the personalized learning experiences (Plass, Homer, & Kinzer, 2015). In general, participants had a moderate to a good understanding of CiteSaga's educational objectives, which points to the effective use of learning and feedback functionalities.

6.5 Recommendations

The recommendations made to improve the *CiteSaga* concept are informed by data collected from the feedback of the respondents. These are presented below:

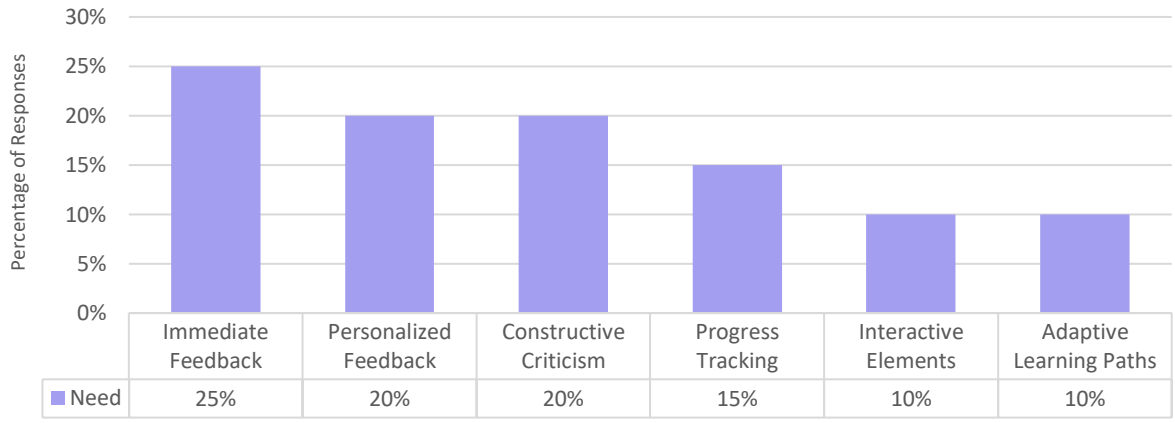


Figure 4: Reportage on the requirements to improve feedback in *CiteSaga*

In Figure 4, the most important aspects that could be enhanced for the learning experience in CiteSaga are stressed. The most important need mentioned by 25% of the participants is feedback which is helpful in learning from the results and correcting mistakes. Other aspects that were considered important included receiving feedback and critiques by 20% of the participants while 15% wanted to have their progress monitored. Also, 10% of the participants pointed to the importance of the interactive features and the opportunity for personalized learning paths. The following suggestions can be made for the improvement of the future iterations of CiteSaga; simplify the instructions, include difficulty levels, provide feedback to the user during the game and

enhance the visual aspect of the game for its accessibility. These changes are intended to improve educational effectiveness as well as levels of user comfort. More statistical analysis can also be conducted to support these findings and provide more information on how CiteSaga can be improved to better cater for different learning requirements.

7. Conclusion

This study addresses the research questions as follows:This study addresses the research questions as follows: *How can the principles of participatory design be included in the development of tabletop serious games for teaching academic integrity and referencing skills?* This information and feedback from the participants in CiteSaga design process was very active, thus it directly informed the changes in game play, story line, and educational content. Notably, 79. Out of all the participants, 83% said that the game was interesting while 69. Out of the total number of respondents 52% were able to demonstrate the knowledge of the education objectives. This feedback supports the use of participatory design in ensuring that the game is in sync with the educational goals and at the same improving on the fun aspect of the game.

Which heuristics are the most suitable in determining the accessibility and usability of educational tabletop serious games? User-based heuristic evaluation revealed the need for easy-to-understand instructions, good graphics, and ease of use. A majority, 72. 16% while 89% of the participants reported that the instructions were clear showing that clear guidelines are important to usability and accessibility. These findings implies that serious game designers should pay much attention to the quality of the visual interface, readability and the clarity of instructions to achieve the intended educational outcomes.

How effective is the design of CiteSaga in promoting academic integrity among the tertiary level of students? The study also showed that 78. 11 % of the respondents reported that they expected to gain more knowledge on citation styles and academic ethics by using CiteSaga. Additionally, 72. Ninety six percent of the respondents believed that the complexity of the game was beneficial to learning and thus the game has incorporated educational content in the right manner to boost academic performance.

In general, CiteSaga was considered to be a good system and participatory design was found to be an important factor in the design process. The integration of design in the material used for the teaching of academic integrity in the tertiary institutions makes it a relevant tool for the same.

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CiteSaga: Conceptualisation of a Serious Game for Citation and Reference Styles

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Abstract: This article asserts that serious games (SGs) are effective tools for teaching citation and referencing styles in higher education. The proposed SG aims to enhance students' understanding and application of these styles through an engaging, game-based approach. We use an agile design cycle combined with educational design and design science research methodologies. The SG's key elements include objectives, rules, mechanics, learning outcomes, and assessment strategies, all integrated into higher education curricula.

1. Introduction

Students must demonstrate their capacity to connect with current knowledge, prevent plagiarism, and contribute to academic debate through proper citation and reference (Duff, Rogers and Harris, 2006; Adhikari, 2018). However, students typically struggle to learn the several citation and reference formats (Lanning, 2016; Hamzaoui, 2021). To solve this difficulty, educators explore creative and engaging ways to teach and reinforce these abilities (Nilson, 2016). Serious games (SGs) can motivate and improve learning by combining enjoyment and teaching (Camilleri and Camilleri, 2019). Using SGs to teach citation and referencing styles can improve student understanding and application, motivation, critical thinking, and academic writing and research. This article describes the conceptualization of an SG to teach and reinforce higher education citation and reference styles. This method uses board games to make studying fun and improve students' citation and reference abilities.

2. The Reasons for Using Serious Games in Education

Over the past few decades, serious games (SGs) have been recognized for significantly improving learning outcomes across various courses (Yu, Gao, and Wang, 2021). They enhance student involvement, promote active and experiential learning, and foster essential skills such as problem-solving, critical thinking, cooperation, and decision-making (Westera, 2019; Rosa et al., 2021). Research indicates that SGs surpass traditional self-regulated learning by increasing participation and facilitating experiential learning (Power, Lynch, and McGarr, 2020). Their application extends to military, healthcare, and educational fields (Amod and Roodt, 2020).

SGs are employed in social marketing to boost engagement and learning outcomes (Dietrich, Mulcahy, and Knox, 2018) and offer unique educational benefits for dyslexic children (Bhatti and Shabbir, 2022). In healthcare, SGs aid novice professionals in understanding risk assessment and management (Mason and Loader, 2019) and promote learning and innovation in global health education (Smith et al., 2020). They also facilitate social learning in sustainable land and resource management by promoting collaboration (Den Haan and Van der Voort, 2018). Furthermore, SGs are effective in professional development, creating engaging environments for skill enhancement (Barnabé et al., 2017). Their growing integration into education and business training underscores their increasing importance and effectiveness across various domains (Cohard, 2019).

Incorporating SGs into higher education curricula, especially in research-focused modules, can significantly enhance student engagement, comprehension, and retention of complex subject matter and research skills. SGs can complement traditional instructional methods (Ferro et al., 2021) and provide dynamic platforms for students to apply theoretical knowledge in practical contexts (Barianos, Papadakis, and Vidakis, 2022). They promote active learning and problem-solving skills (Peña Miguel, Corral Lage, and Mata Galindez, 2020) and simulate real-world research environments, offering a controlled and supportive setting for experiencing academic research challenges (Leendertz and Matthew, 2022; Linderoth and Sjöblom, 2019). SGs also encourage collaborative learning and cooperation, mirroring the collaborative nature of academic research projects (Rodríguez-Rivera et al., 2023).

Aligning with constructivist learning theories like those of Vygotsky and Jean Piaget, SGs promote active engagement, reflection, and knowledge construction through experience (Young et al., 2012). They can motivate students to engage in self-directed learning by encouraging exploration and mastery. Strategically integrating SGs into research-centric topics can foster engaging and experiential learning, thereby enhancing students' research skills, critical thinking abilities, and overall academic performance. SGs prepare students for the rigorous research demands of higher education and beyond. Specifically, for teaching citation and reference styles, SGs offer practical and interactive learning environments that complement traditional classroom instruction.

3. Problem Statement

Students in higher education struggle with citation and reference formats. This makes it harder for them to interact with research, prevent plagiarism, and contribute to academic conversation. Traditional teaching techniques cannot address the variety of citation and reference types, making proficiency difficult. This poor teaching method can cause students to commit reference errors, which harm academic journals and raise expenses for publishers and universities. To address the complexity of referencing styles, educators should emphasise skills like as citation assistance and proofreading (Goodman et al, 2018; Kratochvíl et al, 2022; Rozell, 2022). In other circumstances, students only see reference modules in their first year, which is insufficient to develop and improve these abilities. North-West University (NWU) only teaches citation and reference in the first year (ALDE 111 and ALDE 121), and students first encounter it in their third year in a research methodology curriculum or module that needs a research report. The talent is still needed for postgraduate studies, but not all students have it because it's not part of their curriculum in other courses. These conditions highlight the need for new and interesting strategies to improve students' citation and reference abilities for academic success and postgraduate courses.

In addition to classroom education, an SG that clarifies and improves citation and reference methods may make learning fun and remembered. Integrating an SG into research-focused programmes allows students to effortlessly apply theoretical knowledge to practical situations, bridging the gap between abstract concepts and real-world applications. Since students actively participate in learning, this integration can also boost active learning. This engagement helps kids build problem-solving abilities by forcing them to think critically and find answers. This article suggests that strategically integrating SGs into research or other academic modules might increase students' research (citation and reference), critical thinking, and academic achievement (Ifenthaler and Yau, 2020).

4. Research Objective and Question

The objective of this research is to determine the best approaches to create and implement an SG to assist in learning citation- and referencing skills. The research question derived from that objective is "What are the most effective approaches for designing and implementing a SG to improve citation- and referencing skills among learners?"

5. Methodology

5.1 Educational Design and Design Science Research

The authors address the study question above by suggesting that project goals, context, and needs determine the appropriate SG design methodologies. Design science research (DSR) and instructional design are unique pedagogies. Their aims, techniques, and outcomes differ, although they have several traits (Fahd et al., 2021). Instructional design and DSR both promote problem-solving (Delaney, 2022). They examine and solve challenging educational issues. They aim to fix education. Second, both methods need iteration. Designers and researchers in these paradigms use feedback and assessment to refine ideas through iterative development (Ødegaard et al, 2021). Iteration promotes instructional flexibility. Educational design and DSR are interdisciplinary (Molle and Huang, 2021). Collaboration across education, instructional design, psychology, computer science, and other fields is common for these paradigms. Collaboration is essential to overcome complicated educational challenges. Educational design and DSR prioritise practicality and application (Han, 2022). They propose realistic, reasonable, and implementable ideas to enhance educational processes and outcomes using pragmatic educational practice. Combining education and research can improve results. Both approaches prioritise practical application, but their aims, techniques, and results differ. Educational design

focuses on successful learning experiences and products for varied educational contexts (McKenney and Reeves, 2018). It develops pedagogically sound courses, programmes, and material (McKenney and Reeves, 2021). DSR stresses practical application but also develops theoretical underpinnings (Vom Brocke, Hevner and Maedche, 2020). It creates and assesses new approaches, models, and frameworks to address educational difficulties and improve academic comprehension (Iivari, 2020). Thus, DSR integrates theory and practice (De Sordi, 2021). Educational design assesses learning outcomes (McKenney and Reeves, 2021). Formative evaluation improves design throughout development to achieve educational goals. DSR examines the theoretical and practical impacts of intentional artefacts beyond efficacy assessments (De Sordi, 2021). This multidimensional analysis shows artefacts' domain-wide consequences (Vom Brocke, Hevner and Maedche, 2020). The following were found based on each approach. Educational design that highlights pedagogical principles and learning objectives is essential for structured, successful SG education. However, DSR is effective when adopting a thorough and rigorous research technique to find a novel solution. Following features of these techniques support the claim: (i) DSR research solves educational problems and advances theory. DSR designs products and provides theoretical insights to increase academic comprehension. Educational design develops instructional materials, courses, and experiences for direct deployment in educational contexts to improve learning. Educational design improves learning with real products. (iii) Educational design and DSR share problem-solving, iterative methodologies, interdisciplinary cooperation, and practical emphasis, but their major goals, research-development balance, assessment focus, and outcomes differ.

Combining these two strategies requires choosing the most relevant characteristics. These methods may be combined with the agile design cycle's iterative and incremental reflections (Section 5.2) to create methodological variety and affect educational SG development.

5.2 Agile Iterative Design Reflection Cycle

Agile design, first employed in software development, is being applied in different sectors (Sutherland and Schwaber, 2010). The Agile Manifesto encourages flexibility, teamwork, and customer-centricity. Agile design involves cross-functional teams designing, building, and testing products or components in one- to four-week "sprints" or "iterations" (Sassa et al., 2023). Iterative design adaptation and modification based on end user or stakeholder feedback improves responsiveness to changing demands and market dynamics (Sassa et al., 2023). Agile design cycles encourage frequent communication, openness, and rapid MVP delivery, helping companies respond to changing consumer demands and competitive environments. Agile design works well for projects that need frequent input, fast prototyping, and flexibility to adapt to user needs and market conditions. This study advocates combining design methods to create a user-centered, technologically suitable, and purpose-driven SG (Figure 1).

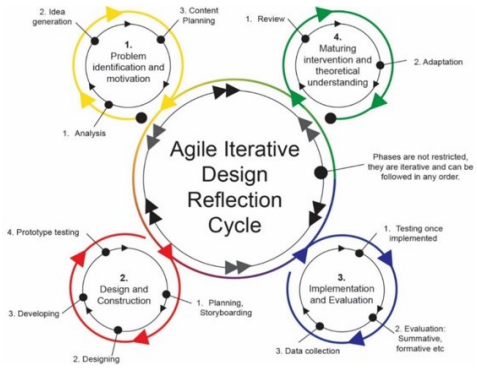


Figure 1: Methodological pluralism between educational design, DSR and agile design

(Source: Own research)

The authors used a mixed-method approach (methodological pluralism between educational design, DSR and agile design) (Figure 1) that encapsulate:

1. Educational design: Start by identifying the learning outcomes you want to achieve with the SG. Then, conceptualise and design the game mechanics and user interface to support these outcomes. This process should be iterative and involve prototyping and testing with users (Mor et al, 2015) at multiple stages of development.

2. DSR: Use DSR to develop new artefacts that can be used in the SG. For example, you could develop a new algorithm for generating game content or a new scoring system that incentivises certain behaviours in the game (Fahd et al, 2021).
3. Agile design: Use agile design to ensure that the development of the SG is collaborative in nature. This fosters a cooperative atmosphere between stakeholders and fosters an environment where the game is developed efficiently and team members work towards the same goals (Bunt, 2020).

6. Details of Agile Iterative Design Reflection Cycle for CiteSaga Serious Game

Effectively teaching citation needs detailed explanation and frequent rehearsal, which may be challenging and time-consuming (Andrianatos and Coetzee, 2023). The NWU Library in Potchefstroom, South Africa, started the Referella initiative to help students learn citations. An animated figure called Referella provides video courses on the university library website (Andrianatos and Coetzee, 2023). Referella assists students with Harvard, APA 7th edition, and footnote styles (Andrianatos and Coetzee, 2023). Thirty free Referella video tutorials on YouTube show how the developers evaluated and reframed the citation manual to make it more user-friendly and understandable (Andrianatos and Coetzee, 2023). Students can also take related quizzes (Andrianatos and Coetzee, 2023). The CiteSaga SG is a subproject of the Referella project. The following discussion covers CiteSaga SG's conception, design, and development. The SG development process iterated and incremented four phases (see Figure 1): problem identification and motivation, design and construction, implementation and evaluation, and maturing intervention and theoretical understanding. These phases are detailed below.

6.1 Phase 1: Problem Identification and Motivations

As with other problem-solving processes, several factors must be addressed before growth. These involve identifying and assessing the problem, producing and selecting solutions, and planning academic content for the answer. Phase 1 (Figure 1) shows several iterations of potential ideas until the most feasible and successful one is determined. We recognised the problem previously in the essay that higher education students fail to understand and use citation and reference styles. Academic writing follows rules like citations. This phase focuses on the stakeholders and target audience engaged in producing and assessing the SG, the learning results (matched with the curriculum and a roadmap for what the game seeks to accomplish), and the development outcomes (game design blueprint) needed to construct the SG. SG conversations and considerations should also include the resources (administration, finance, time, etc.) that would affect alternative solutions. Three NWU faculty members form the project's main development team. The stakeholder map below lists the stakeholders who should be involved in the development of an academic-related SG, along with their roles, activities, and specialisations (Table 1). These parties must collaborate to keep the game exciting, instructional, and produced and delivered.

Table 1: Serious game stakeholder roles, activities, and specialisations

Stakeholder(s)	Role	Activities	Specialisations
Educators	Content advisers	Curriculum alignment, learning objective definition	Subject matter expertise, pedagogy
Game designers	Game development	Concept design, rule creation, playtesting	Game design, mechanics, interaction
Graphic designers	Visual development	Artwork, component design, visual theme	Graphic design, illustration
Developers / Engineers	Production	Prototype creation, manufacturing coordination	Engineering, production
Project managers	Coordination & Planning	Timeline management, resource allocation	Project management, organisation
Students	End users	Playtesting, feedback provision	End-user experience
Investors	Financial support	Funding, investment oversight	Finance, investment
Publishers/ Distributors	Marketing & distribution	Marketing, sales, distribution	Marketing, sales, logistics
Regulatory bodies	Compliance oversight	Ensure compliance with educational standards	Educational regulations, standards
Accessibility experts	Accessibility guidance	Ensure the game is accessible to users	Accessibility design
Legal advisers	Legal oversight	Contracts, intellectual property, compliance	Legal regulations, contracts
Quality assurance	Testing & Quality control	Testing for quality and consistency	Quality control, testing

6.1.1 Learning and Development Outcomes

Most SGs are academic, therefore learning outcomes must be considered. The educational aims and learning results of SGs in an academic or instructional environment are their objectives (Fokides et al., 2019). These

objectives are tailored to the target audience's educational requirements and the content (Dimitriadou et al., 2021). Traditional games focus on amusement, whereas SG emphasises learning, skills, and attitudes (Altomari, Altomari and Iazzolino, 2023). Problem-solving, critical thinking, domain-specific knowledge, cooperation, and decision-making are common goals. Measurable and adaptable SG objectives enable educators and instructional designers to evaluate game effectiveness and optimise learning experience (Perna, 2022; Correia and Simões-Marques, 2023). SG goals show how to use games' immersive and engaging characteristics to create meaningful and purposeful learning experiences (Escudeiro and Gouveia, 2023). CiteSaga's learning objectives emphasise academic writing, citation, and honesty, helping players understand citation and its complexities. Table 2 lists the game's learning goals.

Table 2: Learning objectives of CiteSaga

Learning objectives	Delineation
Recognising citation styles	Teach players how to identify and apply the rules of the three citation styles (Harvard, APA, and Footnote) in a variety of academic contexts.
Academic integrity promotion	Develop an understanding of plagiarism, proper attribution, and the ethical principles that guide academic writing.
Improving critical thinking skills	Improve players' ability to evaluate and synthesise information from a variety of sources while also recognising the relevance and credibility of academic literature.
Improving research capabilities	Improve players' skills in locating, interpreting, and using academic articles, as well as fostering effective research strategies and information literacy.
Promoting collaborative learning	Promote collaborative problem-solving and peer learning while also developing teamwork and communication skills in an academic setting.
Putting knowledge into action	Allow players to apply their theoretical knowledge of citation styles to real world academic articles, bridging the gap between theory and practice.
Encouraging self-assessment and reflection	Encourage self-assessment and continuous improvement in scholarly endeavours by facilitating reflection on players' academic writing skills.

Source: Own research

These learning objectives lay out a path for what the game aims to accomplish, which includes not only the technical aspects of citation but also the broader competencies that contribute to effective academic writing and ethical scholarship. CiteSaga also aims to achieve the following learning outcomes: (a) Improved knowledge of reference styles and citation styles; (b) Enhanced problem-solving and critical thinking skills related to citation challenges; and (c) Increased familiarity with academic resources and reference materials. Educators and developers who follow this blueprint are enabled to create an engaging and educationally meaningful experience by aligning the game's design, challenges, and interactions with these objectives. In order to achieve the SG goals and learning objectives, the following development objectives are established (Table 3).

Table 3: Conceptualising objectives for the development of *CiteSaga*

Development	Delineation
Vision alignment	This ensures that all team members, stakeholders, and potential collaborators understand the concept, mechanics, objectives, and overall vision of the game, therefore aligning everyone's efforts.
Planning & organisation	It functions as a development roadmap, detailing the game's components, rules, mechanics, and more, allowing for efficient planning and organisation.
Communication tool	The game design document (GDD) facilitates clear communication between team members and other stakeholders, such as investors, publishers or subject matter experts. It serves as a common reference point that everyone can refer to and edit.
Risk mitigation	By outlining the game's requirements and constraints in detail, the document aids in the early identification of potential risks and challenges, allowing for proactive solutions.
Educational alignment	The GDD ensures alignment with learning objectives, educational standards, and pedagogical approaches for an SG aimed at education. It serves as a guide to ensure that the game is not only engaging but also effective in meeting its educational objectives.
Resource allocation	It helps to estimate the budget, resources, and time required for development, facilitating informed decision-making and resource allocation.
Quality assurance	GDD helps maintain quality control throughout the development process by defining standards, rules, and objectives.
Research tool	Provides guidelines for playtesting and collecting feedback, ensuring that the game evolves to meet the expectations of the target audience.
Documentation & archiving	The GDD serves as a historical record of the game's development, preserving decisions, designs, and insights for future reference or for use in other projects.

Source: Own research

After determining the stakeholders that are involved in creating and evaluating the SG, creating a path that is aligned with the curriculum and that indicates what the game aims to accomplish (learning outcomes) and creating a blueprint of how the SG is going to be developed (development outcomes), the next phase is to design and construct the components of the SG board game.

6.2 Phase 2: Design and Construction

The design and construction of an SG board game start with planning the design and storyboarding to determine how the game is going to look (e.g. components, look and feel, game setting, etc.) and be played (e.g. gameplay, mechanics, rounds, etc.). This is followed by designing, developing, and prototype testing of everything to evaluate what works and how it needs to be changed. Like the other phases in the agile iterative design reflection cycle, this phase can be iterated multiple times until a final agreement or satisfaction has been reached (see Phase 2 as indicated in Figure 1).

6.2.1 Serious Game Components

SG components serve a fundamental purpose in facilitating effective and engaging learning experiences within educational contexts (Moizer et al, 2019; Fitzgerald and Ratcliffe, 2020). These components, such as game boards, tokens, cards, rules, play pieces, and digital interfaces, should be designed to support and drive the educational objectives of the game (Huang et al, 2021). They provide a tangible or virtual environment that immerses players in a specific learning context, making abstract concepts more concrete and relatable (Van Beek et al, 2022). Components can represent real world scenarios, challenges, and resources, therefore promoting experiential learning and problem-solving (Beatty, Chen and Klein, 2021). Additionally, game components can be used to structure the gameplay, guide player actions, and create opportunities for interaction and collaboration, fostering a dynamic learning process (Wang and Huang, 2021). In essence, the purpose of the SG components is to transform learning into an engaging, interactive, and memorable experience, reinforcing the acquisition of knowledge and skills while aligning with pedagogical goals (Lamrani and Abdelwahed, 2020). Researchers posit that their use is essential in leveraging the potential of SG as effective tools for education, training, and skill development across domains and disciplines (Mittal, Scholten and Kapelan, 2022).

6.2.2 Board Game Design

With the recent emergence of AI and AI-generated content, the design team made use of ChatGPT to generate names for characters, factions, and environments that fit the genre of the game. The designers also used *Fotor* an online AI text-to-image generator where you can choose the style of your images and give a description of the environment you want to generate. The designers used *Fotor* to generate character profiles and different environments in which the players can play the game (Figure 2).



Figure 2: Examples of AI-generated images using *Fotor* text-to-image generator

(Source: Own research)

By using AI to help with the design of the characters and environment allows for multiple iterations of the designs in a short period of time. This also excels in the development process and gives more time to develop other, sometimes more important, aspects that need attention.

6.2.3 Gameplay Mechanics

SG mechanics, which regulate a game's behaviour and structure, impact player engagement and instructional content (Pelser-Carstens, 2022; Correia and Simões-Marques, 2023). The game's mechanics are intentionally developed to meet instructional aims (Platz, Jüttler and Schumann, 2021). Scoring, feedback, resource management, decision-making, and riddles are SG mechanics (Akhtar et al., 2020). These mechanics are carefully interwoven into the game's design for balance and engagement (Jost and Divitini, 2021; Escudeiro and Campos, 2023). Aligning SG mechanics with instructional goals is purposeful (Krath, Schürmann and Von Korflesch, 2021). A scoring system can reinforce right responses and foster mastery, while feedback systems can give quick direction and enhance learning. Prioritisation and allocation may be taught, and decision-making can imitate real-world events that need critical thinking and problem-solving. Players may learn and improve by making challenges and puzzles more difficult. SG use these mechanics to create a structured, dynamic learning environment that promotes active engagement, skill development, and information retention (Pelser-Carstens and Matthew, 2023). SG gaming must be interesting and educationally purposeful, therefore mechanisms are crucial (Czauderna and Guardiola, 2019). To ensure that a serious board game meets educational goals, learning outcomes must be carefully considered throughout design and development (Jääskä, Aaltonen and Kujala, 2021). Designers start by defining clear and measurable learning outcomes based on the knowledge and skills they want players to learn, which guide the game's development (Jääskä, Aaltonen and Kujala, 2021). The game's content, mechanics, obstacles, and situations are then designed to target these learning goals (Neset et al., 2020; Checa, Miguel-Alonso and Bustillo, 2021). If the aim is to increase citation and reference problem-solving, the game may include challenges that require players to accurately recognise and apply citation styles in diverse contexts (Zhang and Lu, 2021). The game progression system scaffolds learning by increasing complexity to help players learn (Plass and Pawar, 2020). The game's design and development incorporate learning objectives to provide a purposeful and engaging learning experience that motivates and entertains players (Jayalath & Esichaikul, 2022).

6.3 Phase 3: Implementation and Evaluation

After planning, designing, and developing the SG's objectives and components, the agile iterative design reflection cycle continues with combining and implementing all significant game elements into a prototype (see Phase 3 in Figure 1). To improve the SG till developers are pleased, this prototype must be tested and refined several times. In this phase, gather as much information as possible on gameplay, components, fun-factor, etc. Determine the game's flaws and what has to be changed to meet unmet learning objectives. Playtesting the game with a sample of the intended population is typical in SG development. Developers highlight issues during playtesting and ask players on what they liked or disliked. Before finalising or commercialising the game, concepts, mechanics, and gameplay may be tested in real life. Despite being the last, this step is crucial to SG growth.

6.4 Phase 4: Maturing Intervention and Theoretical Understanding

The fourth phase (Phase 4 in Figure 1) of the development process involves defined SG objectives and a thorough theoretical understanding of the key ideas and concepts. Based on the intervention aims and theoretical foundations, a high-level conceptual framework is created. Agile design techniques encourage iterative development, which requires a prototype to test conceptual design and theoretical understanding. The design is refined and iterated using playtest and user assessment input. User input is collected through regular testing and assessment, enabling design changes. After a satisfactory iteration, the SG is developed and deployed, with user feedback and intervention evolution informing improvements. SG designers use agile design concepts and a focus on intervention and theoretical comprehension to develop their designs and meet objectives and maximise learning outcomes.

7. Conclusion

In conclusion, the novelty of this work lies in its innovative integration of agile design principles with educational design and design science research (DSR) methodologies to develop a serious game (SG) specifically aimed at teaching citation and referencing styles. This unique combination ensures a dynamic and iterative development process, which is both user-centered and theoretically robust. Additionally, the rapid prototyping using AI tools, such as Fotor for character and environment generation, highlights a forward-thinking approach to educational

game design. This paper not only addresses a critical gap in current educational practices but also sets a precedent for the use of SGs to enhance academic writing skills.

Future research should extend into several key areas to fully realize the potential of the CiteSaga serious game. Firstly, a comprehensive evaluation of the game's impact on students' citation and referencing skills across diverse educational contexts is essential. This includes longitudinal studies to assess retention and application of these skills over time. Secondly, further development of AI-enhanced features within the game could explore adaptive learning pathways tailored to individual student's progress and learning styles. Thirdly, the scalability of the game for different academic disciplines and its integration with various educational technologies, such as Learning Management Systems (LMS), should be investigated. Finally, exploring the potential for multiplayer and collaborative features within the game could provide insights into peer learning dynamics and further enhance the educational experience. These research directions will not only validate the efficacy of CiteSaga but also contribute to the broader field of educational technology and serious games.

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The Ludo-Learning Matrix: A Framework for Understanding Learning in Games

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Abstract: Games have been widely recognized as methods of making learning more engaging. This has proven to be very attractive to those attempting to get complex fields such as cybersecurity training to a wider audience. Unfortunately, there is a failure to understand that each type of game serves a different educational purpose, leading to the situation where the games are being selected incorrectly and are failing to fulfill their promise. To address this issue, key concepts in learning and games were identified from the literature and then operationalized into an analytical framework. The concepts of player agency, message broadcasting, the transfer of learning and the type of challenges present in the game were selected. This generated a framework that is player-focused rather than content-focused and could be applied to any potential learning game. To validate the framework, three cybersecurity games were selected and analyzed using a ludo-textual approach. *Cyberciege*, a single player game aimed at university students, *Spoofy*, a kids' web browser game and *Tallinn Soldier*, a seminar wargame, were selected to give as wide a sample as possible. The paper goes on to report on the results of the analysis and discuss how this may be used to examine and design learning games for cybersecurity in the future. Each of the selected games focus on different mechanisms for learning and engagement, highlighting the design tradeoffs that were made in the creation of the game. The proposed analytical framework can be applied not just to cybersecurity training games but theoretically to understanding any game that has learning as its objective.

1. Introduction

Complex fields like cybersecurity exist between multiple domains requiring not just technical training and skills but an understanding of how humans leverage these technologies for illicit purposes. In addition, with the wide range of people using the internet for everyday life, an understanding of the principles of cybersecurity has become essential. The combination of a complex subject area and heterogenous population has led to concerns about making sure that the education is engaging. Game based learning has been seen as a possible solution (Jin et al., 2018). It is hoped that the use of game-based learning methods will help to increase the engagement with and interaction between the students and the subject matter.

However, selecting games, as with selecting any content, to include in education is a difficult process. A incorrectly selected game may lead to the player internalizing incorrect assumptions or procedures. This can occur because not all games map to the same intended learning outcomes. While the focus of the content area may be the same for multiple games, the approach to learning that they take varies dramatically. This leaves an educator in the unenviable position of not knowing how to select the correct game for their context.

Existing frameworks tend to be focused on the learning content of the games. In many regards they see games as the delivery system for knowledge similar to how Clark viewed media for the purpose of education (Kozma, 1994). These frameworks to select and design games for learning often borrow heavily from instructional design frameworks such as A.D.D.I.E. (Drljača et al., 2017). This produces a very instructor-centric form of design, which may fail to understand what is engaging for the end user in the first place.

Katrin Becker provides her magic bullet model. It focuses on what must be learned to engage with the game, what can be learned through engaging and what external support is needed for the game (Becker, 2017). While this provides a useful method to analyse and understand a game, it ignores the action that the player is going to take in the game and underplays the different pathways that knowledge can be acquired through.

The research into how games promote learning and engagement, however, tends to be highly theoretical and as such not actionable. Gee (2007) proposes 36 learning principles that are embedded in games. Garris et al., (2002) identified 39 different game elements which were condensed to 18 different elements that were mapped to learning by Wilson et al. (Bedwell et al., 2012). Unfortunately, the sheer number of elements in these works make the production of an actionable mental model to understand how a game is promoting learning next to impossible.

This lack of clarity also produces problems for learning game designers. Without a clear mental model of how games are engaging the player in learning, it is difficult if not impossible to design a game to reach a specific objective. Equally, efforts to build off of preexisting games and to repurpose them are hampered by not having

a clear idea of the game from the players' perspective. This leads to situations where every designer is in effect designing in isolation and having to rely on just personal experience in design.

The validity of any framework is another consideration. The model must be capable of differentiating between the learning happening in a wide variety of games, even if they are in a similar genre or content area. The best way to ensure that any framework is valid and robust is to test it against actual games using a ludo-textual analysis (Booth, 2021).

This paper proposes a simple and robust matrix for the analysis and design of learning games. It identifies four key concepts taken from both educational theory and game design and operationalises them. It then shows through a ludo-textual analysis of three games from the same content area how the framework can highlight the different design decisions that have been made.

2. Methodology

Four key concepts found in both learning and games were selected from the literature. A discussion of why each concept was selected is included in the appropriate description in the results. The selection process was described in Callaghan (2022). The key concepts were: 1) the transfer of knowledge, 2) the type of challenge present, 3) the level of agency the player experiences and 4) the type of message being broadcast by the game. Each of these elements was found to have two sub-components, leading to eight operationalised questions to produce the Ludo-Learning Matrix (presented in Table 1).

To keep the matrix at a usable size, certain concepts had to be excluded from the framework. In general, elements were excluded for one of two reasons. One reason is that some elements focused too much on the content of the game rather than on what the player was engaging with. For this reason, elements such as Fantasy, Mystery and Surprise as found in Bedwell (2012) and mirrored in Malone (1981) were excluded. The second reason was that they were already being covered by the proposed labels. For this reason, concepts such as Flow (Csikszentmihalyi, 1991) and the Zone of Proximal Development (Vygotskii & Vygotskiæi, 2012) were rejected as discrete labels, since they were represented in the conceptualization of challenge (Denisova et al., 2020).

To validate the proposed matrix, a ludo-textual analysis, as outlined by Booth (Booth, 2021), was performed. Three games all from the content area of cybersecurity were selected to see if the framework could be used to examine the differences in approach used by their designers. Each game was played multiple times by the author and, in the case of *Tallinn Soldier*, a selection of Master's students in Learning Game Design. Data was captured using video recording and the think-aloud method, as well as notes taken during and after play. The metatextual elements around the game were also explored to ensure thorough understanding of the games and their principles.

2.1 Selection of Games for Analysis

The first criterion for selection was that the game was designed as a serious game: this excluded commercial off the shelf games from this current work. The next criterion for selection was availability: games like *Anti Phisihing Phill (Online Game Helps People Recognize Internet Scams, n.d.)* were rejected due to the cost of their license, and other games that were identified in the literature had to be excluded because copies of the game were not available. Finally, it was decided that as wide a sample of games as possible should be selected in terms of genre, target audience and themes. Three games—*Cyberciege*, *Spoofy* and *Tallinn Soldier*—were selected.

2.2 Cyberciege https://nps.edu/web/c3o/cyberciege

Cyberciege is a workplace simulator, which asks the player to take the role of an executive in charge of the cybersecurity of a small to medium enterprise. The player must decide how to spend resources (money and work tasks) to secure the network and prevent intrusions. It is aimed at an audience of university level students and includes a full 3D environmental representation.

2.3 *Spoofy* https://spoofy.ee/en

Spoofy is a point and click adventure game. The player is trying to gather the components of a spaceship that have been mysteriously scattered across several levels. They do this by interacting with the non-player characters and helping them to solve problems related to the issues around cybersecurity. The audience for this

game is primary school-aged children and the art style is a 2D cartoon style. Originally, there were four levels that a player could play, with a fifth level released in October 2023 (post the study).

2.4 Tallinn Soldier

Tallinn Soldier is an analog seminar-style wargame taken from the Handbook of Cybersecurity Wargaming (Curry & Drage, 2020). It is designed for a group of between 4 and 6 players. Players are presented with printed role cards of the character that they are playing and are then briefed on the situation that is occurring. Players discuss how they would handle the situation and come to an agreement on their course of action. After this, an escalation of the situation occurs and the players must respond again. This game was developed for university level or higher players and is focused on replaying the real-life events of the Bronze Night in 2007 in Estonia.

3. Results

The next sections provide an overview of how the framework was created (3.1) and the analysis of the games using the framework (3.2).

3.1 Transfer of Knowledge

For learning to occur, information must pass from one area to another. The recipient of the information should engage with it actively to help to retain it and to make it actionable. There are many forms of transfer identified in the literature, including positive and negative transfer (Baldwin & Ford, 1988), general and specific transfer (Gick & Holyoak 1987) and horizontal and vertical transfer (Patrick, 1992). It was decided to focus on the low road and high road transfer identified by Salomon & Perkins (1992) and that of far and near transfer as outlined by Ericsson (2010)

Low road transfer is when the context of use closely matches the designed transfer tool. This allows the player to practice for events that may happen in that context in a safe and controlled environment. It also allows for the automatic use of knowledge or skills in the new context.

Similarly, in near transfer the initial learning task is kept as similar as possible to the task to be learned. Examples of these styles of transfer in games are typified by the simulations, especially high end flight simulators.

The key element for near and low road transfer is fidelity of the training to the context of use. In the Ludo-Learning Matrix, this was operationalized into the question: “How closely does the game attempt to reflect reality?”

Far transfer, on the other hand, is where the initial task used to create the learning varies dramatically from the context in which that learning is going to be applied. This meshes well with the concept of high road transfer, which requires the player to make connections between the material that they are being presented with and their experiences of the real world. It requires an active reflective or discussion component for learning to occur. It is not as context-bound in that it is seeking to make connections across context boundaries. This type of learning tends to be more social in nature and practices softer skills.

This was operationalized into: “How much does the game require reflection on the world outside the game?”

3.2 Challenge

“The essence of gameplay is the challenge/action relationship” (Adams 2010).

Challenge has been seen as a primary component of games by many authors, with some going so far as to argue that it is the thing that makes a game a game (Adams 2010.). The challenges tend to map to the cognitive, affective and psychomotor domains of learning.

To operationalize the concept of challenge in games, the study drew on the CORGIS questionnaire on perceived challenge in games (Denisova et al., 2020). It defines four separate types of perceived challenges: 1. cognitive challenge, 2. emotional challenge, 3. performative challenge and 4. decision-making challenge. The concepts of decision-making and emotional challenges were excluded from the operationalization as it mapped very closely to the concept of agency, which was already being included in the framework (as discussed below).

A performative challenge is one which occurs when a game requires rapid and accurate action from the player (Denisova et al., 2020). This was seen as synonymous with twitch reactions and as complementary to the concepts of near and low road transfer.

This was operationalized into: "How much does the game rely on quick decision making?"

A cognitive challenge is when a game requires forward planning, preparation and multitasking. This can be likened to the cognitive load that a player experiences during play. It is also more likely to focus the game on strategic decision-making processes and contemplation in contrast to the quick accuracy required in performative challenges.

This was operationalized into: "How much strategizing is required in playing the game?"

3.3 Messaging

Games are inherently a communicative act. How they differ from other media, however, is that there are two modalities for this communication. Like books and televised media, the messaging can be explicitly encoded. Namely, the message from the sender is made as clear and upfront as possible to prevent polysemy (multiple meanings) and what Eco defines as aberrant decoding from taking place (Munteanu, 2012). This is very similar to the process in instructional design where the intended message or lesson is the end point of the experience. However, as Bogost has pointed out, games also contain a more subtle method of encoding messages through their procedural rhetoric (Bogost, 2007). This is the message that is encoded and transmitted by the way of the game mechanics or how the player interacts with the game artifact. For example, in the *Civilization* series, the mechanics of researching new technologies carries the implicit message that advancement is inherently tied to technological progress and that that progress is linear. It also could be seen as justifying the taking over of less technologically advanced peoples in the name of helping them progress. Procedural rhetoric is a form of encoding that is much more subtle and open to both polysemy and aberrant decoding.

The interplay between these two forms of messaging is complex and interrelated and, in cases one of the two encoding methods, may drown out the messages of the other. An example of this can be seen in the Gundam effect, named after the popular Japanese transmedia franchise, where the softer implicit message of war is bad (a major theme in all the incarnations of the franchise) is being drowned out by the message that giant robots are cool. This can also be seen in games which attempt to promote peace while still making violence appear fun (Dyer-Witheford & De Peuter, 2009).

This can therefore be operationalized into two separate features:

1. Is there an explicit message being promoted by the game? (Explicit messaging)
2. What if any implicit message is being encoded by the procedural rhetoric or rules of the game? (Implicit messaging)

3.4 Agency

Agency can be defined as "the capacity of actors to make practical and normative judgments among alternative possible trajectories of action, in response to the emerging demands, dilemmas, and ambiguities of presently evolving situations." (Emirbayer and Mische, 1998, p. 971)

Agency as a concept in games is similar to the use of autonomy as a component of intrinsic motivation as outlined by self-determination theory (Ryan et al., 2006). When a player has no means of influencing the outcome of a game or becomes aware that the choices that they have are devoid of meaning, the player will disengage. This makes agency an important element of games for teaching, as they are attempting to increase not decrease engagement. Multiple outcomes of the game state will increase the sense of agency, while, conversely, fixed endings decrease the sense of agency.

There are some games which have a fixed outcome or binary outcome that are still engaging in play. Take, for example, chess, where there are only three outcomes: win, lose or draw. However, in the case of chess, the agency is located in how the player chooses to attempt to reach those end conditions. The problem with chess is if a naive player is engaging with a grandmaster, the outcome collapses to a certainty. As the player becomes aware that the ending is preordained, agency falls off, culminating in the old question: why should I bother to play if there is no way for me to win?

This concept can be operationalized into two factors:

1. "Does the game allow for multiple potential endings?" (Agency Choice)
2. "Is the ending balanced between being too predictable or completely random?" (Agency Prediction)

Table 1: Outlines the concepts that make up the framework: a pair of factors for each of the four components.

	Concept	Description	Operationalization
Agency	Choice	The ability of the player to make choices that will impact the outcome of the game.	Does the game allow multiple potential endings that are achievable based on player choices?
	Prediction	The ability of a player to make informed predictions about the value of actions that they are taking while not being certain of the outcome of those actions during play.	Is the player aware of the outcome of the game during play before the outcome is reached?
Messaging	Explicit Message Broadcast	How the designer is encoding explicit messages that the game contains.	What if any message is explicitly stated in the game?
	Implicit message broadcast	How the game mechanics and paratextual elements carry a meaning in the game.	What if any message is being transmitted by how the game is being played?
Transfer of knowledge	Near/low road transfer	The skill and knowledge being transferred is context-bound. The situation in which they are trained is close or nearly identical to the context in which they are to be used. Focused on automaticity of skill use.	How closely does the context of the game mirror reality?
	Far/high road transfer	More context-independent. Relies on the reconceptualization of pre-existing knowledge to the new context in which the skills are to be used.	How much reflection or re-contextualisation is necessary inside the game?
Challenge	Performative challenge	Challenges that require accuracy and speed, often emphasizing fluency of play over thought.	How much does the game rely on quick decision-making?
	Cognitive Challenge	Challenges that require careful thought and consideration while balancing several demands.	How much strategizing is required in playing the game?

3.5 Ludo-textual Analysis

3.5.1 General Comments

The results of the ludo-textual analysis are summarized in Table 2. As expected from the different styles of the games, each displayed different results from the analysis. Some of the variables emerged as co-occurring. For example, games with low agency coincided with games that had stronger explicit messaging; conversely, games with a higher agency had more implicit messaging present. Cognitive challenges were more prominent in games that were attempting high road transfer, while performative challenges were more likely to be linked to efforts at low road transfer. Future work will be needed to establish if these co-occurrences are consistent across a wider variety of games.

Cyberciege: Of the three games, *Cyberciege* was the one which made the most effort to reflect reality. Its setting helped to situate the player in a believable context. It also displayed the most player agency of the games in that it was possible to make the "wrong" decisions. Possibly as a result of this, the level of explicit messaging was low inside the game. It required players to make timely decisions about the spending of resources, and during play there were few opportunities for strategic planning as the events unfolded, throwing up new challenges.

Spoofy: As a point and click adventure, *Spoofy* had an implicit prosocial message that problems can be solved through engaging with the people around you. Its level of agency was more limited than *Cyberciege* in that the player could only choose in which order to engage with the puzzles presented (who do I want to talk to first), but ultimately had to complete all the puzzles to finish the level. Also, the game has only two possible

outcomes—either the player completes the game or they abandon it—thus limiting the agency of the game. To create more of a sense of player agency, the game offers a rewards system of unlocking cosmetic items: hats for the characters to wear in and pets that could be kept in the loading screen area. However, this was separate from the main game and had no effect on its progression. The challenges in the game were more cognitive in nature, as they involved reading and engaging in the story with a high level of reflection on how these events may be similar to personal experiences.

Tallinn Soldier: As opposed to the other two games, *Tallinn Soldier* has a distinct explicit message, which is covered in the historical postscript of the game. The explicit message is that the Bronze Night of 2007 was an unexpected and major defining moment in the history of cybersecurity and cyberwarfare, comparable to watching the nuclear bomb explode in Hiroshima. It also implies that the creation of the NATO Cooperative Cyber Defence Center of Excellence (which is based in Tallinn) was in response to the attacks. *Tallinn Soldier* has the lowest level of player agency out of the three games: the decisions that the player makes have no impact on the outcome of the game or on what is presented next. During playtesting, players quickly realized this and started to pull back from engaging with the game. In terms of challenge, the game is all cognitive challenge, with the essence being the debate between players on what actions to take.

Table 2: Provides an overview of the results of the ludotextual analysis

	Transfer		Challenge		Agency		Message	
	Near low road	**Far High road**	**Performative**	**Cognitive**	**Choice**	**Prediction**	**Explicit**	**Implicit**
Instrumentalised	How close to reality?	How much reflection is required?	How much does it rely on speed and accuracy?	How much strategic planning is needed?	Are there multiple end states reachable by player choice?	Is the game solved or the outcome fixed?	What if any explicit message does the game contain?	What if any message is being transmitted via the mechanics of the game
Game Name								
Cyberciege	Very close to reality. Attempts to make the office environment believable.	Not during game play	Selecting the correct priority and spending resources on it in a timely manner is the essence of the game.	Seems to focus more on doing actions then in long term planning.	Yes. Player choices have direct and measurable impact on the resolution	Obfuscated by the coding	No direct explicit measaging.	You must spend resources to secure a network. The weakest link in a network are the people. You will only get feedback if you get it wrong.
Spoofy	Abstracted to a cartoon world to suit audience	Encourages players to examine situations from own experience	Encourages players to examine situations from own experience	Some planning as there are multiple steps to solve the presented problems	Limited to a binary state. Completed or given up on	Fixed outcome by the nature of the game	No explicit	Prosocial implicit messaging. Problems are solved through communication
Tallinn soldier	Very abstracted from reality	An essential aspect of play.	Accuracy takes second place to discussion	Discussion and debate as the key mode of play. Requires information from outside of the game world	No. fixed beginning and end point player actions have no ability to shape outcome	Readily transparent to the player after turn 2	Explicit messaging contained in debrief section of the game outlining the historic basis for the scenario	Low implicit messaging. Possibly communication as the key to dealing with a crisis.

4. Conclusion

The proposed Ludo-Learning Matrix offers utility to both teachers seeking to use game-based learning and for designers of those learning games. It offers a series of questions that a teacher must engage with before selecting the game for the context. For designers it provides them with insights about how to conceptualize their games before production or how existing games can be used as inspiration for the design of new novel products.

For teachers they must examine the intended learning outcomes of the lesson that the game is supporting. In the area of transfer, it is important to consider if these outcomes require a space to practice discrete skills? Or is it more important to engage the students in discussion? As these two methods require different design decisions in the game. The type of challenge that the teacher is seeking to give their student goes hand in hand with the transfer of knowledge. Physical challenges that require quick responses map to low road transfer. In contrast the more cognitive the challenge the closer it maps to highroad transfer considerations.

In addition, sometimes the learning objectives only require a message to be broadcast. Examples like “Tree” (*TREE*, n.d.) or “One of them” (*One of Them by Pierrec*, n.d.) show that social messaging games do not require as much agency in the player. The purpose of these games can be seen to encourage empathy through a shared experience. However, this may reduce their re-playability or their ability to discuss more nuanced messages

Other times the most important aspect of the learning in the game is the agency and decision making that a student is making. This is especially important for low road transfer games where re-playability acts as reinforcement of the skills that are being practiced. When looking at reinforcement of learning agency becomes a key concept to consider in the selection of the game.

For designer they must ask themselves similar questions because there are different design constraints for each different type of learning game. Low road transfer games can be improved by the addition of stress and time constraints that are anathema to more discussion-based games. In addition, the higher the explicit messaging that is being used in the game the more important story decisions and game mechanic integration have to be considered so that they do not contradict the intended message.

This research presents the first steps in producing a new framework to analyze serious or learning games. As such further research with a wider selection of games will be needed to critically assess the proposed framework and to check its applicability to other fields.

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Empowering Neurodiverse Voices in Research Ethics through a Playful Card-Based Approach

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Abstract: Whenever carrying out research, all participants must know their rights, especially when those participants are perceived as being part of a vulnerable group; however, discussing ethics in investigation can be difficult. To solve this challenge, a playful approach was taken, as playfulness can make dull tasks – especially those that can cause discomfort and difficulties – more entertaining and help people approach them with an open mind. This study reports on four empirical approaches that used a playful process to raise awareness about ethical concerns when doing research with neurodiverse people. For this activity, 39 cards describing and illustrating several relevant and evidence-based ethical principles were created. Then, three case studies were developed, each based on a different focus group composed of ten neurodivergent self-advocates and one with professors and students from Brazil. Each neurodivergent group was also accompanied by three support workers from the partner associations (two of the groups were accompanied by the same individuals). In total, 56 participants engaged in a playful activity that consisted of a game of 'broken telephone' where the title of a card (representing an ethical principle) is read to one of the players who then has to whisper it to the next person in line, repeating this process until reaching the last person. The last person then says what they heard out loud, with the original message being revealed for contrast. The title of the cards was discussed by the groups to understand if it was clear and understandable or difficult and confusing. Although not all the cards were validated through the activity, 14 were flagged by neurodivergent people as "needing changes". The feedback was recorded and is presented here. This study set out to validate a set of cards in easy-to-read language that could introduce ethical concepts to participants in research projects through a playful activity. Future study will see the cards iterated upon through the feedback gathered along with the creation of a small guide on how they may be used in playful activities.

Keywords: Playfulness, Ethics, Neurodiverse People, Participatory Research, Card Games.

1. Introduction

Play is contextual and an expression of our individual and collective character (Sicart, 2017). As an indicator of well-being, play is fun (Bateson & Martin, 2013), and can be experienced outside of the game sphere, through a playful design of objects, actions, and personal experiences. Although playfulness "is the attitude of play without the activity" (Sicart, 2017, p. 21), such as a physical interaction, or a psychological, and emotional attitude toward a specific situation, playfulness can be also seen as a personality trait (Heljakka, 2023; Proyer et al., 2021). According to Proyer (2017), playfulness "allows people to frame or reframe everyday situations in a way such that they experience them as entertaining, and/or intellectually stimulating, and/or personally interesting" (p. 114), having a similar perspective, Barnett (2007) also states that playfulness is "the predisposition to frame (or reframe) a situation" (p. 955).

1.1 Playfulness in Adults

There are several approaches in the literature regarding playfulness, usually associated with children and their education, being seldom studied regarding adults (Fagundes and Menezes, 2021; Guitard et al., 2005; Jovanović, 2021; Leather et al., 2021; Shen et al., 2014), which lead to different conceptualisations or definitions of 'playfulness' (Guitard et al., 2005; Proyer and Wagner, 2015; Shen et al., 2014).

Studies have demonstrated that playfulness has had a comprehensive range of positive outcomes in adults (Proyer and Wagner, 2015) that are similar to those in children (Guitard et al., 2005). Some of these benefits are related to health and productivity indicators, job and academic performance, creativity, positive emotions, stress coping, interpersonal relationships, sense of humour and well-being (Barnett, 2007; Guitard et al., 2005; Leather et al., 2021; Pang and Proyer, 2018; Proyer et al., 2021; Shen et al., 2014).

Many studies involving game activities and mechanics (gamification) are more game-oriented and we want to dissociate from this analysis of playfulness. If we focus on product design, for instance, we see that many of the objects developed reflect the playful characteristic of the designer, a process of playful thinking, in which the form and function of the object are simply replaced by fun aesthetics. The “magic bunny” design by Alessi, is a clear example of when the “form follows fiction” (Legaard, 2020), validating that "the link of playful play to creativity and hence to innovation in humans is strong" (Bateson, 2014, p. 99). This playful play is outside the sphere of the game but within the realm of the creative process of playing with objects, processes, and ideas.

When using a playfulness approach with adults for learning purposes, we can take the case presented model of Nørgård et al. (2017) for a signature pedagogy in higher education that is constructed by three traits of teaching and learning, with a more gameful aspect: (1) the surface (game) structure, which encompasses the visible actions (e.g. game mechanics, adequate and flexible levels of challenge); (2) the deep (play) structure, relating with assumptions (e.g. collaboration, the conceptualisation of possibilities); but also with (3) the implicit (playful) structure, that corresponds to the values (e.g. accepting risk-taking and failure, internal motivation).

The last structure was constructed based on the theoretical lens of the magic circle that relates to playful learning (Nørgård et al., 2017). Simply put, the magic circle of play refers to the space where play happens, being outside reality and featuring its own rules (Huizinga, 1971). When applying the concept in the learning process, Whitton (2018) mentions that it is important to consider that the play space happens outside the real world constructed by the players and that it is safe, where the rules of the real world don’t necessarily apply - although they cannot be entirely forgotten as power relations and tensions are present. In this sense, Whitton (2018) identifies three pedagogical advantages for using playful learning approaches: “the positive construction of failure; support for learners to immerse themselves in the spirit of play; and the development of intrinsic motivation to engage with learning activities” (p. 3).

Playful activities help to create a safe space, but such does not happen immediately, players need time to construct it and develop trust and relationships with the rest of the players and teachers (Whitton, 2018).

Having these aspects in consideration, our main aim was to validate the ethics cards developed with neurodiverse people (PwID and autistic people) while at the same time raising awareness among them about ethical considerations that must be taken into account when participating in research.

Considering that the validation process and learning about ethics can cause emotions of boredom, we decided to take a playful (learning) approach to the activity by using the ‘Broken Telephone’ game mechanics to present the developed ethics cards. These cards are an easy-to-read version of the guidelines developed by Casimiro et al. (2023) surrounding the inclusion of PwID in research processes.

2. Methodology

2.1 Cards Development

The cards’ objective is to offer simple definitions of ethical concerns that should be acknowledged when conducting research with or about PwID. Their main goal is to be informative to this specific group about their rights and duties when participating in research, considering that many PwID have been research subjects many times throughout their lives while also being particularly uninformed about how this process is conducted compared to people without intellectual disability (McDonald et al., 2018). As a secondary objective, the cards have been designed to be easily manageable by facilitators who are not necessarily experts in the subject but want to conduct more inclusive research. This way, with minimal interaction with the cards, they can more easily understand their content and how to use them in a way that promotes the rights of PwID.

Initially, it was determined that the cards needed to include the following information: card title, explanation of the title, card code, ColorAdd code, card classification, illustrative image, QR code, financing agency’s logo, and the project reference. Some prototypes were made, until arriving at a layout for the card's front and back (Figure 1).



Figure 1: Beta version of a card's front and back layouts (The main title of the card in Portuguese language is "The final decision is always mine").

2.2 Participants

2.2.1 Study 1 - Portugal

In Portugal, the study was conducted in two different locations: APPACDM and CECD. In APPACDM, two groups of neurodivergent people participated. These consisted of nine (n = 9) and eight (n = 8) participants, respectively, and both were accompanied by the same three (n = 3) support workers (SW). In CECD, nine participants and three SW participated (n = 12). In total, the study in Portugal consisted of three sessions and a sample of 32 people (N = 32).

All neurodivergent participants were adults ranging from 19 to 54 years old (M = 29,23; SD = 8,69), of which seven were female (26,92%) and 19 were male (73,08%). Although SW participated in the activities, they were not the focus of this study, with data collection focusing on the neurodivergent participants.

2.2.2 Study 2 - Brazil

This study happened during two sessions, hosted by two Higher Education Institutions (HEI) in Rio de Janeiro, Brazil: first, at the Research Group of Identity and Teachers' Knowledge (GPIDOC), of the Higher Institute of Education of Rio de Janeiro (ISERJ) - free translation; and second, at the "Laboratory of Inclusion and Symbolic Mediation, development and learning" (LIMDA), from the Postgraduate Program in Education (PPGE) of the Federal University of Rio de Janeiro (UFRJ) - free translation.

The first was attended by 24 participants: 22 students in varying stages of their undergraduate degrees and two professors, all from the host institution (ISERJ). The second session was attended by one undergraduate student, one graduate student and one teacher from the host institution (UFRJ), and nine attendants from outside institutions, seven of which are postgraduate researchers, one professor and one industry expert, as demonstrated in Table 1.

Table 1: Specification of participants in Study 2

Title		Undergraduate	Graduate	Postgraduate	Professors
ISERJ	Host In.	22	–	–	2
	Outside In.	–	–	–	–
UFRJ	Host In.	1	–	1	1

Title		Undergraduate	Graduate	Postgraduate	Professors
	Outside In.	–	1	7	1
Total		23	1	8	4

3. Procedure

3.1 Study 1 - Portugal

For each of the three sessions (two at APPACDM and one at CECD), neurodivergent people, along with the accompanying SW, gathered in the same room to be part of the activities. For the introduction, each moderator introduced themselves to the participants, with one of them explaining the research project's goals and the participants' roles as valuable contributors to the research. Once this introduction was finished, an icebreaker activity was conducted to incentivise interaction between moderators and neurodivergent people - also fostering interaction between themselves. After this activity, the moderating team introduced the ethics cards, explaining their general purpose and the activities that would be conducted with them. These activities were made to generate opportunities for participants to engage with the contents of the cards in a more playful context, making them more accessible and less daunting. The two activities were:

- **Broken Telephone Game:** A card was given to one of the participants who then had to whisper its title to the person sitting next to them. Once this was done, each participant had to whisper it to the next person in line, continuing in succession until reaching the last person in the group who would then have to say the supposed title of the card out loud. If any participant expressed difficulty in communicating their message, one of the moderators would provide support. After hearing the final result, the actual title of the card was revealed, with the participants and the moderators discussing its meaning.
- **Debating the Cards:** The participants received cards and read them to the rest of the group. Then, moderators encouraged the participants to debate the meaning of the card and attempt to come up with examples of how the guideline could be applied. The goal was for participants to discuss - and for the moderators to assess - how clear the meaning of the card was and how they thought it could be improved.

Throughout the sessions, the activities were adapted to tackle participants' needs and behaviour – such as speech impediments, illiteracy, etc. After conducting the activities, participants were asked what they enjoyed about them and what they thought could be improved - drawing attention back to the cards to see if there was any additional feedback the participants might want to give.

3.1.1 Revision of the Cards

Based on the feedback received during the three initial sessions, some of the titles and descriptions of the cards were edited to be more straightforward, switching some words to more common and simpler synonyms. It was also noted that some more complex words, such as "adaptations", were easier to understand than the research team expected. It was later discussed with the SW from APPACDM that this word, although a little bit more complex than their usual lexicon, was part of their day-to-day lives, especially during discussions about Individualised Education Plans.

This demonstrates that, while it is important to avoid needlessly complicated and uncommon words, we must also recognize that new and more specific words can and should be introduced to neurodiverse people, given the appropriate context, because they can make them better informed. In this specific scenario, the alternative word "change" does not carry the same subjective meaning of "adaptation", and, therefore, would result in them not being as informed as they should be.

Moreover, it was also noted that the participants chose cards mostly based on the colour of their favourite football team, which deviated from the intended purpose of the colour-coding of the cards and led the team to question how the colours were impacting the participants' contact with the varied types of concepts being introduced.

Lastly, we also observed that the explanation of the title on the front of the card sometimes led to confusion: literate participants were unsure whether to just read the title of the card or to also read the text. Upon review,

we also came to realise that the text offered an unnecessary cognitive load to all the steps of the activity and that by moving it to the verse of the card it would still be accessed when participants or facilitators chose to do so.

Considering the previous reasonings, the cards' content was re-evaluated with the intent of minimising cognitive load (removing elements that did not help conduct the activities at hand) and more explicitly separating the contents for participants to interact with (in the front) from the contents meant for facilitators to consult upon (in the back), as demonstrated in Figure 3.

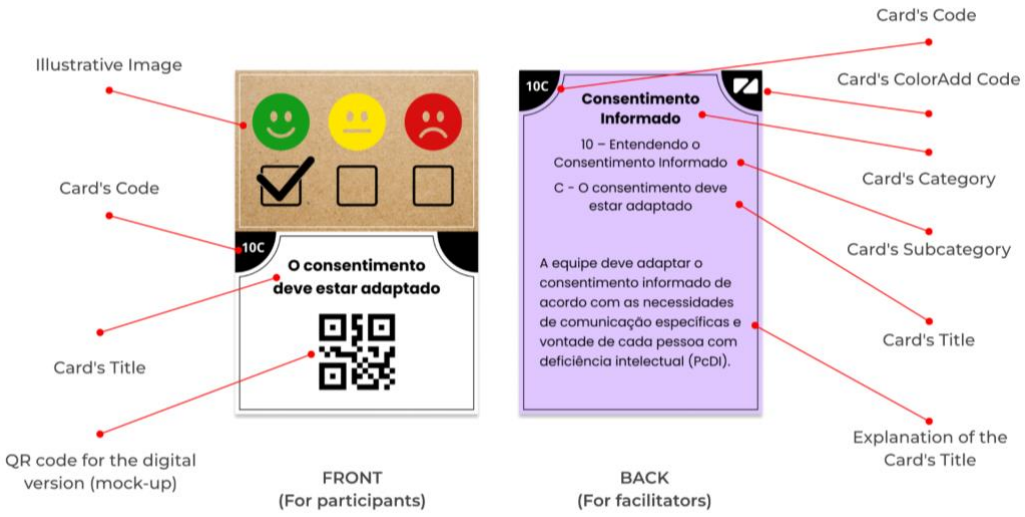


Figure 2: Example of a Card's front and back, with pointers to what's included in it.

3.2 Study 2 - Brazil

After the initial testing of the Ethics Cards with their target audience, we conducted further validations of the cards, this time among peers, during two sessions in two different host institutions: ISERJ and UFRJ. These institutions were selected due to being HEI with dedicated Departments, Postgraduate Programs and Study Groups involved in the research of education, having a particular focus on inclusivity and diversity. Both sessions consisted of the following schedule:

- 30-minute presentation of the GameIN Project, detailing the process behind the development of the Ethics Cards.
- 45–60-minute activity, during which participants formed groups of 4–6 participants, received a corresponding part of the Ethics Cards and needed to select one of them to be used as a guideline to adapt a project, service or activity of their choice, for it to be more inclusive towards PwID.
- 15–30-minute feedback session, during which all participants could ask questions and provide opinions to further develop the cards.

Each group was asked to write a proposal for their project adaptation, addressing which card they selected (and why), what project they selected, and the adaptations they proposed. All groups then presented their projects to the other groups, who then had the opportunity to offer feedback and commentary.

4. Results

4.1 Study 1 - Portugal

4.1.1 APPACDM (Session A)

As the broken phone activity was being presented at the start of the session, one of the participants informed the moderators that they were hard of hearing, giving them the opportunity to adapt the game to their needs. For this, the support workers sat next to two specific participants to facilitate their participation. This layout remained for the rest of the session.

One of the moderators only participated at the start of each round, either reading the card to the first participant or showing it to them so they could say it to the next participant in line. The participants seemed to be enjoying

themselves throughout the activity, interacting with each other and being amused by how different - and 'broken' - the final message was. The moderators believe there is the possibility that some participants were purposefully changing the message to a more humorous one; however, this was not seen as a complete negative as it contributed to the participants' enjoyment of the activity. Regarding the message of the cards, some participants had difficulty understanding the full meaning of the guidelines described in them and gave suggestions on what words to use to make them easier to understand.

During the feedback activity, four specific participants gave most of the comments. Nonetheless, other participants would also make statements that demonstrated that they understood the meaning of the message. When asked what was their favourite part of the session, most participants named the broken telephone activity.

4.1.2 APPACDM (Session B)

This session was affected by the participants being seemingly tired from the offset of the session, with one eventually asking to leave the session to rest and another falling asleep during the session itself, but that had chosen to stay. It is possible that this affected their performance during the activity, even though they stated that they enjoyed it. Same as the previous session, the SW were asked to sit beside the neurodivergent participants who might need more support to participate - one of these was a participant who informed a moderator that they were illiterate.

The participants seemed to have enjoyed the broken phone activity. When discussing the meaning of the cards, one participant, in particular, monopolised the discussion, also discussing them with the moderators and the SW; a significant part of the other participants specifically waited for moderators to ask them directly what they thought of the cards. The more active participant even offered themselves to explain the cards to the other participants, since most were having trouble understanding their meaning.

During the feedback activity, the participants would mostly state that they had no trouble understanding the cards while discussing them, though some would still only comment if explicitly asked to do so. Participants were equally split between which of the activities they enjoyed the most and if they would rather have played in smaller groups.

4.1.3 CECD

The SW were once again placed next to the participants who would have more difficulty in the activities - such as one illiterate participant. When the broken telephone activity was introduced they laughed together at the idea of what could be the final broken message.

As they played, they seemed to be in a good mood, entertaining each other by making exaggerated expressions when the message was passed onto them. Some of the neurodivergent participants also discussed the themes of the cards between themselves, at times discussing them with the moderators and the SW. The moderators, through their observations, suspect that some of them may have purposely changed the message to generate more humorous results, resulting in general laughter by the participants once they heard the final message; it was not possible to confirm this suspicion.

After some rounds, the participants were split into two groups playing the same broken phone activity. This appears to have also worked well, as participants had to wait less time for the message to reach them and some of them also enjoyed the added element of 'competition' as both groups tried to preserve the original message the most. Once the activity was completed, the moderators asked which of the versions they preferred the most, to which they generally answered the one where they all played together. Throughout the activity, on both variations, some of the neurodivergent participants would at times compliment each other for being able to pass the message to the next person in line.

During the feedback activity, some neurodivergent participants engaged in a discussion regarding how sometimes they are not treated as expressed in the cards. Others were reluctant to state that they did not fully understand the cards, but after being motivated by the moderators they would eventually express themselves. Once one of the moderators asked the neurodivergent participants to describe how they would explain the card to one of their friends, they began to open up more and talk to each other. Participants appeared to enjoy both activities.

4.2 Study 2 - Brazil

4.2.1 ISERJ and UFRJ

Both sessions consisted of a mixture of students and teachers from the host institution; however, at UFRJ, there were some outside participants, as well as a higher concentration of postgraduate participants.

These sessions intended to test whether the cards, as they were, acted as viable tools to be used by facilitators who wanted to conduct research activities in partnership with PwID. To assess if they achieved this goal, all participants were asked to respond to two questions: whether they learned something new about conducting research in partnership with PwID - of which most did (*n* = 35) and one did not (*n* = 1) -, and if they perceived the Ethics Cards as effective tools to facilitate activities in partnership with PwID - of which 28 said yes and eight said no.

5. Results and Discussion

Overall, in study one it was possible to see that the playful approach worked in terms of turning a task that could otherwise be boring into a more playful one. The participants, throughout the session, were engaged and liked the idea of the 'Broken Phone Game'. By implementing this strategy both groups of intervenients (research team and participants) could get to know and be familiar with each other. For instance, it was possible to note that there were several types of players: ones that liked to add a fun element to the game by inventing a new phrase and ones that liked to follow the rules.

Altogether, the participants from study one had a good time, were participative, gave their opinions and enjoyed the session. It was also noted that they preferred the game (the traditional version, not the competitive one) rather than just debating the cards.

Regarding the validation of the cards, based on the feedback received, it was concluded that the cards needed to be redesigned. Needing to be simpler on the front (for neurodivergent people) and save the more complete information for the back (for facilitators).

In this sense, the front will only have the illustrative image, the card's code and title, and the QR code (having eliminated the ColorAdd code and the explanation, and added the QR code). Additionally, it was also recommended to leave the background colour on the front of the card white, to help with readability. The back will have the card's code and ColorAdd code, the category, subcategory and title of the card, as well as its respective explanation (having eliminated the QR code, funding agency's logo and the project reference, and added the explanation of the card).

As for study 2, the validation of the cards among peers - professors and students - from Brazil, seemed to show that the cards taught them something new about doing research with PwID and that the cards were perceived as being an effective tool to help facilitate activities with PwID.

By validating with two different groups (neurodivergent people and peers) it was possible to understand if the cards could be useful for both, identifying their positive and negative aspects and their perceived effectiveness in the field.

6. Limitations and Future Directions

As learners need time to create space and to develop trust with the teachers, it is possible that because this session was made so early on in the project, the participants still needed to build a safe space or trust with the researchers. Additionally, due to their experiences with stigma, PwID typically avoid negative criticism (Esdale et al., 2015). Therefore, we noticed that the participants frequently responded, for example, 'No, everything is fine' when asked if they would change anything, although we noticed that they had some difficulties. Moreover, some only gave their opinion when directly asked so, in future studies, it should be considered how researchers might operationalise when such happens.

Considering this, we believe that the relationship established with the participants at a later stage of the project would produce different results.

Also, due to limitations of time, it was not possible to validate all 39 cards. Therefore, in the future, when all the cards are re-designed based on the feedback received, a new validation process is needed in which all cards must be included.

This activity aimed to validate the cards and assess how they could be more accessible for neurodivergent

people, not to assess if the approach implemented facilitated the learning process or if participants learned what was written in the cards. As such, future work could focus on the implementation of the cards with neurodiverse people, through the use of the 'Broken Phone Game' - or any other playful learning approach - and assess if it helped the learning process of this theme.

Lastly, it could also be helpful to translate and validate in other languages for a broader application and to understand how students perceive ethics and ethical research with PwID.

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谈判: Mega-games as Catalysts for Deep Experiential Learning in Higher Education

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Abstract: The study deepens into the transformative potential of mega-games as an innovative educational tool, offering profound and enriching learning experiences across diverse educational landscapes. Mega-games represent a fusion of various elements, including role-play, social interaction, simulations, rule-based systems, economic dynamics, political scenarios, and decision-making processes, all woven into an immersive narrative fabric. Through experiential learning, these games provide a unique platform for students to engage deeply with complex subject matter. This research centres on the application of mega-games within the context of sixth-semester students pursuing a degree in International Business at the Mexico State Campus of Tecnológico de Monterrey. Specifically, the study focuses on the simulation exercise titled 谈判 Tánpàn, which aims to immerse students in negotiation scenarios regarding the final price of a digital device manufactured in China. Drawing upon foundational principles outlined in Jesse Schell's book on game design, the exercise is meticulously designed to emulate real-world negotiation dynamics. The integration of game design principles, coupled with positive student feedback, underscores the efficacy of mega-games as potent educational instruments. Through rigorous analysis, the study unveils the profound impact of experiential learning on students' comprehension and application of negotiation techniques. By simulating authentic real-world scenarios, students are empowered to develop critical problem-solving acumen, hone their analytical thinking prowess, and refine their decision-making aptitude. Moreover, the immersive nature of mega-games fosters a dynamic learning environment that transcends traditional pedagogical approaches, fostering a holistic understanding of intricate subject matter. The success of the 谈判 Tánpàn simulation exercise serves as a testament to the potential of mega-games to revolutionize educational paradigms. It signals a burgeoning opportunity to expand the horizons of mega-games across various academic disciplines and participant cohorts. This study advocates for the widespread integration of mega-games as educational resources within Higher Education, championing their capacity to engender profound learning experiences and cultivate essential skills, heralding a new era of dynamic, immersive, and effective educational methodologies in diverse educational settings.

Keywords: Higher Education, Educational Innovation, Professional Education, Experiential Learning, Mega-Games, Negotiation Techniques.

1. Introduction

This study focuses on the design and implementation of a mega-game conducted with students from the International Business program, aiming to provide a transformative educational experience and overcome the limitations of traditional teaching methods. In this context, the goal was to offer students a clear understanding of complex concepts, especially at a crucial point in their career where they are beginning to enter the business world and require a solid knowledge of these concepts and their practical application in a formal environment.

The exercise, titled 谈判 Tánpàn (which translates to "negotiation" in Chinese), was specifically named to be easily pronounceable in various languages, making it both accessible and engaging for a global audience. This choice was intentional to ensure that the name resonated well with participants from different linguistic backgrounds, aligning with the exercise's goal of facilitating cross-cultural negotiation scenarios.

The exercise was carried out through the implementation of a mega-game specifically designed for this class, with the collaboration of the course instructor and a game creation expert. Twenty-one students participated, organized into seven teams of three members each, with specific roles assigned to each team member. The main objective of the mega-game was to negotiate the final price of a digital device (assumed to be a mobile phone) manufactured in China for the United States market.

The design of this mega-game was based on principles proposed by Jesse Schell in his book "The Art of Game Design: A Book of Lenses" (2019), focusing on an experiential learning approach. During the game, students had the opportunity to apply negotiation techniques and make strategic decisions in a simulated context, leading to a deeper and more practical understanding of the concepts addressed.

In this context, this study seeks to analyze the impact and results obtained from the implementation of this mega-game in the educational process of International Business students, highlighting its ability to provide

meaningful learning experiences and enhance the development of key skills in a dynamic and participatory learning environment.

2. Context

In the context of International Business studies in higher education (HE), it is paramount for students to learn practical and experiential negotiation skills in a language other than their mother tongue. This necessity arises from the widespread use of different languages in international negotiations, where effective communication can significantly impact the outcome of business transactions. The mega-game presented in this study is founded on the premise of financial mindset: "You don't get what you deserve, you get what you negotiate."

Understanding and mastering negotiation techniques in a foreign language not only enhances students' language proficiency but also equips them with essential skills for navigating diverse cultural and linguistic landscapes in the global business arena. In international business settings, negotiations often require individuals to communicate, bargain, and reach agreements in languages other than their native language, making proficiency in these languages a strategic asset.

Moreover, the mega-game served as a crucial component of the students' final assessment, blending experiential learning with practical application as a learning activity. By immersing students in simulated negotiation scenarios, the game provided a platform for them to practice and refine their negotiation skills, applying theoretical knowledge to real-world situations. This approach not only reinforced classroom learning but also instilled confidence and competence in navigating complex negotiation dynamics.

2.1 Traditional Teaching Methods and Mega-games

In traditional teaching methods, topics related to negotiation such as bargaining power, negotiation strategies and tactics, ethical dilemmas, strategic alliances, intercultural communication, cultural mapping, conflict management strategies and tactics, negotiator profiles, negotiation dilemmas, negotiation strategy, planning, and pricing (anchor, reservation, minimum, maximum, walk-away prices) are typically taught through theoretical lectures, and case studies. While these methods provide a theoretical understanding of negotiation concepts, they often fall short in delivering immersive and practical learning experiences that mirror real-world negotiation scenarios.

The problem addressed in this research revolves around the effectiveness of traditional teaching methods in conveying complex concepts to students about international negotiation within the context of the International Business program. Researchers aimed to overcome the limitations of traditional teaching by implementing a mega-game as a learning activity. The objective was to provide students with a hands-on experience and a deeper understanding of negotiation techniques through immersive and experiential learning.

Mega-games represent a novel and evolving concept in the world of gaming, combining elements from traditional board games, role-playing games, and simulations to create large-scale, immersive experiences. Unlike typical board games or simulations, mega-games involve a significantly larger number of participants, often ranging from 20 to over 100 players, each taking on unique roles within a complex, interactive environment.

At their core, mega-games are multi-faceted events where players engage in collaborative and competitive activities, usually over several hours. These games are designed to simulate complex scenarios, such as geopolitical conflicts, economic systems, or historical events. Each player or group of players is assigned a specific role with distinct objectives, powers, and resources, contributing to an overarching narrative that evolves based on collective and individual actions.

Like board games, mega-games utilize structured rules and objectives, providing a clear framework within which players operate. Both formats often involve strategic thinking, resource management, and decision-making. However, while board games typically accommodate two to ten players around a table, mega-games scale up dramatically, encompassing many more participants in a much larger space, sometimes even utilizing multiple rooms or areas.

Mega-games share similarities with simulations in that they both aim to replicate real-world scenarios and systems. Both formats involve participants taking on roles and making decisions based on their understanding of the scenario. However, simulations often prioritize accuracy and educational outcomes, closely mirroring real-world processes and outcomes. Mega-games, on the other hand, blend realism with gameplay elements to

ensure a dynamic and engaging experience. While educational goals can still be a focus, the emphasis on player interaction and narrative development sets mega-games apart.

What sets mega-games apart from other gaming formats is their scale and complexity. The involvement of dozens to hundreds of players introduces a level of unpredictability and interactivity that smaller games cannot achieve. The roles in mega-games are often asymmetrical, meaning different players have different levels of power, information, and objectives, creating a rich tapestry of interactions and negotiations.

Additionally, mega-games are highly adaptable and can be tailored to fit various themes and scenarios, from historical battles to futuristic political landscapes. This flexibility allows for a wide range of creative and educational applications, making them suitable for diverse audiences, including educational institutions, corporate training sessions, and enthusiast gaming communities.

Mega-games represent a unique and engaging form of entertainment that bridges the gap between board games, simulations, and large-scale interactive experiences. By combining elements of strategy, role-playing, and real-world simulation, they offer a robust platform for exploring complex scenarios in an immersive and collaborative environment. Understanding and appreciating the distinct qualities of mega-games can enhance their application and enjoyment, providing participants with a rich, memorable gaming experience.

2.2 Mega-games in HE

Mega-games represent a unique approach to learning within HE, blending elements from role-playing games, tabletop games, and war games into immersive simulations. These large-scale simulations typically involve 20 to 300 participants in a single session lasting several hours, where players assume specific roles with tailored missions. The participants engage in cooperative and competitive interactions to achieve their objectives.

Educationally, several mega-games have been developed with educational purposes in mind. For instance, Darren Green and Liz Cable (Wells, S., 2019) created a mega-game centered around the climate crisis and simulated negotiations between countries regarding carbon footprint reduction. Although this activity was not mandatory for a specific subject, it yielded valuable insights for both participants and organizers from diverse perspectives.

This article is grounded in the financial mindset premise: "You don't get what you deserve, you get what you negotiate." The exercise was integrated into students' final grades as a learning activity. Mega-games trace their origins back to war games played since the 1970s, with the mega-game format conceived by designers Passy Griffith and Jim Wallman (Iparraguirre, A., 2022).

Tánpàn’s game design allows students to engage with various aspects of international business, including market analysis, strategic planning, and decision-making under pressure. Utilizing the lenses from Jesse Schell's "The Art of Game Design: A Book of Lenses" (2019), the game's effectiveness is significantly enhanced.

The lens of curiosity drives players to explore the complex international business scenarios presented in Tánpàn, encouraging them to uncover various negotiation strategies and outcomes. This curiosity is closely linked with problem-solving, as players are required to address intricate problems related to market analysis and strategic planning, thus honing their critical thinking skills.

Games that offer intrinsic value provide players with satisfaction beyond external rewards, and Tánpàn achieves this by delivering educational value that intrinsically motivates students. By engaging with realistic business challenges, students see direct applications of their efforts, which further fuels their motivation. The introduction of novelty through new scenarios and challenges ensures that the game remains fresh and engaging, preventing monotony and promoting continuous learning.

Secrets within the game simulate real-world uncertainties, compelling players to think more strategically and explore deeper into the game’s mechanics. Goals are clearly defined for each session, giving players a sense of direction and purpose, crucial for maintaining engagement. Well-defined rules create a structured environment where students can apply their knowledge and strategies without ambiguity, while competition drives students to perform better, fostering a healthy competitive spirit that mirrors real-world business environments.

Cooperation is also emphasized, as players must work together to achieve common goals, reflecting the collaborative nature of international business. Effective reward systems provide positive reinforcement, encouraging students to apply themselves and recognize the value of their contributions. Constructive feedback

and penalties for poor decisions, as part of punishment, help students understand the consequences of their actions, promoting better decision-making skills.

The elegance of Tánpàn's design lies in its simplicity and depth, avoiding unnecessary complexity while providing a rich learning experience. Balance is maintained to ensure that all players, regardless of skill level, can engage meaningfully with the game, fostering an inclusive learning environment.

By incorporating these lenses, Tánpàn not only enhances students' understanding of international business but also provides an immersive and effective educational experience as a Mega-game (Schell, 2019).

Mega-games serve as more than just entertainment; they serve as effective educational tools. Examples of their application in HE include ALLIANCE, a political science simulation mega-game by Shawn Mcmillan (2015), and the game "VIRUS: Bunny Apocalypse" by Ted Castronova, both played in the United States. Additionally, Linköping University conducted a Climate Change mega-game in 2020 as part of an ongoing research project, engaging players in real-life experiences and role-play to stimulate discussions around the topic.

Despite limited research on mega-games in Mexico, previous exploration of gamification in various studies, particularly conference proceedings, has laid the groundwork for innovative learning experiences. National creations such as Robledo-Rella's (et al., 2017) Cocogame and González & Montalvo's (2018) BluRabbits internet-based platform have also contributed to diverse learning experiences among Tecnologico de Monterrey's undergraduate students.

A mega-game implemented into our educational context, was created by Martínez (et al., 2023) and documented in the study titled "Kuxtal: Student Motivation Through Mega-games in HE Design Students," presents a significant opportunity. This implementation, carried out at Tecnológico de Monterrey, yielded positive results, showcasing the potential of mega-games as engaging and effective tools for addressing complex challenges. By incorporating educational innovations that enhance student motivation and involvement, mega-games such as Kuxtal foster collaboration, critical and creative thinking, and practical actions among students, impacting their immediate academic contexts and fields of study. This successful case serves as an encouraging call to educators aiming to develop immersive learning experiences and innovative teaching methods that empower students to think critically, learn actively, and take meaningful actions. Additionally, the paper advocates for further exploration of mega-game design and integration in HE environments, particularly in programs that emphasize collaborative problem-solving and research participation.

Mega-games, characterized by their large-scale, interactive, and multi-faceted nature, have been increasingly recognized for their educational value in higher education. These games facilitate active learning by immersing students in complex scenarios that require strategic thinking, collaboration, and problem-solving.

谈判 Tánpàn was selected for this study because of its potential to simulate real-world negotiation scenarios within a controlled educational setting. The game's design allows students to engage with various aspects of international business, including market analysis, strategic planning, and decision-making under pressure.

2.3 INCOTERMS Meaning

"The INCOTERMS® are a set of eleven individual rules issued by the International Chamber of Commerce (ICC) which define the responsibilities of sellers and buyers for the sale of goods in international

3. Methodology

The experiential learning exercise, 谈判 Tánpàn, was implemented with a focus on providing students with practical experience in international trade negotiations. The game's structure is designed to mimic real-world trading conditions, requiring participants to navigate the complexities of market demand, cost management, and strategic alliances.

This research employed a qualitative approach, utilizing a semi-structured group interview as the data collection instrument with all students. The researchers conducted a mega-game simulation titled "谈判 Tánpàn" with a group of 21 students divided into seven teams of three members each. Each team member assumed a specific role: the manufacturer, the exporter, and the seller. The objective of the mega-game was to negotiate the final price of a digital device manufactured in China for the United States market.

Before the negotiation session, teams were given time to organize and decide their roles in the negotiation. Subsequently, each role was provided with exclusive relevant information for their position. Manufacturers received the information first, followed by exporters, and finally sellers. All negotiations were conducted in English, based on the rationale that despite being part of the International Business program, the students lacked confidence in using languages other than Spanish This approach was chosen to provide students with the opportunity to practice and improve their English communication skills in a professional context, which is crucial for their future careers in international business. Conducting negotiations in English with their peers facilitated the potential for negative experiences and embarrassment to be overcome as the exercise progressed, and students had one hour to reach an agreement.

The negotiation time allotted for students was one hour, after which each team would present their results to the mega-game facilitator. The best results among the three-member teams would receive the highest grades, emphasizing that adherence to the rules was crucial for evaluation.

Following the general activity presentation, the activity commenced, and exporters and sellers were instructed to leave the negotiation space. Manufacturers were then provided with the following instructions:

- The cost of materials and labor for each digital device was $400 USD.
- If more than 5,000 devices were manufactured, this cost would decrease to $250 USD per unit.
- If more than 10,000 devices were manufactured, this cost would further decrease to $220 USD per unit.

The manufacturer’s objective was to maximize profits.

Manufacturers were then excused, exporters were called back, and they were given the following instructions:

- The cost for exporting under INCOTERM 2020 DDP per device was $100 USD.
- Exporters aimed to achieve profitability that was double their cost.

Finally, exporters were excused, sellers were called back, and they were provided with the following information:

- They had a capital of $5 million to purchase digital devices.
- The projected demand was approximately 8,000 units.
- They had to negotiate the quantity of units to purchase, considering that the maximum market value per unit was $650 USD.
- The cost of sales per unit was $25 USD.
- If they managed to have two more sellers within their team, their cost increased to $28 USD but generated a sales reach of 10,000 units.

This research employed a qualitative approach, utilizing a semi-structured group interview as the data collection instrument with all students. The interviews were recorded to ensure accuracy in capturing the students' responses and to facilitate detailed analysis.

The group interviews were conducted immediately after the mega-game session, allowing students to reflect on their experiences and insights while they were still fresh.

The interviews were transcribed verbatim, and the data was analysed using thematic analysis. This involved coding the data to identify key themes and patterns related to the students' experiences and the effectiveness of the mega-game as an educational tool. The thematic analysis enabled us to draw meaningful conclusions about the students' learning processes and the impact of the mega-game on their understanding of negotiation techniques.

This study followed an action research methodology, which involves a cyclic process of planning, acting, observing, and reflecting. Action research is particularly suited to educational settings as it allows for the practical implementation of innovative teaching strategies and their iterative refinement based on feedback and observed outcomes. In this context, the mega-game "谈判 Tánpàn" was designed and implemented as an educational intervention, and its effectiveness was evaluated through the collected data. The insights gained from this action research will inform future iterations of the mega-game and other similar educational activities.

Previously, the same class had been conducted without using "谈判 Tánpàn". After incorporating the mega-game, there was a notable improvement in student satisfaction, as reflected in the professor's evaluation results, which showed a 5% increase in overall group satisfaction. Students shared positive feedback about the experience, with comments such as, "it allowed me to practice my English without embarrassment and with the

help of my classmates", “I explored different alternatives to what others proposed and we negotiated for the future of the company", and “I learned that you cannot only think of yourself when negotiating".

4. Results

The utilization of mega-games in educational contexts demonstrated significant benefits compared to traditional teaching methods. Students employed diverse strategies during the negotiation exercise. While some adhered to the estimated problem parameters, others utilized divergent thinking to maximize their profits. Upon completion of the exercise, students expressed their interest in the activity as it provided experiential learning and allowed them to grasp topics that are typically taught in a theoretical manner. They found it enjoyable to negotiate with their peers to achieve mutually beneficial agreements.

Furthermore, negotiating in English helped them overcome previous fears and negative experiences with using a foreign language. Students reported that as the exercise progressed and they were in a trusted group, their fluency with the language improved significantly.

The name 谈判 Tánpàn was well received by the participants, who found it memorable and reflective of the game's focus. The choice of name also contributed to the game's international appeal, making it a relevant and engaging tool for students from various cultural and linguistic contexts.

The game rules for the negotiation exercise were that all discussions had to be conducted in English. There were no other constraints imposed on the students, which allowed them the freedom to think creatively and propose new deals. Students were encouraged to negotiate not only for a single transaction but also for long-term business arrangements. This flexibility enabled the emergence of innovative solutions and strategies that extended beyond the immediate scope of the exercise.

The dynamics of the game included fixed roles, with students not alternating roles to maintain confidentiality. Each role received specific information, and it was up to the individual to decide whether to share that information with others. This design was intended to simulate real-world negotiation scenarios where parties do not have complete visibility into each other's information.

Regarding the grading structure, innovative solutions conceived by students were not initially considered due to the simplicity of the game and its new introduction. However, one team designed a contract for a long-term relationship, which earned them additional marks. This demonstrates that while the grading structure was basic, innovative approaches were recognized and rewarded when they contributed to the game’s objectives.

Students were required to document their process and outcomes by calculating both individual and group profits. Following this, they analysed their results in comparison to others to understand how they could maximize profits for both them and the entire group. This analysis was intended to improve overall business success and encourage a strategic approach to future negotiations.

One team discovered that by minimizing the exporter's profits and "sacrificing" their own role, they could obtain higher profits and achieve the highest grade. An additional secret prize was revealed at the end: among the six teams that did not receive the highest grade, the team member who achieved the highest profits in each role would also receive the highest grade. Other participants would receive a 20% penalty if they achieved their role objectives but were not the best in their category, and a 60% penalty if they did not. Students who did not participate in negotiations would not receive a grade.

In addition to the evident results, this mega-game succeeded in incentivizing creative thinking among some teams, resulting in alternative negotiations with "out-of-the-box" proposals. Some of the negotiated deals involved strategic alliances with counterparts, offering additional accessories or services that, despite increasing the price, remained attractive for purchase or simply generating commitments for future transactions such as discounts or exclusive rights or primacy on new technological developments. These outcomes reinforced not only their knowledge of topics like intercultural negotiation but also concepts they have learned throughout their studies such as the supply chain, value chain, competitive advantage, and value creation for the customer, demonstrating their ability to create win-win scenarios and trust that such scenarios can be realized.

The innovative solutions devised by the students were varied and strategic:

1. **Forming supply chain integrations through alliances**: Some teams collaborated strategically to integrate their supply chains, optimizing efficiency and reducing costs.

2. **Negotiating current purchases with conditions but signing agreements for future contracts with better win-win conditions**: Several teams negotiated ongoing purchases while securing agreements for future contracts with more favorable terms, showcasing their forward-thinking approach.
3. **Including services or variables that were not initially considered in the mega-game's parameters**: Students demonstrated their creativity by incorporating additional services or variables into their negotiations, expanding the scope of the deals beyond the initial framework.
4. **Incorporating innovation themes with exclusivity deals for future models to be launched**: Certain teams proposed exclusivity deals for upcoming innovative models, leveraging anticipation and market demand in their negotiations.
5. **Considering changes to the INCOTERM to make the business more attractive or including accessories in the phone sales to enhance the negotiation**: Some teams explored altering INCOTERMs or bundling accessories with phone sales to add value and make their offers more enticing, showcasing their adaptability and business acumen.

One of the main limitations in this action research work was the limited time allocated to the mega-game due to the class's short duration. As a result, the mega-game was applied on a small scale. However, based on the results obtained, it has been proposed to create a longer-lasting version of the game. This extended version would involve adding nationalities and a cultural map to the negotiators, creating profiles tailored to different types of negotiators that remain secret to other players, and changing the ways negotiations occur among them.

The implementation of this exercise within the educational environment lays the groundwork for the creation of future mega-games involving a larger number of participants. Given that negotiation is a flexible skill applicable in various disciplines, this game could be expanded to encompass multiple fields. The results highlight the effectiveness of experiential learning in enabling students to understand complex concepts and apply them practically. By engaging in negotiations and facing real-world challenges, students developed a deeper understanding of negotiation techniques, enhancing their ability to negotiate effectively in the future.

The integration of mega-games in educational contexts provides a dynamic teaching approach that surpasses traditional methods. By simulating real-world scenarios, students encounter authentic experiences that improve their problem-solving skills, critical thinking, and decision-making abilities. The positive feedback from students regarding their participation and enjoyment suggests that mega-games have the potential to enhance the learning experience and facilitate a more comprehensive understanding of complex topics such as international negotiation.

Expanding the mega-game to include multidisciplinary teams with participants from different areas or departments of the company, as well as other supply chain stakeholders, could enhance the experience and provide a more realistic simulation of negotiation scenarios in diverse organizational contexts.

By creating a mega-game experience with more roles, actors, nationalities involved, and different negotiation strategies across disciplines, we continue to be amazed by the innovative capacity that new generations forge throughout their professional careers.

5. Conclusions

The mega-game 谈判 Tánpàn proved to be an effective strategy for teaching complex concepts of international negotiation. Through the experiential learning approach, students were able to actively engage in simulated negotiation situations and tackle real-world challenges.

The results obtained revealed that experiential learning provided students with a deeper understanding of negotiation techniques and enabled them to apply them practically. By assuming specific roles and negotiating as a team, students acquired problem-solving, decision-making, teamwork, and effective communication skills.

Additionally, the integration of the mega-game showcased a dynamic and enriching teaching approach. Students were engaged and motivated throughout the process, allowing them to learn more meaningfully. The positive feedback from students evidenced their enjoyment and perception that the exercise provided them with a rewarding and enjoyable learning experience.

These findings support the notion that mega-games can be valuable tools for the development of soft skills across different academic disciplines. They also suggest the importance of incorporating experiential approaches in education to enhance understanding and application of complex concepts. Ultimately, the 谈判 Tánpàn mega-

game exemplifies the potential of innovative educational methodologies, emphasizing the role of immersive and interactive learning experiences in fostering holistic student development.

Declaration of Interest

This is to acknowledge that the authors report there are no competing interests to declare.

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Advanced Gamification and Mega-games to Enhance Lifelong Learning in Higher Education

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Abstract: This study investigates the effects of advanced gamification and Mega-games on student engagement and motivation within a rigorous semester-long course demanding 48 hours of weekly commitment. Conducted from February to June 2022, the research targeted sixth-semester students in Video Game Studies at Tec de Monterrey, with virtual classes for groups in Guadalajara and Querétaro. Using a mixed-method approach, the study employed participatory observation on the OASIS Discord server, incorporating gamification elements. Data collection also involved documentary research, online questionnaires, semi-structured group interviews, and faculty documentation reviews. Findings indicate that the integration of gamification elements effectively heightened student involvement and motivation, with positive feedback on instructor support and course content. However, challenges such as burnout, economic disparities, and varying engagement levels were identified. The study underscores the potential of gamification to enhance educational experiences while highlighting the need for careful management of challenges to prevent negative impacts on student well-being. Future research should focus on the psychological effects of continuous gamification and Mega-games, seeking to balance engagement with mental health considerations. Understanding these dynamics will be crucial for optimizing educational strategies and ensuring their sustainable application in diverse academic settings.

Keywords: Experiential Learning, Higher Education, Gamification, Mega-Games, Educational Innovation, Professional Education.

1. Introduction

Gamification has increasingly gained recognition within educational circles as a potent strategy to boost student engagement and motivation. While conventional gamification methods, typically featuring elements like storytelling, rewards, and leaderboards, have become widespread, they may not fully exploit the potential for more profound learning experiences. This paper aims to investigate advanced gamification techniques, particularly the incorporation of Mega-games, to cultivate lifelong learning in Higher Education (HE).

This research ventures into a more sophisticated gamification, defined by the application of less conventional game design elements within educational frameworks. It draws on the game design philosophies articulated by Jesse Schell in "The Art of Game Design: A Book of Lenses" (2019), with the intent of identifying novel gamification components that can positively influence educational environments. The academic focus is on exploring these elements more deeply to discover innovative methods of student motivation, while the professional interest, particularly within game and instructional design, lies in highlighting the advantages of integrating a game designer into the educational experience design team.

In recent years, the concept of Mega-games has gained prominence, offering a comprehensive approach to immersive learning experiences. Mega-games are an innovative and evolving phenomenon in the gaming world, blending aspects of traditional board games, role-playing games, and simulations to create expansive, immersive experiences (Iparraguirre, A., 2022).

For Digital Art majors in HE, it is essential that course design, implementation, and delivery are meticulously aligned with the intended learning objectives. These components must not only be appropriate for achieving the desired outcomes but also engaging and appealing to students. Furthermore, integrating real-world challenges that resonate with students can serve as a compelling motivator, driving them to actively engage in resolving contemporary regional, national, or global issues. This strategy not only enhances their educational experience but also instills a sense of purpose and relevance in their academic journey.

The central aim of this research is to evaluate the outcomes of implementing these strategies and to develop new gamification elements that can be leveraged in future studies. By exploring advanced gamification methods and embedding Mega-games within the learning process, this study seeks to promote lifelong learning among students.

Ernest Cline's *Ready Player One* serves as a vital source of inspiration for the storyliving element of the course, especially for a group of students who have directly felt the effects of a post-pandemic world. The novel's portrayal of an immersive virtual universe, where the boundaries between reality and virtuality are blurred,

aligns perfectly with the course's focus on exploring technologies that span these dimensions. This connection offers a relatable and visionary framework for students as they engage with cutting-edge technologies that mirror the book's digital oasis.

By integrating themes from *Ready Player One*, the course enhances its relevance and appeal, allowing students to deeply explore the spectrum between reality and virtuality. This immersive approach not only makes the learning experience more engaging but also equips students with the skills to innovate and navigate an increasingly interconnected digital landscape. Through this lens, students are inspired to envision and create solutions that reflect the transformative potential depicted in the novel, preparing them for future challenges in a digitally integrated world.

Also, this paper emphasizes the critical importance of cultivating soft skills such as communication, critical thinking, self-management, and collaboration. These competencies are vital for students to successfully navigate the complexities of modern and future careers. By embedding real-world issues into the learning experience, students are encouraged to engage actively in problem-solving, thereby enhancing the purpose and relevance of their educational journey.

2. Context

The educational landscape experienced a profound transformation in 2020 due to the COVID-19 pandemic, which necessitated a shift from traditional classrooms to virtual platforms like Zoom. This transition not only altered the delivery of education but also disrupted the social interactions among students, cutting off access to university facilities, advanced technological resources, and extracurricular environments. It became clear that learning extends beyond the physical classroom, prompting innovative strategies to facilitate education amidst these challenging circumstances.

Despite the challenges posed by the pandemic, important lessons emerged, demonstrating that knowledge acquisition is not confined to physical spaces. Creative solutions surfaced, enabling students and educators to collaborate and engage in learning experiences across geographical barriers. This period highlighted the limitations of telecommunication services while also showcasing the potential of video recordings to maintain educational continuity for all students.

The context of the activity takes place within the framework of the Tec21 educational model, specifically in a course module known as a "block." This block involves 24 hours per week of supervised class activities by the professor, spread over 15 weeks and divided into three periods with one week in between each. In addition to these supervised hours, students are expected to engage in 24 hours per week of asynchronous assignments, resulting in a total commitment of 48 hours per week.

The primary learning outcomes for this activity include the development of critical thinking, systemic thinking, project production in art and technology, project costing, and the management of human and technological resources for projects of varying scales. These projects utilize technologies within the spectrum of reality and virtuality, such as augmented reality, virtual reality, mixed reality, augmented virtuality, and integrated reality. Students will also gain insight into working within specific departments of experience creation, whether as producers, designers, developers, or artists. This activity is conducted for sixth-semester students in the Digital Art Bachelor's program, involving 35 students aged 20-22 from various cities in Mexico. They are divided into two virtual regional groups, each taught by three professors.

2.1 Student Motivation in Higher Education

Seifert (2004) underscores the importance of creating learning environments that encourage creativity, autonomy, inclusion, and active student participation in the learning process, all of which are key drivers of motivation at various academic levels.

The responsibility for enhancing student motivation often falls on educators, which can lead to passive engagement from students. However, intrinsic motivation, defined by a genuine desire to learn and active participation, is equally essential (Williams-Pierce, 2011). Although there is no universal formula for fostering student motivation, Williams-Pierce (2011) identifies key factors: 1) the willingness of students to learn, 2) effective rapport and guidance from instructors, 3) content that captivates student interest, 4) presentation in an engaging manner, and 5) the creation of an inclusive and innovative environment that nurtures both learning and creativity.

In higher education, maintaining student motivation is crucial and should be a priority for educational institutions. Rizkallah and Seitz (2017) stress the importance of strategic focus throughout a student's academic journey—from discovery and establishment to engagement and forward-thinking phases—with faculty support being pivotal for improving retention rates.

On a classroom level, student motivation is a complex challenge. Liu, Bridgeman, and Adler (2012) note that college learning encompasses more than just traditional assessment metrics; it spans a wide range of disciplinary subjects. They observe that motivated students tend to perform better in evaluations and acquire a deeper understanding of the material. Educators in higher education must value student perspectives, encourage active input, and cultivate creativity to drive motivation toward the desired learning outcomes.

Incorporating games, such as Mega-games, can be a valuable tool in this effort, offering innovative pathways for engagement and learning.

2.2 The Role of Gamification in Higher Education

Gamification, as conceptualized by Deterding et al. (2011), involves the application of game design elements in non-game contexts to enhance engagement, motivation, and behavior. This approach leverages the captivating and often addictive nature of games to influence and improve educational experiences (OIE, 2016). Games are designed to be engaging, encouraging persistence and creativity in overcoming challenges, which can foster problem-solving skills and a mindset conducive to learning (Teng & Baker, 2014).

Prominent figures in the field, such as Jane McGonigal (2011), emphasize that games create enjoyable learning environments by offering opportunities for trial-and-error learning, immediate feedback, and social interaction (Hertz, 2013). This immersive experience can lead to persistent engagement and strategic thinking beyond the game itself (Kiang, 2014). Historical milestones, from Thomas W. Malone's early work on intrinsically motivating computer games (1981) to Nick Pelling's coining of "gamification" (2003) and Jesse Schell's contributions in "The Art of Game Design" (2019), have shaped the evolution of gamification.

Despite its benefits, recent studies highlight the need for a critical examination of gamification's limitations. Li, Yang, and Hu (2024) identify a U-shaped relationship between competition in gamified systems and technological exhaustion, suggesting that excessive competition can lead to increased fatigue. This underscores the importance of balancing competitive elements to avoid adverse effects on users. Similarly, Prieto-Andreu (2024) reviews various negative impacts of gamification in education, such as the novelty effect and overjustification, and proposes an instructional model to address these challenges. Their insights emphasize the necessity of careful design and ethical considerations to prevent negative outcomes while leveraging gamification's potential.

While gamification has the potential to enrich educational experiences by enhancing engagement and motivation, it is essential to critically assess and address its limitations. Understanding both the positive aspects and potential drawbacks of gamification can lead to more effective and balanced educational strategies, ensuring that gamified approaches contribute positively to student learning and development.

2.3 Mega-games in Higher Education

Playing is a fundamental aspect of human nature, deeply rooted in our instincts. Huizinga (1955) notes that play predates culture, underscoring its essential role in human life. Play brings joy and fulfillment, embodying structured elements such as goals, rules, feedback systems, and voluntary participation (McGonigal, 2011).

Mega-games are an innovative and evolving phenomenon in the gaming world, blending aspects of traditional board games, role-playing games, and simulations to create expansive, immersive experiences. Unlike conventional board games or simulations, Mega-games involve a significantly larger number of participants, often ranging from 20 to over 100 players, each assuming unique roles within a complex, interactive setting.

At their essence, Mega-games are intricate events where players engage in both cooperative and competitive activities over extended periods. These games are crafted to replicate intricate scenarios such as geopolitical conflicts, economic systems, or historical events. Each participant or group is assigned a specific role with particular objectives, powers, and resources, contributing to a dynamic narrative that evolves with both collective and individual actions.

Similar to board games, Mega-games have structured rules and objectives that provide a framework for player interactions. Both formats require strategic thinking, resource management, and decision-making. However,

while board games typically involve a smaller number of players around a table, Mega-games significantly expand in scale, accommodating many more participants across larger spaces, sometimes extending into multiple rooms or areas.

Mega-games also share common ground with simulations, as both aim to replicate real-world scenarios and systems. Participants assume roles and make decisions based on their understanding of the scenario. However, while simulations often focus on accuracy and educational outcomes, closely mirroring real-world processes, Mega-games blend realism with gameplay elements to ensure a dynamic and engaging experience. Although educational goals can be part of Mega-games, their emphasis on player interaction and narrative development distinguishes them from simulations.

What differentiates Mega-games from other gaming formats is their scale and complexity. The involvement of dozens to hundreds of players introduces a level of unpredictability and interactivity unattainable in smaller games. The roles in Mega-games are often asymmetrical, meaning players have varying degrees of power, information, and objectives, creating a rich tapestry of interactions and negotiations.

Moreover, Mega-games are highly versatile and can be customized to fit a range of themes and scenarios, from historical battles to futuristic political landscapes. This adaptability allows for a wide array of creative and educational uses, making them suitable for various audiences, including educational institutions, corporate training sessions, and gaming communities.

Mega-games offer a distinct and engaging form of entertainment that bridges board games, simulations, and large-scale interactive experiences. By integrating elements of strategy, role-playing, and real-world simulation, they provide a robust platform for exploring complex scenarios in an immersive and collaborative setting. Recognizing the unique features of Mega-games enhances their application and enjoyment, offering participants a rich and memorable gaming experience.

Resource management is a key element in Mega-games, where players must make strategic decisions based on limited resources such as money, technology, information, or materials (Rycroft-Smith, 2016). While they are primarily a form of entertainment, Mega-games have also been recognized as valuable educational tools, as demonstrated by examples like Shawn McMillan's "ALLIANCE" (2015) and Ted Castronova's "VIRUS: Bunny Apocalypse," both implemented in the United States.

Moreover, Mega-games have been utilized in academic settings to engage students in real-world experiences and role-playing, such as the Climate Change Mega-game at Linköping University in 2020, contributing to ongoing research on interactive learning methods.

In contrast, as we explore the context of this paper, research on Mega-games in Mexico is still emerging. Notable contributions include the work of Mexican developers like Robledo-Rella et al. (2017) with "Cocogame" and González & Montalvo (2018) with the "BluRabbits" platform, showcasing innovative approaches to creating immersive learning experiences for students at institutions like Tecnológico de Monterrey.

The implementation of Mega-games in education, as highlighted by Martínez et al. (2023) in their research titled "Kuxtal: Student Motivation Through Mega-games in Higher Education Design Students," presents a significant opportunity. Developed at the same university in which the present work focussed, this implementation yielded positive outcomes, demonstrating the potential of Mega-games as a playful and effective approach to addressing complex challenges. By integrating educational innovations that boost student motivation and engagement, Mega-games like Kuxtal promote collaboration, critical-creative thinking, and real-world actions among students, influencing their immediate contexts and disciplines.

3. Methodology

The methodology for this research was shaped by the necessity to motivate students in a demanding course which spans through all semester long and needs a commitment of 48 hours of work per week. The research employed a mixed-method approach to measure student commitment and motivation following the implementation of advanced gamification elements during the February to June 2022 period in the New Realities course. The study targeted the sixth semester of Video Game Studies in the Digital Arts Bachelor's program at Tec de Monterrey, with two groups based at the Guadalajara and Querétaro campi, conducted virtually.

The research aimed to evaluate advanced gamification, Mega-games, and their impact on motivation and commitment to learning by assessing both student and faculty experiences. Data collection methods included:

Participatory Observation - took place from February to June 2022. The interaction occurred within a platform called OASIS, a Discord server configured with both groups' six implementing professors and a total of 35 students, divided into two groups of 16 and 19 students respectively. The MEE6 plugin was used on this server to incorporate many features and tools of the advanced gamification such as virtual currency, experience points, roles and secrets. The server included statistical participation data, and a leaderboard based on engagement levels within the OASIS.

Documentary Research - involved searching the Scopus database curated by Elsevier from 2019 to 2023, analyzing implementation data and results for each case to develop the best gamification and mega-game taking in consideration the results.

Online Questionnaire (Caudillo, 2022) - structured into three main parts:

Demographic Information: Collects data on age, campus, group enrollment, gender, pre-semester enthusiasm and motivation, and attitudes toward continuing in a virtual format. It also inquires about the participant's level in OASIS and their player type according to Richard Bartle taxonomy (1996).

Advanced Gamification Analysis: Evaluates participants' responses using a Likert scale to assess their perceptions of gamification elements, such as the impact of gamification, the effectiveness of storyliving elements, the utility of Discord, and the enjoyment and curiosity generated by the gamified experience. It includes open-ended questions about enjoyable and unenjoyable aspects, motivations, and the impact of gamification on participation and skill development.

Overall Experience and Future Improvements: Gathers opinions on whether the gamified experience enhanced motivation and commitment compared to other blocks and semesters, suggestions for improvements, overall motivation, and participation in additional activities prompted by the gamification approach.

Semi-structured Group Interviews - aimed to explore students' reactions to their previous semester's gamified experience, focusing on what they liked and disliked. It also assessed whether gamified courses increased their commitment compared to traditional formats, sought suggestions for improvements, evaluated the effectiveness of the implementing teachers versus others, and discussed the appropriateness of the challenges and grading methods.

Student Opinion Survey - evaluates the professor's expertise, challenge level, promotion of a supportive environment, adequacy of support, overall learning experience, and interactions within the virtual Tec model. It also seeks comments for future students considering the course with the same professor.

Documentation Review Interviews with Faculty Members - A meeting will be held with the implementing professors this semester to gather data on their observations of the semester, the design of the New Realities course, and the gamification elements integrated to motivate students in the game design area..

An inductive analysis method was applied to specific elements of the implementation to draw broader conclusions about the effectiveness of advanced gamification and Mega-games in higher education settings.

3.1 Course Design

The course design, developed by Carlos Astengo, Lorena Martínez, and Mario Caudillo, proposed an immersive experience integrating gamification elements and Mega-games to foster the cross-competence of collaboration. The design drew inspiration from the narrative universe of Ernest Cline's *Ready Player One* because of the relation of topics treated in class and in this science-fiction book.

The implementation spanned two regional groups, each guided by three professors. Mario Caudillo led one group, while Diego de la Mora led the other. These coordinators collaborated to utilize the platform for the Mega-game and conducted joint classes with students from both groups to explain its operation.

The course was divided into three modules:

1. The Creative Planet: This module focused on creatively publishing in reality-virtuality continuum, such as games and applications in augmented reality, extended reality, virtual reality, integrated reality, augmented virtuality and mixed reality, requiring students to implement at least two forms of these technologies. The title of the course "New realities" referred this reality-virtuality continuum as the "new realities".

2. The Video Game Planet: This module concentrated on the pre-production phase of the students' capstone projects, which they would continue developing over the next two semesters and deliver as their final terminal project of the Bachelor in Digital Arts.
3. Sector 18: Planet Doom: This module involved the Mega-game, simulating a professional work environment in which students need to participate with four different roles in four different projects, gaining Prestige virtual currency as if they are in real-life, mechanics as tax payments and freelance work negotiation were some of the activities experienced by students in this module.

Students were immersed in the following narrative, which set the stage for the course:

Mexico - Year 2045. Following misguided pandemic management policies since 2020, the world faces a bleak reality. Many people seek to escape this reality, and you will be their hero, showing them that they can go to another place without even moving. In this course, you will see the future and build it, giving people a place called OASIS, where the boundaries of reality are those of your imagination. You can go anywhere, create anything, like the Video Game Planet for your capstone project or the Creative Planet to publish and share new realities. Or face the challenges of professional life in Sector 12: Planet Doom. In OASIS, you can be anything or anyone, creating the reality you want. Welcome to New Realities. Ready Player One?

3.2 Gamification and Mega-game Design

In the first seven weeks, the platform, referred to as the OASIS, allowed students to accumulate virtual currency called Prestige, which governed the Mega-game's economy, this economy also has a 10% of the course's final grade. Participation earned students experience points, unlocking features as they progressed.

Students focused on wealth accumulation, logging their class hours using the "/work" command in the Mega-game and earning Prestige as payment, this could be seen as their work hours, when they use this command, admin roles got the notification and could ask for what they are working at, if the students lied about working when they are not working they got a fine in Prestige.

The final eight weeks simulated the professional work environment. Students worked on four distinct projects to meet course competencies, assuming various roles such as artist, developer, designer, and producer. The producer role was pivotal in ensuring the smooth operation of the OASIS, as they generated jobs to fulfill the roles of other students.

Producers selected projects from a Job Board, defined project scope, resources, budget, payment agreements, and timelines, and presented this to the simulation board, consisting of at least three of the six professors. Upon approval, the board allocated 50% of the necessary Prestige virtual resources. The producer then recruited a team and commenced work, followed by a project closure and post-mortem meeting to assess project completion and requirements.

4. Results

The central aim of this research is to evaluate the outcomes of implementing personalized attendance tracking within the Tec21 educational model and to develop new gamification elements that can be leveraged in future studies. By exploring advanced gamification methods and embedding Mega-games within the learning process, this study seeks to promote lifelong learning among students. Additionally, the study emphasizes the importance of cultivating soft skills such as communication, critical thinking, self-management, and collaboration, which are crucial for navigating the complexities of modern and future careers. By embedding real-world issues into the learning experience, students are encouraged to engage actively in problem-solving, thereby enhancing the purpose and relevance of their educational journey.

In analyzing the effectiveness of these strategies, we employed the categorization framework established by Williams and Pierce (2011) to assess student motivation and engagement. This framework was chosen due to its comprehensive identification of key factors that contribute to fostering intrinsic motivation, an essential element for active and meaningful student participation in academic settings. According to Williams and Pierce (2011), while educators bear the responsibility of enhancing student motivation, true engagement stems from a combination of student willingness, effective instructor-student rapport, captivating and well-presented content, and an environment that promotes inclusivity and creativity.

4.1 Willingness of Students to Learn

Quantitative data revealed that students felt challenged to develop new skills and concepts, with an average score of 8.9 and a standard deviation of 1.2. Additionally, initial sentiments and motivation data indicated that 64% of students reported positive sentiments and high motivation levels at the start of the semester. Qualitatively, this willingness was further evident in the use of gamification elements, such as rewards and constant challenges, which increased engagement and motivation. However, some students experienced burnout due to the continuous nature of these challenges, suggesting that excessive stimuli can negatively affect the willingness to learn.

4.2 Effective Rapport and Guidance from Instructors

Students rated their instructors highly, with an average score of 9.1 and a standard deviation of 1.24, indicating effective guidance and a strong rapport between students and teachers. The adequacy of support and feedback was also highly rated, with an average score of 9.0 and a standard deviation of 1.5, underscoring the importance of continuous and effective guidance. In the model of virtual education delivered by Tec de Monterrey, even remote interactions between students and instructors were positively evaluated, with an average score of 8.9. Peer and professor interactions were largely positive, though some students found the constant connectivity burdensome or had issues with the platform's interface.

4.3 Content that Captivates Student Interest

The overall learning experience was rated with an average of 8.1 and a standard deviation of 1.88, reflecting that, while the content was generally engaging, there was variability in how it captured students' interest. Gamification elements, such as Prestige virtual currency and a leaderboard, effectively captured the interest of many students. However, the competition and stress associated with these elements also led to anxiety and disinterest in some cases. The "Ready Player One" narrative elements integrated into the course also received mixed reactions, with 36% of students responding positively, 36% neutral, and 28% negatively, indicating varying degrees of immersion and engagement.

4.4 Presentation in an Engaging Manner

Students felt that the content was presented in a way that fostered a positive and respectful environment, with an average score of 9.1 and a standard deviation of 1.2. This positive environment was crucial for maintaining interest and engagement. However, some students reported that restrictions on how they could interact on the communication platform made the experience less enjoyable and more linear, negatively impacting the presentation and enjoyment of the course. Moreover, the overall enjoyment of gamified experiences was mixed, with 41.6% of students holding negative opinions, 41.7% neutral, and 16.6% reporting enjoyment, suggesting that the presentation's effectiveness varied.

4.5 Creation of an Inclusive and Innovative Environment

The virtual education model enabled inclusive interaction in a remote setting, with a score of 8.9, reflecting efforts to create an inclusive environment, though there is room for improvement. Qualitatively, the use of a Mega-game simulating a video game studio allowed students to experiment with different roles in a highly inclusive and creative environment. However, challenges such as economic disparities emerged, with issues arising from the rapid accumulation of virtual currency and wealth disparities by the 14th week. Additionally, the emergence of social classes within the OASIS highlighted limitations in the perception of inclusivity, necessitating thoughtful design and implementation to balance gamification with educational goals.

5. Conclusions

The research into advanced gamification elements and Mega-games within an immersive post-pandemic educational setting has yielded several important conclusions regarding their effectiveness in enhancing student engagement and motivation. The integration of these elements, particularly through platforms like Discord, has proven to be a significant factor in fostering student commitment, collaboration, and competition. The immersive nature of the OASIS platform, with its hidden surprises and dynamic challenges, effectively sparked curiosity and motivated students to actively participate in their learning. However, aligning these challenges more closely with project details could further optimize learning outcomes.

Random dynamics, requiring students to engage frequently with the platform, successfully increased their commitment. However, the research also highlighted the need for safeguards against potential negative consequences, such as the risk of gambling addiction, necessitating the implementation of limitations to mitigate harm. Additionally, the study found that preventive measures against "farming" experience points helped students focus on meaningful content, fostering a more authentic commitment to their educational experience.

The use of rewards to incentivize extra-academic activities was particularly effective in generating commitment and emphasizing the importance of continuous learning. This approach underscored the value of lifelong learning and the ongoing development of skills, particularly through platforms like MOOCs. However, the study also revealed the challenges associated with balancing assessment pressures with the overall educational experience, especially among students with scholarships. This finding underscores the importance of creating a supportive environment that maintains motivation and well-being.

In a global context, the research provided a comprehensive understanding of how gamification is implemented worldwide, identifying both well-established and novel elements. By comparing these elements with previous implementations, the study offered valuable insights into their effectiveness and potential to enhance student motivation. This research supports the hypothesis that advanced gamification elements can be successfully implemented across different educational contexts, marking a new frontier in gamification with the potential to improve student engagement and motivation.

The findings of this study offer valuable guidance for educators and practitioners interested in implementing advanced gamification. By exploring new elements and tailoring them to specific educational contexts, student motivation and engagement can be significantly enhanced. The study encourages continued innovation in gamification, suggesting that these advanced elements can lead to sustained motivation and improved learning experiences.

5.1 Implications for Future Implementation

Future research should focus on understanding the potential impacts of prolonged exposure to continuous stimuli from gamification and Mega-games, particularly in intensive implementations that demand up to 48 hours of weekly engagement. While these methods can significantly boost motivation and engagement, the nature of the challenges and the relentless demand for interaction may pose risks to students' well-being, including heightened stress, anxiety, and burnout.

Exploring the psychological effects of extended gamification is crucial, as continuous engagement may have unintended consequences on students' mental health. It's essential to identify the balance between healthy engagement and overexposure to avoid negative outcomes. Equally important is the need to critically examine the ethical implications of using such immersive and competitive methods. Educators and institutions bear the responsibility of safeguarding student welfare, ensuring that the intensity of these activities does not lead to harmful dynamics or compromised well-being.

A critical analysis of the effectiveness of these approaches is also necessary to determine whether the educational benefits justify the potential costs to students' health. It is important to question whether alternative methods could achieve similar outcomes without the associated risks. Furthermore, understanding the long-term effects of these educational strategies on students' learning perceptions, resilience, and sustained engagement is essential for assessing the sustainability of gamification and Mega-games in large-scale educational settings.

Addressing these concerns will provide a more nuanced understanding of the implications of these innovative approaches, ensuring they enhance student learning without undermining their health or well-being.

Declaration of Interest

This is to acknowledge that the authors report there are no competing interests to declare.

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The Open Data Newsroom: A Game Approach for Developing Open Data Competencies in Elementary School

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Abstract: Open Data refers to digital data that is made available to anyone with the legal and technical conditions to be freely used, reused, and redistributed. Although it has emerged as a new common with the potential to increase citizen participation and transparency, current literature suggests the lack of skills for managing data and participating in Open Data processes, as one of the main barriers to achieve these benefits. Integrating Open Data in school education has been recognized as key to fostering a larger community able to participate in Open Data ecosystems. This study showcases the design of a role-playing game grounded in authentic learning principles for the development of Open Data competencies in elementary school. The Open Data Newsroom is a game approach that immerses students in solving a mystery with data. In the game, students play Open Data Journalists engaging in a three-phase authentic process to get, understand and deliver data. The learning goal in the game is that students build open data competencies: data literacy and real-world problem solving. A design-based research methodological approach is applied to develop theory based and practically grounded educational designs. Two interventions in Danish schools have been conducted, each one with the participation of seventeen students in 7th to 9th grade and three teachers. Interventions are aimed at iteratively designing and testing the game. The discussion section elaborates on opportunities for redesigning and systematically developing the game as a learning design for Open Data competencies.

Keyboards: Open Data Competencies, Open Data Literacy, Authentic Learning, Elementary School Students, Game Design, Open Data Journalism

1. Introduction

Open Data (OD), which is data made freely available to anyone, has been stated as a new common available for all members of society (Morelli et al., 2017; Mulder et al., 2019). Although OD is leveraged to increase citizen participation and social value (Kassen, 2013), few citizens have the competencies for actually achieving these benefits (Janssen et al., 2012). Within the OD field the lack of skills of citizens for managing data and integrating in OD processes is a major concern (Van Loenen et al., 2021). This represents a challenge for achieving OD ecosystems (Van Loenen et al., 2021) where people engage and benefit from available OD to participate as active citizens, critically think about governmental performance and create novel products and services. OD is then an available resource but lowly exploited since the majority of people struggle to engage with it. Although integration of OD in schools has been established as one of the strategies for promoting inclusive and fair OD ecosystems (International Open Data charter, 2015), educational designs, tools and methods are still scarce.

Current OD initiatives in education mainly seek to equip students with essential skills needed for the current fast changing and data-driven society (Cook et al., 2018). Potentials of using OD mainly have been related to the connection of classroom activities to real facts, and secondly, to increasing teacher's and student's motivation (Coughlan, 2020). OD learning activities have ranged from using OD in regular school subjects such as chemistry and geography (Pence et al., 2015), engaging with local problems and data in undergraduate courses about OD (Palova & Vejacka, 2022), and extracurricular activities such as public hackathons (Davis & Shneyer, 2020). Previous research has shown that the learning goals of current initiatives in elementary school are often related to increasing awareness about OD and developing criticality (Celis Vargas et al., 2023). For example, Badioze Zaman et al. (2021) focus on preparing young students to use OD by using in the classroom pet robots and IoT, and Saddiqa et al. (2019) have related data literacy in schools with the ability to identify which types of data are needed for solving a problem, and the abilities to use visualisation technologies for exploring and presenting the data in greater detail and understandable way. Furthermore, research of Pellegrino & Antelmi (2023) has shown that OD initiatives in school level primarily are focused on the use of open datasets or data exploitation rather

than on their production. The development of OD competencies based on data literacy and real-world problem solving in elementary school students has been the focus of the development of learning designs that allow future engagement and current participation of elementary school students in OD ecosystems (Celis Vargas et al., 2024).

The current paper investigates how it is possible to develop a game-based learning design for students to develop OD competencies in elementary school. We present the design of a game approach and preliminary test results. Some of the main design considerations include making OD less abstract for non-technical users, and getting students engaged in the process of learning data literacy competencies for solving real-world problems.

2. Background

With the aim of developing tools and methods for building OD competencies in elementary school, a game approach was designed based on authentic learning principles and with the goal of building competencies for Data Literacy and Real-World problem solving. The goal was to enhance the authentic aspects, and theoretical and experimental practices by assigning students the role of Data Journalists in the game. According to Gray & Bounegru (2024) data journalism is a critical data practice including a reflexive work and considering not just the ways in which data is analysed, created, and used, but also the social, cultural, political and economic circumstances in which such practices are embedded. This perspective provides an authentic frame for learning OD competencies which are grounded in data literacy and real-world problem solving.

A game-based approach helps to make the knowledge that is abstract and common for experts more concrete and embedded in a situation (Greeno & Gresalfi, 2008) by acquiring new words and new forms of language for using OD for real-world problem-solving. Games are a form of active learning that enable the learner to have some control of the game activity and engage in interaction (Gee, 2004). Game-based learning (GBL) is grounded in active learning methodologies and encourages learning activities by building on engagement and challenges to achieve the intended learning objectives (Romero et al., 2015).

Essential elements of game design have been described by Costikyan (2002) as five: goal, struggle, interaction, structure, and endogenous meaning. In brief these can be described as defining clear goals for players to strive towards, creating a sense of purpose and direction within the game. Struggle and challenge in fostering players' engagement and satisfaction. The internal rules and systems, known as endogenous mechanisms, that govern players' interactions and outcomes. The importance of structure in organising gameplay elements and guiding player progression. Finally, the interaction refers to both within the game environment and between players.

2.1 Data Journalism

From Journalism's foundation, journalists have used a plethora of approaches to explore, detect, and uncover newsworthy stories. In our contemporary society, the plethora of data that is available to journalists led to the establishment of the term 'Data Journalism.' According to Veglis & Bratsas (2017), it involves the use of data at all stages of the journalistic process including the extraction of information, compilation, and visualisation in a comprehensive way. Furthermore, with the adoption of the OD movement by governments all over the world, new data sources have been made available to journalists. According to Papageorgiou et al. (2023), OD provides them a better insight into important social problems and government activities to create 'evidence-based' journalistic articles.

According to the Data Journalism handbook 1 (Bounegru et al., 2012), the data journalism process consists of three major moments: Getting data, Understanding data and Delivering data. Initially, the data collection step or *Getting Data* can incorporate gathering data from a variety of sources. This can include scraped data, data acquired from freedom of information requests, publicly available data, and OD provided by governmental or other institutions. After the data collection, the data that is of interest to the journalist have to be analysed. The *Understanding data* step requires the discovery of trends, patterns, and the extraction of insights. The next moment, *Delivering Data* requires thinking of different audiences and may include serving data with stories, data driven applications and data visualisations. The perspective of data journalism as a critical data practice emphasises on the process of inquiry with data (Gray & Bounegru, 2024).

3. The Open Data Newsroom

The Open Data Newsroom is a role-playing game for elementary school students to solve a fictional mystery with OD through engaging in authentic activities as real data journalists would do. The game is a simulation grounded in two authentic elements. On one hand, the game develops around a mystery which is relevant for students and close to a real-world complex challenge. On the other hand, in the game students act as data journalists engaging in a simulation of an authentic OD process.

The game builds a narrative where professional data journalists in a local newspaper receive a call from the *Global Investigative Open Data Network* to unravel mysterious events that they believe are connected. The *data journalists* (students) in the newsroom work on getting, understanding, and delivering data to explain the mysterious events to the community in a press conference. The *chief editor* (teacher or external facilitator) facilitates the game flow and challenges the data that the students' outcome is based on. Data journalists are divided in teams of 4 to 5 people trying to have a variety of interests and abilities. The game dynamic guides the players into a data journalistic process where activities relate to OD abilities such as finding and analysing data, assessing if some data is real or fake, creating visualisation and presenting a data-based story explaining a problem. Table 1 presents the game flow that consists of several phases guiding the players into the game narrative and data journalistic process to achieve the outcomes. Game phases are mainly five: (1) introducing the mystery and goal, (2) getting data and understanding data, (3) preparing a data story, (4) editorial meeting and (5) delivering data. First the mystery, game goal and dynamic are introduced to the players. Following this step, a phase of getting and understanding data immerses the journalists' teams in two activities supported by physical and digital elements. On the one hand, the players start defining storylines based on further information about the mysterious events. On the other hand, the players navigate open datasets presented through interactive visualisations to analyse the facts behind the mysterious events and identify data insights to unravel the mystery. In the third phase, the journalists receive instructions to prepare for the press conference where they will deliver a realistic and convincing story based on data to the local citizens. At the same time, each team works on building their final data story and presentation. An editorial meeting helps them to strengthen their outcome. During the editorial meeting, the chief editor meets each group to hear their hypothesis and challenge the storylines and the data behind. Finally, the phase for delivering data has arrived. Each team presents their story receiving questions from the critical audience. An official solution is presented by the chief editor. The game is finalised with comments from the chief editor to each team and an introduction to work on a future press release and to leverage the data generated during the investigation. Figure 1 shows the interaction and engagement of players during the different phases.

Table 1: Game flow

Game Phase		Description
Introducing the mystery and goal		The chief editor presents the mystery, game goal and dynamic
Getting and understanding data	Defining storylines	Players receive physical envelopes with news and social media posts about the mysterious events to build their own case
	Finding data insights	Player analyse OD trough visualisations in the platform
Preparing the data story		Players prepare for communicating their solutions to local citizens in the press conference
Editorial meeting		Each team meets the chief editor for max. 5mins
Delivering data: Press conference		Each team presents in max. 5 mins. The chief editor presents the case solution



Figure 1: Players engaged in different game phases (anonymised). From left to right: 1. Players creating a case board while defining storylines (Getting data). 2. Players interacting with the online tool during analysis of data and finding data insights phase (Understanding data). 3. Players presenting their data story in the final Press conference (Delivering data).

Considering that the expected learning outcome is the critical analysis of data for solving problems, OD activities in the game focus on the analysing of data visualisations rather than on the management of raw data. Players navigate different interactive visualisations in a digital and online platform. In the game, we have used two datasets in connection to the game mystery, one related to water quality and one related to teenagers' health issues. Firstly, the *Bathing Water Directive - Status of bathing water,* Denmark dataset (European Environment Agency, 2023) is used. Associated metadata is briefly presented in the game platform. This repository presents data from 2009 to 2022 and we created data for two more years 2023 and 2024 since the mysterious incidents are occurring in the current year. Secondly, we created a second dataset about skin disease cases in Denmark following the same structure of the previous dataset presenting data from 2009 - 2022.

4. Methodology and Test Design

The Open Data Newsroom has been tested in two Danish schools with students aged 14 - 16. The focus of these tests has been to investigate the following research perspectives: firstly, the study aims to understand how OD competencies for Data Literacy and Real-world problem solving can be developed in elementary school. Here we were particularly focused on understanding how the game strengthens students' skills for critically analysing data, distinguishing between real and fake data, solving problems with data, and building a story. Secondly, we aim to understand students' interests and motivations for engaging in solving a problem. These research perspectives have been tested in two cycles of research and development which will be described below.

4.1 Design Based Research and Interventions

A design-based research (DBR) methodological approach is applied to develop theory-based and practically grounded educational designs (Bakker, 2018). In DBR, design experiments aim to produce actionable knowledge that can be used to achieve some educational goal through design (Cobb et al., 2003). DBR develops in iterative cycles of problem definition, design, intervention, and redesign (Brown, 1992). Two cycles are aimed at iteratively developing and testing the game design with students and teachers. The first intervention was developed in January 2024 in a Danish school with 17 students in 7th grade. The second intervention was developed in March 2024 in a different Danish school with 17 students in 8th and 9th grade.

Figure 2 visualises the two cycles and iterative process.

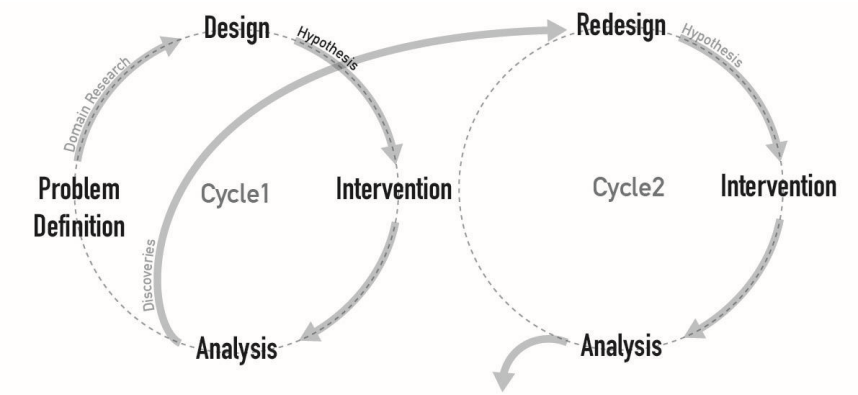


Figure 2: Design Based Research DBR cycles and iterative process.

In the first cycle of design and intervention with the game, the focus was on testing if the game created an authentic experience as data journalists for the development of OD competencies and the general engagement of the students with the mystery and the narrative. In the second cycle, the focus was on strengthening the experience of the students for using OD to solve an authentic challenge. Based on the results from the first intervention, the game was further developed to address areas of improvement such as the mystery being too simple (thus not sufficiently challenging and satisfying for students), the role of data journalist being loose (hence not contributing much to solving the mystery), and the data being highly abstract and in a rigid format (not facilitating deeper analysis).

Interventions were conducted in Danish schools during regular school time and with the presence of the teacher who occasionally engaged in asking critical questions to the students. Each intervention lasted 3 hours. During the intervention the researchers introduced the research aim, the game, and the role of data journalists to the class. Following the introduction, the test of The Open Data Newsroom was conducted during approximately 2 and a half hours. One member from the research team adopted the role of *Chief editor* to facilitate the game flow. Meanwhile a second member of the research team focused on making observations during the whole session. During the first intervention students were asked to create physical visualisation and several materials such as colour papers, markers and paper sheets were given, however two out of four teams opted for creating slides presentations for the final press conference. During the second intervention, students used their own laptops for the data analysis using the platform and preparing slides presentations for the final press conference. In both cases, students discussed storylines and hypotheses to solve the mystery. Table 2 summarises the main characteristics of each intervention.

Table 2: Description of interventions

Intervention	School 1	School 2
Participants	17 students in 7th grade aged 14 to 15 1 teacher	17 students in 8th and 9th grade aged 15 to 16 2 teachers
Game teams	4 teams (3 teams of 4 students and 1 group of 5 students)	4 teams (3 teams of 4 students and 1 group of 5 students)
Duration	3-hour session	3-hour session
Design tested	Physical game elements	Physical and digital game elements

Students' participation was documented using audio and video recording as well as photography. The class was asked to complete a written questionnaire with two qualitative questions "What did you like about the activity? Why?" and "What was the most challenging? Why?". In addition, semi-structured qualitative interviews (Kvale & Brinkmann, 2005) were conducted with the entire class for around 30 minutes, and with the teacher for 45 minutes after the test. During the interview, students answered qualitative open questions related to their game experience, the learning experience, and the game development, such as "How did you feel as Data Journalists solving the mystery? Was it interesting? Was it fun?" "What was different from everyday teaching?" and "How could the game be more interesting or fun for you?"

4.2 The Iterative Development of The Open Data Newsroom in School Interventions

The Open Data Newsroom was developed and iteratively modified with the specific focus of serving as a learning design for developing OD competencies in elementary school. The learning outcomes refer to competencies for the critical analysis of data for solving authentic problems. Examples of the iterative design are making the mystery more complex in relation to the data analysis and integrating a digital tool for the analysis of data. During the first intervention the students received two envelopes, one with printed news and social media posts about the mystery, and a second envelope with printed data in different formats such as visualisations and statistical reports about the mystery. During the game-playing session the students struggle to analyse the data in these formats, losing interest and motivation to dive deeper in the game. Later, during the second intervention we added a digital platform for analysing data through data visualisations. Figure 3 shows two groups of students during the interventions, firstly analysing the case physically and secondly, engaging with the digital tool included for the data analysis.



Figure 3: Students during the game-playing session (anonymised). On the left, the first intervention with a physical game. On the right, the second intervention included physical and digital game elements.

During the first interventions students concluded the solution without the help of the data, it was too obvious for them. Therefore, during the second intervention we increased the complexity of the mystery in relation to the data analysis. Students needed to discover hidden clues in the printed material about the mystery, and during the data analysis they had to consider several variables such as the time frame, the number of cases over time, and the age of the sick teenagers.

The digital platform was hired as a service (Juice Analytics, 2024). This solution was the only platform that we identified allowing users to immerse in interaction with visualisations for data analysis and data storytelling. The intended audience for the platform is a commercial audience, however, we found it highly useful and relevant also for educational purposes. This platform allowed us to create an online report as a landing page with our own images, narrative, and datasets. This online tool allowed the students to interact with several data visualisations by filtering, correlating variables, and capturing their insights. Figure 4 shows the final interface and the type of data visualisations presented to the students.

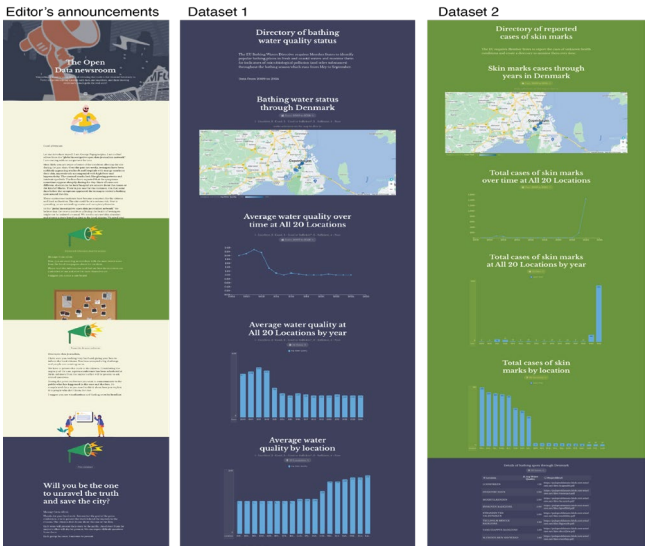


Figure 4: Final game interface in the platform

5. Results

5.1 Test in School 1

Students could solve the mystery in the game, however they did it very easily without the use of data. Their solutions and analysis lacked depth and were overly simplistic. These results show a lack of engagement with the game and a faulty demonstration of OD competencies. For example, one student commented that "The final product was hard to make, as only one other person did any work". We could observe that the mystery was overly simple and did not need data to be solved. For example, students commented in the qualitative interviews and the written questionnaire after the test that "the subject was kind of boring", "There wasn't anything difficult about the subject". During the final presentation, some of the teams created fictional narratives such as a team that elaborated on a lethal virus that was the cause behind the mystery. Even though this narrative helped them to personalise and differentiate their story from the other teams, it was not originated or supported by the data provided. During the press conference, all teams had the same conclusion, and the argumentation was insufficient. Furthermore, we observed that students were initially interested and motivated, but especially during the data analysis moment, some students began to lose interest. Results from the qualitative interviews after the test and written questionnaire indicate that the data was highly abstract and difficult to process. These results were discouraging, but it was a clear indicator of the need of a digital tool for the interaction with data, and for designing a more complex and engaging mystery.

Regarding the authentic experience as data journalists, students did not fully immerse themselves in the narrative. In the qualitative interview they expressed that they did not feel like data journalists. However, in the written questionnaire, students commented positively about the activity regarding the role and the goal. For example, "It was cool that we got to create a solution" "I liked figuring out by ourselves why people got sick" "It was cool doing role play".

5.2 Test in School 2

In summary, the results showed that the students displayed a high level of analytical depth and comprehension in unravelling the mystery. Their solutions and final presentations were characterised by thorough exploration and nuanced understanding. We could observe that students exercised OD competencies in the game such as the identification of a problem, critical analysis of data to solve a problem, assessment of real and fake data, creation of a data story to communicate their outcomes, identification of needed data to be collected, among others. A very interesting observation is that several teams of students questioned the veracity of the datasets in the game. For example, some teams discovered that the bathing water status open dataset was presenting data from 2024, however the bathing season has not yet started. This insight showed us that the students engaged deeply with the data and metadata. Students also identified that the social media posts given in the first envelope to contextualise the mystery were not providing relevant or useful information. One of the students mentioned "the social media posts are misleading and have no data". These reflections led discussions in the different teams about the veracity of the sources. Furthermore, during the final press conference, students were able to present their final data story using data for argumentation by referring to time frames, quality of the water, locations, and number of cases. The students used data visualisations to present their hypothesis. Two teams found additional relevant geographical open data on their own initiative to create hypotheses about other phenomena possibly related to the mysterious events such as rain levels or high temperatures. Figure 5 shows an example of an insight captured by one team during the data analysis and used as visual support for the final presentation.

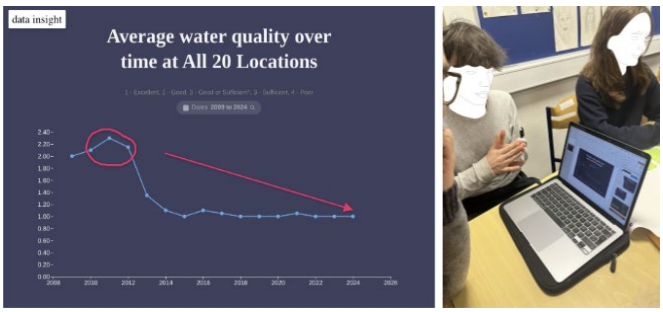


Figure 5: Data insight from the visualisation captured by a team of students during the game test in school 2. Student (anonymised) using the data insight during the editorial meeting.

The game and set up in the class provided a strong experience of engaging in an authentic OD professional use. For example, students commented in the written questionnaire that "It was an engaging story which actually made me want to find the answer. The website was well designed and helped with our research ", "It was fun because we got to be like journalists", "It was interesting to investigate and find reasons why our theory was or wasn't right", "I liked the topic about the disease, it was interesting". The authentic narrative helped the students to make decisions and focus on a storyline to build their narrative. For example, one student during the qualitative interview said, "The narrative helped me to think in my audience and decide what to say and how to present the story during the press conference". Regarding the engagement with the mystery, the teams deepened in their understanding. Two out of four teams explored different hypotheses beyond the one thought by the researchers' team. In addition, students identified the need for more data which could lead to a further development including data collection. Furthermore, results from the qualitative interviews and written questionnaire show that the challenge in the game or struggle was adequate and engaging for the students. Referring to what they liked about the game, students commented on "How interactive it is and how it easy to follow - but not easy to solve", "it got us to think, and analyse our information", "I liked the challenge that we got and the perfect amount of data for us to find out the problem". Finally, physical, and digital elements contribute to each other and enhance the experience, as a student commented "I liked that it was very interactive. It was both on the computer, but you also wrote stuff down. The website was very easy to use".

6. Discussion and Conclusion

The results presented in this paper show that a game approach increases students' understanding of OD, their awareness of what it is, how it is created and how it can be critically used, but also allows them to exercise OD competencies associated with Data Literacy and Real-world Problem Solving. Furthermore, the game approach contributes to understanding learning designs for the use of OD in elementary school. The results described in this paper indicate that a game approach integrating authentic knowledge close to students' interests offers new approaches to develop learning designs for OD competencies in elementary school. This approach might also be applied for understanding social issues in elementary school and create a reflection on the students about the need and assessment of data.

Results of the second iteration show that various design challenges remain to be addressed even further. This presents an opportunity for further systematic development of the game with students and teachers. Challenges to be addressed are related to several aspects of the game, for example the team formation was done by the teacher, however groups could be created according to the interests of the students in order to make the game experience more relevant to them. During qualitative interviews, students and teachers elaborated on the slightly unpleasant experience of presenting the same solution but from different teams during the press conference. In the future, teams could collaborate on different aspects, working together as a big newsroom. Students were constantly in need of feedback during the game which was addressed by the editor and during the editorial meeting, however feedback mechanisms on OD skills development could be explored in upcoming iterations. For the final press conference that at the same time is the end of the game, for some students it was not rewarding enough, perhaps including an authentic critical audience could enhance the authenticity of this final moment. Finally, regarding the OD competencies, an extension of the game could address more competencies such as the integration of data collection activities and simulation of the interaction between stakeholders, as it occurs in real OD ecosystems.

Further research could drive frameworks for the integration of this game approach in school curriculums and for the assessment of the learning outcomes.

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Escaping Online: Teacher Student Engagement in a Digital Escape Game

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Abstract: Escape games have become popular as a learning activity and are being used in a large variety of subjects (e.g., chemistry (Peleg et al, 2019), music (Babazadeh et al, 2022)). Research has shown that they are generally engaging for students (Veldkamp et al, 2020). However, the study of engagement is often limited to its observable aspect (e.g., the students are having fun; they are participating in the learning activity) or is not the focus of the analysis. Fewer studies are also investigating the use of escape games in fully online settings, when students are each playing from their own location. This research study is exploring engagement from the students' perspective, within a fully online course in a teacher education program at a Norwegian university. Teacher students were invited to play Radioaktiv, a digital escape game for natural sciences on the topic of radioactivity. Six pairs of students also participated in guided interviews after playing. Reflexive thematic analysis of the interview data with the students was conducted to investigate what characterised the students' experience of engagement while playing the online escape game Radioaktiv. Through this research question, the study is taking a closer look at what it means when the students say they were engaged in the game. Findings show four main aspects of the students' experience of engagement. First, the time pressure was found to be a double-edged sword. Students found the timer engaging, but some were also too stressed by its presence to the detriment of learning outcomes. Second, students were engaged in completing tasks for their own sake, independently from other game aspects. Third, students appreciated having a read thread, but were not engaged in the specific narrative of the escape game. Finally, students positioned themselves as teachers and it strongly defined their experience of engagement in the game. They saw the game through the potential it held for their own pupils. These findings raise questions about the selection of escape games for learning in online environments and when and how to use them (e.g., discover a new theme, repetition, focus on soft skills).

Keywords: Escape Game, Online Learning, Game-based Learning, Engagement, Teacher Education

1. Background

Escape games have become popular as a leisure activity, especially in the form of escape rooms, but also as boardgames or video games. They are "live-action team-based games in which players encounter challenges in order to complete a mission in a limited amount of time" (Veldkamp et al, 2020: 1). This trend has also been picked up by educators, who started using and developing their own escape games for the classroom to provide students with a more active way of learning. Educators have used either digital programs (Bisanti et al, 2022) or a physical paper format (Babazadeh et al, 2022) to adapt these games to the classroom and develop students' content knowledge or soft skills, and bring variation in learning through interactive and engaging activities (Botturi et al, 2020; Fotaris et al, 2022).

The interest in escape games for learning has also reached the scientific community, e.g., a special track in the *European Conference on Games Based Learning* (ECGBL), a special issue in the journal *Sciences du jeu* (2021: 16). Review articles (Veldkamp et al, 2020; Taraldsen et al, 2022) show that students are engaged while solving escape games. However, the study of engagement is often limited to its observable aspect or peripherical in the studies. Fewer studies also have digital escape games used in online learning as their research focus (see section 3 for a review of the field).

Through the example of one digital escape game, *Radioaktiv,* used in a distance learning course, this paper will investigate the students' experience of engagement while solving the game and answer the following research question:

What characterises the students' experience of engagement while playing the online escape game *Radioaktiv*?

2. What is Engagement?

There is a general agreement in educational research that engagement is a multifaceted construct (Reschly and Christenson, 2022). However, a review of research studies on engagement in online learning reveals no clear consensus on how to define student engagement. Firstly, engagement is defined as student investment in their learning, for example the energy that students devote to their learning (Heilporn et al, 2021). Similarly, Bolliger and Halupa (2018) describe it as the psychological investment in learning expressed through the effort students

are putting towards learning. Secondly, engagement is conceptualised in several dimensions: Behavioural, Cognitive and Emotional (Nkomo et al, 2021; Muir et al, 2019). Each of these dimensions is representing an aspect of engagement, e.g., the actions the students perform, the feelings and emotions linked to being engaged or disengaged in learning. This type of framework is closely linked to the literature on school research and dropout, where engagement is often divided in four dimensions, e.g. academic, behavioural, affective and cognitive (Reschly et al, 2020).

In the field of Game-Based Learning (GBL), where educational escape games can be placed, the understanding of engagement is more fragmented. Sometimes engagement is not even linked to learning but instead is understood as the use of the program or software and operationalised through frequency of use, quality, or duration of engagement (Looyestyn et al, 2017).

Engagement in learning, however, is sometimes defined as how much the students participate in their learning and sometimes analysed through one specific aspect of the engagement framework, e.g., academic engagement (Martín-Hernández et al, 2021). In their framework developed specifically for GBL, Ke et al. (2016: 1183) define engagement as "a collection of mindfully goal-directed behaviors and reflections" and propose four facets to develop this definition: affective, cognitive, content engagement, and gameplay relevance.

In their review of engagement in GBL, Jabbar et al. (2015: 741) focus on the emotional aspect of engagement and define it as the connection the students create with the activity and game features, as well as students' actions towards their goals.

In this study, although we want to acknowledge the complexity of this research field, we will take a pragmatic understanding of engagement in digital GBL and define it as the students' emotional and cognitive investment in the activity. We will now turn to empirical research and see how engagement relates to GBL, and more specifically educational escape games.

3. Empirical Studies of Student Engagement

3.1 Different Aspects of Engagement in Game-based Learning

Studies from the field of game-based learning (GBL) generally show that games and playful learning are engaging students. Engagement can be a direct result of using a game or gamified programme: e.g., Kahoot (Eltahir et al, 2021). In their systematic review, Yu et al. (2020) have found a positive relationship between student engagement and GBL. Studies found that student engagement was higher in GBL, or gamified learning activities, than previously used instructional methods (Zainuddin et al, 2020; Tsay et al, 2020). Similar findings were discovered in the use of games in online education (Dominguez et al, 2013) or in connection with flipped classroom (Huang et al, 2019). Students in gamified learning activities for foreign language learning were also engaged and completed tasks out of their own initiative (Cruaud, 2016).

Different elements in GBL can promote engagement. In their systematic review, Jabbar et al (2015) show that narratives and storylines are engaging elements, albeit not always recognized as important by the students, especially when using longer introductory texts. In the same way, videos and their content are often ignored by the students. Challenges are an effective engaging element, and they make students curious about the content (Jabbar et al, 2015). Some of the most engaging elements in Jabbar et al.'s (2015) review are pedagogical concepts: e.g., scaffolding, built-in learning tools.

However, Jabbar et al (2015: 767) also remark that "engagement is related to students' cognitive and emotional involvement in the gameplay" calling attention to the fact that student engagement is more complex and that other factors can come into play.

3.2 Escape Games: Engaged and Active Students

Research on escape games for learning is a growing field within Game-Based Learning research. The reviewed studies on escape games accord well with the previous section and reveal that most students find this type of learning activity enjoyable. Indeed, we can read in a central review that "in all studies [investigated] a vast majority of students enjoyed the activity and educators concluded that students were highly engaged and active during the activity" (Veldkamp et al, 2020: 8).

In their recent comparative study, Olombel et al. (2022) did not find any difference in learning outcomes between using the escape game for learning or the non-ludic learning activity. However, they do note that pupils

showed more engagement when using the escape game. The researchers report for example signs of excitement, joy, and positive behaviours. In the same way, Peleg et al. (2019) have found nursing students to be very engaged in the learning activity when using an escape room for learning chemistry. Many studies and reviews report similar findings: observations or self-report showed that students were engaged while playing an escape game for learning (e.g., Ho, 2018; Cain, 2019; Veldkamp et al, 2020).

However, in their study about grade 3 students' development of 21st century skills, Duncan (2020) found no significant difference in engagement between the escape game or the traditional learning activities, even though students said that they enjoyed learning in the game-based class. Differences in study duration and research methods might explain this contrasting finding and more generally differences in the literature (Taraldsen et al, 2022).

4. Escape Games for Learning: a Research Project

The research project Escape Games for Learning, funded by the Norwegian Regional Fund, aimed at investigating the potential and limits of digitalising escape games for use in the classroom. Three researchers (including this paper's author) investigated the use of one digital escape game: *Radioaktiv*.

4.1 Radioaktiv: a Digital Escape Game for the Classroom

Created by the Norwegian company Escape History, *Radioaktiv* is a web-based digital escape game. According to the developers, this game is aimed at first year students of upper-secondary school and has for theme radioactivity (science class – *naturfag*). In the version of the game that is investigated here, two players are solving collaboratively five consecutive puzzles while communicating over Zoom within a 45-minutes playtime.

After selecting their role (player 1 or player 2), students access two parallel webpages each with a map of the laboratory of Dr. Doppler followed by a long introductory text. The text narrates the situation in which the players find themselves: during a visit to a research laboratory an alarm starts ringing and Dr. Doppler is stuck with radioactive substances. The mission is then presented: save Dr. Doppler before the time runs out or he will die of radiation exposure. Each webpage contains a narrative text, often giving hints, a puzzle (e.g., fill in the blanks, finding a code, crossword) and sometimes a contextual video on the theme of radioactivity (e.g., biography of Marie Curie, the three types of radiation and their effects). Players have access to different information on their respective webpage and need to collaborate to solve the riddles. The answer to the puzzle is then entered in the form of a password or code, in a padlock on the next page. A correct code will open the padlock and grant the students access to the next page and puzzles.

4.2 Data Collection

To gain insight in both the experience of playing the game and a reflexion on its potential use in the classroom, teacher students from a Norwegian university were invited to try *Radioaktiv* during one of their courses. As students were taking the class from home, they played the game in pairs over Zoom. A total of six online game sessions and the following group interviews were recorded for the main project and used as data for this present study (a total of twelve participants). After playing the game, the students participated in a guided interview in a conversational form (Brinkmann and Kvale, 2015). Interviews were selected as a preferred data collection method to access the students' perspective of their experience of engagement. Reflection notes were considered but would have not given the possibility for the research to ask follow up questions.

The recordings of game time and interview were then transcribed with some detail of interaction (e.g., gestures, tone) and anonymised. The videos were reviewed alongside the transcripts during the analysis process to support interpretation. The extracts presented in this article were translated from Norwegian to English by the researcher.

5. The Students' Experience of Engagement

5.1 Methods: Reflexive Thematic Analysis

Reflexive Thematic Analysis (RTA) was used to interpret the students' experience of engagement through what they were saying about it and the latent meanings in their conversations (Braun & Clarke, 2006; 2019). RTA gives the researcher an active role in the analysis (Braun & Clarke, 2006; 2019). As this study is placed within a dialogic understanding of learning, where researchers bring their own voice to the interpretation process, RTA was a

fitting methodical choice. This methodical trait of RTA will be made explicit by the use of the first-person subject in the following presentation of methods.

As the author of this paper, I conducted the analysis of the interview data. However, another member of the research project was involved during the analytical process. We started with an early data-familiarisation workshop to go through all the recordings together and discuss first impressions, as different researchers had collected and observed different play sessions. Then I coded the data following an inductive (data-driven) approach. Extracts were marked with both semantic and latent codes (e.g., time pressure; distance from narration). I created initial themes, that were then presented and discussed in a workshop with both researchers. The themes were then revised, and the analysis was completed during the writing process.

The following thematic map (Figure 1) presents the four themes I generated through the analysis and their main strands of meaning.

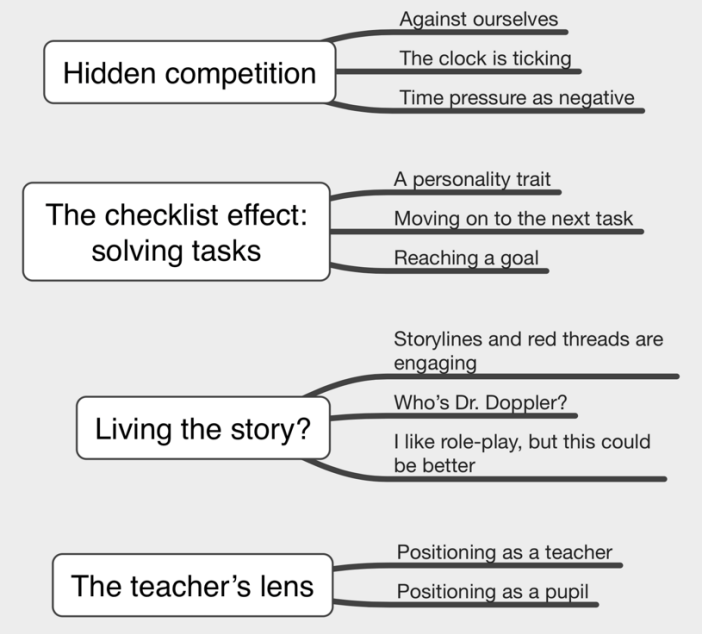


Figure 1: Thematic map of the four generated themes

5.2 Hidden Competition

Radioaktiv is not presented as a competitive game. Students are solving the tasks together and must collaborate to succeed. As they play over Zoom, they do not have contact with other teams, and thus no way of knowing how well (or bad) they are doing compared with other students. However, the students are trying to find ways to compete. In the following occurrence two students reflect on the competitive aspect of the game:

> Stefan: Yes, but was it the competition aspect that was engaging?
>
> Kjetil: Yes, without there being really any competition.
>
> Stefan: Yes.
>
> Kjetil: There was in fact no competition. We have not competed against anyone other than ourselves and the clock.

Competition is an engaging factor for most students, either against oneself or sometimes within the team. Another aspect students find engaging is beating the clock. The game must be finished within the time limit of 45 minutes and a timer is present at the top of the screen. The ticking clock is an image that comes back a lot in the interviews and students discuss its effect on them:

> Dan: yes so, it's just, it's the fact that you have a clock blinking, right? (blinks with his hand) just fuck, we have to make it!

> Malin: I think I felt more tension now [compared to another escape room] considering that you have this clock that counts down and, yes, like you said earlier that it's kinda oh I was stressed by this clock and we have so little time (laugh together)

Feeling the time pressure seems to be one way to keep students engaged on the tasks at hand. However, this engagement can border on stress and even turn into a negative experience when the pressure becomes too stressful. Group 6 did not manage to finish the escape game as they were stuck for a long time on the first puzzle. As the clock was ticking the minutes away, they began to question the usefulness of spending time watching the videos:

> Erlend: I think the video in and of itself is quite nice, but I think they should rather demand that we have to watch the video, and that the clock stops [while watching]
>
> Lise: Yes, I think so too
>
> Erlend: something like that. Because you're kind of sitting there and looking at the ticking clock, and then you start thinking, but what can I use of this here?

If the subject content is supposed to be presented through the videos, it might come in direct opposition to the time pressure effect of the clock: students will want to speed up and may pay less attention to the content presented to finish the tasks on time.

5.3 The Checklist Effect: Solving Tasks

If finishing the game within the imparted time is crucial, students find finishing each individual task also to be engaging. As in checking items from a list, students want to keep going to the next puzzle, advancing in the game, sometimes to the detriment of other aspects of the game:

> Kjetil: I wasn't thinking so much about the map and these other things. I was mostly concerned with moving on, moving on, moving on.

Some students also express being engaged by problem-solving in general, also in other contexts. They present it as a personality trait independent of the game, as something they enjoy:

> Malin: I think it was really engaging, I like this type of problem-solving tasks as I mentioned earlier […] so I like in a way that you get a challenge

Personal interest can explain why some students are particularly focused on solving the tasks. Some also find going towards a goal very engaging as it gives the tasks more meaning:

> Hanna: It's a different way of learning because you, you sit down. You have a goal. You must find information about, in this case, radiation and radioactivity and because you're going to use it for something. It's a really nice way of learning.
>
> Knut: yes, I think it was a fun way to work with this theme here. And the fact that you get to collaborate, to work towards a given goal.

Solving tasks is an engaging factor for students. Students do not seem to mind what type of tasks they are undertaking, if they can solve them and come closer to a final goal.

5.4 Living the Story?

The goal of the escape game is an important part of the narrative, and students find having a narrative, or storyline, engaging.

> Petter: I think it is smart of them that there is a kind of story. Well as I have said I haven't tried another escape room, so I don't really know how it is, but to have someone to save worked for me.

However, students don't seem to be particularly engaged by the storyline of *Radioaktiv*. For example, some students mixed up the storyline (saving Dr. Doppler) with the theme of the videos from the first puzzle (biographies of Marie Curie and Henri Becquerel):

> Hanna: You got a in a way a bit, you got a bit engaged by it in a way. That there was a theme throughout, that you understood, you understood the story. And understood what they were trying to do. Quite

> early. Considering that it was Marie Curie and Henri Becquerel. So there was a red thread and it was quite all right.

Hanna appreciates having a red thread, but she forgets all about the main character of the narrative: Dr. Doppler. Other students are directly expressing not caring about Dr. Doppler or his fate. They are not empathising with the main character and are generally more interested in the tasks and puzzles:

> Kjetil: yes. I wasn't really feeling, I wasn't really feeling like it was Dr. Doppler I was supposed to save. I just have to say it. I didn't get a great impression like 'oh, I have to save Dr. Doppler.'

The map showing in which room the two players and Dr. Doppler are in the laboratory at each stage of the story is an important way of inviting players in the storyline. But these elements are mostly ignored:

> Kjetil: You didn't have a map either?
>
> Stefan: yes, it was right at the start I think, let's see… No, I think I had several maps. […] But I forgot to pay attention along the way [to the maps]

Even students that are particularly interested in role-play express ways to improve this game and to make it more engaging, for example, by making it more multimodal:

> Dan: but I was about to say, you did have, I don't know how it would have worked, but if they could have played this voice then,
>
> Lene: yes
>
> Dan: like through the sound system, instead of having to read it then, that we get, that it becomes even more multimodal in a way
>
> Lene: yes [unclear, speak at the same time]
>
> Dan: it would have been cool, to have this kind of narrator's voice

Erlend's comment on *Radioaktiv* highlights what might be the challenge with the design of this game – the balance between tasks and story – and underlines the potential for engagement that was maybe untapped:

> Erlend: it was quite like focused on tasks in a way. It was less story, it was less escape room and more just tasks.

5.5 The Teacher's Lens

Students are taking a meta-perspective on playing the game. They do not only experience *Radioaktiv* as students conducting a learning activity, but also as teachers in training. Students discuss how they would use it in their own teaching:

> Petter: my immediate reaction was that this here, could be extremely instructive for the pupils.

This teacher's perspective comes back in all the students' answers in the interview, even when the questions were only directed towards their own experience of playing the game. When Dan and Lene discuss the possibility of making the game more multimodal, Dan links this topic to inclusive learning:

> Dan: it would have been cool, to have this kind of narrator's voice and then you would get, well you and I can read this, but if we're thinking about it in a school context, then we could also get to include pupils that are struggling with reading.

This positioning as teacher, or in the case of Dan special education teacher, comes back clearly in the interview. A secondary positioning appears also when the students are bringing imaginary pupils' voices in their conversation. They discuss how their pupils would react and experience the game:

> Sindre: Pupils like that, because it's digital and, yes, because it's cool

This metaperspective on playing the game is an important aspect of the students' experience of the digital escape game *Radioaktiv*.

6. Discussion

Time pressure is a central aspect of escape games. Solving the game within the given time limit is an engaging factor in the analysis of the students' experience. However, the effect of the timer can become too stressful for some students, and they start hurrying and paying less attention to the content. This relates to the concept of perceived cost of information learning as presented in Ke et al.'s (2016: 1192) framework on engagement in GBL. If students perceive the activity as not being in direct relation with the main goal of the game, for example watching a long video instead of solving the puzzle, they will consider it as wasting time and not bother with it. The presence of a timer turns then into a double-edged sword, useful for engaging with the game but sometimes to the detriment of learning engagement.

A second aspect of engagement is completing individual tasks for their own sake, independently of other aspects or goals of the game. This finding relates to need for a sense of achievement where players are receiving adequate challenge and level of difficulty as well as continuous stimuli in the form of new challenges (Ke et al, 2016:1187). This sense of achievement is closely linked to the player's affective engagement with the game.

The third aspect of engagement is linked to the presence of narrative elements. If the theme and red thread in the game were an important part of the students' experience of engagement, the narrative did not mark the players. Similarly to Jabbar et al.'s (2015: 757) findings, the story of Dr. Doppler was not recognised as important for the students. This finding is closely link to the previous one, where students clearly showed engagement in solving the tasks independently of the storyline. The lack of engagement in this specific story might have been improved by alterations to the design, e.g. more multimodal formats, or shorter texts. Jabbar et al. (2015: 755) found that longer texts were often ignored by students and in the case of Radioaktiv, the whole narrative was presented in writing.

A last aspect of the students' engagement is their positioning as teachers. Students took a meta-perspective and saw the game and its activities not only as players but also as educators. Their perspective was defining for their experience of engagement as it related closely to how they connected to the game emotionally and how they connected cognitively to the game's features (Jabbar et al, 2015: 741).

7. Implications and Conclusion

This study is limited to one class of teacher students and can only illustrate one example of the use of escape games in higher education. However, the findings presented in this paper have concrete implications for designing and selecting escape games for learning. On the question of narratives' roles in escape games we can ask if a digital educational escape game can focus equally on tasks and narrative. But also, if a good and engaging storyline is a must-have or a bonus. The presence of a time-limit can reinforce engagement, but also weaken the students' interest in the content. As timers are a central element in the design of escape games, teachers will need to think about how they want to use these games in their teaching. They might be good activities to train soft skills (e.g., collaboration, communication) instead of focusing on learning content. Escape games might also work best as an introduction activity, creating a common memory of a new theme that the teacher can build upon later in the course. The teaching unit becomes less abstract by anchoring it in the students' experience of the game. In the same way, the emotional connection with the game could make online learning a more humane experience, giving students an intimate experience of being engaged in the activity and in their course.

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The use of Educational Escape Rooms in the Lifelong Training of Mathematics Teachers

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Abstract: Educational escape rooms represent an innovative and engaging educational approach, with a high potential for the development of problem-solving and collaboration skills. That is why it is important to familiarize teachers with them and support them for their use in the teaching practice. Our paper presents a case study investigating the utilization of two versions of digital educational escape rooms (DEERs) within the lifelong training of mathematics teachers. Thirty-two mathematics educators of pupils aged 10 to 19 participated in the research. DEERs were developed in two digital platforms: Room Escape Maker and Google Forms, offering an interactive adventure game and a story-based text game, respectively. The study aimed to explore teachers' perceptions of these DEER versions and their potential applications in teaching. Data collection employed observation and a questionnaire survey, followed by qualitative evaluation through thematic analysis. The research's limitations include the sample size and the specifications of the utilized DEERs.

Keywords: Mathematics, Teachers, Educational Escape Rooms, Design, Lifelong Learning

1. Introduction

Escape rooms are defined as live-action, team-based games in which players discover clues, solve puzzles, and accomplish tasks in one or more rooms to achieve a specific goal, typically escaping from the room, within a limited amount of time (Nicholson, 2015). Specific examples of the use of escape rooms in education are digital educational escape rooms (DEERs). These represent modern digital applications of game-based learning that offer engaging, hands-on learning experiences across various educational settings.

Educational escape rooms show promise as an innovative and captivating approach to supporting active learning. Numerous studies indicate that well-designed escape rooms can enhance pupils' motivation and improve their enthusiasm for learning (Fotaris & Mastoras, 2019; Fotaris & Mastoras, 2022; Manzano-León et al., 2021; Taraldsen et al., 2022; Veldkamp et al., 2020; Videnovik et al., 2022). Fotaris and Mastoras (2019) emphasize that educational escape rooms offer an enjoyable experience, engaging pupils as active participants in the learning process. By solving challenges within these rooms, learners gain insights into problem-solving from diverse perspectives, engage in collaborative teamwork, and develop social connections, all contributing to their educational experience.

Regarding pedagogy, escape rooms adhere to a social-constructivist framework (Vygotsky, 1978), where learners build their understanding by actively engaging with challenges presented in real-time within the escape room. These challenges consist of tackling novel and sometimes intricate problems, fostering collaboration among peers to solve them effectively.

Taraldsen et al. (2022) highlight healthcare, STEM fields, including science, technology, engineering, and mathematics, as prominent areas benefiting from DEERs. Similarly, Fotaris and Mastoras (2019) identify health, natural sciences, mathematics, social sciences, journalism, and ICT as common subjects integrated with DEERs. Although escape rooms find application across educational levels, higher education predominantly utilizes them.

As educators face evolving demands, continuous professional development becomes increasingly crucial. Educational escape rooms offer a novel approach to engaging participants in meaningful learning experiences, fostering collaboration, problem-solving, and critical thinking skills (Veldkamp, 2020). Consequently, they hold significant potential for integration into the lifelong learning of practicing teachers.

This paper investigates DEERs application in the lifelong training of mathematics teachers, aiming to explore their opinions on their use and their preferences for two different DEERs' designs. The goal of our paper is to share our observation from the use of two different DEERs during the lifelong learning session with the 32 mathematics teachers organized at the Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava and their opinions on the use of such pedagogical tools and on the preferences for design for each educational escape room.

2. Methodology

In our research, we adopted a qualitative approach (Creswell, 2012), specifically a case study, due to the aims of the paper, the nature of the research, and the research sample. Thirty-two in-service mathematics teachers participated in the research. Participants worked in groups of 2-3 while playing DEERs. Overall, we chose the research methodology to obtain information that will help us answer the research questions:

Q1: What was the activity and engagement of the players during the DEERs playing?

Q2: How did the participants like the given DEERs?

Q3: How did participating mathematics teachers rate the DEERs in terms of their appropriateness for their pupils and usability in the classroom?

Q4: How did teachers compare the two different versions of the DEERs and which design elements did they prefer?

Q5: What interest would the teachers have in other similar escape rooms?

We used several methods to collect the necessary data. We observed participants' reactions and their engagement and activity during the gameplay. After playing each of the games, participants completed an online form that included survey items to determine how they liked each DEER and their opinions about the applicability of the DEER in the classroom and its appropriateness for their pupils. After playing the two DEERs, the teachers used the online questionnaire to compare the rooms, which differed in their design and content. This questionnaire also asked whether teachers would like to have more of such games available.

We analyzed all the collected data qualitatively to answer our research questions. For the study of written data that we obtained through the online questionnaires, we used content analysis (Schreier, et al., 2019). We processed the data using open coding in MaxQDA and based on it, we identified several topics connected with our research questions.

Regarding the individual DEERs, in the following text, we provide the context of their application during the research and their characteristics. The escape rooms were used in the context of a lifelong learning session for mathematics teachers of pupils aged 10-19. This training is entitled "Activating Motivational Methods for Developing Positive Attitudes of Pupils towards Mathematics in Primary and Secondary Schools" and is offered by the Faculty of Mathematics, Physics and Computer Science at Comenius University in Bratislava. The training has online and face-to-face sessions and the meeting was the second face-to-face meeting with the participants. In the morning, the teachers attended a popularization lecture on the history of mathematics, and the use of DEERs constituted the afternoon program lasting about 3 hours.

First used DEER (Vankúš, n.d.) was implemented within Google Forms. It was a series of mathematical problems that were linked by a story in which their solution led to the players escaping the castle. By its nature, therefore, the first DEER can be characterized as a story-based text game. The theme and problems used were inspired by an existing escape room by Elizabeth Joyce, from Pinellas County Schools in Florida (Joyce, n.d.). As part of our used DEER's version, we adapted the task assignments, the graphic design of the escape room, and localized it into Slovak language. In this escape room, learners solve 6 contextually focused problems from different areas of mathematics, such as combinatorics, numerical operations, geometry, divisibility of numbers.

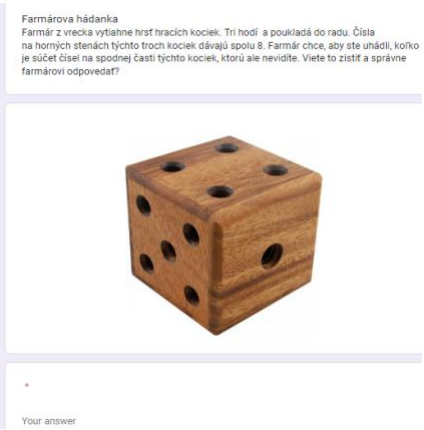


Figure 1: Sample from DEER Escape from the Castle

Second DEER (Terezkajesuper, n.d.) was created by mathematics education students in the Faculty of Mathematics, Physics and Computer Science as part of the online tool Room Escape Maker https://roomescapemaker.com/. This escape room can be characterized as an interactive adventure game. We have described the process of creating this escape room in our previous publication (Čujdíková & Vankúš, 2023). The game requires the use of several interactive elements such as a bolt cutter, a remote control, a battery, scissors, a crowbar, a hammer, and two lock keys. The escape room contains 4 coded locks, where in two cases the key is a word password and in two cases a numerical password, which is obtained by numerical operations with the data found during the game. In one of the problems leading to the numerical code, there is an error in the assignment where a parenthesis is missing. This fact could have potentially affected the participants' work to some extent.



Figure 2: Sample from Students' DEER

During the solving of both escape rooms, both authors of the article were available to answer any questions the teachers might have.

In the text that follows, we describe the results we obtained with the research instruments and our evaluation of the data in terms of each of the research questions.

3. Results

In this chapter, we present our findings. Sections 3.1 and 3.2 also present our answers to research questions Q1, Q2, and Q3. In Section 3.3, we present our findings for research questions Q4 and Q5.

3.1 Escape From the Castle

As the game Escape from the Castle took the form of a simple online form, we did not find it necessary to explain to the participants how to play it. Therefore, we only instructed them to form groups of two or three and start playing.

We could observe the excitement and commitment while playing this room. Participants read the story within their group with enthusiasm and discussed their ideas for solving each puzzle. The solving process was smooth and fluid, and it was not the case that any group could not figure something out for an extended period of time. Different groups took different lengths of time to escape, but in the end everyone managed to escape successfully.

Based on the observation of the participants during the course and their answers in the questionnaire, we can assess that they perceived this escape room very positively. As we can see in Figure 3, when asked to comment on how much they liked the room, up to 89.5% of the groups chose the values 9 or 10.

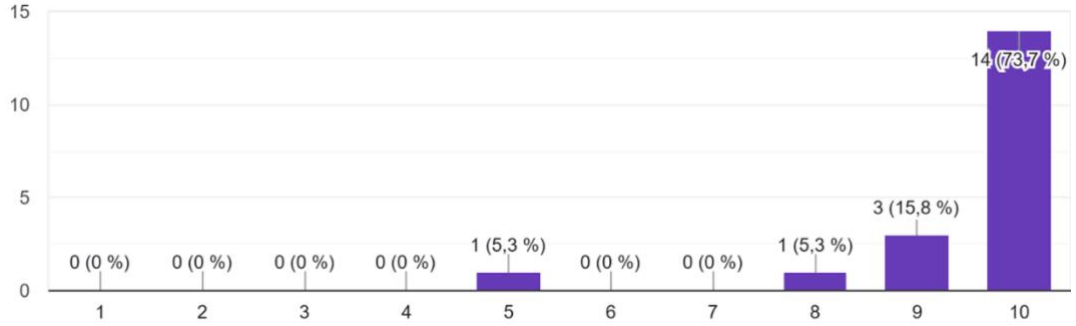


Figure 3: Participants' rating of how much they liked the Escape from the Castle escape room (1- I didn't like the room at all, 10- I liked the room a lot)

This room was also perceived by the participants as being very suitable for pupils. As can be seen in Figure 4, up to 89.5% among all groups rated its suitability for pupils as 9 or 10. No group rated it as unsuitable.

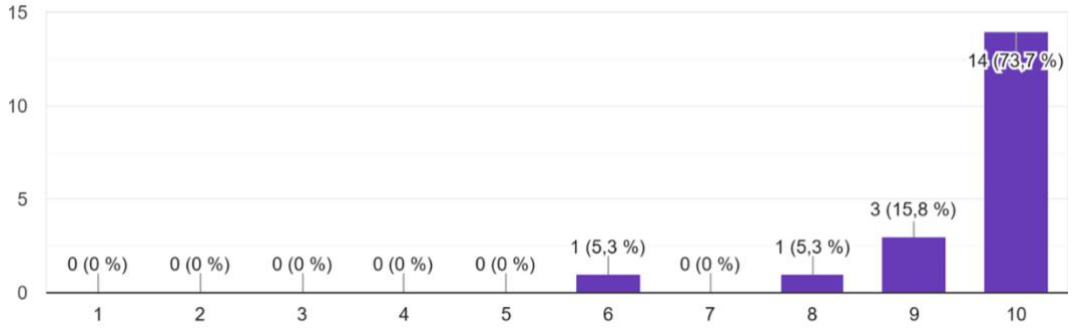


Figure 4: Participants' assessment of their perception of the suitability of the Escape from the Castle escape room for pupils (1 - I consider the room completely unsuitable, 10 - I consider the room very suitable)

Several groups indicated that this escape room is particularly suitable for pupils in the second year of primary school. The mathematical areas they identified in it included working with numbers, number theory, number operations, divisibility of numbers, geometry, combinatorics and logic.

Opinions varied as to how specifically they would use this escape room with their pupils. Some teachers could envisage its use within a regular mathematics lesson, particularly in revision. Apparently because they perceived that the room covered a wide range of mathematical topics, they indicated that they would use it for "practicing the material in all topics" or "for ninth graders as a general review." There was also a suggestion to use it as part of a motivational lesson. Other groups evaluated that they could imagine using it more in a substitute lesson or for a special occasion, e.g., "as part of a St. Nicholas celebration" or "to brighten up the classroom at the end of the school year." Other groups considered it appropriate only in activities outside the regular classroom, e.g. in an after-school club or mathematics competition.

3.2 Students' DEER

For the second type of escape room, which took the form of an interactive adventure game, we assumed that its rules might not be clear to all participants. We expected that teachers who had no experience with such games would be present at the training. For this reason, we selected two Students' DEERs. We wanted to run the first Students' DEER together with everyone to familiarize them with the rules of the game, and the second Students' DEER was to be played independently in groups afterward. However, to our surprise, all participants, after we showed them the first steps, had already started solving this first escape room on their own. Thus, we stopped presenting the solution and devoted ourselves to observing the participants and helping them when needed. Based on this situation, we spontaneously decided to change the plan and omitted the second Students' DEER completely, focusing only on this first Students' DEER. This is the room we introduced in the previous chapter.

We could also observe a great deal of enthusiasm when dealing with this escape room. Participants discussed in their groups and explored the game environment together with interest. They enjoyed every object they

discovered as well as finding a way to use it. They were also delighted if they managed to enter the correct code. However, after some time, the first problems started to appear in some groups and we could observe their growing frustration. In this case we tried to find out the reason and help them to overcome the problems. One of the problems was trying to solve a problem with a wrong assignment. We then revealed to them that there was a bracket missing in the example and this was mostly enough for them to go on to solve it successfully. In other cases, the group got to the point where they couldn't find a particular item they needed or figure out a way to use the items. In those cases, we tried to give them hints that would guide them to a solution but not completely give it away and rob them of the joy of their own discovery. In a small number of groups, we observed that they felt definitely lost and clicked helplessly on random objects in the hope of randomly carving out a room.

In spite of the problems mentioned above, based on the overall prevailing atmosphere during the meeting but also based on the answers from the questionnaire, we can assess that a large part of the groups perceived this room quite positively as well. As we can see in Figure 5, when asked to comment on how much they liked the room, up to 53% of the groups chose the values 9 or 10 and another 17.9% chose 8. At the same time, however, the number of groups that did not like the escape room at all or hardly at all increased compared to the first escape room. A total of 3 groups or 17.3% chose values 1 to 3.

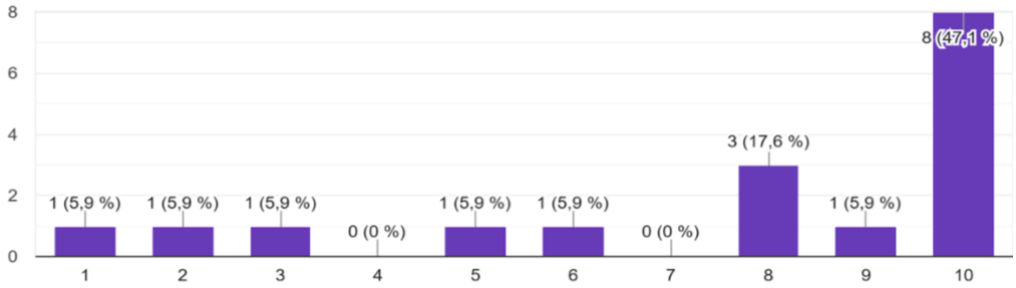


Figure 5: Participants' assessment of how they liked the Students' DEER (1- I didn't like the room at all, 10- I liked the room a lot)

This escape room also received an overwhelmingly positive evaluation from the different groups regarding its suitability for pupils. As can be seen in Figure 6, 64.5% of them rated its suitability for pupils as 9 or 10. This indicates that a larger proportion of the participants also perceived the escape room as a valuable tool for teaching. On the other hand, some groups (23.6%) rated it with grades 1 to 3, expressing doubts about its suitability for working with pupils.

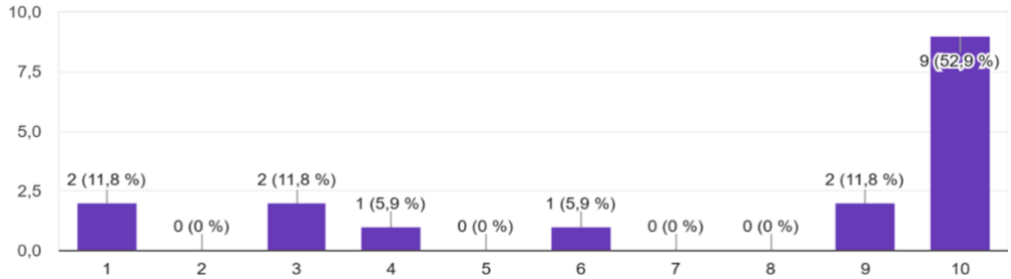


Figure 6: Participants rating of their perception of the suitability of the Students' DEER for their pupils (1 - I consider the room to be completely unsuitable, 10 - I consider the room to be very suitable)

Participants perceived this escape room as more suitable for secondary school pupils. The specific mathematical areas they identified included numerical operations, functions, equations, combinatorics, and logic.

Again, some of the groups could imagine using the game as part of their regular teaching, specifically in teaching the areas they directly identified in the game, especially equations or logic. Another part saw its suitability more in the context of substituted lessons or on a special occasion. Some groups expressed the belief that the game would be more appropriate for computer science lessons. However, there was also a statement pointing to the link between the two subjects: "I like the game as a reinforcement of cross-curricular links with computer science - pupils may be motivated to create such an escape game one day." Even with this escape room, several groups

perceived its use to be more outside the regular classroom, in clubs or competitions. In addition, there was a view from several groups that they would not use it at all with pupils.

3.3 Comparison of the Perception of Individual DEERs

Participants perceived the Students' DEER as more visually interesting and attractive to pupils. Compared to that of the Escape the Castle room, they appreciated that it contained more mathematical tasks. They described the mathematical tasks in this game as "more concrete" than in the Students' DEER. For the Students' DEER in comparison, some perceived that "more logical thinking and searching is needed." Other participants expressed the view that the Students' DEER did not contain enough mathematical tasks and emphasized more on "frantic clicking."

The two escape rooms also differed in that in the first case it was a linear game and in the second case the challenges could be solved in different order. Participants rated the linearity more positively. One group stated, "With the first one we liked the 'immersion' and that the line was clear, the problems came one after the other and you just had to solve them." The non-linearity in the second DEER may have contributed to some groups getting 'lost' and not knowing how to continue the solution. As the same group assessed, "With the second game, we felt more of that 'randomness' - at some point we didn't know what to use where and just clicked everything to everyone."

Participants also pointed out that the game Escape from the Castle contains more text. This was perceived positively by one group: 'The castle was more meaningful, it makes you read', but others assessed that this could be perceived by pupils as more of a disadvantage. In this regard, there were comments along the lines of, "The other one would appeal more to children because they do not have to read." Or that "there was more text in Escape from the Castle and sometimes pupils do not want to read." One group even speculated, "maybe the whole text would not be read by the children."

We also surveyed participants to see if they would be interested in more escape rooms like Escape from the Castle and Students' DEER being made available. As we can see in Figure 7, all participants agreed that they would be interested in DEER similar to Escape from the Castle. Up to 84.2% of all groups chose the value of 10, i.e. they agreed that they would be very interested in similar games. Participants were slightly less interested in DEER similar to the Students' DEER. As we can see in Figure 8, 64.7% of the groups chose a value of 10, i.e. they would also be very interested in this type of DEER. Another 11.8% chose values of 7 and 8. However, 17.7% of the groups would not be interested at all or hardly at all in a similar DEER.

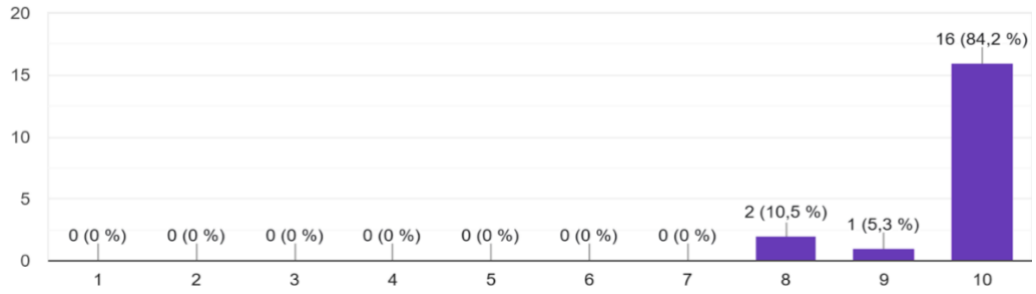


Figure 7: Interest in escape rooms similar to Escape from the Castle (1 - I would not be interested at all, 10 - I would be very interested)

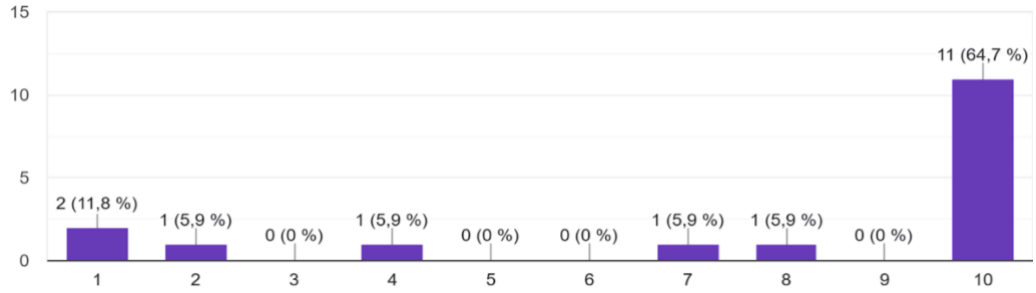


Figure 8: Interest in escape rooms similar to Students' DEER (1 - I would not be interested at all, 10 - I would be very interested)

4. Conclusion

In our paper, we present the findings of a case study in which we investigated mathematics teachers' perceptions of two DEERs and their appropriateness for pupils. We were also interested in what specific elements of game design they most valued in these DEERs. The first DEER, Escape from the Castle, was implemented using Google Forms; the second DEER was an interactive adventure game created by our students in the online tool Room Escape Maker. The research was conducted with 32 teachers in a lifelong learning session. During the meeting, the participating teachers played both DEERs in groups consisting of two to three members.

While playing both DEERs, we could observe mostly engagement and enthusiasm in the participants. The solution of the first DEER went smoothly in all groups without our help until the end. During the second DEER, some problems were encountered in some groups. One of them was related to an error in the assignment of the mathematical problem, which we were not able to correct due to environmental constraints (more details in (Čujdíková, & Vankúš, 2023)). Other issues were related to the fact that some groups could not find a certain needed game item or a way to use the items they had available. After a little help from our side, they were mostly able to continue successfully. However, some participants became frustrated with the problems encountered and the enthusiasm in their group waned. In a follow-up survey to assess how much they liked the given DEER, for the first one, a large proportion of the teachers rated that they liked it a lot. No group outright disliked this DEER. The second DEER was also liked by the majority of the groups, but a smaller proportion did not like it at all or hardly at all. At the same time, participants rated both rooms as largely suitable for pupils. They perceived the first DEER as more suitable. The main criticism of the Students' DEER was that it contained few directly assigned mathematical problems.

For both DEERs, participants appreciated several elements of the game design. For DEER Escape from the Castle, they positively perceived its linear design. They suggested that the non-linearity in the Students' DEER may have caused some confusion in solving it. For the Students' DEER, they particularly appreciated the eye-catching visuals. Several also considered the fact that this DEER contained less text to be positive for pupils. There was great interest among participants in other similar educational escape rooms, especially those such as "Escape from the Castle," indicating a demand for similar educational tools.

A limitation of our research is the small number of participants. We also suspect that the rating of the Students' DEER, and therefore the overall lower rating of this type of DEER, may have been influenced to some extent by the specific choice of the selected room and its particular shortcomings. The second room, which we had prepared and did not use in the end, was free of errors and also contained more directly assigned mathematical examples. Therefore, in the future, we plan to conduct another similar research with a different group of mathematics teachers using this particular room.

Acknowledgement

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Exploring the Affordances of Vernacular Digital Games in Developing 21st-Century Skills

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Abstract: The past decade has witnessed an unprecedented surge in technological advancements and an exponential growth in mobile device ownership world-wide. Such transformations have intensified access to digital content, opening up new avenues for non-formal learning. This was particularly true during subsequent crises such as the COVID-19 Pandemic and natural and man-made disasters which have disrupted formal learning and left many learners immobilised. This paper contends that capitalising on the intersection of formal and non-formal learning experiences is integral to innovative planning and value-added education. To dismiss engagement in non-formal leaning transactions is to exclude a significant part of learners' cognitive processes, preferences and experiences. In particular, this paper focuses on vernacular digital games as an apt example of pervasive technology and a non-formal learning arena. Described as a popular culture text, vernacular games are originally intended for entertainment, as opposed to pedagogical, purposes. However, embedded in their designs are social and developmental affordances that render them potent tools for serendipitous learning and dynamic spaces for developing competencies. In the light of this, this paper proposes a move from gamification, i.e. adding a gaming layer to non-gaming contexts, to adding an educational layer to non-formal digital gaming contexts. To consolidate this proposal, it investigates the 21st-century competencies reportedly acquired and developed through digital gameplay. It also delves into possible design-related paradoxes. More precisely, the paper reflects on how key game design features such as multimodality, adaptivity, cultural narratives and affinity spaces can be harnessed to better cultivate much in-demand 21st-century skills. Although learning skills (in their metacognitive form of higher-order thinking) are part and parcel of 21st-century skills, literacy skills and life skills are equally important. The further longer-term aim is to map development opportunities and optimise learning in ways that are in harmony with today's changing scenarios, demands and objectives.

Keywords: Vernacular Digital Games, 21st– Century Skills, Non-formal Learning, Critical Thinking, Multimodal Literacy, Affinity Spaces

1. Introduction

Fast-paced technological advances have profoundly impacted the objectives, dynamics and operations of many sectors, including education. Disruptive technologies and disruptive crises – natural and man-made – have fundamentally altered socialization, communication and learning. Concurrently, the exponential increase of mobile device ownership has also contributed to initiating, and sustaining, new popular cultures such as digital gaming. The pervasiveness of technological tools has opened up new avenues of informal cross-platform individual engagement and knowledge construction. It is, therefore, counterproductive to overlook the interplay between this type of knowledge and formal education in any strategic organizational plans that aim to add value to individual experiences.

The influence of technology on learning is not new, although currently intensified. Back in 2001, Prensky emphasised the radical transformation in thinking and information-processing across generations, induced through engagement with interactive digital technologies. He coined the term "digital natives", setting a distinction between those learners who grew up surrounded by technology and immersed in its use and between "digital immigrants" – then teachers -- who had to adopt and adapt to technology at a later point (pp.1-2). More than 20 years later, however, this discrepancy in attitudes persists, as pronounced in recent studies (e.g. Gutierrez et al., 2023), even though one would expect the inter-generational gap to have narrowed. For example, vernacular digital games are still marginalised by some teachers, even as a supplementary text, or denounced as illegitimate (*ibid*.). Prensky succinctly sums up the dilemma: digital natives will be taught the old way or teachers should become acculturated to the new (2001, p.3).

Indeed, as a multitude of interactive tools and knowledge resources abounds, the effectiveness of rigid knowledge transmission, typical of traditional teaching, comes into question. The content mastery model, heavily reliant on the textbook culture, is no longer synonymous with 21st-century learning and job requirements (Jan and Jaydon, 2016, p.9). Rather, crucial to enhancing the value of contemporary education is recognizing and capitalizing on the intersection of non-formal and formal learning processes. In this vein, the concept of "edutainment" has emerged to emphasise the increasingly blurred boundaries between education and entertainment. Reconceptualising priorities in today's educational landscape is necessary to equip students with

what is relevant and empowering. As conventional notions of competency are no longer adequate to thrive or survive in a digitally saturated world, 21st-century skills become pivotal as will be next explained.

2. Definition of 21st-Century Skills

With the ubiquity of multimedia resources such as videos and digital games, "post-typographic forms of text production, contribution, and reception" (Koltay, 2011, p.211) have emerged. In other words, text has evolved beyond the two-dimensional print format into multi-dimensional multimodal variations. In parallel, the classical flat notion of literacy as an isolated practice of reading and writing is now overwritten by the concept of literacy as "social practice" and "critical interaction with text as intrinsic multimodal constructions" (Hanghøj, Kabel and Hannibal Jensen, 2022, p.4). This has necessitated the development of new competencies that are uniquely human and irreplaceable by artificial intelligence. Critical thinking, collaboration, technological literacy, emotional competence, multimodal and information literacy skills – are all identified as key 21st-century competencies and can be seen as affordances of vernacular digital games. They represent not only "learning skills" but also "literacy" and "life skills" (Ahmad, 2023).

It is not feasible to have a conclusive list of 21st-century skills as they are ever evolving and intimately interrelated. Neither is it realistic to claim that one technology or learning context can nurture such skills single-handedly. Rather, the development of 21st-century skills is a holistic process that involves utilizing the affordances of multiple contexts. It may also be worth noting that games do not uniformly nurture the same skills since game design, themes and components vary widely, as the following sections will elaborate.

3. Vernacular Digital Games

The term "digital games" encompasses a wide array of genres, features, play modes and contexts of use, among others. This paper is concerned with unpacking the potential of vernacular, also termed commercial-off-the-shelf (COTS), digital games in developing 21st-century skills. Described as "popular culture texts" (Guiterrez et al. 2023, p. 5), vernacular digital games are entertainment games that are not intentionally designed for pedagogical purposes (Reinhardt and Sykes, 2012, p.32). Nevertheless, it is contended that the cultural, social and educational implications of video games render them valuable learning tools in non-formal contexts (Cerezo-Pizarro et al., 2023). In theory, gameplay is seen to be conducive to incidental learning or learning "in the wild" (Reinhardt and Sykes, 2012, p.38). In practice, however, substantial attention is given to gamification, defined as utilising motivational affordances to create gameful experiences in non-gaming settings (Hamari, Koivisto, and Sarsa, 2014). What is yet to be crystalised is harnessing the educational potential of entertainment games in non-educational settings. Additionally, existing research into the effectiveness of digital games primarily focuses on consequences or adopts a "media comparison" approach. To portray a fuller picture, there is a need for a different line of inquiry that explores the interplay between game design features and learner characteristics (Schrader, 2023, p.1260). In other words, a move away from "proof-of-concept research (i.e., whether … games are effective) to the value-added research (i.e., how to design games to make them more effective)" (Gui et al., 2023, P.22) can inform future research and design directions. In alignment with this focus, the purpose of this paper is to reflect on design features that make such games impactful in developing 21st-century skills. However, the skills identified in the subsequent sections cannot be discussed in isolation from others as previously mentioned, so cross-reference to other skills will be made throughout the paper.

4. The Impact of Game Design Features on Developing 21st-Century Skills: Affordances and Inherent Paradoxes

4.1 Multimodality and Adaptability vs Multimodal Literacy and Critical Thinking

One of the significant by-products of digital gameplay is the development of "multimodal literacy". Multimodal literacy is cultivated through players' ability to critically select, orchestrate and process multiple semiotic modes of information -- visual, textual, aural and oral – in order to progress in a game (Toh and Lim, 2022).

A sophisticated multimodal experience that mimics the complexity of real-life tasks is also seen to heighten engagement and facilitate grasp of abstract notions (Dayoub, 2019, p. 803). Further, modelling rich and authentic scenarios and challenges that are inquiry-based and grounded in real-life research is considered a property of 21st-century games (Romero, Ott, and Usart, 2015; Jan and Jaydon, 2016). Such games have the potential to promote higher-order thinking and problem-solving skills that are more compatible with job market

demands than content mastery is (Jan and Gaydon, 2016, p.10). Shaffer et al. further argue that the very design of what they term “epistemic games”, i.e. games that are based on meaningful professional practice, presents an “alternative educational model” that is well aligned with the key competencies and insights pertinent to postindustrial societies (2005, p.12).

By virtue of the multimedia affordance, in-game models (e.g. simulations) can replicate real-life artefacts and systems. However, in-game models do not always comprehensively represent all the details of what they are modelling; rather, they can be simpler depictions of some of their features. In either case, their real value lies in facilitating and enriching problem-solving experiences (Gee, 2009, pp.72-75). Accordingly, the level of multimedia sophistication is not the sole catalyst for developing problem-solving skills. What actually cultivates problem-solving is the attention to problems that the model design enables and optimises. This is corroborated by Gui et al. who dismiss the significance of the “level of realism” in game design, concluding that it has no impact on learning in the domain of science and computers. They alternatively suggest the use of serious educational games to foster learning in such disciplines (2023, p. 22).

Additionally, designing multimedia involves careful consideration of the types of cognitive load embedded in the gaming experience. Effective design eliminates overwhelming distracting multimedia elements that serve no purpose other than creating verbal and visual noise (Clark and Mayer, 2016, pp.133-134). Another consideration here is whether multimodality hampers meaningful interaction. This is an issue of whether progression in a game is merely based on visual feedback and random selections or whether it requires the gamer to meaningfully connect and coordinate multimodal nodes of information.

Undoubtedly, multimedia elements add an entertainment value to vernacular digital games, which is associated with enhanced intrinsic motivation during gameplay, especially when coupled with an appropriate adaptable level of challenge (Hamari et al., 2016, p. 177; Stafford and Vaci, 2022, pp. 52-53). Adaptivity is an affordance of vernacular digital games that serves to create a flow zone, i.e. a “narrow zone between things being too hard ("I give up") and things being too easy ("I'm not challenged at all")” (Prensky, 2005, p. 26). Adaptable games gradually introduce problem-solving scenarios, progressing from initial “routinized, taken-for-granted” tasks and culminating into more complex problems that require higher-order creative thinking. As such, good games are “models for the production of expertise” (Gee, 2003, p.3). According to the flow theory, the right dose of challenge, elevated enjoyment and concentration are fundamental to experiencing flow and learning through immersion in a game (Hamari et al., 2016, p. 172).

4.2 Cultural Components vs Critical Cultural Awareness and Information Literacy

Games are perceived as “genuine cultural products” that can sharpen critical cultural awareness (Reinhardt and Sykes, 2012, p. 35). Cultural discourse, artifacts and storylines are interwoven in the design of many vernacular digital games. While some of these games promote cultural inclusiveness, others perpetuate stereotyped second-hand narratives of cultures, reinforcing thereby existing cultural biases. Ideally, gameplay provides users with “the abilities to explore, expand, subvert, reframe, intervene, restore, and rebuild historical and cultural realities, contexts, or settings” (Vairinhos, Costa, and Cardoso, 2021, p.5). In some instances, however, cultural models are deeply ingrained within the game’s design, content and characters.

In the context of formal education, it is argued that confining class text to the “historically validated” types of text, i.e. text that subscribes to normalised values, is detrimental to the formulation of multicultural societies and future skills. Interrogating cultural, gender, and race representations in games is a competency much needed in today’s curricula (Gutierrez et al., 2023, pp.7&9). Put another way, “checking facts” is integral to developing information literacy, a key 21st-century skill in an era when information and misinformation dissemination has never been easier (Koltay, 2011; Ahmad, 2023). In the same vein, research shows that gameplay sensitised players to cultural misconceptions and assumptions as players expressed the need to undo stereotyped distorted images of their cultures (Dayoub, 2019, p. 801), prompting a call to create meaningful shifts through participatory content creation. Central to this are play features that empower gamers to counter ideologically laden narratives that promote and re-produce “hegemonic ideals” and dominant cultures (Cerezo-Pizarro et al., 2023, p.3). This echoes Glas et al.’s research-informed criticism of media literacy games for failing to target “participatory, creative or socially oriented competencies” due to the “highly linear forms of progression, leaving little agency to the player to deviate or experiment” (2023, p.14). Role-playing games have been specifically identified as having a positive impact on critical thinking (Mao et al., 2023), which reinforces the link between player agency and cultivating higher-order skills. The role of player agency or player-centric design in promoting and disseminating culture is a question that is worth further investigation. Research

tangentially touches on or only broadly evaluates the cultural dimension in vernacular digital games. More research is needed to provide and analyse concrete examples of the cultural implications of such games.

On the other hand, vernacular games do not only portray existing cultures, but also generate cultural legacies. Vernacular digital games receive predominantly negative press (Prensky, 2005, p. 22) and are usually associated with violence, exposure to health issues and gaming addiction. This is approached in the literature as an opportunity to develop reflection and critical thinking through metacognitive activities in-class (Toh and Lim, 2022, p. 13). “Flipped gaming” is, for instance, a “fact checking” activity where students play a game prior to class and then judge the aspects of the game they deem unrealistic or controversial (Headleand, 2021). In this sense, the game is utilized to promote information literacy. Vernacular digital games are also stigmatised as isolating although this may be an oversimplification. A "value-sensitive approach" to game design would utilise adaptivity to make mainstream games accessible to players with disabilities. As such, games can be inclusive as they empower such players "to be on an equal footing with others, irrespective of disability" (Cairns et al., 2019). A more accurate question, therefore, would be: do vernacular digital games lead to isolation in real-life social settings, or do they foster socialisation during times of isolation (e.g. The Coronavirus Pandemic). In other words, is the notion of communicative competence context-confined, i.e. viable only in the same context in which it is born?

Overall, the above suggests that raising critical cultural awareness during gameplay can be achieved either through mediation and structured opportunities for reflection or through inclusive design of game features. Such design should enable the gamer to produce their own user-generated plots and co-create their own versions of the narrative. Player-enacted unique stories or trajectories is identified by Gee (2009, p.76) as an essential game property that can shape powerful and emotionally meaningful learning experiences. Controllability is often underlined in the literature in terms of adaptivity of difficulty level and flexibility to direct and customise game activities (Schrader, 2023, p. 1261). Deconstructing and reconstructing cultural narratives can extend this definition to reflect the contemporary notion of media literacy with its emphasis on production, as opposed to mere consumption, of media messages (Gee, 2003; Koltay, 2011, p.211; Hanghøj, Kabel and Hannibal Jensen, 2022, p.4). Indeed, the notion of a “prosumer” (producer-consumer) is considered a key competence of transmedia literacy (Scolari et al. 2018, p.810).

4.3 Affinity Spaces vs Collaboration, Emotional Competence and Technology Literacy

Particularly relevant to the question of participation is the gamer’s self-expression and interaction in online forums. Online communication is pivotal to understanding today’s concept of literacy. One of the “hallmarks of entertainment games” is complex collaboration, including choice, strategy and tactical characteristics. It is identified as one of the most effective game mechanics for developing 21st-century skills (Romero, Ott and Usart, 2015, pp. 166&170). Complex collaboration is not confined to the game world. Passion for games drives players to what Gee (2017) terms shared affinity spaces i.e. “fan-based, interest-driven Internet sites” or physical spaces for discussing, learning or teaching about games, especially in a multi-player configuration. He further argues that such places are “becoming prime spaces where people engage in 21st-century teaching, learning, doing, and being” (pp. 28-29).

Self-initiated interactions not just *in*-game but also *around*-the-game, can create fertile grounds for acquiring different skills, literacies and know-hows. Examples include emotional competence such as empathy (Toh and Lim, 2022), recruiting and connecting with fans (Gee, 2017, p.30), self-regulation and persistence (Kahila et al., 2019). Such interactions also enhance technology literacy skills such as multimodal content production, software use, social networking, and maintaining high traffic on Websites (Gee, 2017, p.30). Virtual affinity spaces are melting pots of gamers with shared interests but diverse cultures, social profiles, languages and levels of knowledge. Such dynamic spaces can develop the capacity to communicate effectively and purposively to construct collective knowledge: resolve a game-related problem or learn a strategy. Collaboration in massive multiplayer games, nurturing collective intelligence and co-producing “distributed and dispersed knowledge within a community” would appeal to “any contemporary high-functional-team-centered workplace” (Gee, 2003).

Another form of connecting and synthesising information afforded by vernacular digital games is transmedia storytelling where stories are no longer narrated through a single channel but rather dispersed through multiple media platforms, including classical novels, animation and digital games. Digital games that afford transmedia storytelling can develop the gamer’s “transliteracy” defined as “movement not only *across*, *through* and *beyond* multiple media platforms, but also *across*, *through* and *beyond* literacies” (Freire, 2020, p. 16). Stimulating the

capacity to actively link a game to "other games, media, texts, and the world" is described as "education at its best" (Gee, 2003, pp.1-2). Games, in this sense, trigger the player's curiosity to borrow a book, create a story or draw characters related to their themes. As such, they promote cross-platform engagement and competencies.

5. Challenges and Conclusions

A significant challenge to gaming research is to identify whether skills transfer occurs from in-game to out-of-game real-world contexts (e.g. the workplace or academic settings) or vice versa (e.g., Romero, Ott and Usart, 2015 p. 169; Toh and Lim, 2022). In Toh and Lim's study, for example, there was no evidence of transfer of critical thinking and empathy developed in-game to academic contexts. To facilitate transfer, the researchers propose introducing pedagogic mediation and metalanguage (2022, p.12). Other studies argue that metagaming activities in physical affinity spaces enable socialisation outside the gaming context (through turn-taking or watching the others play), even if the game itself is not social (Kahila et al. 2019). The question of whether players perform well due to skills acquired in-game or because of the individual backgrounds and repertoires they bring to the gaming space – is worth further investigation.

The above discussion underlines two points about gameplay: The design of vernacular games can present valuable affordances for developing 21st-century skills; however, it also harbours paradoxes. Such paradoxes give prominence to the role of mediation in harnessing the developmental potential of such games, reminding us again that the role of human expertise in indispensable in our technologically fuelled world. It must be reiterated, however, that the impact of vernacular digital games on competency acquisition cannot be generalised since games are too varied in their inherent affordances, levels of challenge, content, interactive features, underlying ideologies, and intended audiences, among others. This is compounded by the inconsistency of the population researched in current empirical evidence (Schrader, 2023, p. 1260). Longitudinal research, clear indicators of 21st-century competencies in-game and in real-life, homogenous participants and specification of game design features can inform methodological choices in future pursuits of rigorous and comparable research findings.

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Exploring Current Challenges and Opportunities in Media Literacy Skills for Youth: Stakeholders' Perspectives

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Abstract: The widespread dissemination of contradictory information through various media platforms can increase anxiety and confusion among younger generations. This highlights the need to promote Media Literacy (ML) skills, enabling them to evaluate online information's validity critically. Video game-based learning can be valuable in this context, fostering active learning and critical thinking. Therefore, developing and sharing innovative resources like interactive content and video games is crucial to enhancing young people's ML skills and resilience to disinformation. The YO-MEDIA project, involving three universities in Italy, Portugal, and Spain and a journalist association, aims to develop ML in young people during times of crisis (e.g., pandemics and wars) through game-based learning strategies and professional training. The project carried out 29 semi-structured interviews in the partner countries with various stakeholders to understand perspectives on media design practices and ML formulation for young people in crises. These interviews aimed to collect education and media professionals' insights on promoting ML and critical thinking among youth during crises. It also seeks to gather best practices and understand these professionals' challenges when fostering ML among youth. This study's findings suggest that the interviewees deem ML vital for distinguishing accurate information from misinformation during crises, especially relevant for young individuals. Essential skills for these young people include critical thinking, filtering information, and recognizing online threats. Effective strategies involve operating within digital environments frequented by young people, encouraging critical thinking, and nurturing collaboration. Professionals face challenges such as a lack of training, engaging young people's attention, and keeping pace with digital environments. The interviewees also emphasized the importance of ML training for informal educators and media professionals. They recommended Massive Open Online Courses (MOOCs) for their flexibility and accessibility. According to the interviewees, an ML game should involve research, interpretation, and decision-making processes and be accessible to young people with disabilities. They identified several ML projects and resources, including multimedia labs, youth parliaments, and critical thinking tools. This study contributes to developing games that promote critical thinking and ML in young people. It also aids in establishing ongoing professional training in ML for informal educators, teachers, media professionals, and other stakeholders.

Keywords: Media Literacy; Critical Thinking; Educators and Media Professionals; Game-based Learning; Professional Training.

1. Introduction

In the current digital era, the volume of online information available is growing unprecedentedly, as is the ease of accessing this information via the Internet (Majerczak & Strzelecki, 2022). The inability to distinguish between true and false information available on various media platforms can increase anxiety and confusion, especially among younger generations. This aspect demonstrates the urgent need to promote ML (Johnson et al., 2020; Pennycook & Rand, 2020), which is related to the ability to understand critically, question the reality and veracity of what we see, hear, read, and consume through the media (Buckingham, 2015).

ML has increased importance during crises such as pandemics and wars, as it is in these moments that the sharing of information and disinformation is particularly high (Johnson et al., 2020; Pennycook & Rand, 2020). Young people have daily access to a vast amount of information and digital tools, but there is a lack of knowledge in managing and correctly using this data (Buckingham, 2015). Therefore, it is essential to prepare these individuals for moments of crisis from an early age through the development of skills and competencies in ML, so that they have critical thinking, become consumers and creators of media, and know how to critically evaluate the validity of online information (Buckingham, 2015; Jones-Jang et al., 2021; Kellner & Share, 2019).

Several European Union countries present basic notions and limited content about media and journalism in their current educational models (Petranová et al., 2017; Qerimi et al., 2023), often preferring practical activities instead of active learning about the media. The lack of opportunities for critical reflection and skills development makes it impossible for young people to discern the veracity of information and dubious sources. For this reason, it is necessary to rethink strategies for promoting ML to educate young people with the skills to consume and produce media correctly. Video game-based learning can be valuable in this context as numerous studies highlight the practical implications of video games in fostering "active learning" (Saleem et al., 2022; Zeng et al., 2020). In games, it is possible to incorporate specific ML content (e.g., identification of false information, digital security and privacy issues, and media skills, among others) (Contreras-Espinosa & Eguia-Gomez, 2023), which provides players with new experiences that equip them for real-life problem-solving, particularly in crises (Moro et al., 2022). Moreover, video games can stimulate "critical learning" (Bunt & Grosser, 2020; Mao et al., 2022; Scheibenzuber & Nistor, 2019) by offering players a meta-awareness of these domains. This understanding helps them comprehend how media can influence them and how their environment affects their perception of a problem (Gee, 2003).

In this sense, the ongoing YO-MEDIA project focuses on leveraging game-based learning strategies and professional training to develop ML skills in young people during crises. It involves a mixed-method approach to assess the effectiveness of games in raising awareness about misinformation through interactive learning experiences. The project, which involves three universities in Italy, Portugal, and Spain along with a journalists' association, aims to achieve two main objectives: increasing awareness and knowledge among young people regarding the reliability of media information and enhancing the professional skills of informal educators/stakeholders, teachers, and media professionals in promoting ML during crises. To achieve these goals, the project involves various research activities such as literature reviews, stakeholder interviews, co-creation of hybrid games with young participants aged 16 to 18, and developing a MOOC to educate about ML.

This paper presents the results of 29 semi-structured interviews conducted in partner countries with teachers, journalists, and other stakeholders to understand the diverse perspectives on media design practices and ML formulation for young people in crisis.

2. Methods

In the initial phase of the study, the YO-MEDIA project team conducted semi-structured interviews in Italy, Portugal, and Spain with 29 individuals (10 interviews in Italy, 9 in Portugal, and 10 in Spain), including teachers, journalists, informal educators, and other stakeholders with experience in media studies, games, and crisis management. These interviews aimed to bring together diverse perspectives from education and media professionals on promoting ML and critical thinking among young people during crises. The project team chose interviews as a means of data collection, as the purpose of the study was to collect in-depth qualitative data. Although the focus group was considered as an option, this tool was disregarded due to the impossibility of bringing together the interviewees as they lived in different cities in each country and did not have available agendas.

Interviewees were selected based on experience working with young people and/or participation in ML-related projects to include individuals with diverse professional experiences to gather different perspectives on young people's ML. In this context, participants consisted mainly of (i) informal educators/stakeholders who should have professional experience working with young people in different contexts (e.g., libraries and youth associations involved in community projects or municipal departments promoting projects in the area of ML); (ii) journalists, from different news organizations and areas (e.g., video games, sports, or digital issues) and who work on research projects in the area of ML; and (iii) teachers, from public and privately-funded schools, who were involved in projects to promote ML in secondary education and universities and who have experience in research projects.

The interviewees provided informed consent, acknowledging the objectives, process, risks, and benefits of the research, and made a free and voluntary decision about their participation. The 29 in-depth interviews were conducted between April and June 2023 using the Zoom® video-conferencing application. The project team from each partner country interviewed participants in the country's official language (Italian, Portuguese and Spanish) and the interviews lasted approximately 100 minutes, were video recorded and transcribed verbatim. To facilitate the interviews, the Portuguese project team developed an interview guide that was followed in the three countries (Figure 1):

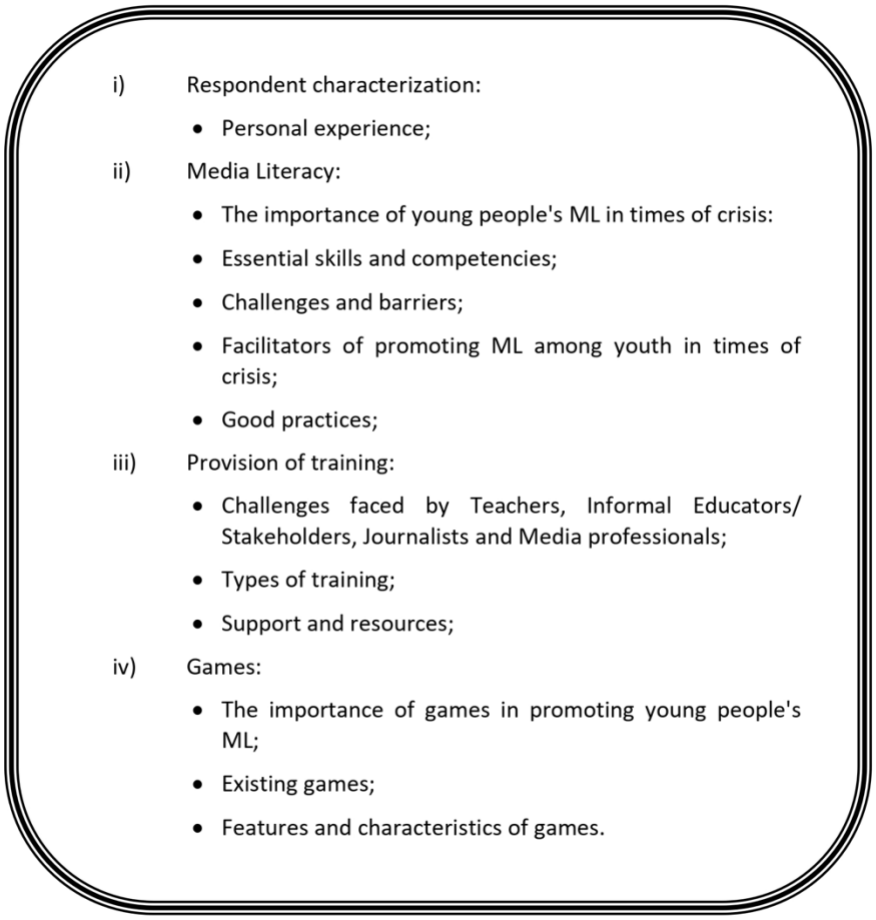


Figure 1: Interview guide.

Data analysis from each country was based on the critical thematic approach to identifying and examining patterns (Braun & Clarke, 2006). The analysis involved coding the text and identifying patterns, and repeated discourses. From the interview transcripts, the emerging patterns of the data were defined, namely: (i) ML in today's digital age, (ii) important skills and competencies, (iii) strategies and approaches to promote ML, (iv) providing teacher/journalist training, (v) games: features, and characteristics. The unique transcription corresponding to each pattern was collected and coding tables were then produced with the most interesting and pertinent quotes.

2.1 Participants

In total, 29 professionals were interviewed, being 14 women and 15 men with an average age of 46.4 (SD 5.2) years. The participants in the interviews had professional experience as informal educators/stakeholders (IESn=8, 27.5%), journalists (Jn=8, 27.5%), and teachers (Tn=13, 45%). Each interviewee presents a varied experience in ML. Some paved the way for digital media as a topic for young people in their community or in school training, finding students to talk and work on ML (e.g., teachers and informal educators in the three countries); others work in associations dedicated to promoting the well-being of young people through the media (e.g., Steadycam, Italy) or in projects focused on preventing disinformation (e.g., IBERIFIER project, Portugal and Forum against Disinformation Campaigns, Spain). Some have developed games to address hate speech and violence on social media (e.g., Gariwo, Italy). More detailed information about the participants (age, gender, role and experience with ML) from each country is presented in Annex 1.

3. Findings

Analysis of interview data conducted by researchers from each country identified the following common themes: (i) ML in today's digital age, (ii) important skills and competencies, (iii) strategies and approaches to promote ML, (iv) providing teacher/journalist training, (v) games: features, and characteristics. The results for each of the themes are presented in the following sections.

3.1 ML in Today's Digital Age

For the interviewed, ML in the current era is essential in times of crisis due to the dangers young people encounter in the media. As examples, professionals highlighted: the difficulty in distinguishing reliable sources of information and true or false information, the speed with which things are processed, excessive time that young people spend online, misinformation, multiple media stimuli, AI, information bubbles and social media as sources of unverified information, populism, radicalism and hate speech, among others. In this context, interviewees justified the importance of ML for young people for the following reasons (Table 1):

Table 1: Categories of the theme "ML in today's digital age", number of individuals who commented on each category, and citations supporting the categories.

Categories	Individuals, n	Citations (examples)
Socialization	• Italy:2 • Portugal:5 • Spain:6	"*Digital tools can be strong tools to support bonding and relationship, which in a crisis situation is even more necessary to maintain*" (Italy, IES2).
Frantic and disintermediated access to information in times of crises	• Italy:3 • Portugal:6 • Spain:6	"*We are talking about a high-speed consumption of information; there are many fragments of information on multiple subjects*" (Portugal, T4).
The different means of disseminating information, due to the increased use of new media (e.g., social media) compared to traditional media (e.g., television, radio, or newspapers)	• Italy:4 • Portugal:6 • Spain:7	"*We are living in a time of over-information that has nothing to do with traditional media because information reaches us through social media and many other channels that cannot be considered informative media. That is, a hyper-informed, hyper-communicated society, but poorly managed*" (Spain, J1).
New fears that arise from moments of crisis and can generate serious consequences for individuals (e.g., divisions in society and impacts on mental health)	• Italy:2 • Portugal:5 • Spain:6	"*It is important that they also create mechanisms and manage to defend themselves from fake news, which is very stressful, and even true news can also be very stressful. They must create those mechanisms, manage, and understand when it's time to switch off so it doesn't affect their mental health*" (Portugal, J2).

3.2 Important Skills and Competencies

For the informal educators interviewed, young people are often competent consumers, but they lack critical skills in media consumption and production. Respondents highlighted the following skills and competencies that young people need to develop (Table 2):

Table 2: Categories of the theme "Important skills and competencies".

Categories	Individuals, n	Citations (examples)
Critical thinking about media messages and assessment of their credibility and bias	• Italy:4 • Portugal:5 • Spain:8	"*I believe we should aspire to become a critical society, an educated and informed society. In this sense, ML is essential*" (Spain, J1).
Know how to access, analyse, and filter information and information sources effectively and ethically	• Italy:3 • Portugal:6 • Spain:9	"*Know how to navigate, know what they are looking for, know which sources are credible*" (Portugal, T1).
Ability to assimilate and understand information, as well as identify the veracity of facts	• Italy:3 • Portugal:6 • Spain:9	"*Even if students have a minimum ability to read the text, the evaluation is conditioned by incorrect prior information or what they heard...so I would work both on accessing and evaluating information*" (Italy, T3).
Understand artificial intelligence, with a combination of ML education, critical thinking skills, guidance from informal educators, and responsible use of technology	• Italy:2 • Portugal:4 • Spain:6	"*Figure out what's on offer, what's on your mind. What do they propose according to the algorithm and what do students really want to look for? What are the things that really interest you?*" (Italy, T1).
Respect the diversity of opinions, cultures, and perspectives, in addition to recognizing and combating stereotypes and prejudices in media messages	• Italy:1 • Portugal:2 • Spain:7	"*The issue of gender, inclusive language... we have worked on that. For instance, statements such as: 'A Moroccan man robbed a store'. They could have mentioned instead that 'it was a young person*" (Spain, IES1).

Categories	Individuals, n	Citations (examples)
Debating ability, so that young people can participate and give their opinion in conversations and debates	• Italy:1 • Portugal:2 • Spain:8	"*What should be strengthened in children and young people is their argumentative abilities and their critical thinking. Only with a good ability to talk to each other can they discuss social issues and develop the connection between them*" (Portugal, IES1).

3.3 Strategies and Approaches to Promote ML

Regarding effective strategies or approaches to promoting ML among young people, interviewees highlighted that it is very important to reason more *on how*, rather than *on what* to say to young people. And because ML is strongly related to critical thinking, one of the main practices suggested by interviewees is the promotion of activities that encourage thinking and questioning and give students a voice. Teachers considered that these practices should start early in student learning, and, for this, it is necessary to rethink the educational model, "*and, perhaps, to be closer to this reality of young people, to adapt to the platforms, the languages, the contents, and the contexts where they are*" (Portugal, T4).

Another fundamental point identified in the interviews is the effective collaboration between teachers, informal educators, journalists, and parents to share knowledge, training, and good practices to promote ML (e.g., "*Observe good practices with and on the media, bringing a different form of design and of mental and cultural approach*" Italy, T3). Respondents also consider it essential to work in gamification contexts, using digital games to promote ML, as games are a media extensively used by young people (e.g., "*students talk about things they know, where they feel recognized, so we talk about videogames as a cultural object. At the same time, we acquire skills in developing critical thinking*" Italy, IES4).

Some interviewees also suggested other good practices for promoting ML, such as: sharing concerns about crises with students, empowering informed decision-making, promoting changes in habits of sharing information online, exchanging intergenerational experiences between adults and young people, supporting empathy and identification in the information exchanged.

Furthermore, participants highlighted successful projects in their countries that aim to promote ML, combat disinformation, and promote critical thinking and transparency through fact-checking and data journalism: Open the Box (Italy), Fact-checking Spring School (Portugal), Fact-checking maldita.es (Spain), among others.

3.4 Providing Teacher/Journalist Training

In the interviews, participants pointed out the need for specific actions and courses that provide them with mastery of ML and the necessary tools to teach the subject to young people. Despite the lack of these practices, professionals face challenges in the process due to great resistance on the part of teachers in adopting media or video games as teaching tools in the classroom. Respondents consider it necessary for teachers and informal educators to use the platforms and content that students are consuming today, in order to create a connection between real life and school, establishing a balance between learning and the media (e.g., "*ML also means the ability for teachers to decode a TV series, to watch it, as students watch it and talk about it at school*" Italy, IES3).

Resistance on the part of education professionals to adopting new media may also be linked to the lack of training in ML and the difficulty in keeping up with constant updates to digital environments. According to one of the interviewees, in certain countries, such as Portugal, the teaching profession is ageing, with the average age of teachers being between 50 and 55 years old (DGEEC, 2023). These individuals have difficulties in following the development of digital technologies, as "*we are teachers who, when we took the course, the Internet was not a big reality in Portugal. We were doing training, etc. The most interested ones did much training. Those who are not so interested still have many difficulties in dealing with digital media. They don't understand social networks very well; for example, many of my colleagues don't understand*" (Portugal, T2). In Spain, the same scenario is also pointed out by one of the journalists, who always must be up to date with changes and the emergence of new digital technologies, as these are one of the main tools of his work: "*For example, when I started teaching in 2005... we learned to use email, later Google, and then came social media. From 2005, everything started to change with Facebook, Twitter, search engines, smartphones... and today, with artificial intelligence*" (Spain, J2).

Furthermore, another critical challenge highlighted by informal educators and teachers concerns the difficulty in capturing and maintaining young people's attention and interest during the learning process, especially in

times of crisis, when students' effort generally decreases (e.g., "*During the pandemic, the level went down, and we are seeing senior students with a shallow level that are used to giving the minimum; in that sense, it would be important to rescue the notion of effort*" Spain, T4).

Regarding the format of ML training, interviewees prefer that they are (i) in a MOOC format, because they allow greater flexibility in learning and do not require traveling to the training location; and (ii) that continuity programs are made available, as this allows them to deepen their knowledge.

3.5 Games: Features, and Characteristics

Gamification was one of the interviewees' suggestions to promote ML among young people. Comments pointed out that games can be valuable in the sense that they allow individuals to explore, understand and interact with media content actively and critically, in addition to challenging young people to make decisions, solve problems and critically evaluate information, thus promoting the development of critical thinking (e.g., "*The question of playing presupposes the interacting, the relating, the stimulating, the challenging, and the competing, be it with another player, be it against the machine*", Portugal T4).

Respondents consider that games, especially video games, work well among young people due to aspects such as: (i) the narrative dimension, which allows young people to explore and experience different stories, characters, and virtual worlds, which supports learning, motivation, student engagement and deeper understanding of media elements (e.g., "*and the game is an act, and it is an enjoyable media stimulus. If it has an environment, a narrative that engages me, I hardly leave that environment. So maybe that is a good space to work with young people and complicated topics, as such a crisis*" Portugal, T4); (ii) interaction and engagement, which can help young people develop communication, teamwork, and conflict resolution skills (e.g., "*their most exciting dimension is when it is a collective game, not an individual. So, I think that the game, if we want to follow this line of promoting ML, should promote dialogue and interpersonal relationships*" Portugal, IES1); and (iii) the possibility to start over from where you failed and reason about it (e.g., "*if you fail, you can start over or maybe from a certain point, you encourage a reflection on the cause and the effect of actions*" Italy, T2).

In interviews, participants consider that despite the valuable benefits that games can provide to young people, there is still a lack of use of gamification in classrooms. This deprivation of the use of games is mainly due to a lack of time on the part of teachers and informal educators, especially at higher educational levels, before accessing university, which again reinforces the need to rethink the educational model: "*I don't use board games during this History course because, as compared to last year, we have one hour less per week. Instead of three, now we have two, and I need to provide the same content as before. I don't think games are a waste of time, because they aren't, but if I apply games in the methodology, we just won't make it.*" (Spain, T5). A solution presented by most interviewees would be to implement games in project disciplines, which are very present in classrooms nowadays: "*We would include games within a project, as there is a tendency now to include project-oriented learning methodologies. For instance, in secondary school, there is a subject called Culture and Values, which is a complement to the mentoring hours*" (Spain, T3).

Regarding the suggestion of functionalities and characteristics for the game to be created, the interviewees suggested (Table 3):

Table 3: Categories of the theme "Games: Features, and Characteristics".

Categories	Individuals, n	Citations (examples)
Have a connection with real problems/stories to reinforce the emotional aspect of the game and enable young people to identify with the characters	• Italy:2 • Portugal:5 • Spain:7	"*It is necessary to use examples of concrete situations... to encourage thinking and discerning in a critical manner which options would they choose, and that consequences follow upon the decision taken*" (Spain, T5).
Possibility to evolve in the game, go through different levels of difficulty and challenges	• Italy:2 • Portugal:4 • Spain:8	"*I think the Game has to have this idea of the challenge, the difficulty and the conquest*" (Portugal, T3).
Purchasing rewards to keep young people engaged and keep them playing to win more prizes	• Italy:1 • Portugal:3 • Spain:6	"*A game where you put the acquisition of anything, be it points, gadget in the game, something that will allow you to evolve or your character or acquire another kind of characters or other kinds of pluses that they can use in terms of the game*" (Portugal, IES3).

Categories	Individuals, n	Citations (examples)
Involve research, interpretation and decision making, making young people question information and develop critical thinking	• Italy:2 • Portugal:5 • Spain:6	"*A research game that implied reading and interpretation to help decision making. In a logic of a reaction that is not a need for a quick decision, that implies "pondering, implies a collection of information or thoughtful interpretation and then decision making*" (Portugal, T4).
Promote healthy competition among young people through games that use an ethical component	• Italy:3 • Portugal:2 • Spain:7	"*I believe they should have the skills, the tools, the strength, and the self-esteem to thrive in a competitive world*" (Spain, J1).
Involve experts from different areas, teachers, and students in game development, because the exchange of ideas and experiences will contribute to the development of a game with greater usability and accessibility to the most varied types of users	• Italy:2 • Portugal:2 • Spain:7	"*I would take developers with me to work with my students to have a different look. So, developers don't work for us, but with us*" (Italy, T3).

4. Discussion and Conclusions

The 29 interviews performed with informal educators, teachers, and journalists in the three countries participating in the YO-MEDIA project (Italy, Portugal, and Spain) help to understand the different perspectives of these professionals on promoting ML and critical thinking among young people during crises. The points raised by professionals reinforce the indispensable role of ML in discerning true information during disinformation exacerbated in times of crisis. The need to develop skills on how to consume and produce media is especially pertinent for young people.

As essential skills for young people, improving critical thinking skills, adequate information filtering, and recognizing online threats are highlighted. These skills must be cultivated in individuals from an early age and as pointed out by interviewees, for this to happen it is necessary to rethink education models, which currently teach basic notions about the media and journalism (Petranová et al., 2017; Qerimi et al., 2023). If the academic curricula do not have courses focused on critical reflection and analysis of misinformation, young people will have difficulty achieving a high ML level. To try to reverse this situation in the educational scenario, teachers and informal educators suggest as effective strategies for promoting ML, immersion in digital environments frequented by young people, encouraging critical thinking and cultivating collaborative efforts between education and media professionals.

However, in addition to the challenge of training young people in ML, professionals also state that they themselves encounter barriers to learning and teaching about ML. The lack of training opportunities, the difficulty in capturing and maintaining the attention of young people and the difficulty in keeping up with rapidly evolving digital environments were some of the obstacles highlighted by those interviewed. For professionals, it is necessary to integrate ML training into the curriculum of informal educators and media professionals, suggesting MOOCs as a viable solution due to their flexibility and accessibility.

Furthermore, interviewees advocate the development of ML-based games that involve research, interpretation, and decision-making processes, while ensuring accessibility for young people with disabilities. The use of games in learning ML can provide positive results for young people, allowing them to develop critical thinking skills, decision-making and strategies to combat misinformation (Contreras-Espinosa & Eguia-Gomez, 2023; Glas et al., 2023).

The results of this study contribute to promoting the creation of educational games that aim to improve critical thinking and ML skills among young people, while also facilitating ongoing professional development and ML training initiatives for informal educators, teachers, media professionals, and other stakeholders.

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Game-based Learning Assessment: Quantifying Educational Efficacy of the EDURINO App

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Abstract: Assessing the potential and efficacy of educational apps is crucial for parents, educators and EdTech stakeholders. This paper presents evidence from two quantitative studies on EDURINO, a game-based learning app targeting children aged 4-8. It features seven subject areas and is designed to be used with an ergonomic pen that facilitates fine motor skill development and pen-holding gesture. In Study 1, parents (N = 45) used a validated index (Kolak et al., 2021) to evaluate the app's educational potential across 10 features. In study 2, a larger cohort of parents (N = 235) reported on their children's school readiness and fine motor skills. Specifically, we adapted the Brief Early Skills and Support Index (BESSI) to measure changes in behaviours and cognition. We also included items from the Child Development Inventory and Ages and Stages Questionnaire to assess fine motor skills. Study 1 results indicated high ratings for EDURINO's meaningful learning and social interactions, but lower for adaptive learning. Parents' evaluation of EDURINO did not differ by child gender, age, or subject area, but varied with parental education level (the higher the educational attainment, the lower the ratings). Study 2 found that there were statistically significant improvements in children's behavioural and cognitive development as well as fine motor skills after playing EDURINO. Changes in those areas were independent of children's age, gender, and subject area. Moreover, children's improvements were positively correlated with the length of playing. However parental engagement level influenced and was negatively associated with children's improvements in EDURINO targeted area. Overall, these studies provide evidence on EDURINO's efficacy while highlighting the necessity for improvement with personalised and adaptive learning. The importance of transparency and collaboration between academia and industry, along with the influence of demographic factors are discussed.

Keywords: Game-based Learning, Educational Technology, App Evaluation, Child Development, Fine Motor Skills, Efficacy Study

1. Introduction

Touchscreen mobile devices, such as smartphones and tablets, have become internationally ubiquitous for young children. There has been increasing effort and popularity in research and industry to understand, design and test digital games and activities (Kabali et al., 2015). Recommendations have also shifted from preventing screen time holistically to more constructive views of providing meaningful content to facilitate learning outcomes (Hirsh-Pasek et al., 2015). Indeed, educational mobile applications, shortened as 'educational apps', have witnessed an exponential growth followed by the rising concerns over their quality, efficacy, and influence on child development (Common Sense Media, 2013). Recent meta-analysis has reported clear learning benefits for early academic skills, particularly in young children's mathematics and literacy knowledge (Griffith et al., 2020). Moreover, non-app related factors have been shown to impact the efficacy of educational apps; in terms of demographics, preschool children and those from lower socioeconomic backgrounds seem to benefit the most (Common Sense Media, 2013; Kim et al., 2021). Research has also considered the way in which children engage with digital learning and highlighted the advantage of parent-child co-use of digital media (Taylor et al., 2023).

Children acquire, practice and perfect their cognitive and learning development through play and experts of game-based learning have argued that conventional educational principles can and should be applied to the digital environment (Bang et al., 2023). Notably, a key component in both traditional and digital learning is to support and adapt for children's 'zone of proximal development' (ZPD, Vygotsky, 1978) where task difficulty should be above their current capacity but within reach for progress (Plass & Pawar, 2020). In digital environment, open-ended play context provides the learning structure where children are able to explore content freely (Hatzigianni, 2018). Despite the differences in how learning materials are presented and communicated, educational apps should, in principle, provide similar experiences as to traditional pedagogy settings where there are opportunities for tailored feedbacks and interactions (Mulliner & Tucker, 2017).

EDURINO, developed by an EdTech start-up based in Munich, is an educational app for children aged 4-8 and it aims to support school readiness and fine motor skills. Currently, there are seven subject areas, namely Mathematics, Literacy, Nature & Science, Human Body Biology, Coding, Social Emotion Learning and Creative Arts, with content available in both German and English. A unique feature of EDURINO is the use of a stylus pen. Pen-holding gesture has been associated with early writing ability (Rowe, 2019), which inspired the development of EDURINO's 'magic pen' (Figure 1). The ergonomic pen supports different pen-holding grips and was specifically designed to train children's handwriting gesture and fine motor skills. In terms of learning content, EDURINO has holistic as well as detailed scope and sequences of learning objectives, which are in line with country-specific curriculum, for example the Early Years Foundation Stage (EYFS) statutory framework in the UK. EDURINO's content structure is also informed by pedagogical theories of learning trajectories (Simon, 1995) and mastery/competent-based learning approach (Plass & Pawar, 2020). More importantly, for better engagement and learning outcomes, all materials are presented in a playful and engaging digital platform with clear context and narratives (Fisch et al., 2012). After the initial steps of account registration and setting up parental control features, children can explore and play EDURINO games in a self-guided way without parental engagement and guidance.

The overarching aim of the current study was to investigate EDURINO's efficacy and quantify its educational benefits among the target audience (children aged between 4-8). It was also of research and industry's interests to examine the role of players' demographics on the app's efficacy. To this end, we selected a range of demographic and app-related factors that have been identified in the literature. Specifically, we included measures of child age group, child gender, parental education, subject area of EDURINO games, parental engagement style and length of playing. Given it was the first empirical research conducted on EDURINO, the study was exploratory with no specific and prior assumptions. In the current study, first we utilised a quantitative instrument to examine parents' evaluation of the app and content (Study 1); second, we administered a parent-reported survey focusing on the educational benefits of playing EDURINO (Study 2).

Specifically, we explored the following research questions:

1. What is the educational potential of EDURINO, and whether demographic and app-related factors influence parents' evaluation?
2. Do children show any developmental improvements after playing EDURINO, if so whether the educational benefits are affected by any demographic or app-related factors?



Figure 1: EDURINO played on a tablet (left), the magic pen(middle) and screenshot of a Maths game.

2. Method

2.1 Ethics

All procedures performed in Study 1 & 2 were in accordance with the ethical standards of the University of Cambridge Psychology Research Ethics Committee and have been reviewed by the senior author as an independent consultant on the project. All study materials including survey questions were initially prepared in English as the original source of research. The standard translation and back translation procedures were followed to generate the German version. Any discrepancies were resolved between two native German speakers who were fluent in English and had Education degrees (Erkut, 2010). Participants were provided with study information and gave consent online before answering survey questions. After completing the study, they were gifted with a 20% off discount code for EDURINO products.

2.2 Study 1: Assessing EDURINO's Educational Potential With Validated Research Index

2.2.1 Participants and Procedure

Participants were recruited by email invitation from the mailing list of EDURINO's online research community, where commercial users of the app take part in product and design testing. In total, 45 adults (Germany: *N* = 37; UK: *N* =8) completed the online survey which consisted of one evaluation questionnaire and several standardised demographic questions. Data collection took place in January 2024.

2.2.2 Measures

Parents were asked to rate EDURINO's design and content, and the questions were based on a research instrument that specifically developed for assessing educational potential for preschooler's apps (Kolak et al., 2021). The evaluation index included 10 items: learning goal, meaningful learning, solving problems, feedback, social interactions, opportunities for explorations, storyline, quality of language, adjustable content, and app design. Parents were provided with descriptions for each assessment area and rated EDURINO against a 3-point Likert scale (0,1,2) with higher scores indicating higher educational potential. The index was designed for a general audience including caregivers, educators, and researchers and has shown high content validity, internal consistency, and reliability. In terms of demographics (summarised in Table 1), we included questions of country, child age, gender, respondent's relationship to the child, respondent's educational level, as well as which EDURINO figurine(s) children own (each figurine represents one subject area, for example Mika for Maths). Data of some measures was collapsed and merged into one category due to the small number of cases, for example the category of father and grandparents. Other categories were decided based on previous research (age group of players: preschoolers and children of school age) and differences among EDURINO games in terms of learning content and game design.

Table 1. List and percentage breakdown of different categories for each demographical and app-related factor in Study 1.

Factors	Category	
Country	Germany (82.8%)	UK (17.8%)
Parental education	Below Bachelor (57.8%)	Bachelor and above (42.2%)
Relationship to the child	Mother (77.8%)	Father & grandparents (22.2%)
Child gender	Male (42.2%)	Female (57.8%)
Child age group	4-5 years (73.3%)	6-8 years (20.0%)
Subject area	STEM & Literacy (28.9%)	Mix* (71.1%)

*Note. The mix category included all figurines of the STEM & Literacy games, *plus* Yuki for Creative Arts. The Yuki subject is distinctive from the rest because it has the most open-ended play areas with less structured learning content and objectives. We did not list Yuki as a single category by itself due to the small number of cases.

2.2.3 Results

The total scores across 10 items were used to represent the educational potential of apps, and we further divided the questions to reflect two different dimensions, namely 'learning content' and 'app feature'. Specifically, learning content (possible score range 0 - 10) was measured and calculated by the sum of 5 items: learning goal, meaningful learning, solving problems, feedback, and adjustable content. App feature (possible score range 0 - 10) was assessed and summed across 5 items: social interactions, opportunities for explorations, storyline, quality of language, and app design. Table 2 represents the percentages of respondents' rating of EDURINO for each of the items in the evaluation index, as well as the descriptive statistics of learning content, app feature and the overall educational potential.

Table 2: Descriptive statistics of EDURINO's educational potential (N = 45).

Evaluation Area	Rating Scale		
	0	1	2
Learning goal	-	7 (15.6%)	38 (84.4%)
Meaningful learning	-	4 (8.9%)	41 (91.1%)

Evaluation Area	Rating Scale		
Solving problems	-	8 (17.8%)	37 (82.8%)
Feedback	2 (4.4%)	5 (11.1%)	38 (84.4%)
Social interactions	-	4 (8.9%)	41 (91.1%)
Opportunities for explorations	2 (4.4%)	7 (15.6%)	36 (80.0%)
Storyline	-	6 (13.3%)	39 (86.7%)
Quality of Language	-	5 (11.1%)	40 (88.9%)
Adjustable content	6 (13.3%)	12 (26.7%)	27 (60.0%)
App design	-	8 (17.8%)	37 (82.8%)
	Mean	SD	Range
Learning content	8.844	1.461	5 – 10
App feature	9.244	0.981	7 – 10
Educational potential	18.089	1.929	14 – 20

To investigate whether parents' evaluation of EDURINO would differ as a function of demographic and app-related factors, non-parametric Whitney U-tests were performed to examine the influence of country, child gender, child age group, parental education, and subject area of EDURINO. The results revealed that parents' evaluation of EDURINO's overall educational potential and app feature did not vary as a function of any demographic or app-related factors (all *ps* >.05, Table 3). However, when evaluating learning content, across both Germany and the UK, parents whose highest educational attainment were below Bachelor rated EDURINO's learning content more favourably (M = 9.307, SD = 1.049), than those who have completed Bachelor and postgraduate degrees (M = 8.211, SD = 1.718).

Table 3: Whitney U-tests statistics on the effect of demographic and app-related factors on EDURINO evaluation.

	Educational Value	Learning Content	App Feature
Country	*z = -1.119, p = .285*	*z = -.922, p = .405*	*z = -.904, p = .422*
Parental education	*z = -1.780, p = .075*	*z = -2.152, p = .031*	*z = -.053, p = .879*
Child gender	*z = -.048, p = .976*	*z = -.198, p = .857*	*z = .104, p = .928*
Child age group	*z = -.688, p = .491*	*z = -.172, p = .863*	*z = -1.158, p = .247*
Subject area	*z = -.840, p = .401*	*z = -.188, p = .851*	*z = -1.096, p = .273*

2.3 Study 2: Quantifying EDURINO's Educational Benefits for Child Development

2.3.1 Participants and Procedure

Participants were recruited using the same method as in Study 1. In total, 235 adults, all based in Germany, completed the online survey which measured parent-reported educational benefits of playing EDURINO across various developmental areas. Data collection took place in February 2024.

2.3.2 Measure

Specifically, questions used to assess children's behavioural adjustment and language/cognitive development were based on the Brief Early Skills and Support Index (BESSI, Hughes et al., 2015). The BESSI was developed to measure school readiness, therefore a suitable instrument for the current study. Research demonstrated that BESSI was of good reliability, longitudinal stability, and measurement invariance (Hughes et al., 2017). To examine fine motor skills, we further selected questionnaire items from the Child Development Inventory (Ireton, 1992) and the Ages and Stages Questionnaire (Bricker et al., 1999). Each item measured a specific aspect of fine motor movement appropriate for the study sample's age range, such as the ability to play with interlocking puzzles, colour and draw pictures with precise features. Overall, we included 25 questions to measure 3 separate areas of child development, of which 12 tapped into children's behavioural development, 6 measured cognition and language, and 7 focused on fine motor skills. Each question/statement described a specific child behaviour or trait, and parents were asked '*after playing EDURINO*, your child is better at _/show more progress in _?'. Responses were rated against a 5-point Likert scale (5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, 1-Strongly Disagree). Across the 25 questions, 10 were reverse items in which parents were asked "'*after playing EDURINO*,

your child is worse at _?/show more _ (problematic behaviours)' of which responses were reversely coded for analysis following Hughes et al. (2015) scoring instruction.

To measure demographic information, parents were asked to report child age, gender, respondent's relationship to the child, respondent's education attainment, how long the child has played EDURINO (in months), whether the respondent engage with the child while playing EDURINO, and which EDURINO figurine(s) the child own. Similar to Study 1, we further divided demographic information to specific categories, and Table 4 represents the list and percentages of each category.

Table 4: List and percentage breakdown of different categories for each demographic and app-related factor in Study 2.

Factors	Category	
Parental education	Below Bachelor (58.4%)	Bachelor and above (41.6%)
Relationship to the child	Mother (89.3%)	Father & grandparents (10.7%)
Engagement style	No (53%)	Yes (47%)
Child gender	Male (44.5%)	Female (55.5%)
Child age group	4-5 years (74.8%)	6-8 years (25.2%)
Length of playing EDURINO	< 6 months (67.6%)	> 6 months (32.4%)
Subject area	STEM & Literacy (33.3%)	Mix (66.7%)

2.3.3 Results

2.3.3.1 Quantifying the Educational Benefits of Playing EDURINO

Before conducting the formal analysis, we additionally created a composite measure, namely EDURINO targeted area, which was the total score across 4 items that asked about children's development in identifying letters of alphabet, recognising name in print, one-to-one numerical correspondence and song and rhymes. The composite score was a useful additional measure, since it holistically captured the behaviours and traits that the EDURINO app directly aimed at improving, therefore a suitable variable when examining educational efficacy.

In the survey, parents were asked whether children were better/worse for a range of behaviours after playing EDURINO, thus their exact responses on the 5-point Likert scale were taken as the post assessment of EDURINO's efficacy. Although there was no direct measure of the pre-assessment of EDURINO's efficacy, we were able to compute it because of the wording and design of the questions. Notably, parents would have selected the 'Neutral' response in the exact same item before children started playing the app. Therefore, we separately computed the baseline measure for each development area by summing scores representing the 'Neutral' response from corresponding items. As a result, we obtained the following scores as the *baseline* measure for educational efficacy: 36 for behavioural development, 18 for cognitive development, 12 for EDURINO targeted area, and 21 for fine motor development. Normality check was performed and there was homogeneity of variances (all *ps* >.05 for Levene's test). Also, data were normally distributed with no outliers, assessed by boxplot inspection, and comparing the Kurtosis and SE Kurtosis value against with the critical value of 1.98.

To quantify EDURINO's efficacy, we conducted paired t test to investigate whether playing EDURINO have introduced positive educational benefits for children, by comparing parents' initial perception of its efficacy (based on the neutral responses in the survey) with the post assessment of efficacy after children have played the app. Notably, *after playing EDURINO* games, parents reported significant improvements across children's behaviour, cognition/language, fine motor skills and EDURINO targeted area (all *ps* <.001, Table 5, Figure 2).

Table 5: Descriptive statistics of pre & post efficacy of EDURINO and results of paired t-tests with effect sizes.

Assessment area	Mean (SD) of post efficacy	Mean difference (SD) between pre & post	Paired t test
Behaviour	41.871 (5.193)	5.876 (5.193)	*t (233) = 17.309, p <.001, d = 1.132*
Cognition	21.449 (3.864)	3.449 (3.863)	*t (233) = 13.655, p <.001, d = 0.893*
EDURINO targeted	14.889 (2.730)	2.889 (2.730)	*t (233) = 16.185, p <.001, d = 1.058*

Assessment area	Mean (SD) of post efficacy	Mean difference (SD) between pre & post	Paired t test
Fine motor	25.026 (3.693)	4.026 (3.693)	*t (233) = 16.675, p <.001, d = 1.090*

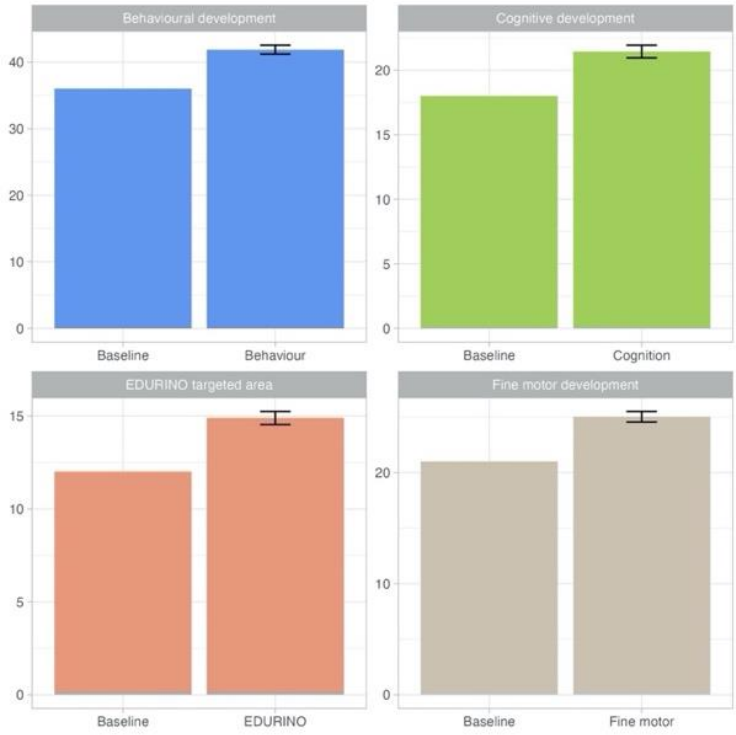


Figure 2: Mean efficacy scores of EDURINO *before* (baseline level, left bar) and *after* playing (right bar) with error bars represents standard deviations. There were no variations in the computed scores of baseline efficacy, thus error bars were omitted.

Second, independent-samples t-tests were conducted to examine the effect of demographic and app-related factors on parents' reported efficacy of EDRUINO across the 4 different development areas (Table 6). Notably, when quantifying EDURINO's educational benefits, parents who did not or rarely engage with children while they play the EDURINO app (*N* = 124) reported *higher* improvements in children's cognitive development (M = 21.99, SD = 3.723; t (232) = 2.305, *p* =.022, *d* = 0.299) and EDURINO targeted area (M = 15.28, SD = 2.649; t (232) = 2.363, *p* =.019, *d* = 0.307), compared to those who often/always engaged with their children (*N* = 110) during the playing session (Cognition: M = 20.84, SD = 3.943; EDURINO targeted area: M = 14.45, SD = 2.765). We also conducted exploratory analysis to test all possible combinations of interaction effects using one-way analyses of variance (ANOVA) and the data met all assumptions. There were no significant interactions between demographic and app-related factors on parents' perceived efficacy of EDURINO on children's development (all *ps* >.05).

2.3.3.2 Examining Correlational Trend of App-usage and Child Development

First, we tested the relationships between the different developmental areas; after controlling for age (measured in year with one decimal place) and child gender, all 4 areas were significantly correlated with each other (all *ps* <.001, table 7), suggesting convergent validity of the measures. Next, we explored the relationships Table 6. Independent samples t-tests on the effect of demographic and app-related factors on parent-reported EDURINO's efficacy.

Factor	Developmental area			
	Cognition	Behaviour	EDURINO targeted	Fine motor
Child age group	t (224) = -.806, *p* =.421	t (224) = .663, *p* =.508	t (224) = -1.018, *p* =.310	t (224) = -.763, *p* =.446
Child gender	t (227) = .914, *p* =.362	t (227) = -.340, *p* =.734	t (227) = 1.252, *p* = .212	t (227) = -.032, *p* = .974

Parental education	t (217) = 1.721, *p* =.087	t (217) = 1.243, *p* =.215	t (217) = 1.916, *p* =.057	t (217) = -.154, *p* =.878
Subject area	t (232) = .394, *p* =.694	t (232) = .044, *p* =.965	t (232) = .237, *p* = .813	t (232) = -.713, *p* =.477
Parental engagement	*t (232) = 2.305, p =.022*	t (t (232) = .311, *p* =.756	*t (232) = 2.363, p =.019*	t (232) = 1.559, *p* =.120
Length of playing	t (220) = -1.686, *p* =.093	t (220) = .600, *p* =.549	t (220) = -1.906, *p* =.058	t (220) = -.983, *p* =.327

Between children's overall improvement and specific skills, and demographic and app-related factors. The majority of the results were non-significant (all *ps* >.05), except for the following. Notably, parents' engagement style was significantly and negatively correlated with the perceived improvements in children's cognitive development (Spearman's correlation: *r* = -.159, *p* =.015) and EDURINO targeted area (*r* = -.165, *p* =.011), suggesting that the lesser parental involvement during the playing session, the greater improvements children demonstrated (as perceived by parents). In terms of specific skills, children's playing length (measured in month with no decimal places) were significantly and positively correlated with the improvement in print recognition (*r* = .145, *p* =.031), numerical one-to-one correspondence (*r* = .230, *p* =.011), the ability to draw precise human/body features (r = .142, p =.034), and hand manipulation of folding papers and using scissors (*r* = .133, *p* =.048), while significantly and negatively related to children's tendency to interrupt inappropriately at social interactions (*r* = -.141, *p* =.036).

Table 7: Partial correlations between different developmental areas after controlling for child age and gender.

	1	2	3	4
1. Cognition	-	.426***	.957***	.566***
2. Behaviour		-	.406***	.593***
3. EDURINO targeted			-	.564***
4. Fine motor				-

Note. *** indicate p <.001, ** indicate p <.01, * indicate p <.05.

3. Discussion

The current research was the first attempt to empirically assess EDURINO's educational efficacy. In Study 1, we adopted a validated evaluation index and EDURINO demonstrated great potential not only in learning content but also with its app feature. In Study 2, parents reported changes in children's school readiness, i.e., behavioural and cognitive development, as well as fine motor skills and the findings suggest that there were significant improvements and benefits after children playing EDRUINO.

In answer to the first research question (Study 1), EDURINO's top 2 strengths were 'meaningful learning' and 'social interactions'. Indeed, games in EDURINO were designed to meet specific learning objectives with clear context, instructions, and learning trajectories (Simon, 1995). The use of physical figurines to unlock the digital learning world is well-received among children. The characters also guide and interact with children during their learning journey, further enhancing the social experiences of playing EDURINO. On the other hand, EDURINO's most glaring limitation was 'adjustable content', also a common challenge across the industry (Callaghan & Reich, 2018). Yet, with the fast-developing AI tool, educational games that tailor content and pace to users' performance are more than ever promising and feasible. Notably, EDURINO's educational potential did not differ among specific user group or subject area, indicated by the non-significant effects of child demographics and app-related factor. Although the evaluation was based on parental ratings only, the findings were insightful and reliable considering the index was developed specifically to be used for a wider audience including parents (Kolak et al., 2021). However, parents' educational level did influence their evaluation of the app; this is important to consider when EDURINO enters markets where there are higher competitions and parents are more familiar with EdTech products. Future study on EDURINO should aim to adopt the multi-informant approach by including researchers and educators in the evaluation process.

Addressing the second research question (Study 2), we measured parent-reported changes in different child developmental areas using items from established instruments (Bricker et al., 1999; Hughes et al., 2015; Ireton,

1992). The results provided empirical evidence to first support and second quantify the efficacy of EDURINO. In percentage terms, children improved by 24.1% in EDURINO targeted areas, 19.2% in fine motor skills, 19.2% for cognitive/language development and 16.3% for behavioural adjustment. The findings suggest that there were holistic educational benefits across multiple developmental areas. Worth highlighting is that demographic and app-related factors did not influence how parents perceive children's changes in their school readiness and fine motor skills, suggesting the educational benefits were evident for all EDURINO users. Moreover, there seems to be some cumulative benefits for playing EDURINO for longer term, indicated by the positive associations between playing length and children's drawing ability, fine motor skills, print recognition and numerical knowledge. Interestingly, in contrary to existing literature (Taylor et al., 2023), parents perceived children's improvements (in EDURINO targeted area) to be higher when they did not engage during the playing session. Additionally, parental engagement style was negatively correlated with improvement in cognition and EDURINO targeted area. EDURINO was introduced to parents as a self-guided/paced app for children with educational games, and this may have influenced their judgment and impression. One possibility is that parents expected and were more likely to identify and report improvements when children engaged with the learning content independently. However, it is vital to recognise that in the current study parents were asked about *changes* in children's behaviour, which was prone to bias and demand characteristics. A more robust research design would use the same assessment items but ask parents to rate children's current level of development at two time points, then report educational efficacy based on the pre-post differences.

4. Strength and Future Research

To date, there has been no investigation on EDURINO's efficacy using research validated tools, therefore the current research adds a novel contribution not only to its internal stakeholders but also provides transparency to parents, educators and EdTech researchers. It also sets an example of collaboration between research and industry since to the best of our knowledge it is the first commercial app to utilise Kolak's educational index. Nevertheless, the current research has several limitations which point to fruitful directions for future studies. First, there was insufficient British respondents in the study sample and future research should aim to recruit equal number of participants from both countries where EDURINO are played. Second, instead of relying on parent report, it's more ideal for efficacy study to directly measure children's literacy, mathematics, and any targeted skills with standardised tasks outside the game context. Training study and randomised control trials would provide the strongest evidence for efficacy.

5. Conclusion

The current research provides first evidence that EDURINO, a game-based learning app for children aged 4-8, can significantly improve young children's school readiness of behavioural adjustment, cognitive and language development as well as fine motor skills. The app demonstrates strong and holistic educational potential with its meaningful and developmentally appropriate learning content and user-friendly app feature. On a broader level, the study not only highlights areas for ongoing refinements to EDURINO but also offers actionable insights to the EdTech industry.

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Analysing Game Data to Evaluate Children's Learning Progress with the EDURINO App

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Abstract: Game data offers a unique way to examine children's learning progress in a gameplay context. Despite its relevance in evaluating the efficacy of game-based learning, this area is less researched than engagement and usability study. This paper presents a quantitative investigation of EDURINO, an educational gaming app targeting children aged 4-8. We implemented learning metrics to track children's performance in EDURINO games. Specifically, the measurements included standardised variables from educational and experimental psychology, such as error count and duration. Here we reported data from a total of 18 EDURINO minigames in Literacy and Maths. Game data was collected by the learning metrics tracking system. A total of 66,463 players' data was analysed using generalised linear mixed models with the *lm4* package in R. Overall, children have shown improvements while playing the EDURINO app. We examined the relationships between children's game performance, player demographics and game-specific features and discovered different patterns. First, the significant main effects of age and gender indicated that EDURINO's educational content was developmentally sensitive and age appropriate. Second, children made fewer errors and spent less time when they were in the later rounds within a game or have played the same game more than once. Third, higher difficulty level undermined game performance. Worth noting is that the effect of game-specific factors varied among different educational content, and such discrepancy could be attributed to the nature of game design. When presented with engaging and interactive content, children may have chosen to deliberately make mistakes for fun effects. These findings are discussed in relation to game-based assessment for learning in EdTech research and industry. We also considered the interpretation of learning progress in EDURINO's gameplay context while highlighting the need for further efficacy research.

Keywords: Game-based Learning, Educational Technology, Game Data, Learning Progress

1. Introduction

The rapid integration of technology and digital devices into children's life has fundamentally transformed educational practices. With the EdTech industry estimated to reach $342 billion by 2025 (IQ Holon), there is an increasing emphasis on the development of digital platforms to enhance learning outcomes. The combination between engaging educational content and evidence-based pedagogical principles makes the field of game-based learning particularly promising (Behnamnia et al., 2022; Hirsh-Pasek et al., 2015; Tang, 2020). Indeed, cumulative research has demonstrated significant learning benefits of educational apps, with a meta-analysis revealing a medium positive effect size of +0.31, particularly in enhancing young children's mathematics and literacy skills (Griffith et al., 2020; Kim et al., 2021).

However, a critical gap remains in understanding the mechanism of specific educational apps. Traditional efficacy research predominantly employed methods of training study, survey, and randomised-controlled trials. However, few studies have conducted in-depth analysis of the educational tools themselves, specifically, to show how real-life player data can be utilised to assess and measure learning within the gameplay context (Bang, Li and Flynn, 2023; Fisch et al., 2024; Walsh and Bokhove, 2021). The current study aims to fill this gap by investigating real-life player data from the EDURINO's app.

EDURINO is an educational gaming app for children aged 4-8. There are nine subject areas covering STEM, humanities, and social-emotional learning in both German and English. Its unique features include a 'magic pen' stylus and haptic figurines that bridge digital and real-world learning (Figure 1). EDURINO's educational content has both holistic as well as detailed scope and sequences of learning objectives and the structure is informed by pedagogical theories (Plass and Pawar, 2020). In EDURINO's competency-based learning context, children are

given small activities to learn and practice specific knowledge. Also, all materials are presented in a playful and engaging digital platform with clear context and narratives.

To examine the gameplay data from EDURINO, this study was informed by different methodological frameworks of learning processes within digital games (Baker, Gašević, and Karumbaiah, 2021; Siemens and Baker, 2012). Notably, the entitative/reductionist paradigm has been the mostly widely adopted in research on educational apps (Fisch et al., 2024; Halverson and Owen, 2014). It focuses on breaking down complex phenomena, i.e., learning within a game, into their constituent components, e.g., game design and player behaviour, to understand relationships between these factors. Nevertheless, the uncertainty and noise in game-based assessment data require detailed examination of the game content and mechanics to establish reliable and meaningful learning metrics (Xu et al., 2021).



Figure 1: EDURINO's haptic figurines (upper left), game played with the "magic pen" on a tablet (upper right), screenshots of a literacy game (lower left), and a maths game (lower right).

The current study is the first empirical research utilising EDURINO's gameplay data. Firstly, we adopted the reductionist approach to define learning metrics while accounting for specific game design and mechanics. Second, we internally implemented the tracking system in the EDURINO app to collect data from real players. Given the exploratory nature of this study, we did not make specific and prior assumptions.

Building on the identified gaps and challenges, the current study explored two research questions:

1. Is there any evidence to suggest that children are learning within EDURINO's gameplay context?
2. What are the relationships between player features (demographics), game-specific features (design and content), and children's game performance in the EDURINO app?

2. Material and Methods

2.1 Participants and Ethics

Participants were active registered users of the EDURINO app (DACH version). The collection and report of children's game data did not violate the data privacy statement, since it was used only for research purpose, and all analyses were conducted by EDURINO's internal researcher with no third-party involvement. Furthermore, all procedures performed in the current study were in accordance with the ethical standards of the University of Cambridge Psychology Research Ethics Committee and have been reviewed by the senior author as an independent consultant on the project.

2.2 Data Source

The study utilised real-life player data of children's game performance, which was collected by the learning metrics tracking system and stored in a centralised cloud database. In EDURINO's learning world, there are 12 different episodes/subjects and each episode consists of numerous minigames which cover multiple learning

objectives of that subject. Within each minigame, there are at least two rounds of activities/tasks that children need to complete. Notably, the number of rounds for each minigame is fixed by design. This paper focused on a subset of EDURINO games, specifically 10 minigames from Episode 1 Mika Literacy in German (E1) and 8 minigames from Episode 2 Robin Mathematics (E2). The learning objectives of each minigame were outlined in Supplementary Material (Table S1). Data reported in this study was collected from 29th May 2024 to 1st July 2024. Data collection was conducted remotely through the implemented tracking system, in that player data was collected automatically while children were playing the app. There was no fixed duration for the study since children interacted with the app at their own pace and choice.

2.3 Measures

Multiple measures were first defined then tracked for each minigame (Table 1). The unit of collection is by round. Each round/minigame is designed to teach and test children's knowledge of specific learning objectives and they are given a task/activity to complete. In addition, we extracted information of age and gender for each player, which was entered by parents when setting up a child's player profile.

Table 1: Definition of measures.

Measure	Definition
Error	The total number of errors the child makes in a round, e.g., choose the wrong symbol/quantity to complete a mathematical equation.
Duration (in seconds)	The total length the child takes to successfully pass a round.
Round number	The specific, discrete and ordered segment of a minigame; the child needs to successfully complete certain task/activities in a round in order to move to the next round.
Difficulty level	The level of how difficult the learning content is in a round, set by curriculum and game designers. The higher the difficulty level, the more challenging the content.
Play count	The number of how many times the child has played a particular minigame, play count = 1 indicates first-play and so on.

2.4 Analytic Plan

To investigate how changes of children's performance in EDURINO games were associated with demographic variables and game-related factors, we fitted a series of Generalised Linear Mixed Models (GLMM) with the lm4 packages in R (Bates et al., 2015). For each response variable, we ran two models. Specifically, the first model only examined children's first play experience (play count = 1) while the second model utilised the full dataset (all play count included). In E1, we fitted models with fixed effects of age group (6 groups, 3-8 years), gender (male, female), round number, and play count (only for model 2), while participant ID was entered as a random effect. Based on market research, we extended the age range to include 3-year-olds to account for this customer group in the analysis. Notably, for E2, we included *difficulty level*, rather than round number, as fixed effects in the models. Minigames in E1 do not have varying difficulty levels whereas in E2 there are adaptable difficulty levels based on children's game performance. Taken the multicollinearity problem into account, we decided against fitting the models using both round number and difficulty level simultaneously. Therefore, the final fixed effects for all E2 minigames were age group (6 groups, 3-8 years), gender (male, female), difficulty level, and play count (only for model 2), while participant ID was entered as a random effect. Moreover, no interaction terms were included given the exploratory nature of the current study and the scarcity of relevant literature. Steps on data preparation are explained in Supplementary Material (https://figshare.com/articles/online_resource/Supplementary_Material_for_the_full_length_paper/26395765?file=48349339).

3. Results

Descriptive statistics of learning metrics measures in E1 and E2 were outlined in Table 2. The breakdown of player demographics was presented in Supplementary Material (Table S2). In GLMM, a significant estimate of fixed effect indicates that a particular independent variable, i.e., a game-specific factor, has a statistical meaningful impact on the outcome variable, i.e., error count and duration per round.

3.1 Children's Game Performance in E1

In children's first play, age group, gender, and round number were all significant main effects for predicting children's game performance (Table 3, 4). Older children made fewer errors and spent shorter duration to pass a round than the younger group. Also, children made fewer errors and spent less time with the later rounds than

the earlier rounds within the same minigame, except for Boss Fight 1 & 2, and Rhyme Wolverine. Moreover, female outperformed male in all minigames, except for Boss Fight 6 and Bridge of Word Holes.

Table 2: Descriptive statistics of learning metrics measures. *N* refers to the number of players.

Minigame	Round number	Difficulty level	Mean of error	Mean of duration
Episode 1 Mika Literacy				
Boss Fight 1 (*N* = 5869)	6	-	0.485	18.601
Boss Fight 2 (*N* = 4398)	5	-	0.194	21.482
Boss Fight 6 (*N* = 2284)	5	-	0.320	11.691
Bridge with Word Holes (*N* = 5427)	8	-	0.129	13.312
Burping Fish (*N* = 4098)	3	-	0.736	41.543
In the Head of Ava (*N* = 5414)	8	-	0.122	11.027
Rhyme Wolverine (*N* = 8077)	2	-	2.200	62.849
Wheel of Sounds 1* (*N* = 2957)	8	-	1.011	35.733
Wheel of Sounds 2* (*N* = 2308)	8	-	1.230	32.351
Wheel of Sounds 3* (*N* = 2118)	8	-	1.305	32.739
Episode 2 Robin Mathematics				
Bridge of Numbers (*N* = 2844)	4	2	0.427	35.227
Capture Shapes (*N* = 4270)	8	4	0.859	19.679
Construction Scale (*N* = 2486)	5	3	0.418	36.775
Put in Numbers (*N* = 3671)	4	2	0.359	30.346
Transport Building Material 1 (*N* = 3737)	5	3	0.206	42.124
Transport Building Material 2 (*N* = 2400)	5	3	0.229	42.749
Treasure Map (*N* = 2053)	6	3	0.095	27.557
Wheel of Fortune (*N* = 2052)	5	3	0.589	38.679

Note. There are three variants of the minigame Wheel of Sounds; each variant has the same learning objectives and game design but was separately tracked.

When all play counts were included, age group, gender, and round number were significant main effects in predicting the number of errors and duration spent in a round (Table 5, 6). Yet, the effect of play count differed among minigames. In Boss Fight 1 & 2, and Rhyme Wolverine, the number of errors increased with higher play count. Whereas for In the Head of Ava, children made less errors when they have played the minigame more than once. Similarly, higher play count was significantly related to shorter duration in all the minigames except for Boss Fight 6. To visualise the relationship between each main effect predictor and response variables, we generated graphs based on the GLMM models using the *ggeffects* package in R (Lüdecke, 2018). For instance, Figure 2 illustrates the marginal effect of how each predictor and duration was associated in Boss Fight 1. All figures for E1 minigames were presented in *Figshare (https://figshare.com/articles/figure/E1_marginal_effect_figures/26349118)*.

Table 3: GLMM models (error as response variable and play count is 1) in E1.

	Estimates of fixed effects for error			
Minigame	**Age group**	**Gender**	**Round number**	**Constant**
Boss Fight 1	-0.294***	-0.169***	0.093***	-0.203**
Boss Fight 2	-0.123***	-0.039	0.054***	-1.520***
Boss Fight 6	-0.402***	-0.064	-0.093***	0.948***
Bridge with Word Holes	-0.350***	-0.068	-0.048***	-0.715***
Burping Fish	-0.208***	-0.082**	-0.050***	0.724***
In the Head of Ava	-0.240***	-0.088**	-0.075***	-0.940***
Rhyme Wolverine	-0.237***	-0.146***	0.086***	1.001***
Wheel of Sounds 1	-0.246***	-0.114**	-0.163***	1.652***
Wheel of Sounds 2	-0.243***	-0.091**	-0.219***	2.078***
Wheel of Sounds 3	-0.255***	-0.079**	-0.224***	2.231***

Note. *** - p < .001** - p < .01* - p < .05.

Table 4: GLMM models (duration as response variable and play count is 1) in E1.

	Estimates of fixed effects for duration			
Minigame	**Age group**	**Gender**	**Round number**	**Constant**
Boss Fight 1	-0.085***	-0.007	-0.022***	3.453***
Boss Fight 2	-0.085***	-0.021*	-0.076***	3.747***
Boss Fight 6	-0.103***	0.003	0.032***	2.870***
Bridge with Word Holes	-0.067***	0.002	-0.018***	3.015***
Burping Fish	-0.056***	-0.024***	-0.044***	4.135***
In the Head of Ava	-0.059***	-0.006	-0.053***	2.987***
Rhyme Wolverine	-0.065***	-0.016*	-0.167***	4.800***
Wheel of Sounds 1	-0.074***	-0.012	-0.061***	4.244***

	Estimates of fixed effects for duration			
Minigame	**Age group**	**Gender**	**Round number**	**Constant**
Wheel of Sounds 2	-0.061***	0.001	-0.085***	4.151***
Wheel of Sounds 3	-0.055***	0.005	-0.077***	4.099***

Note. *** - p < .001** - p < .01* - p < .05.

Table 5: GLMM models (error as response variable) in E1.

	Estimates of fixed effects for error				
Minigame	**Age group**	**Gender**	**Round number**	**Play count**	**Constant**
Boss Fight 1	-0.280***	-0.146***	-0.002	0.293***	-0.139*
Boss Fight 2	-0.132***	0.016	-0.013	0.190***	-1.422***
Boss Fight 6	-0.401***	-0.068	-0.102***	-0.027	0.999***
Bridge with Word Holes	-0.318***	-0.061	-0.051***	-0.010	-0.825***
Burping Fish	-0.199***	-0.051**	-0.029**	-0.023	0.670***
In the Head of Ava	-0.201***	-0.097**	-0.074***	-0.209***	-0.916***
Rhyme Wolverine	-0.257***	-0.146***	0.070***	0.161***	1.095***
Wheel of Sounds 1	-0.232***	-0.092***	-0.167***	0.016	1.594***
Wheel of Sounds 2	-0.238***	-0.069*	-0.218***	0.003	2.038***
Wheel of Sounds 3	-0.257***	-0.074**	-0.221***	-0.008	2.229***

Note. *** - p < .001** - p < .01* - p < .05.

Table 6: GLMM models (duration as response variable) in E1.

	Estimates of fixed effects for duration				
Minigame	**Age group**	**Gender**	**Round number**	**Play count**	**Constant**
Boss Fight 1	-0.079***	-0.009	-0.014***	-0.095***	3.483***
Boss Fight 2	-0.081***	-0.015	-0.050***	-0.121***	3.769***
Boss Fight 6	-0.103***	-0.004	0.032***	0.001	2.874***
Bridge with Word Holes	-0.058***	-0.005	-0.006***	-0.044***	2.961***
Burping Fish	-0.047***	-0.020***	0.002	-0.051***	4.035***
In the Head of Ava	-0.046***	-0.013***	-0.036***	-0.095***	2.931***
Rhyme Wolverine	-0.055***	-0.021***	-0.085***	-0.104***	4.698***
Wheel of Sounds 1	-0.068***	-0.010**	-0.055***	-0.117***	4.296***
Wheel of Sounds 2	-0.057***	0.002	-0.081***	-0.070***	4.196***
Wheel of Sounds 3	-0.055***	-0.007***	-0.074***	-0.073***	4.156***

Note. *** - p < .001** - p < .01* - p < .05.

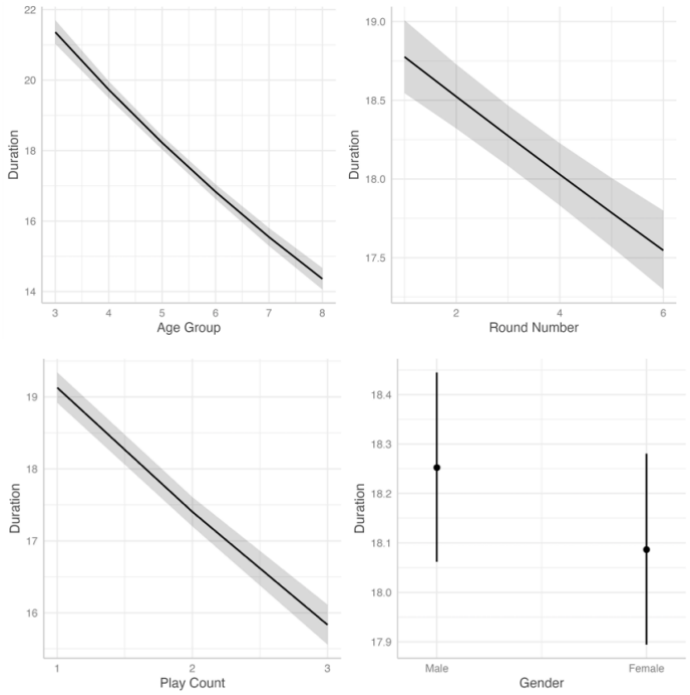


Figure 2: Predicted marginal effects of age group, round number, play count, and gender on duration spent for BOSS Fight 1, with 95% confidence intervals. Each chart illustrates how changes in a specific main effect are associated with variations with duration, holding the other main effects constant.

3.2 Children's Game Performance in E2

Irrespective of play count, age group was a consistent and significant main effect predictor for children's game performance, i.e., error count and duration, across all the minigames (Table 7, 8). Similar to E1, gender was the second most consistent main effect: female made less errors and took less time to pass a round. In terms of difficulty level, when play count = 1, higher difficulty level was associated with more errors or longer duration in Bridge of Numbers, Put in Numbers, Wheel of Fortune, and Capture of Shapes. However, we also found the opposite and less expected pattern: higher difficulty level was associated with fewer errors or shorter duration in Construction Scale, Transport Building Material 1&2, and Treasure Map.

When all play counts were included for analysis, higher difficulty level was associated with fewer error count in Put in Numbers and Transport Building Material 1 (Table 9). Yet, for Bridge of Numbers, Capture Shapes, and Wheel of Fortune, higher difficulty level was associated with poorer game performance, i.e., greater errors and longer duration to pass a round. Higher play count was a significant predictor for shorter duration for all minigames except for Wheel of Fortune. However, the pattern was less clear with the error count; higher play count was associated with better performance in Construction Scale, Put in Numbers, Transport Building Material 1, yet related to more errors in Capture Shapes and Transport Building Material 2. We followed the same procedure as in E1 to generate figures to visualise GLMM model results. For instance, Figure 3 illustrates the marginal effect of all fixed effects predictors of error count in Put in Numbers. All E2 figures were presented in *Figshare*

(https://figshare.com/articles/figure/_sup_E2_marginal_effect_figures_sup_/26349130)

Table 7: GLMM models (error as response variable and play count is 1) in E2.

	Estimates of fixed effects for error			
Minigame	**Age group**	**Gender**	**Difficulty level**	**Constant**
Bridge of Numbers	-0.155***	-0.060	0.265***	-0.767***
Capture Shapes	-0.186***	-0.072***	0.014	0.535***
Construction Scale	-0.150***	-0.038	-0.202***	0.231*
Put in Numbers	-0.180***	-0.045	0.021	-0.477***
Transport Building Material 1	-0.232***	-0.25	-0.310***	0.183
Transport Building Material 2	-0.219***	-0.258***	0.014	-0.998***
Treasure Map	-0.225***	-0.216**	0.020	-1.936***
Wheel of Fortune	-0.239***	-0.126**	0.391***	-0.327***

Note. *** - p < .001** - p < .01* - p < .05.

Table 8: GLMM models (duration as response variable and play count is 1) in E2.

	Estimates of fixed effects for duration			
Minigame	**Age group**	**Gender**	**Difficulty level**	**Constant**
Bridge of Numbers	-0.063***	-0.001	0.280***	3.443***
Capture Shapes	-0.108***	-0.046***	0.101***	3.220***
Construction Scale	-0.061***	-0.020	-0.050***	4.025***
Put in Numbers	-0.063***	-0.0001	0.169***	3.396***
Transport Building Material 1	-0.065***	0.009	-0.235***	4.633***
Transport Building Material 2	-0.069***	-0.003	-0.257***	4.699***
Treasure Map	-0.050***	-0.014	-0.112***	3.849***
Wheel of Fortune	-0.079***	-0.018	0.355***	3.366***

Note. *** - p < .001** - p < .01* - p < .05.

Table 9: GLMM models (error as response variable) in E2.

	Estimates of fixed effects for error				
Minigame	**Age group**	**Gender**	**Difficulty level**	**Play count**	**Constant**
Bridge of Numbers	-0.165***	-0.035	0.292***	0.001	-0.753***
Capture Shapes	-0.187***	-0.049*	0.035***	0.029*	0.364***
Construction Scale	-0.159***	-0.0002	-0.048	-0.151***	0.032
Put in Numbers	-0.183***	-0.055	-0.216***	-0.084***	0.077
Transport Building Material 1	-0.230***	0.021	-0.144***	-0.295***	-0.313*
Transport Building Material 2	-0.233***	-0.299***	0.042***	0.027***	-0.958***
Treasure Map	-0.193***	-0.130	0.038	0.034	-2.076***
Wheel of Fortune	-0.229***	-0.070	0.259***	0.037	-0.160***

Note. *** - p < .001** - p < .01* - p < .05.

Table 10: GLMM models (duration as response variable) in E2.

	Estimates of fixed effects for duration				
Minigame	**Age group**	**Gender**	**Difficulty level**	**Play count**	**Constant**
Bridge of Numbers	-0.059***	-0.0002	0.296***	-0.029***	3.427***
Capture Shapes	-0.102***	-0.033***	0.100***	-0.034***	3.223***
Construction Scale	-0.059***	-0.012	0.017***	-0.082***	3.941***
Put in Numbers	-0.056***	0.004	0.011	-0.044***	3.701***
Transport Building Material 1	-0.067***	0.032***	-0.101***	-0.167***	4.478***
Transport Building Material 2	-0.073***	0.001	-0.125***	-0.146***	4.550***
Treasure Map	-0.052***	-0.005	-0.036***	-0.065***	3.735***
Wheel of Fortune	-0.073***	-0.010	0.177***	-0.001	3.678***

Note. *** - p < .001** - p < .01* - p < .05.

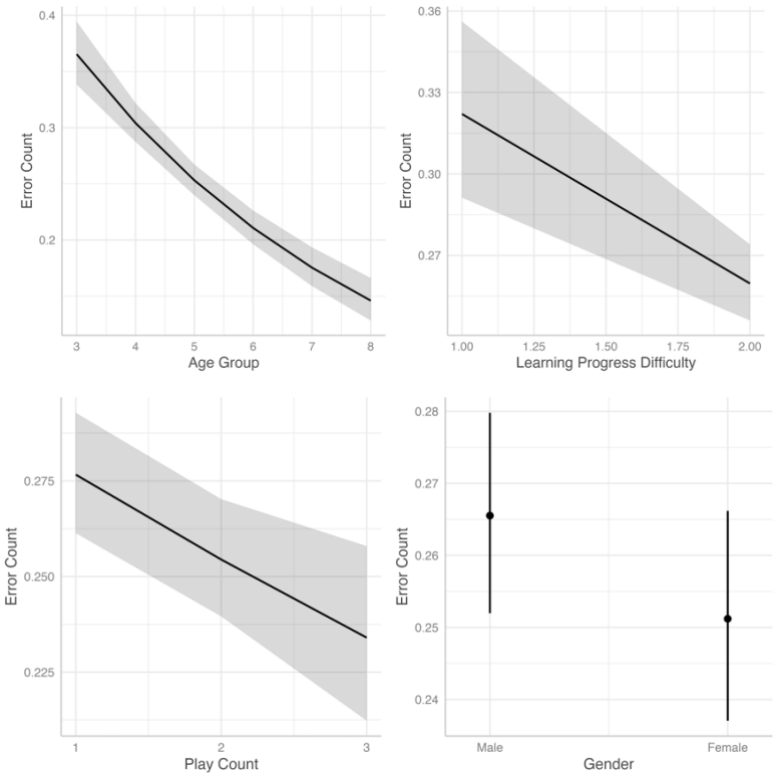


Figure 3: Predicted marginal effects of age group, difficulty level, play count, and gender on error count for Put in Numbers, with 95% confidence intervals. Each plot illustrates how changes in a specific main effect are associated with variations with error count, holding the other main effects constant.

4. Discussion

The current study was the first investigation to utilise EDURINO's game data to examine children's learning progress in the gameplay context. First, based on standardised practice from educational and experimental psychology, we defined an array of measures for learning metrics. Then, we implemented the tracking system to collect data of children's performance in EDURINO's educational games. Overall, children demonstrated learning progress within EDURINO's gameplay context, and their performance was closely related to both player demographics as well as game-specific features.

In answering the first research question, interpretation of game performance between rounds and play count warrant discussion. Across all minigames in Episode 1 for literacy, round number was a significant main effect in GLMM. Specifically, children made fewer errors and spent less time to pass the later rounds than the earlier rounds within the same minigame. The findings indicate improvements within a very short amount of time, and therefore by themselves may not be seen as conclusive evidence of learning. Play count, which has been observed over a longer course of time, was also associated with clear improvements in children's game performance. Children continued the trend of making less mistakes and taking less time to pass when they have played the game more than once. Worth highlighting is that although rounds within the same minigame have the same game mechanics and learning objectives, children are presented with different content in each round,

for example detecting different quantities. Therefore, children's improvements could not be explained entirely by repetition or practice effect (Fisch et al., 2024).

Taken together, EDURINO's game data was indicative of learning progress within the gameplay context. Nevertheless, game data are at best, assessment of constrained skills on specific skills such as sorting shapes and counting, rather than an assessment of unconstrained skills of broader domain knowledge such as problem solving. As noted by Kim et al. (2021), educational apps show constrained learning benefits with a small and fixed body of knowledge. To address this gap, more research is needed to test EDURINO's efficacy with transferred contexts and broader materials to show unconstrained learning benefits (Aladé et al., 2016; Pearson et al., 2020).

To address the second research question, we fitted several main effects in GLMM models to elucidate the relationships between player and game-specific factors on children's game performance. Not only did the findings provide insights into EDURINO's game design, but also highlighted the challenges for game-based learning and assessment. First, across all minigames assessed in the study, older children consistently outperformed younger children. Additionally, there were also clear gender differences in that female exhibited better game performance than male, particularly in E1 for literacy games. The significant main effects of age and gender suggested that EDURINO's learning content and educational materials were developmentally sensitive and age appropriate, since it follows the universal age and gender-related patterns and trajectories (Eriksson et al., 2012; Bang, Li and Flynn, 2023).

Difficulty level, on the other hand, led to more mixed results. In some minigames, such as Capture Shapes, Construction Scale, Treasure Map, and Transport Building Material, children made fewer mistakes and spent shorter duration with content of higher difficulty level. There were also cases where children started to make more errors yet spent a shorter time when they have played the game more than once. Several explanations are possible. First, certain games' difficulty level might not correspond to children's ability and skills and need adjustment. Second, children might have already mastered the skills required for the games but started to play for fun by deliberately making mistakes. EDURINO incorporates the 'giggle factor' feature in design so that errors are presented and responded with fun and interactive effects. This posits a wider question and challenge of how to reliably assess game-based data for educational content when the content is presented in a gameplay context (Fisch et al., 2024; Walsh and Bokhove, 2021). Using data mining techniques, advanced tracking system and analytic approach would be powerful tools to account for the noise in game data (Baker, Corbett, and Aleven, 2008; Chen et al., 2020).

A particularly novel contribution of the current study was utilising game data from real players to examine game-based learning, a largely under researched field with very little literature (Behnamnia et al., 2022; Kiguchi, Saeed, and Medi, 2022; Kucirkova et al., 2014; Walsh and Bokhove, 2021). The clear and precise definition of more than one outcome measures (of error count and duration) allows for a richer interpretation of findings and could be adopted by other apps in the industry to establish comparable learning metrics (Siemens and Baker, 2012). The very large sample size and robust statistical analysis ensured the results are consistent with academic standards and practice, and we advocate that other commercial companies adopt inferential methods for research design. However, the study relied on game data which is naturally prone to errors and uncertainty (Xu et al., 2021). Most importantly, the findings indicate improvements within EDURINO's gameplay context, further investigation outside the gameplay context, for example longitudinal efficacy research, is essential before any conclusion is drawn about its long-term learning benefits for unconstrained knowledge.

5. Conclusion

The current research focused on game-assessment data to reveal that children shown clear improvements in EDURINO's gameplay context. Learning progress was evident within a single play session as well as across multiple play sessions. The app's engaging content was age appropriate and children's game performance followed universal developmental trajectory. We consider game-based learning as an important piece of the puzzle in understanding the holistic benefits of educational apps. Yet, the significance of traditional efficacy research cannot be underestimated.

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Real-World Geopolitical Influences on In-Game Financial Behaviour

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Abstract: This paper explores how real-world geopolitics can influence financial decision-making in virtual environments. The study primarily focuses on trading dynamics in a pandemic simulation game. The players manage resources and trade with each other to save their population. We compared two groups: one playing with made-up country names (control) and another with real country names (test). The players were not permitted to communicate outside of the resources the game provides and were finally ranked based on the number of months survived and trade volume. Our findings reveal two distinct player archetypes, one focusing on maximising trade volume and a second focusing on resource conservation. Real country names compared to color-coded labels seem to delay the perception of competition and reduce overall trade volume, suggesting increased immersion and a more conservative approach towards resource management. Observations from gameplay footage reveal instances of potential bias, with players forming diplomatic ties based on national identities. The data collected suggests that real-world geopolitics can influence financial behaviour in virtual environments as hypothesised. It also explores virtual environments to study how political narratives and dynamics affect human decision-making. The findings offer practical insights for game developers regarding fostering player engagement, mitigating bias, and creating fair economies. While parallels with real-world resource trading and allocation during pandemics were noted, further analysis would be required to explore these connections.

Keywords: Polarisation, Game Design, Pandemic, Trade, Perception, International Affairs

1. Introduction

The convergence of the domains of video games, political polarisation, financial behaviour, pandemics and disasters is initially unexpected. Games themselves encompass a virtual microcosm where players engage in economic transactions and strategic decision-making akin to the mechanisms of real-world financial systems. Simultaneously, games often embed geopolitical elements, mirroring global political scenarios and introducing players to dynamic narratives that simulate real-world sociopolitical landscapes. These virtual economies can also be influenced by real-world events, such as pandemics and disasters, blurring the lines between the virtual and the tangible.

1.1 Political Polarisation and Cooperative Dynamics

The COVID-19 pandemic has revealed a remarkable confluence of global coordination challenges and political balance. During this period, the intersection of politics, media, and public perceptions has become evident (Chen *et al.*, 2020; Bobba and Hubé, 2021). The trading of resources between nations and the opening and closing of borders have become victims of internal strife, with each country adopting its approach to the pandemic. These decisions, often made without a template for collaborative legislation, reflect the paradox of a shared global challenge met with fragmented responses (Allam, 2020), but also underscore the interconnectedness of global economies. Nationalistic policies, supply chain disruptions, and collaborative efforts for resource sharing indicate how geopolitical decisions affect international trade and economic dynamics. Allam (2020) posits that the potential for global coordination could provide a more effective solution, without politicisation. Intriguingly, as markets and trade relations are scrutinised by citizens, they, too, become subjects of societal discourse, influencing public opinions, electoral politics, and mobilisation (Zürn, 2014). Consequently, instrumental questions about problem-solving and effectiveness intertwine with issues of legitimacy, fairness, rationality, and equity (Goggin, 2012; Caplan, 2011; Singer *et al.*, 2019).

Rationality often contends with group dynamics and polarisation (Singer *et al.*, 2019). The ability of rational agents to polarise after sharing evidence highlights the intricate interplay between individual rationality and group-level dynamics. This phenomenon resonates with the potential for player financial behaviours to diverge as real-world geopolitical elements are introduced into virtual game contexts.

Examining the intersection of game theory and financial behaviour within virtual environments provides a lens through which to understand the dynamics of player interactions. In cooperative games, a fundamental implicit assumption prevails - players form coalitions and establish agreements on how to distribute the proceeds of their cooperative efforts (Hart, Chinn and Soroka, 2020). Cooperative games strive to maximise collective profits and promote social welfare through collaborative strategies.

In contrast, non-cooperative games emphasise strategic interactions among players, where each participant makes decisions to optimise their individual outcomes. The pursuit of equilibrium, where no player has an incentive to unilaterally deviate from their chosen strategy, characterises the essence of non-cooperative games (Hart, Chinn and Soroka, 2020). In this context, price setting emerges as a pivotal determinant in the success of trading and the equitable redistribution of profits.

These game-theoretic principles resonate within virtual economies as players engage in financial transactions and decisions that mirror real-world economic behaviour. The interplay between cooperative and non-cooperative dynamics, and the significance of achieving equilibrium, underscores the intricacies of player financial behaviour within virtual worlds.

1.2 Game Design, Social Interaction, and Player Financial Choices

Studies on player experiences in multiplayer games reveal that higher player interdependence fosters more communication, leading to understanding the social dynamics, social well-being, and strategy discussions among players (Balicer, 2007; Emmerich and Masuch, 2017; Lofgren and Fefferman, 2007; Szell and Thurner, 2010; Martončik and Lokša, 2016; Zhang and Kaufman, 2017; Belaza *et al.*, 2020). Augmentation effects (Qin, Cho and Zhang, 2021) emphasise how players' social interactions impact their gaming experiences. This suggests that real-world geopolitical elements might lead to financial decisions shaped by players' social contexts.

Exploring finance within gaming through classroom simulations (Holt, 1996) underscores the relevance of supply and demand models in understanding virtual economies. Dynamic bilateral trading games (Athey and Segal, 2007) highlight the role of serial correlation and buyer incentives, which can be interconnected with game design elements to shape financial decision-making. The financialisation of everyday life, observed in virtual economies (Zürn, Binder and Ecker-Ehrhardt, 2012), emphasises the blending of real and playful economies, potentially affecting player perceptions of in-game financial choices (Snow *et al.*, 2015).

1.3 Research Significance and Implications

Using games, we seek to unearth whether the virtual worlds reflect real-world financial behaviours and political dynamics. Such a setup offers a novel perspective on how virtual environments can serve as laboratories to understand human behaviour, financial decision-making, and political polarisation. A game designed with a theme of the evolving dynamics of the world's response to the pandemic would capture accurate sentiments and behavioural responses to such an event.

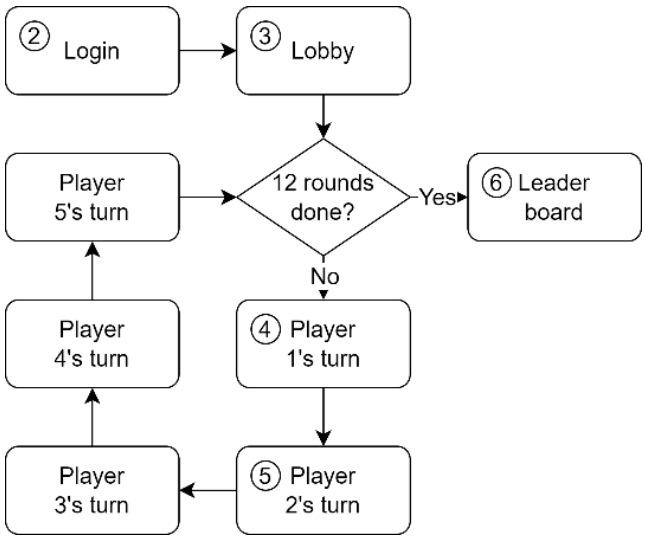


Figure 1: Flow of the game

In this paper, from the player behaviour data collected using an in-house developed unique game, we study decision-making under uncertainty (infection rates), understanding or awareness of real-world geopolitical relations and personal bias that manifests in-game behaviour. The game designed, developed, and play-tested during the pandemic (2020-2021), reflects the struggle for commodities and resources required by each country to save the population. The findings contribute to understanding the role of possible bias (personal and geopolitics) in trade partnerships and strategies applied to cooperate and save lives.

2. Methodology

2.1 Hypothesis

This study aims to investigate how real-world geopolitical contexts influence financial decision-making within a virtual environment. The methodology involves detailed observation of players' trading patterns, leaderboard performance, and qualitative insights gathered from game sessions. This multifaceted approach can provide insight into geopolitical biases and the manifestation of perceptions in virtual game economies.

The primary hypothesis of this paper is that in-game financial behaviour alters when the player represents a real country as opposed to a fictitious one. This hypothesis subsumes the premise of bias due to political polarisation that influences financial decision-making even in times of crisis.

2.2 Game Description

Figure 1 shows the block diagram for all screens of the game. It is a digital competitive multiplayer game that five people play simultaneously. The player assumes the role of the leader or policy decision-maker of the country being represented. Each game goes on for twelve rounds, each round being titled as a month in-game. Each round is turn-based, with players taking their turns in a fixed decided sequence. Once twelve months (sixty turns) have passed, the game ends, and the players are displayed on a leaderboard. Each turn is clocked to a one-minute maximum.

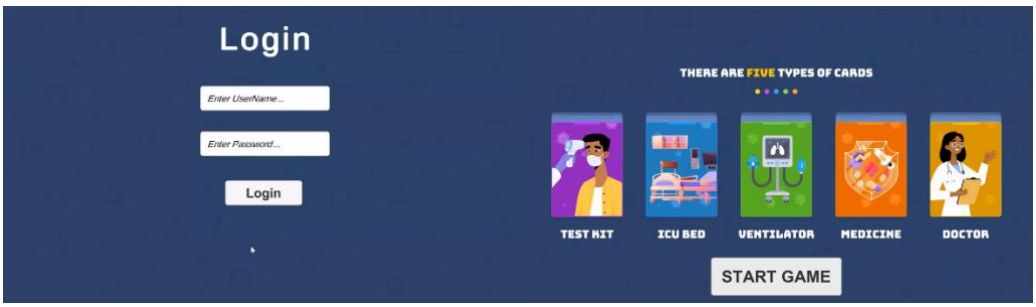


Figure 2: The login screen (left panel) where players enter their credentials. The screenshot of the lobby on the right displays the assets the players can trade.

Each player enters credentials to the login screen (Figure 2) to access the game lobby. Once logged in, the player is randomly assigned one colour-coded country (in the control case) or a real-world country (in the test case) to represent the game's duration. The countries chosen are the USA, Russia, China, India, and Brazil. The player enters the lobby where a screen (Figure 2 right) is displayed till all five players are logged in and choose to start the game. The lobby displays the five resources that the player can trade with other players: test kits, ICU beds, ventilators, medicine, and doctors.



Figure 3: left: Player's dashboard during their own turn, right: pop-up when another player offers to sell a requested resource.

Figure 3 presents the main dashboard of the game. The bottom panel, in the colour of the player, displays the player's current available resources and current in-game money. The countries that each player represents have in-game starting money closely based on their real-world foreign exchange reserves, modified with the intent to balance the game. The number of infections each country will face is also based on the predictions hosted on

the world COVID-19 tracker (Worldometer, 2020) to provide a more realistic simulation. The game was designed in 2020 and hence uses predictions of infection rates till February 2021.

The panel on the top has on the left the number of infections that the player has on the centre of the current month, and on the right the clock displays the time left in the current turn. There are four tabs, two on each side of the screen, representing the other four players.

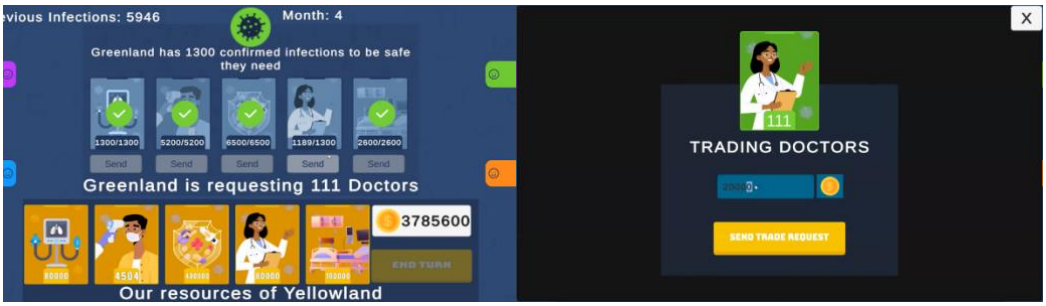
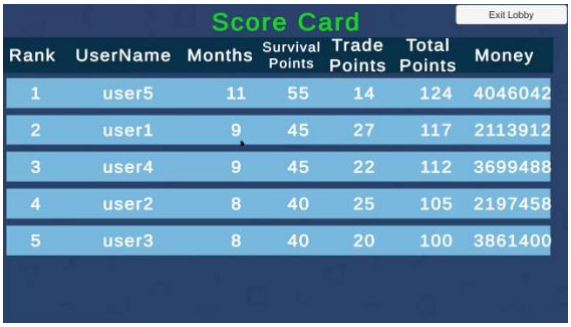


Figure 4: Left: Player's dashboard during another player's turn, right: modal to enter amount or sale price when offering resources to another player.

The centre of the screen is occupied by request buttons for the player to procure resources. Once the player requests a resource, the other four players can view the request and the number of infections in the land requesting the resources (middle area in Figure 4 left). If one of the other players decides to sell to the current player, they are displayed the modal (Figure 4 right) to enter the price for which they wish to sell the respective resource. When an offer is made by another player, it is displayed as a pop-up box next to the player who made the offer (Figure 3 right). The current player can choose to accept any of the offers.



Rank	UserName	Months	Survival Points	Trade Points	Total Points	Money
1	user5	11	55	14	124	4046042
2	user1	9	45	27	117	2113912
3	user4	9	45	22	112	3699488
4	user2	8	40	25	105	2197458
5	user3	8	40	20	100	3861400

Figure 5: Leaderboard shown at the end of 12 rounds.

Once a trade is accepted and the player's resources reach the sufficient minimum amount required to deal with the player's current infections, the player is said to have 'survived' the month. At the end of the game, the leaderboard (Figure 5) displays the number of months survived, followed by the number of trades done by the country. This is briefed to the players prior to beginning the game. The ranks are provided based on the months survived and then trade points, and intentionally not based on the money left with a player. The players are made aware of this information before playing the game.

2.3 Tools Used

The game was developed in the Unity game engine and targeted for Windows. It uses a GameSparks cloud back-end. All participants logged in via Zoom meetings in their isolated environments. To record all data and ensure no verbal communication between participants, all participants were placed in their own breakout rooms, with screen recording.

2.4 Participants of the Study

The participants of the study were undergraduate computer science students between the ages of eighteen and twenty-two, who all speak English fluently and had proficiency in digital games. Of the 30 participants, fifteen were assigned the control group, and fifteen were assigned the test group. Each game requires five participants, and hence this caused a total of six successful runs of the game. The control groups played a version of the game

that did not mention real country names. The names 'Orangeland', 'Yellowland', ‘Greenland’, ‘Purpleland’, and 'Blueland' were used. Real country names - India, Russia, China, Brazil, and the USA - were used with the test groups.

The participants were briefed for thirty minutes about the game before playing it, including a discussion segment. For the duration of the game, the participants were not allowed to communicate with each other. Once the leaderboard was displayed at the end of the game, the participants engaged in a second discussion segment.

2.5 Data Collection and Analysis Methods

Three types of data analysis have been conducted, the first being qualitative, the second being quantitative, and the third being anecdotal.

The first analysis is on the turn-by-turn log data. All the players’ trade offers and acceptances are recorded in a table. The data entered is each trade offer given, received, and accepted. All these data points are then line plotted. Since it is a five-player multiplayer game, each player interacts with four other players. This means that four graphs for twelve rounds, those of the interactions of a single player with four others, can be plotted as overlapping. These graphs are noted to be similar to quadratic graphs. When a best-fit quadratic curve is applied to the line graphs, the quadratic curve can be classified as either an upward or downward parabola, and the peak of the parabola (maximum for downward, minimum for upward) is noted. The peak’s averages and variances are then calculated for all control and test groups separately. This allows us to observe typical player archetypes.

The second analysis is on the final leaderboards of all six games and thirty players. Variances and means are plotted. This data is presented as aggregate and not individual. Since the game is granular, with only five players at a time trading five resources, it is challenging to balance the game. Therefore, it is only appropriate to study the difference generated between the control and test groups and not the difference generated between countries ignoring the control and test groups.

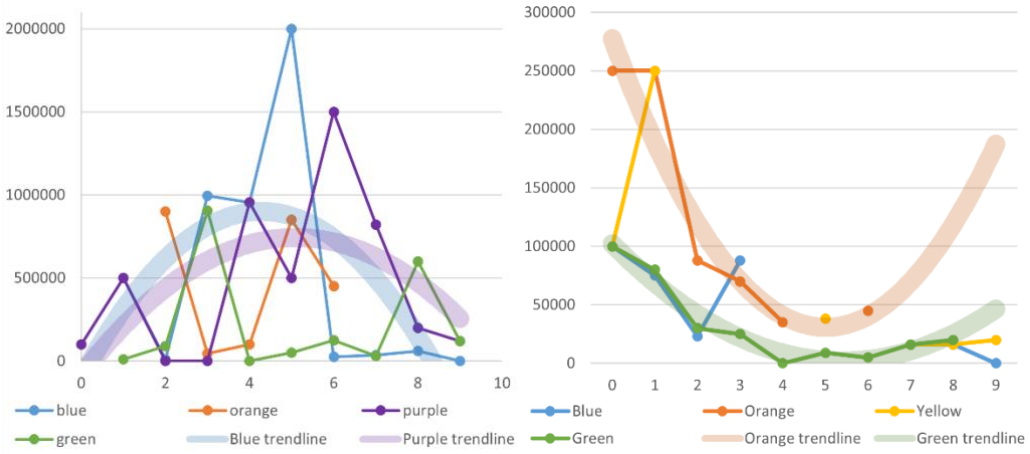


Figure 6: Representation of the two typical archetypes players show - upward and downward parabolas. The first graph (left) is for a player representing ‘Yellowland’, and the second graph (right) is for a player representing ‘Purpleland’. The X-axis represents months passed, the Y-axis represents in-game money traded, and the colours represent all other players.

The third analysis is on the footage captured during a few game sessions. It consists of audio quotes of players if they remark on other players while in the game or oral musings during decisions. It also goes through parts of the gameplay footage when an ’irrational’ decision has been made.

3. Results

The final leaderboard results are available from all thirty participants, while anecdotal evidence is available from only twenty participants. Complete turn-by-turn data is also available from twenty of the participants. The first two rounds are typically rounds with zero infections across populations, effectively the data is from ten of the twelve rounds.

3.1 Observed Player Archetypes and Shifts

Turn-by-turn trading data was recorded for twenty of the thirty participants of the study. There are two common archetypes observed from the players. One type of player's trading pattern trendline follows an upward parabola, while the other type follows a downward parabola (Figure 6). Fifteen of them, that is 75% of the player trajectories have been upward parabolas. It is reasonable to assume that if the number of players and rounds in the game is increased then the data will begin to look increasingly like its trend line. While most players follow an upward parabola, the downward parabola following players is not negligible.

The rationale behind following an upward parabola is that the player might care more for the trade volume aspect of the game rather than wealth accumulation initially, an expected but recognisable distinction. The prices continue to drop and trade volume continually increases (minima of the trendline), when the player realises that the increase in cases demands a more conservative approach to trading. Since the scarcity of resources is more abundant towards the end of the game, trade volume is typically reduced. Therefore, demand is less, and prices begin to increase.

The hypothesised rationale behind following a downward parabola is that the player keeps increasing prices for resources since they are in more demand initially. An increasing price however is more prone to rejection, as competition is still present within the game. At the maxima of the trendline, the player has accumulated enough rejections of trades to realise that more competitive pricing would be an optimal strategy. Beyond the maxima, trade volume has reduced since the typical player is in resource conservation mode. This causes rejection of trade at falling prices, further causing the trendline to fall.

Table 1: Average difference in peaks of all trade graphs

Scenario	Colours		Countries		Difference of means
	Mean	Variance	Mean	Variance	
Selling	4.2	0.8	4.7	1.2	0.5
Buying	3.8	1.6	4.4	0.8	0.6

Table 2: Average difference in peaks of upward parabola trade graphs

Scenario	Colours		Countries		Difference of means
	Mean	Variance	Mean	Variance	
Selling	4.3	0.8	5.0	1.0	0.7
Buying	3.3	0.5	4.5	0.8	1.2

In the control experiment where country names were hidden, the average peak (between 0 and 9) for selling by ten players was 4.2 with a 0.8 variance, while for buying it was 3.8 (with a 1.6 variance). In the test condition (country names displayed), the average peak for selling resources shifted forward to 4.7 with a 1.2 variance, while for buying it shifted forward to 4.4 with a 0.8 variance (Table 1). If the downward parabola graph interference is removed from this (considering that only 25% of the players generated a downward parabola graph), in the control condition the average peak for selling resources was 4.3 with a 0.8 variance, while for buying it was 3.3 with a 0.5 variance. In the test condition, the average peak for selling resources shifted forward to 5.0 with a 1.0 variance, while for buying it shifted to 4.5 with a 0.8 variance (Table 2).

3.2 Shifted Means and Variances in the Final Scores

From Figure 7, illustrating the difference in ranks between control and test groups, it is evident that players representing India received the most significant leaderboard rank boost as expected since the players were all from India. In the cases of Russia and China, there is an increase in the standard deviation of the data, reflecting that the participants possibly hold possible higher bias regarding them, causing a larger variance in gameplay outcomes. Brazil loses their leaderboard rank the most while maintaining consistency in deviation. The United States performs consistently poorly in both control and test cases but with no significant difference in trade volume.

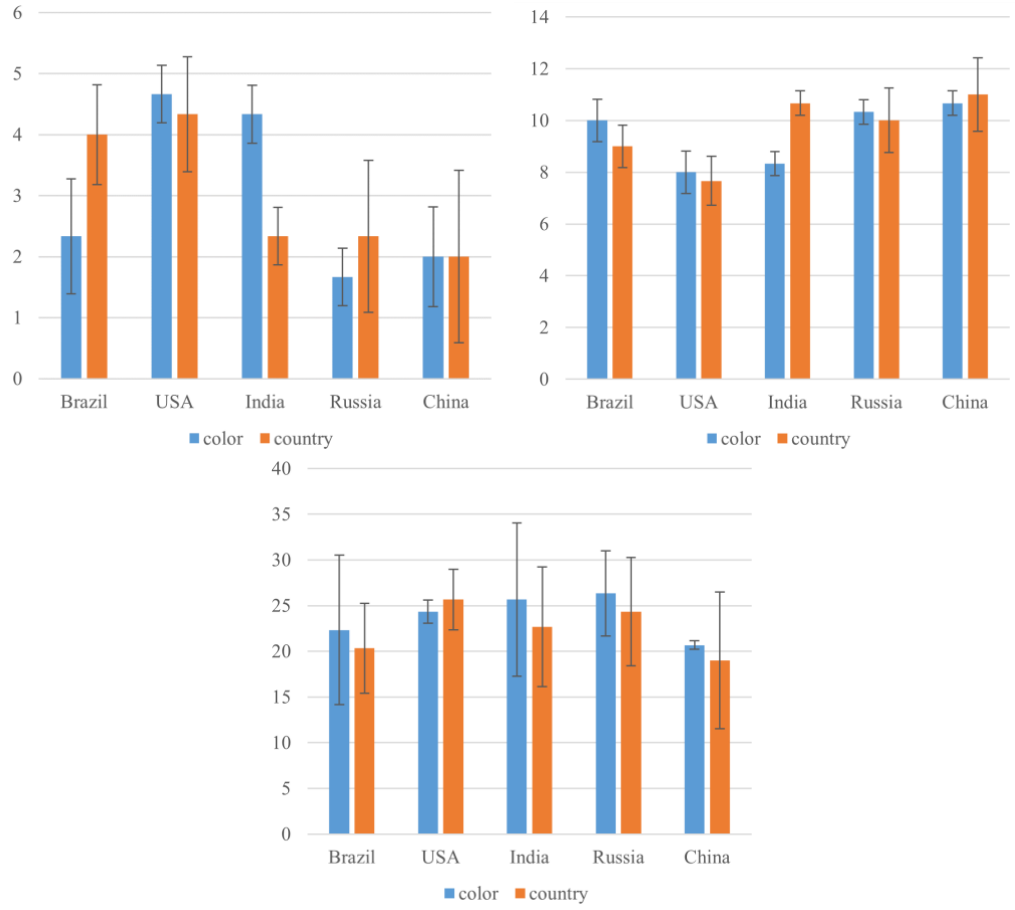


Figure 7: (clockwise from top left) Average leaderboard rank (lower is better) with standard deviation, average months survived (higher is better) with standard deviation and average number of successful trades with standard deviation.

3.3 Anecdotal Findings

Going through the footage of the game reveals the thought process behind a few of the choices that players have made.

In the eighth month of a game in the test group, the player of India, while requesting resources, chooses to trade with China for 8000 coins over the USA for 5000 coins, stating, “Let me give China the business for this round”. In the ninth month, the player repeats this ‘irrational’ purchase but with Russia for 1000 coins, over the 300 coins offered by the USA as well as China, stating almost the same thing, “Let's give Russia the business for this round”. It appears that the player wants to start building diplomatic ties with other players amidst the resource-deprived part of the game. This strategy, however, is not optimal, since the other players cannot see the options this player has, or access the player’s thought process, making the gesture useless. It is more reasonable and supported by this anecdote, for the players whose trades have been accepted to simply assume that they have made the lowest offer, which is why their trades have been accepted. The latter now becomes a mistaken assumption, offsetting the trendlines for the rest of the players.

In the twelfth month, the last round, the same player of India while trading, states, "USA, you were playing so good, but you screwed up in the end; I could try to help; I'm sorry." The player says this while not having offered any trade to the USA for months eight, ten, eleven and twelve. This statement might not reveal any non-optimum behaviour by the player; however, it does reveal the player's tendency to cognitively believe that they are playing not with other players like them, but rather with other countries. For months five to ten, the player of China ensures to accept the trade with Russia every time, either exclusively, or while accepting other trades as well. Three of these trades are not optimal trades, as better offers are available at the same time.

In month seven, the player from Brazil recognises that the player from China is playing well, based on their infection count. In month eleven, when prompted, the Brazilian player ranks the other competitors as "USA, then India, then Russia, then China" from best to worst. When the actual leaderboard is revealed, the order is China, then Russia, then India, and then USA for the round. Essentially the player initially correctly actively remarks that China is doing well, however still has an inherent bias towards India and the USA, which reveals itself when the player is asked to compare all their competitors to one another. This causes an inversion in a more accurate assumption about the situation.

4. Discussion

4.1 Interpretation of Findings

In terms of player archetypes, meeting the peak of the parabola has been delayed in trials where real country names were used. This can either be attributed to the presence of country names and involvement of prior perceptions of international relations, a distraction bias in the game strategies, or to recognition of the competition within the game as lesser than it actually is, since there is a greater self-identity when identifying as a real-world country as opposed to representing a colour-coded country. It is also important to note that, unlike the sense of uniformity perceived by colour-coding, identifying by countries makes the players consider factual data, such as perhaps the size of the economy, political stance, manufacturing prowess, etc. Hence, it is believable that there is a more non-uniform sense of competition perceived by the participants in the gameplay with country names, further delaying the perception of competition.

From the total volume of trades in the games, it is observed that, in general, trade between countries decreases in the test condition as opposed to the control condition. It can be hypothesised that there is a higher degree of immersion involved in the game once real-world country names are used. This makes the players more conservative since resource stockpiling seems to be felt as a more secure mechanism for dealing with the pandemic. The players are less dissociated with the identity of the countries they represent, making the consideration of more abstract ideas such as trading away resources slightly more discouraging. This could also be why the peaks of the round-wise trade data trendlines arrive later than they should in the test groups.

As per Figure 7, India has performed better in the test cases than in control cases. This can be attributed to the fact that all participants of the study have been citizens of India and therefore hold an implicit bias towards India. Brazil's poorer performance in the test case could stem from the fact that politics or trade with Brazil is far less covered in Indian media. USA's deficient performance across all participants while maintaining trade volume needs to be further analysed with respect to survey findings (Purushothaman, 2022; Fuchs and Thurner, 2014).

4.2 Theoretical Implications

The literature review highlights the parallels between the politicisation and polarisation observed in real-world geopolitics during pandemics and disasters and the potential for similar patterns to emerge within virtual environments. The findings from this study support the idea that introducing real-world geopolitical elements into virtual games can delay the perception of competition and influence player behaviour. This suggests that virtual environments can serve as a valuable testing ground for understanding how political narratives and dynamics impact human decision-making, both individually and collectively, supporting the findings from Belaza *et al.*, 2020.

4.3 Practical Implications

4.3.1 Game Design for Enhanced Engagement

Game developers can use these findings to design virtual environments that encourage player engagement and immersion. Incorporating real-world geopolitical elements while maintaining a balance to prevent bias or distortion can create more captivating and thought-provoking gaming experiences.

4.3.2 Mitigating Implicit Bias

The findings indicate that players may exhibit biases in favour of their real-world countries. Game developers should be aware of these biases and take steps to balance gameplay. Virtual games with economic components should prioritise fairness and transparency in their in-game financial systems.

4.3.3 Incorporating Real-World Relevance

Educational and serious games can benefit from incorporating real-world political and economic elements to provide players with valuable insights into the complexities of global issues. Educational institutions and policymakers can consider integrating virtual economic simulations into curricula to enhance students' understanding of economic principles, decision-making, and the impact of real-world events on financial choices.

4.4 Limitations of the Study

The primary methodological constraint of the study is the number of teams considered for the analysis and the lack of diversity among the participants. The generalisability of the findings is restricted to the age group and country of origin of the participants in the study. All participants were from India, the advantage of this being that the five countries within the game could be selected to maximise variance in perception and response as tailored to an Indian audience. The disadvantage here is that it makes inferences strong only for the Indian population. The same disadvantage goes for age restriction. The experimental data was captured entirely during the COVID-19 pandemic when a controlled lab testing environment to ensure physical uniformity was inaccessible.

5. Conclusion

The findings of this study provide intriguing insights into player archetypes and the impact of real-world country names on in-game decision-making. The presence of real-world country names appeared to delay the peak of resource trading patterns, potentially due to players' immersion in the geopolitical context and their consideration of factors like the size of the economy and political stances. This study sheds light on the complex relationship between real-world geopolitics and player financial behaviour in digital games. The methodology can be expanded to detect a difference in political polarisation across various ranges of people. One of the focuses in the future of this study is to detect a perceivable difference in political polarisation across age ranges, through children, young adults, as well as senior citizens.

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Rights Quest: A Game for Child Rights Awareness

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Abstract: The interactive video game "*A Way Home!*" is a serious game for promoting pro-social change by raising awareness of children's rights, as outlined in the United Nations Convention on the Rights of the Child treaty. All countries except the United States have ratified this treaty. Through a collaborative effort, faculty and students developed this game using an open-source platform to create an immersive first-person video game experience to disseminate crucial knowledge about children's rights and the need for ratification. Game design guides players through real-world comparative scenarios depicting environments that support or do not support those fundamental rights. Through engaging gameplay and storytelling, iterative development processes facilitated the game's effectiveness in conveying complex concepts, such as the distinction between rights and responsibilities. The significance of children's fundamental rights, such as access to food, a safe, clean home, the right to speech, and freedom of expression, as enshrined in the CRC, are emphasized by juxtaposing different environments and depicting the consequences of choices. Grounded upon the Diffusion of Innovations theory (Rogers 2010), the first step to adopting cultural change is education. Using gameplay elements, including rewards for positive choices and learner guidance instructions, *"A Way Home!"* rights quest motivates players to explore and understand the principles of children's rights. The player wins the game when they achieve the goal of being heard in a court of law. By combining education with entertainment, the game aims to inspire empathy and foster understanding, with the ultimate goal of teaching about the need for ratification of the CRC Treaty in the U.S. and empowering players to take action and advocate for children's rights. This paper depicts the methodology involving participants (n=17) from one southeastern university in the States to capture qualitative and quantitative feedback through a perception survey to evaluate the first demo model. Results support advancing data collection for the next version developed using virtual reality (V.R.) headsets to further immerse the learners in the experience.

Keywords: Game*, DGBL, VR, Child*, Rights, CRC

1. Introduction

Since the birth of the Convention on the Rights of the Child (CRC) in 1989, the United States (U.S.) remains the only United Nations (U.N.) member in absentia to ratify this human rights treaty. The CRC Treaty encompasses fifty-four articles centered around four key themes: survival, development, protection, and participation. Articles 12 and 13 articulate that children should have the equitable right to express themselves freely and that all legal proceedings affecting them count their voices (Patel et al. 2021). The challenge is that many may be unaware that a list of fundamental human rights exists for children to improve their well-being or that any children in the States may even be suffering and need the protection of fundamental human rights. The researchers, a small team of faculty and research assistants set forth to develop a prototype (Ensmann 2017) into an interactive video game called "*A Way Home!"* as a serious game to begin pro-social change by raising awareness of the CRC treaty and that the U.S. stands in absentia.

Serious games, crafted to educate and motivate action, have emerged as influential tools for tackling social issues, including children's rights. Examples include "*Ayiti: The Cost of Life,*" which allows players to manage a family in Haiti and deal with poverty, education, and health challenges (Oygardslia 2015). Although not explicitly marketed as such, this game engages players with the challenges outlined in the CRC, particularly the right to education and a standard of living adequate for the child's development. Jennifer Anne's Group offers several other examples of fostering an annual competition to raise awareness, education, and advocacy to improve social issues seen in teenage domestic violence (Crecente 2014), which largely supports communication, further aligning to articles 12 and 13 in the CRC. These examples illustrate the power of serious games to convey important social messages. At the same time, the gap in the literature reflects that no previous games demonstrated that the U.S. still needs to be present in ratifying the CRC treaty for equality amongst all children in the States. Oygardslia's study also suggests that game developers have the crucial role of guiding players from awareness to action, serving as a catalyst for social change (2015). Bacon suggests that "Knowledge is power" (García 2001, p. 109). Thus, disseminating this knowledge about the CRC and the need for ratification, with specific action steps for players, offers a step to begin this change.

1.1 Does This Matter Anymore?

According to the American Community Survey, 68% of children between the ages of 12 and 17 and 75% of children under the age of 6 lived with parents in two different households (U.S. Census Bureau 2023),

representing millions of children in the middle of a family law case between estranged parents. The courtroom determines the fate of many of these children. Only if that jurisdiction upholds children's rights will the children's voices be permitted. Even when the children are allowed to speak, their words are often discounted based upon engrained practices (Collins 2012). Whether their words are fairly weighted is left up to a judicial system that is often not trained in mental health issues to make these determinations (Lemon 1999). Examine the disparity within the court system. Criminal cases have acknowledged that children can credibly express their views, such as in the 1967 Gault Case (Federal Judiciary 2015). The Juvenile Detention division may deem children "fit to be heard." However, these same children may be considered "unfit" in the Family Law division (Taylor 2009) regarding where they feel safe to sleep and are nourished and protected. Likewise, children's rights vary by state and county. Forty states provide children a voice in their dependency cases, creating inequality for the children in the other states (Breger 2010; Rodham 1973). These rulings do not stem from research reflecting the children's ability to express themselves better in one court of law over another but from legislative traditions. LaShanda Taylor, a staff attorney with the American Bar Association Center on Children and the Law, summarized the need for children to have a fair voice:

> *Denying the child a voice in the lawyer's advocacy 'reinforces... lessons learned most thoroughly by abused*
>
> *and neglected children that he [she] should not expect to have any control over his [her] fate* (2009, p. 617).

To further support the need, a thirty-year study reveals that U.S. children continue to rate in the bottom percentile compared to adopters of the CRC (Vandenhole et al., 2019). UNICEF's "Report Card" series evaluates the well-being of children in economically advanced countries, focusing on various aspects such as education, health, and inequality. Since the first publication of *The State of the World's Children* in 1980, there has been a significant reduction in child mortality rates. At that time, 10% of children born that year died from preventable causes, but by 2018, this figure had decreased to 3%. Global milestones like the 1989 adoption of the Convention on the Rights of the Child contributed to this decrease, bringing children's rights to the forefront of global and national policy agendas, a previously lacking focus (UNICEF**,** 2019). Report Card 16 examined the worlds of influence to understand what shapes child well-being in rich countries and found that "Only Chile, the United States, and Malta are in the bottom third of rankings for each of the three well-being outcomes" (p. 10, 2020). This report included mental well-being, physical health, and social skills, as shown in Figure 1.

Overall ranking	Country	Mental well-being	Physical health	Skills
1	Netherlands	1	9	3
2	Denmark	5	4	7
3	Norway	11	8	1
4	Switzerland	13	3	12
5	Finland	12	6	9
6	Spain	3	23	4
7	France	7	18	5
8	Belgium	17	7	8
9	Slovenia	23	11	2
10	Sweden	22	5	14
11	Croatia	10	25	10
12	Ireland	26	17	6
13	Luxembourg	19	2	28
14	Germany	16	10	21
15	Hungary	15	21	13
16	Austria	21	12	17
17	Portugal	6	26	20
18	Cyprus	2	29	24
19	Italy	9	31	15
20	Japan	37	1	27
21	Republic of Korea	34	13	11
22	Czech Republic	24	14	22
23	Estonia	33	15	16
24	Iceland	20	16	34
25	Romania	4	34	30
26	Slovakia	14	27	36
27	United Kingdom	29	19	26
28	Latvia	25	24	29
29	Greece	8	35	31
30	Canada	31	30	18
31	Poland	30	22	25
32	Australia	35	28	19
33	Lithuania	36	20	33
34	Malta	28	32	35
35	New Zealand	38	33	23
36	United States	32	38	32
37	Bulgaria	18	37	37
38	Chile	27	36	38

Note: A light blue background indicates a place in the top third of rankings, medium blue denotes the middle third, and dark blue the bottom third. The rankings in the table were produced as follows: (1) We calculated a z-score for each indicator (reversed where necessary so that a higher score represents a more positive outcome); (2) we calculated the mean of the two z-scores within each dimension; (3) we calculated the z-score for each mean; and (4) for the overall ranking, we then calculated the mean of the mean z-scores for each dimension. This table includes the 38 OECD/EU countries which had data of sufficient quality across at least five of the six Outcomes indicators listed in Box 1. We were unable to include Mexico and Turkey due to low coverage rates in the Programme for International Student Assessment (PISA) 2018 survey (which provides three of the six indicators that make up the league table). We were also unable to include Israel as data were missing on two of the six indicators.

Figure 1: Innocenti Report Card 16. Worlds of Influence: Understanding What Shapes Child Well-being in Rich Countries Reproduced with Permission from the Global Office of Research and Foresight (UNICEF 2020)

Figure 2 defines the indicators used to determine these areas of well-being.

Box 1: Indicators used in the report

	Dimension	Components	Indicators	Source
Outcomes	Mental well-being	Life satisfaction	Percentage of children with high life satisfaction at 15	PISA, 2018
		Adolescent suicide	Suicide rate for 15- to 19-year-olds	WHO Mortality Database, 2015
	Physical health	Child mortality	Child mortality rate (all causes), 5–14	UN IGME project, 2018
		Overweight	Percentage of children overweight, 5–19	State of the World's Children, 2016
	Skills	Academic proficiency	Percentage proficient in mathematics and reading at 15	PISA, 2018
		Social skills	Percentage who make friends easily at school at 15	PISA, 2018
Activities	Play	Playing outside	Frequency of playing outside at 10 years old (days per week)	Children's Worlds, 2017–19
	Digital	Internet use	Average duration of Internet use by children	EU Kids Online, 2018–19
Relationships	Family	Family support	Level of family support reported by children at 15 years old	HBSC, 2017/18
		Family participation	Percentage of children aged 10 totally agreeing that they participate in decision-making at home	Children's Worlds, 2017–19
	Peers	Being bullied	Frequency of children being bullied at 15 years old	PISA, 2018
	School	School belonging	Sense of belonging at school at 15 years old	PISA, 2018
		School participation	Percentage of children aged 10 totally agreeing that they participate in decision-making at school	Children's Worlds, 2017–19
Networks	Parent–community	Parental support networks	Main sources of support for parents in looking after children	European Quality of Life Survey, 2016
	Parent–work	Work–family balance	Percentage of employees struggling to fulfil family responsibilities	European Quality of Life Survey, 2016
		Hours worked	Average weekly hours worked on main job	OECD based on Labour Market Statistics, 2017
	Parent–school	Relationship with school	Parents' rating of their relationship with school	European Quality of Life Survey, 2016
Resources	Household resources	School books at home	Percentage of children aged 15 having books at home to help with school work	PISA, 2018
	Neighbourhood resources	Local play facilities	Percentage of children aged 10 who agree that there are enough places to play in their local area	Children's Worlds, 2017–19
Policies	Family policy	Parental leave	Weeks of full-rate equivalent parental leave in early childhood	OECD Family Database, 2018
		Child poverty	Percentage of children in households below 60% of median income	Eurostat, HILDA, LIS and national statistical agencies, 2018
	Education	Early childhood education and care	Percentage of children attending early childhood education and care one year before school	UNESCO, 2017, *Report Card 15* and UNSTATS
		NEET	Percentage of 15- to 19-year-olds out of school, employment or training	OECD Family Database and Eurostat, 2018
	Health	Immunization	Measles immunization	WHO/UNICEF, 2018
		Low birthweight	Percentage of newborns weighing less than 2,500 grams	OECD Health Database and WHO, 2017
Context	Economy	Income	Gross national income per capita in international dollars	World Bank, 2018
		Jobs	Unemployment rate (percentage of active population)	World Bank, 2019
	Society	Social support	Percentage of adults who have someone to count on	Gallup World Poll, 2016–18
		Violence	Homicide rate	World Bank, 2017
	Environment	Air pollution	Mean levels of fine particulate matter PM2.5	Global Burden of Disease Study, 2017
		Water quality	Percentage of population using safe water	WHO/UNICEF Joint Monitoring Programme, 2017

Figure 2: Innocenti Report Card 16. Worlds of Influence: Understanding What Shapes Child Well-being in Rich Countries Indicators Reproduced with Permission from the Global Office of Research and Foresight (UNICEF 2020)

1.2 Disseminating the Knowledge

In the U.S., the Entertainment Software Association (ESA) conducts surveys to gather data on video game usage, and a recent report shows that approximately 190.6 million Americans play video games weekly, with the average player age (2024). The report further reflects those consumers spent $57.2 billion (including content,

hardware, and accessories) in 2023 (2024). Studies reflect that digital game-based learning (DGBL) is a motivational means to learn (Justice and Ritzhaupt 2015) and improves focus, learning cognition (Eichenbaum et al. 2014), and retention (Brent and Felder 2009; Gee 2008; Gordon 1970). Reasoning and critical thinking skills become by-products of problem-solving instruction (Gordon 1970), and systematic thinking and processing are vital parts of simulations (Prensky 2001; 2006). Gee posits that brain function embodies sensory involvement (2008). Video games, therefore, serve as a logical platform for learning based on how the brain works. Games provide a problem, and players select avenues of advancement to solve it. Players advance or retreat through game stimuli, learning through each experience (Connolly et al. 2012; Gee 2008; Hamari et al. 2016; Plass et al. 2015).

Gaming has been used to educate about other U.N. treaties. For example, in answering the call to promote sustainable energy, Ball State University initiated the Second Chance Game for Global Awareness and Responsibility development in collaboration with local partnerships. The outcomes of this DGBL initiative demonstrated that teaching social justice knowledge and getting buy-in from key players to develop innovative educational strategies go beyond governments creating treaties or passing laws (Pacheco et al. 2006). Moreover, gaming in education has far greater capabilities of influencing learners than traditional instructional methods, as highlighted in the article "Can a Video Game Make Someone Nice?" (Kapp 2012). In both instances, players who engaged with the game were more likely to influence others to make positive choices and were more inclined to help someone in need (Kapp 2012). Note that the terms *player* and *learner* are used changeably in this paper. Each term brings opposing entertainment, and educational positive or negative connotations based on readers' experiences. Therefore, to have the most significant impact on the broadest population, this instruction is designed for all adults who play games in an immersive, first-person video game. The goal is to shift the cultural paradigm to one where mindsets realize that players can learn and can be motivated to transfer knowledge uncovered by playing with others and using serious games for learning.

2. Research Question

The research questions this game set out to answer are:

Can the rights quest game, A Way Home

1. *inform people about the CRC Treaty and change their perceptions about the need to support children's rights in the U.S.?*
2. *motivate players to take action by sharing the game and/or information learned from the game?*

The long-term social impact goal is to ultimately encourage Americans to ratify the CRC in the U.S. to improve the quality of life for all children. For the short-term goal, we aim for users to consider "Never believe that a few caring people cannot change the world… indeed, that is all who ever have,*" Margaret Mead.*

3. Methodology

3.1 Game Design and Development

The primary investigator and research assistants embarked on creating a first-person video game using the Unity Engine, an open-source 3D game development platform. The development team selected this platform as a cost-effective means that provides ample free tutorials for educational institutions and independent developers to produce high-quality games without the significant financial burden often associated with game development. The game design facilitates gameplay with unfolding scenarios in which the player navigates the world through the eyes of a child. By leveraging narrative, interactive elements, rewards, and consequences, players move through each experience, highlighting the impact of children's rights, as listed by the CRC articles, as they are supported and when they are not. Scenarios include the fundamental right to play, nourishment, a safe environment, freedom of expression, and the right to equitable speech, the latter being the ultimate win the player can achieve at the end of the game. Scenes compare and contrast with music and imagery. For example, the first scene reveals an environment where the child has ample food and a safe home, as depicted by a caring parent who engages them in discourse about the difference between rights and respectfully communicating desires.

In contrast, the next scene offers an unsafe environment, denoted by barren land, hostile ambiance, lack of food, broken windows, and unsafe provisions for the toddler teetering on a slide alone. Rewards are embedded

based on players' game decisions whereby players can achieve collectibles for positive choices, such as being *kind*. A heart on the player's wrist, designed like a watch, grows points when the player selects choices to be kind, such as feeding a bird, picking up garbage, or looking after a sibling. Conversely, players lose points by making poor decisions throughout the game, such as disrespectfully speaking to the parent or making demands. The heart on the player's wrist that grows with positive actions serves as a tangible representation of moral choices, aligning with the concept of "serious games" that aim to provoke reflection and inspire action (Michael and Chen 2005). Imagery and audio continue to evoke emotion and changing attitudes.

Developers used ongoing iterations of formative evaluation to guide revisions and drive improvements to game performance. Advancing the instruction from the 2-dimensional prototype (Ensmann 2017) into a realistic video game takes ample time, expertise, and hardware capable of handling the graphics. Specific design decisions embedded into the first two scenes include beginning the game with common elements players are most likely to be familiar with (such as a soccer ball and a bird) to capture their attention (Gagne 1981) while moving into the fanciful and interactive elements (through user-driven exploration) to motivate gameplay (Gunter et al. 2008). For example, players may play soccer with their siblings to achieve more game points. Game controller navigation uses players' prior knowledge based on common prompts in the game industry. Still, detailed instructions also appear within the first scene for learner guidance before introducing complex concepts (Gagne 1981). The team designed the demo as a computer-based game and redesigned the next version for delivery using V.R. headsets. This experiential learning approach aligns with research showing that interactive digital environments can significantly enhance the retention of complex social and moral concepts (Gee, 2008; Prensky, 2003). The game taps into emotional responses by contrasting positive and negative environments to change attitudes and deepen learning (Bogost 2007).

3.2 Evaluation Instrument

According to the literature, survey methods offer the quickest response rate and cost-effective advantages for mid to large-sized populations (Babbie 1973; Creswell 2017; Fowler 2009). Therefore, the researchers used consensus agreement (Creswell 2017) to create a mix of closed- and open-ended survey questions to enhance numerical data and capture a rich perspective of participants' responses focused on the guiding questions:

Can the rights quest game, A Way Home,

1. inform people about the CRC Treaty and change their perceptions about the need to support children's rights in the U.S.?
2. motivate players to take action by sharing the game and/or information learned from the game?

The survey included instructions and three Likert scale questions regarding gameplay, each followed by open-ended questions for participants to elaborate qualitatively. Three additional open-ended questions offered participants the option to elaborate further. The nine-item survey inquired about the game's motivational aspects and specific facts about the CRC Treaty. Lastly, demographic questions consisting of four multiple-choice and two Likert scale questions captured the participants' gaming habits.

The content questions were distributed to two university students to test the instrument for interrater reliability and reflected a 78.78% agreement rating. Questions were revised based on consensus agreement to offer further clarity (Creswell 2017), resulting in 100% agreement. For example, raters found the first question confusing: *Did the game motivate you to engage?* Consensus agreement offered the modification: *How do you rate the game's features for motivating gameplay?* For the second question, raters found a misspelling corrected by revising a pronoun from "you" to "your."

Each survey began with informed consent, and the university's International Review Board approved the study protocol.

3.3 Participants

Faculty in the Communications department agreed to administer a voluntary pilot test to undergraduate student volunteers (n=17) enrolled in their classes as a convenience sample to gather formative evaluation for game improvement. Students who volunteered between the ages of 20 and 24 at a university in the southeastern region of the U.S. No one was excluded from the pilot test. Researchers did not gather any identifiable information, and the participants were anonymous. Due to the 3D game prototype being in the demo phase of development, the researchers had concerns about possible technical issues the participants could experience if they were to download and play the game themselves. Therefore, a brief video demonstration recording of

gameplay portrayed navigation through all scenes and showcased all the available game interactions. The protocol included having participants watch the video demonstration and then answer the short perception survey to gather information about user experience and knowledge gained about the CRC Treaty.

4. Findings

The first question inquired how the game's features motivated gameplay. Most students answered positively (n=12); some stated that it did not motivate them (n=3); and the rest had a mixed answer (n=2).

The second question inquired about the players' interest in staying in the game until the final scene. While three stated that they did not lose interest, the rest of the answers mentioned specific moments that varied across different stages of the game, from the opening credits to the last scene of the demonstration.

When asked, "What was the game about?" most participants described the contrasting quality of life between different children (n=11) and provided a general description of children's rights (n=4). Others stated that the game concerned high-risk behavior (n=1) and nutrition (n=1).

When listing one fundamental human right in the Convention on the Rights of the Child treaty, most (n=11) could recall at least one right, while some (n=6) did not remember any rights. The most common right mentioned in the answers was the right for children to have nutrition (n=4), followed by the right to love (n=3), to play (n=2), freedom of expression (n=1), and the right to own things (n=1), the latter being the only answer that was not accurate.

When prompted, "Which nation has not yet adopted the treaty?" Most participants (n=13) answered correctly that the U.S. is the only country yet to do this. A few (n=3) did not know the answer, and one responded that Venezuela had yet to adopt the treaty.

When asked about their motivation to take action, such as sharing this game with someone else, most participants (n=8) stated yes, some (n=6) stated no, and the rest of the responses were uncertain. Quotes listed below represent the range of responses:

Finally, regarding participants' gaming habit demographics, most of the sample did not identify as gamers. When asked, "Do you identify yourself as a gamer?" only one person selected "Definitely yes." One chose "Probably yes," two chose "maybe," seven selected "Probably not," and six chose "Definitely not." For the question, "How many hours a week do you play games?" two participants indicated that they play between 4 to 7 hours weekly, seven participants between 1 and 2 hours weekly, and the rest did not play games. Table 1 offers a range of direct quotes.

Table 1: Findings During Formative Evaluation to Improve the Game

Variable	Sample Range of Quotes
Did the game's features motivated gameplay	• *Yes the game motivated me to engage, it was very capturing for my attention* • *not really, I did not understand the point of the game and it was too boring* • *I was engaged, but at times was looking more at the content and missed some of the words on the screen, especially in the beginning.*
Interest in staying in the game until the final scene	• *Halfway thru because of the graphics* • *it was pretty interesting, but I know children are treated like that! so sad.* • *The dialogue needs to be improved, I feel like it's a small detail but would have encouraged*
What was the game about?	• *about solving some kind of escape room by showing the way children are treated in different areas of the world.* • *Provided a way to show people that many children are bless[ed], but others don't have as well made. With that being said at the end of the day the game showed me that no matter their circumstances all children deserve rights.* • *Raising awareness that children around the world or even two houses down from you are treated differently.*
Which nation has not yet adopted the treaty?	• the U.S. (majority)
Motivation to take action	• *yes I would definitely send this game to others* • *Yes since it will create conscious awareness!* • *no because the game looked too unreal.* • *Yes the second situation made me sad and I explained the game to my roommate* • *Yes, with educational school boards. Have children play the game and if a child's circumstance reflects or invokes familiar feelings of negative children's right then provide a prompt for the kids to click "I need help.".*
Do you identify yourself as a gamer?	• No (majority)

5. Discussion

The results indicate that the first game demo positively conveys the intended message and motivates most participants to take action. Most participants could recall critical information about the CRC Treaty and empathized with the disparity between children's quality of life. Many answered that they were motivated to

share information about this game and the topic. The two most common themes the participants recalled were that the U.S. is the only country that has not ratified the CRC and that children deserve fundamental rights. While most participants did not identify as "gamers," they did understand the overarching theme and the importance of raising awareness of this social justice issue. Participants also provided helpful insight regarding the usability of the game and the clarity of how the content unfolds in the game environment. For example, the game development team used participants' responses such as "the game looked too unreal," a need for "dialogue," or references to "boring" to move the game into the V.R. realm. Based on the literature and evolving technologies, future iterations were designed for V.R. headsets like MetaQuest 2 and 3 to improve graphics and motivation.

The transition from a 2D prototype to a fully realized V.R. game represents a critical technological and educational advancement in the project. V.R.'s immersive nature has enhanced empathy and understanding of social issues by placing players in the shoes of those experiencing these challenges (Herrera et al. 2018). This move to V.R. is a technological upgrade and a strategic decision to deepen the game's emotional impact and educational value.

Finally, survey responses revealed opportunities for improvement to clarify the rights listed by the CRC and how players can take action. See Table 2 for sample revisions.

Table 2: Sample revisions based on testing.

Scene	Survey responses and technical challenges	Final VR Version 1
Begin	Wordiness and scrolling across the screen made it difficult for players to read.	Developers truncated scripts to reveal one concept per canvas, and words are directly in front of the player to avoid scrolling.
All Scenes	Participants recommended more contrasts between fundamental human rights provided and not provided and dialogue to clarify concepts. See Figure 3.	Because cultures and experiences vary, the player is now provided with background information prompts to assist in recognizing the environment.
All Scenes	Game elements such as collectibles motivate players to collect treasures for random acts of kindness, such as a gem for admiring the crow rather than scaring him. Still, nothing aggregates the wins for further motivation.	The VR environment now includes a heart on the player's wrist, reflecting points that grow, or decline based on the player's actions. Points now accumulate to spark competition. See Figure 4.
Second Scene	To motivate gameplay, audio evokes emotion, such as in the scene that reflects an impending fall a child could take standing upon a highly misaligned structure. Responses suggested graphics could be more realistic.	The child now falls and cries, offering a more realistic experience than the fantasy created in the demo version. All scenes now have realistic characters. See Figure 5.
End	Users wanted to continue playing at the end.	This version offers Play and Exit options.
All Scenes	Testers suggested that gameplay include realistic graphics and dialogue to reduce player boredom and increase motivation. Still, character agents and assets with high poly counts caused glitching in the Meta Quest headsets.	Beautiful high-poly-count assets were added and then deleted due to the VR headsets' inability to handle them, and developers began using low-poly-count assets again. See Figure 6.



Figure 3 : The first scene was revised to include food and pleasant discourse, compared to the opposing scene with an empty refrigerator and grunts.



Figure 4: The game now includes a heart on the player's wrist, which grows or loses points based on positive or negative player actions.



Figure 5 *:* The game now offers a sense of realism repurposed for VR headsets. The computer-based demo version images are on the left, and the final Version 1 images are on the right.



Figure 6: Developers included revisions with high-poly assets to add realism but removed them to improve functionality in VR headsets. Revised high-poly version images are on top, and the final photos are on the bottom.

6. Limitations

Limited funding offered constraints of time and expertise. This project cost approximately ten thousand dollars, which falls short in the industry that produces sustainable games with millions for V.R. environments. Testing results of the game may also include variances due to participants watching a recording rather than playing the game as per the protocol referenced under Methodology 3.3. The sample may be biased due to a

lack of randomization because it only represents a small population, leading to limited generalizability of the findings.

7. Conclusion and Future Work

The initial testing phase of *A Way Home* demonstrates the potential of using a first-person video game to raise awareness about children's rights in the U.S. and educate players on the CRC treaty. Developed using the Unity Engine, this game provides an immersive experience where players navigate the world through the eyes of a child, encountering scenarios that illustrate the profound impact of acknowledgment of children's rights—both when they are upheld and denied. The game's design incorporates unfolding narratives, interactive elements, and moral choices reflected through a tangible in-game mechanism: a heart on the player's wrist. This heart grows or shrinks in response to the player's decisions, symbolizing the consequences of their actions in real time. By engaging with everyday scenarios—like playing soccer or interacting with family—players earn rewards for positive actions, such as kindness, and lose points for negative behavior, fostering a deep connection between gameplay and the moral lessons it aims to convey.

As the game transitions from a 2D prototype to a more immersive VR environment, it leverages advanced technology to enhance its emotional impact and educational value. VR's capability to evoke strong emotional responses by placing players in contrasting environments—safe versus unsafe, nurturing versus neglectful—is crucial for fostering empathy and driving attitude change. This experiential learning approach, supported by research, emphasizes the game's role as a tool for awareness and a catalyst for social change.

Ongoing iterative revisions, guided by formative evaluations, have refined the game's performance and effectiveness. Integrating familiar elements, such as soccer balls and birds, with complex social concepts ensures that players are gradually introduced to the deeper messages of the game, enhancing retention and comprehension.

This concept aligns with Rogers' Diffusion of Innovations theory (2010), which suggests that cultural change is a gradual process driven by early adopters. *A Way Home* seeks to participate in this cultural shift. By building on the historical context of U.S. support for international human rights—dating back to President Reagan's work on the CRC Treaty and continuing with strong endorsements from Presidents Carter and Obama—the game aims to influence public opinion and inspire action toward ratifying the CRC in the U.S. As the game moves forward, the next research phase will explore its ability to motivate gameplay (affective domain), educate players about the CRC (cognitive domain), and inspire civic action in the V.R. environment. By continuing to refine and expand the game's capabilities, *A Way Home* aspires to be a powerful tool in the fight for children's rights, ultimately contributing to a better future for all children.

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Board Games and Entrepreneurial Skills Acquisition: A Mixed-Methods Study on the Efficacy of the EntreComp Framework in Higher Education

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Abstract: The landscape of higher education has witnessed a paradigmatic shift towards methodologies that are more interactive and engaging. The integration of gamification and board games as active learning methodologies in higher education, as well as the instruction in entrepreneurial competencies, has garnered significant interest for its potential to engage and motivate students, thereby enhancing learning outcomes. Gamification, characterized by the incorporation of game design elements into non-game contexts, offers a captivating and novel learning experience that fosters intrinsic motivation and active participation among students. One of the main ways of applying gamification is through board games, providing hands-on opportunities for students to apply theoretical knowledge in practical scenarios. A critical aspect of this educational innovation is its contribution to the instruction of entrepreneurial competencies, a domain gaining traction within higher educational settings. The European Entrepreneurship Competence Framework (EntreComp) stands at the forefront of this educational endeavor, offering a comprehensive blueprint for cultivating entrepreneurial skills and mindsets. This study is anchored in the context described above, with a focused aim to delineate which entrepreneurial competencies, as outlined by the EntreComp framework, are most effectively developed through these novel educational interventions. To facilitate this investigation, the "Game It Away!" project was initiated, encompassing three pilot studies. These pilots innovatively employed board games as the medium through which participants could acquire and hone their entrepreneurial skills. A key component of the learning process within these pilots was the maintenance of a learning journal by the students. This journal, filled with various reflective questions, provided a structured mechanism for participants to document and reflect upon their learning journey throughout the project. In this way, by using qualitative and quantitative methodologies, it is possible to verify the evolution of certain competences. The integration of gamification and board games within educational settings, particularly through the lens of the "Game It Away!" project, represents a pioneering approach to fostering entrepreneurial competencies among students. This study, leveraging both qualitative and quantitative methodologies, has illuminated the substantial potential of these innovative pedagogical strategies to revolutionize the teaching and acquisition of entrepreneurial skills as outlined by the EntreComp framework.

Keywords: Gamification; Board games; Entrepreneurship; EntreComp; Active Learning Methodologies

1. Introduction

In the evolving landscape of Higher Education, the shift towards more interactive and engaging teaching methodologies has become paramount in addressing the dynamic needs of contemporary students. This paper explores the integration of gamification and board games as transformative educational tools within the framework of the European Entrepreneurship Competence Framework (EntreComp), a leading strategy in cultivating entrepreneurial skills in higher education settings.

The increasing recognition of gamification, defined as the incorporation of game design elements into non-game contexts, presents a novel approach to education that stimulates student engagement and motivation. This methodology extends beyond traditional learning paradigms by harnessing the intrinsic motivation of students through competition, achievement, and rewards, thereby enhancing both cognitive and emotional engagement in learning processes.

In parallel to the rise of digital gamification, board games have emerged as potent educational tools. These games are not only pivotal in simulating real-world challenges that require strategic thinking and problem-solving, but also in promoting social interactions and teamwork among students. Such interactions are invaluable as they cultivate a suite of soft skills, including effective communication, negotiation, and collaboration, which are essential for both academic and professional success.

Central to this study is the EntreComp framework, which outlines a comprehensive array of competencies necessary for entrepreneurial success across three core areas: Ideas and Opportunities, Resources, and Into Action. Each of these pillars focuses on different aspects of entrepreneurship education, from the ability to identify opportunities to the practical application of ideas into tangible outcomes.

To empirically test the efficacy of integrating board games and the EntreComp framework, the "Game It Away!" project was initiated, involving a series of pilot studies at the University of Aveiro. These studies aimed to provide hands-on experiences where participants could develop entrepreneurial competencies through carefully designed board games. A significant aspect of the learning process in these pilots was the incorporation of learning journals, which allowed participants to reflect on and document their experiences and the competencies they developed throughout the intervention.

This innovative approach not only addresses the theoretical and practical components of entrepreneurial education but also offers a blueprint for future educational practices aimed at developing the necessary skills for today's global economy. By detailing the structure and outcomes of these pilot studies, this paper highlights the potential of gamification and board games to revolutionize the way entrepreneurial skills are taught and learned in higher education.

2. Literature Review

2.1 Gamification in Education

The rise of gamification in educational settings is not merely a trend, but a significant evolution in pedagogical strategies aimed at enhancing student engagement and improving learning outcomes. This methodology employs game design elements in environments traditionally empty of such characteristics to create a compelling learning experience. Gamification involves integrating game dynamics such as competition, achievement, and rewards into the educational process to foster a more engaging and motivating environment (Deterding et al., 2011).

The effectiveness of gamification has been substantiated through various studies. For example, a comprehensive review by found consistent positive impacts of gamification on user engagement and motivation across different domains (Hamari et al., 2014). This includes educational settings where traditional teaching methods might not sufficiently capture or sustain student interest.

Beyond just engagement, gamification can enhance retention and deepen the learning process. It does this by leveraging the natural human tendencies for competition and achievement—elements that are often strong motivational drivers. This is further supported by research from Sailer et al. (2017), who observed that gamification promotes not only cognitive engagement but also emotional and social engagement, thereby enriching the educational experience from multiple dimensions.

However, the application of gamification in education must be approached with nuance and precision. As cautioned by Whitton (2012), poorly implemented gamification can risk trivializing the content or overwhelming the educational goals with too much focus on the game aspects rather than learning outcomes. To this end, Caponetto et al. (2014) recommend that educators design gamified elements that are inherently linked to educational objectives, ensuring that these elements serve to reinforce the curriculum rather than distract from it.

2.2 The Importance of Boardgames as Learning Tools

When we talk about gamification nowadays, we often think about digital contexts. This tends to happen given the importance of digital games in the education of young people. However board games have also been recognized for their educational value.

According to Qian and Clark (2016), those games often simulate real-world challenges that require strategic thinking and tactical planning. This kind of gameplay encourages players to engage deeply with the content, applying theoretical knowledge in practical scenarios, which enhances their understanding and retention of information. The cognitive demands of these games can vary greatly, ranging from simple pattern recognition in younger children to sophisticated resource management and long-term planning in older students.

One of the most significant advantages of using board games in education is their ability to foster social interactions among students. According to Whitton (2012), board games naturally bring players together, creating opportunities for face-to-face interaction and teamwork. During these interactions, players learn to communicate effectively, negotiate with others, and work collaboratively to achieve common goals. These social skills are invaluable, as they translate directly to real-world abilities necessary for teamwork and cooperation in both academic and professional settings.

Research by Boyle et al. (2015) supports the notion that board games not only stimulate cognitive development but also encourage the growth of social competencies through collaborative and interactive gameplay. These games effectively simulate complex real-world challenges within a controlled setting, making them ideal for educational use.

Other impacts that need to be addressed is that traditional board games have also inspired digital adaptations, which combine the physical interaction of board games with the dynamic capabilities of digital technology. These hybrid forms of board games can include elements like apps or online platforms that augment gameplay with multimedia content, real-time data, and interactive features. This integration of technology enhances engagement and expands the educational possibilities of board games, making them more appealing and relevant to digital-native students.

2.3 The EntreComp Framework

The European Entrepreneurship Competence Framework, known as EntreComp (Bacigalupo et al., 2016), has established itself as a vital tool to guide the embedding of entrepreneurial skills within educational curricula. This framework outlines a comprehensive set of 15 competencies categorized under three pillars (figure 1): Ideas and Opportunities, Resources, and Into Action (Bacigalupo et al., 2016).

The pillar “Ideas and Opportunities” involves the ability to identify and seize opportunities for personal, professional, and societal benefits. This includes creative thinking, vision development, and ethical and sustainable thinking, which are essential for fostering an innovative mindset (Bacigalupo et al., 2016). As for the pillar of “Resources” incorporates both tangible and intangible elements, such as mobilizing and managing time, finances, materials, and human resources. This area emphasizes the importance of self-awareness and self-efficacy as foundational competencies for lifelong learning and adaptability. Lastly, the pillar of “Into Action” focuses on the ability to act upon opportunities, turning ideas into action. This includes planning and management, coping with uncertainty, ambiguity, and risk, as well as working with others to achieve common goals (Bacigalupo et al., 2016).



Figure 1: EntreComp Framework

These competencies are designed to be applied across a variety of educational and professional contexts, promoting a comprehensive approach to entrepreneurial education. The framework not only facilitates individual skill development but also supports the creation of a more entrepreneurial society.

Aligning gamification, board games, and the EntreComp framework in educational settings represents a transformative approach that aligns with contemporary educational needs. Gamification and board games enhance student engagement, motivation, and skill acquisition through interactive and enjoyable learning experiences. The EntreComp framework extends this impact by providing a structured approach to develop entrepreneurial competencies essential for the modern workforce.

Together, these elements create an innovative educational landscape where students not only acquire knowledge but also develop the critical, collaborative, and innovative skills needed in today's global economy. This holistic approach ensures that education is not only about information acquisition but about preparing learners to navigate and shape the future effectively.

3. Study Case

This article builds on the work developed under the scope of the project "Game It Away!", which aims to develop and implement a new transdisciplinary and student-centred approach to teaching entrepreneurship, making it more effective in promoting an entrepreneurial mindset and skills and making entrepreneurship teaching more accessible to a wider and more diverse number of Higher Education students. That being said, the new approach is centered on learning entrepreneurship using gamification techniques, namely the creation of board games.

To put this new approach into practice, two pilot tests were carried out at the University of Aveiro in a makerspace under the SER+ project, a University of Aveiro project that allows students to get involved in teaching-related activities. In both pilots, a target of 25 participants was set, exclusively students from the University of Aveiro, and as a means of dissemination, publicity was carried out on social networks, by e-mail, posters were put up around campus and flyers were distributed.

3.1 First Pilot

In the initial pilot study, the participants comprised students from diverse academic levels: 61.5% were undergraduates, 23.5% were enrolled in master's programs, and 15.4% were doctoral candidates. Regarding nationality, the breakdown was as follows: 69.2% Portuguese, 15.4% Guinean, 7.7% Brazilian, and 7.7% Mozambican aged between 18 and 26. The pilot also highlighted a broad range of courses represented, including political science, psychology, public administration, tourism management and planning, economic and business sciences, engineering and industrial management, languages and business relations, physical engineering, and computer engineering.

3.2 Second Pilot

As for the second pilot, it followed the same pattern as the first pilot, i.e. a probabilistic sample, but only a total of 11 participants were obtained, all from degree courses and of Portuguese nationality, aged between 18 and 21. In terms of the courses they attend, the following were identified: quality management, electronic and computer engineering, quality management, marketing, and information technology.

3.3 Methodology

In the pursuit of this dynamic and innovative teaching methodology, it's important to highlight that the primary objective is to impart entrepreneurial skills to students using board games. This developed methodology combines theoretical learning with practical application, enabling students to engage deeply and reflect their understanding in a learning journal provided at the start of their participation. The methodology unfolds in five distinct phases: starting with an icebreaker, followed by a theoretical overview involving a presentation on EntreComp and game design, then progressing to the theme selection, prototype creation, and finally, the pitch presentation (figure 2).

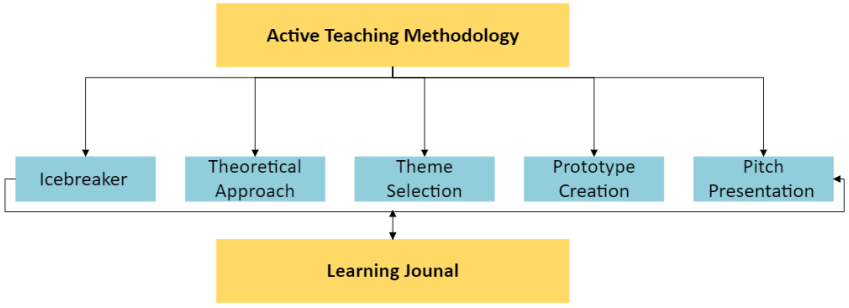


Figure 2: Active Teaching Methodology

Initially, considering that many students were unfamiliar with each other and recognizing that entrepreneurship thrives on network collaboration, an icebreaker was utilized. This was designed to focus on themes pertinent to the subsequent sessions, especially gamification. The activities might include simple games or mimics of popular games to facilitate easy understanding and prompt group formation, with groups capped at five participants.

Following the icebreaker, the session moves into a theoretical discussion that introduces various key concepts. This includes a literature review on EntreComp, which outlines essential competencies for entrepreneurial

success. Here, the facilitator uses captivating examples and encourages students to select, in groups, three competencies they wish to embody in their game design. Additionally, the segment on game design addresses the concept of game design itself, exploring different functions games can serve, common mechanics in board games, and practical examples, such as the mechanics used in Monopoly.

The subsequent phase involves choosing a theme for the game. This process includes guiding the students to consider factors such as target audience, cost implications, originality, the narrative of the game, and its cultural relevance. Creative themes are suggested to foster innovation.

Then, students move on to create a prototype, ideally in a makerspace equipped with all necessary materials. They are provided a worksheet to document important game aspects, including the game's name, theme, mechanics, rules, intended skills development, cost analysis for mass production, number of players, suitable age group, duration, resources needed, and the game's objectives.

The final phase entails a pitch where students present their game to other teams. This presentation strategically omits which skills the game aims to develop, challenging classmates to identify and justify these competencies. This ensures an evaluation of whether the game meets its intended educational objectives and skills development.

Throughout the process, students should be encouraged to reflect in their learning journal, which should then be handed in with an evaluation of the pilot.

4. Results

During the first pilot, students demonstrated a high level of satisfaction with the whole experience, averaging a score of 4.5 out of 5 on the Likert scale. They successfully identified desired themes and competencies to incorporate into their games, with nearly all games reflecting these competencies effectively. Additionally, students easily recognized the competencies in the games created by their peers. Notably, there was no repetition of themes, showcasing a broad range of creativity. However, reflections in the learning journal revealed that students desired more time for prototyping and less emphasis on theoretical content. Some also noted difficulties in reaching a consensus on the theme chosen by their group.

The second pilot maintained a high satisfaction level, with the same average score of 4.5 on the Likert scale. While the competencies chosen were clear in the games, students faced greater challenges than in the first pilot in selecting competencies and themes. The learning journals from the second pilot highlighted some frustrations, as several groups experienced significant discord regarding the choice of theme and competencies. Despite these challenges, students were proficient at identifying the intended competencies in the created games, and once again, there was no thematic repetition.

5. Discussion

The "Game It Away!" project was implemented through two pilot studies that utilized board games to instil and enhance entrepreneurial skills in students. Each pilot was designed to engage students from various academic programs and involved a multi-phased methodology that included an icebreaker, a theoretical overview, theme selection, prototype creation, and a pitch presentation. Feedback collected through learning journals indicated that while students enjoyed the interactive and practical aspects of the methodology, they expressed a desire for more time dedicated to the prototyping phase and less emphasis on theoretical content.

Across both pilots, students reported high satisfaction; however, they encountered challenges in theme and competency selection, with notable frustration and discord noted in the learning journals of the second pilot. These insights are crucial for refining the methodology, suggesting a need for improved guidance and support in the initial phases of the project.

Despite these challenges, the project successfully demonstrated that board games could be an effective tool for applying theoretical knowledge in practical scenarios, thereby enhancing the understanding and retention of entrepreneurial competencies. The absence of theme repetition and the ability of students to identify competencies in others' games underscore the creative engagement and depth of learning achieved.

6. Conclusion

The "Game It Away!" project has explored the integration of board games and the EntreComp framework in higher education to foster entrepreneurial skills, demonstrating a pioneering approach in pedagogical strategies. This study has highlighted the significant potential of gamification to revolutionize the way entrepreneurial competencies are taught and learned.

Through the deployment of two pilot studies, we have observed that board games not only make theoretical knowledge accessible but also engage students in a practical, hands-on manner that promotes deeper learning and retention of entrepreneurial skills. The learning journals served as a crucial tool in this process, allowing students to reflect on their learning experiences and providing valuable insights into the effectiveness of the methodology.

Students reported high levels of satisfaction across both pilots, underscoring the appeal of this interactive approach. However, challenges such as difficulties in theme and competency selection and the desire for more practical and less theoretical focus suggest areas for further refinement. The feedback from the learning journals particularly highlighted the need for better facilitation in the initial stages of theme and competency selection to reduce frustration and enhance the learning experience.

The absence of theme repetition and the successful identification of competencies by students in the games created by their peers demonstrate the project's ability to stimulate creativity and critical thinking. These outcomes affirm the value of board games as powerful educational tools that can effectively simulate real-world challenges and foster the essential skills required in today's entrepreneurial landscape.

Looking forward, we are planning to conduct a third pilot study. This next phase will incorporate the lessons learned from the previous pilots to further enhance our methodology. We aim to refine our approach to theme and competency selection and balance the theoretical and practical components more effectively.

Overall, the "Game It Away!" project contributes to the ongoing discourse on active learning methodologies by proving that well-designed gamification can significantly enhance student engagement and competency development. This initiative not only supports the acquisition of knowledge but also prepares students to navigate and shape their futures effectively, making it a valuable model for integrating entrepreneurial education into higher learning curricula. As we continue to refine and expand this methodology, it holds the promise of making entrepreneurial education more dynamic, accessible, and impactful for a broader and more diverse student population.

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A Literature Review: Which, How and What for the Use of Artificial Intelligence in Gamification

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Abstract: Artificial intelligence (AI) is integrated into educational methods through game-like elements, including gamification and serious games, offering tools and approaches to enhance teaching and learning experiences. A comprehensive review was adopted in this study to generate an overall trend or effect on AI in gamification. The paper selection was based on the three databases. Related 22 articles were collected by searching through academic journals or conference proceedings that were published in English from 2019 to 2024. The findings present that machine learning is utilised in serious games, favouring AI that might support gamification and improve results such as enhanced learning outcomes. Some included studies discuss the direct and indirect connection between technologies and gamification, including personalisation, adaptive difficulty, feedback and motivation, predictive analytics, and data-driven Insights. Overall, those interested in the intersection of artificial intelligence and gamification, including researchers, practitioners, developers, educators, and policymakers, can benefit from the literature review.

Keywords: Artificial Intelligence, Gamification, Serious Games

1. Introduction

This research delves into the synergies between artificial intelligence (AI) and gamified elements, concentrating on facets like customisation, scalable complexity, interactive feedback, engagement enhancement, foresight through analytics, and insights informed by data. Its objective is to provide meaningful information for an audience comprising scholars, industry professionals, creators, teachers, and decision-makers eager to integrate AI in gamified learning settings.

1.1 Background

Deterding and colleagues (2011) describe gamification as applying game design elements in non-game contexts to enhance engagement, motivation, and overall user experience in activities beyond conventional gaming spheres. They highlight the use of game-oriented frameworks, designs, and methodologies in sectors not commonly linked with gaming. Fitzgerald & Ratcliffe (2020) support this definition by highlighting the significance of game-related structure, design, and methodology in serious games, which are a practical application of gamification. Furthermore, the core elements of gamification are detailed by Wood & Reiners (2015), who identify game dynamics (including player behaviours, interactions, and experiences), pedagogical or instructional design, and game mechanics (procedures and rules) as fundamental components. Additionally, common gamification tools, such as points, badges, leaderboards, and timed performance, are utilized to enhance user engagement and achievement recognition (Buckley et al., 2018; van Gaalen et al., 2021).

As discussed by Deterding et al. (2011), Serious games have been utilised across various non-entertainment domains such as education, healthcare, research, and marketing (Chicchi et al., 2018). In the field of education, gamification is widely implemented to enhance engagement, motivation, and active participation among learners by leveraging the inherent allure and interactive nature of gaming (e.g., Hamari et al., 2014; Dicheva et al., 2015; Landers & Landers, 2014).

Artificial intelligence technologies are employed in gamified educational frameworks to examine and understand the behaviours, preferences, and academic outcomes of students (Buckingham and Ferguson, 2019). This application provides tailored challenges, feedback, and rewards, thus making the learning process more effective and engaging (Zhou et al., 2020). For example, Buckingham and Ferguson (2019) explore how AI can dynamically adapt game elements in educational settings to match the individual learner's level, thereby optimizing the learning experience for each student. This adaptive learning approach ensures that tasks are neither easy nor challenging, keeping students in a state of flow and maximizing engagement. Zhou et al. (2020)' study discusses the role of AI in personalising learning paths within gamified education platforms. They propose that through data analytics and machine learning algorithms, AI can identify patterns in a learner's interaction with the content and adjust the difficulty, type of content, and rewards in real-time to meet the learner's specific needs and learning goals. Furthermore, Santos et al. (2021) highlight the potential of AI-driven analytics in gamified education to allow educators to monitor progress and optimise teaching strategies. These analytics help teachers

understand how different aspects of the gamified experience contribute to learning outcomes, enabling them to tailor the educational content more effectively.

1.2 Research Aims and Questions

This literature review Identifies and analyses trends from 2019 to 2024 in AI application within gamified education and its effects on learning interventions. Explore how AI technologies connect with gamification strategies, including Personalisation, adaptive learning, and data insights, to improve educational experiences. Offer insights for a broad audience including researchers, educators, and policymakers, highlighting the value and potential of AI in educational gamification. With the intended purpose of this study, the following Research Questions (RQ) to address the specific objectives are presented:

RQ1: In what specific ways is artificial intelligence utilized within gamified education systems?

RQ2: How does AI enhance gamification strategies to improve learning outcomes and engagement in educational settings?

RQ3: What are the primary objectives behind integrating AI with gamification in educational contexts, according to recent studies?

2. Methods

The study utilised a literature review methodology to investigate AI's integration strategies in educational gamification. This approach reviewed academic sources to map out the current landscape, pinpointing theories, processes, and existing gaps by critically evaluating pertinent literature, including books, articles, and journals (McCombes, 2021).

A qualitative data collection strategy was centred on “AI and gamification in education,” targeting research published from January 2019 to March 2024. Data were extracted using specific keywords within Summon 2.0 which includes various popular digital libraries (e.g., PsycINFO, PubMed and Web of Science), Scopus and IEEE Xplore, employing Boolean queries to refine the search: (Artificial Intelligence OR personalised OR adaptive OR machine learning OR AI-enhanced) AND (education) AND (gamification OR serious game OR digital game). The inclusion and exclusion criteria were meticulously designed to ensure the relevance and quality of the selected studies, which are presented in Table 1.

Table 1: Inclusion and exclusion criteria

Inclusion	Exclusion
1). Covers the period from January 2019 to March 2024.	1). Papers unrelated to gamification and AI.
2). Be published in English.	2). Study unrelated to digital games.
3). Study related to the utilisation of gamification and AI.	3). Redundant papers.
4). Study related to digital games.	4). Literature review.
5). Journal articles and conference proceedings.	
6). Full-text and open-access papers.	

3. Results and Discussion

From an initial pool of 1,163 studies (Summon 2.0 1020; Scopus 91; IEEE Xplore 52), 489 articles were evaluated against the inclusion and exclusion criteria, narrowing the field to 87. Upon detailed review, 22 studies were chosen for in-depth analysis. These studies span four key dimensions of AI application in gamified learning: Personalisation, adaptive difficulty, feedback and motivation, predictive analytics and data-driven insights. See Table 2.

Table 2: The examples involved the four dimensions

Five Dimensions	Intervention Status	Examples
Personalisation	direct	Castellano et al. (2023); Hassan et al. (2019); Oliveira et al. (2022); Sayed et al. (2023); Huber et al. (2024); Chen (2023); Nam (2021); Ahmad et al. (2022); Hare et al. (2023); Reshetov & Makarova (2023); Escolano et al. (2023); Blatsios & Refanidis (2019); Maher et al. (2020)
	indirect	Rodrigues et al. (2021); Sanchez et al. (2020); Zainuddin et al. (2020); Rodrigo et al. (2020); Duggal et al. (2021); Yang et al. (2023)
Adaptive Difficulty	direct	Nam (2021); Koravuna & Surepally (2023); Hassan et al. (2019); Oliveira et al. (2022); Sayed et al. (2023); Huber et al. (2024); Chen (2023); Duggal et al. (2021); Cascella et al. (2023); Escolano et al. (2023); Blatsios & Refanidis (2019); Maher et al. (2020)
	indirect	Duggal et al. (2021); Rodrigues et al. (2021); Sanchez et al. (2020); Zainuddin et al. (2020); Rodrigo et al. (2020); Yang et al. (2023); Castellano et al. (2023); Hare et al. (2023)
Feedback and Motivation	direct	Ahmad et al. (2022); Cascella et al. (2023); Hassan et al. (2019); Oliveira et al. (2022); Sayed et al. (2023); Huber et al. (2024); Duggal et al. (2021; Koravuna & Surepally (2023); Nam (2021); Castellano et al. (2023); Grammatikopoulou et al. (2019); Hare et al. (2023); Reshetov & Makarova (2023); Maher et al. (2020)
	indirect	Chen (2023); Rodrigues et al. (2021); Sanchez et al. (2020); Zainuddin et al. (2020); Rodrigo et al. (2020); Chen (2023); Yang et al. (2023); Ahmad et al. (2022); Blatsios & Refanidis (2019)
Predictive Analytics and Data-Driven Insights	direct	Huber et al. (2024); Sayed et al. (2023); Hassan et al. (2019); Oliveira et al. (2022); Sayed et al. (2023); Duggal et al. (2021); Cascella et al. (2023); Ahmad et al. (2022); Hare et al. (2023); Escolano et al. (2023); Maher et al. (2020)
	indirect	Rodrigo et al. (2020); Zainuddin et al. (2020); Rodrigues et al. (2021); Sanchez et al. (2020); Nam (2021); Castellano et al. (2023); Blatsios & Refanidis (2019)

The results highlight the symbiotic connection between AI technology and educational gamification, particularly in terms of Personalisation, adaptive difficulty, feedback and motivation, predictive analytics, and data-driven insights. These elements converge to craft learning experiences that are not only more captivating and efficient but also tailored to individual needs. Specifically, the following findings elucidate how AI is employed in educational gamification across four crucial dimensions:

1. Personalisation: AI can tailor challenges, rewards, and feedback to each user's individual preferences and abilities (e.g., Rose & Ferschke, 2016; Pardos & Heffernan, 2011; Settles, 2016). This is seen in the use of AI to provide answers that match students' questions or search online for solutions, suggesting a form of Personalisation in learning environments. This relationship is shown on direct and indirect sides. For example, Huber et al. (2024) highlighted the role of game-based learning in catering to individual learner needs by creating environments that allow for autonomy, competence, and relatedness. Although not explicitly named "Personalisation," the concept is embedded within the game design principles supporting individual psychological satisfaction and intrinsic motivation. This personalisation is central to the engagement and effectiveness of educational games. Grammatikopoulou et al. (2019) do not explicitly mention the term "personalisation" in the provided excerpts. However, the creation of game-like applications for ICH education inherently suggests a level of Personalisation, as these applications are designed to cater to the specific learning needs and cultural backgrounds of their users. The design module and customizable game-like applications mentioned could imply a degree of Personalisation in how content is presented and interacted with by users. Furthermore, the dimension, echoing the sentiments from Yang et al. (2023) and the discussion in Duggal et al. (2021), emphasizes the role of AI in creating personalised learning scenarios. This is achieved by analysing learner data to tailor educational content and challenges to individual needs and preferences.
2. Adaptive Difficulty: Research highlights AI's pivotal role in developing gamified educational systems that dynamically adjust the complexity and difficulty of tasks in line with the learner's performance. This adaptive difficulty approach, as outlined by studies such as those by Rowe et al. (2011) and

Heffernan & Heffernan (2014), aligns with our findings (e.g., Duggal et al., 2021; Cascella et al., 2023). While the reviewed articles may not explicitly mention adaptive difficulty, the concept is inherently linked to the Personalisation strategies they describe, especially within the gamified frameworks examined by Duggal et al. (2021). These frameworks evaluate student engagement and performance, with the potential to modify task difficulty levels to ensure they remain appropriately challenging for each student.

The discussion around multidimensional personalisation in these selected studies indirectly points to the utilization of AI for real-time difficulty adjustment, underpinning the effort to sustain an optimal learning trajectory. This demonstrates AI's crucial role in personalising educational content and enhancing the effectiveness of gamified learning environments through adaptive challenge levels.

3. Feedback and Motivation: firstly, according to Cascella et al. (2023), AI provides real-time feedback based on learners' actions, enhancing the learning process, and promoting quicker skill development. This immediate feedback loop serves as a motivational tool, sustaining high levels of engagement over extended periods. Secondly, Yang et al. (2023) and Duggal et al. (2021) emphasize the role of AI in creating personalised learning scenarios. This is achieved by analysing learner data to tailor educational content and challenges to individual needs and preferences. The aim is to increase learning effectiveness by aligning educational materials with the learner's specific learning styles and requirements. Additionally, such a study by Grammatikopoulou et al. (2019), does seem to consider feedback and motivation, especially when it discusses the engagement of learners and the promotion of extrinsic and intrinsic motivation through modern digital games. Feedback is an integral part of learning games, necessary for guiding learners and keeping them motivated. The positive response to the usability of the ITGD module and the intention to use the games alongside traditional teaching methods imply that the games provide motivating feedback to learners.
4. Predictive Analytics and Data-Driven Insights: AI's role in forecasting future behaviours within gamification frameworks is instrumental, enabling the refinement of strategies through predictive analytics. This approach leverages data-driven insights to tailor learning experiences more closely to the anticipated needs and behaviours of students, as illustrated by Castellano et al. (2023). Duggal et al. (2021) highlight the significance of machine learning in analysing student performance and spotting early signs of disengagement. They stress the critical importance of data quality and volume for accurate predictions, proposing a methodology that integrates key machine learning parameters with gamification to boost educational outcomes. This approach underscores the pivotal use of data-driven insights for enhancing gamification processes and results.

While Huber et al. (2024) do not explicitly address predictive analytics within the context of game-based learning, the foundational technology design and digital learning principles they discuss imply a data-informed approach to game design and learning experiences. Their emphasis on expanding Self-Determination Theory (SDT) research and analysing player engagement points towards an interest in using data to understand and elevate the educational value of games, albeit not overtly mentioned. The indirect mention of predictive analytics through the evaluation of virtual assistants and suggestions for performance enhancement suggests a reliance on data-driven insights for guiding learning strategies and decisions, reflecting the overarching theme of employing AI to analyse and predict learner behaviours and preferences efficiently.

Based on the selected studies, the primary objectives behind integrating AI with gamification in educational contexts can be summarised as follows:

3.1 Enhancing Personalised Learning Experiences

These papers—Yang et al. (2023), Duggal et al. (2021), Sanchez et al. (2020), and implicitly referenced works such as Castellano et al. (2023) and Nam (2021)—discuss the goal of integrating AI with gamification strategies in education. This integration aims to tailor learning content and challenges to meet the unique needs, abilities and learning paces of individual students. The Personalisation of learning experiences, as further explored by Rodrigues et al. (2021), seeks to enhance learning efficiency. It makes the learning process more relevant and engaging for students, as underscored by the practical examples and theories proposed in these studies.

Such personalisation, highlighted across diverse contexts from the detailed algorithmic approaches in Chen (2023) to the empirical evidence provided by Ahmad et al. (2022) and Rodrigo et al. (2020), underlines the transformative potential of AI in educational settings. Moreover, the insights from Zainuddin et al. (2020) and

Oliveira et al. (2022) illustrate how data-driven gamification can dynamically adjust to students' evolving learning journeys, thereby fostering a more immersive and interactive learning environment.

This body of research emphasizes the critical role of AI in diagnosing learning styles, predicting student engagement, and customizing educational content. This customization not only aims to align with individual learning trajectories—as discussed by Huber et al. (2024) and Sayed et al. (2023)—but also to significantly elevate the educational experience by making it more engaging and effective for each student.

3.2 Adaptive Difficulty

Duggal et al. (2021) and Sanchez et al. (2020) propose a transformative approach within gamified learning environments, where AI's role is pivotal in dynamically adjusting the difficulty level of challenges and tasks. Fine-tuning this modification according to the continuous performance of the learner guarantees that everyone consistently functions within their ideal developmental proximal zone. The essence of this notion is to establish equilibrium, avoiding tasks that are too simple and hence boring, or too complex, which could lead to frustration.

The adaptability facilitated by AI is designed to maintain an engaging and balanced level of challenge for each student, making learning not just a process of acquiring knowledge, but also an engaging journey of exploration and achievement. Such an approach underpins the integration of AI with gamification, seeking to personalize learning content and challenges to align perfectly with the unique needs, abilities, and learning pace of every student.

The intention behind this personalised learning experience is multifield: to enhance learning efficiency, to make the learning process more relevant to each learner, and to significantly boost engagement. This objective draws strength from a constellation of studies including Nam (2021), Koravuna & Surepally (2023), and Huber et al. (2024), which collectively underscore the potential of AI to offer bespoke educational experiences.

Further supporting research, such as that from Oliveira et al. (2022), Sayed et al. (2023), and Chen (2023), validates the efficacy of AI-driven Personalisation in fostering improved educational outcomes. This is achieved by ensuring that learning activities are not only aligned with each student's learning trajectory but are also adaptable to their evolving needs and capabilities, as discussed in works by Rodrigues et al. (2021).

In essence, the synergy of AI with gamification in educational settings promises a more effective, relevant, and engaging learning experience. The collective insights from these studies advocate for a future where education is not just about what is learned, but how it is learned, emphasizing the critical role of adaptability and Personalisation in meeting the diverse needs of learners.

3.3 Improving Feedback and Motivation

The research underscores the transformative role of AI in enhancing education by providing real-time, personalised feedback, which significantly boosts student motivation and engagement. This is primarily due to AI's ability to offer instant responses to student inputs, a feature critical for sustaining high engagement levels, as noted by Ahmad et al. (2022) and further corroborated by Cascella et al. (2023). AI's real-time monitoring of student progress and tailored feedback is pivotal for encouraging ongoing learning and improvement, a concept underscored by studies from Cascella et al. (2023) and Hassan et al. (2019).

Furthermore, the application of AI in gamified educational settings amplifies student motivation by fostering a dynamic and interactive learning atmosphere. This aspect is highlighted by Sayed et al. (2023) and Huber et al. (2024), demonstrating how the blend of gamification and AI-driven feedback can maintain and enhance student engagement and motivation over time. Practical implementations of AI for feedback, illustrated in case studies like Oliveira et al. (2022), offer a glimpse into how this technology can be effectively used to bolster student engagement and motivation.

Key insights from Duggal et al. (2021) suggest that AI's capability to deliver immediate, personalised feedback has wide-ranging implications for boosting student motivation and engagement across educational landscapes, indicating a profound potential impact on educational practices and systems.

3.4 Predictive Analytics and Data-Driven Insights

The collected articles in this study offer a comprehensive examination of how AI is utilized to forecast future user behaviours, particularly within educational environments that employ gamification frameworks. AI algorithms analyse extensive data from student interactions on gamified platforms. This analysis is pivotal in identifying

learning behaviour patterns and trends, crucial for predicting how students are likely to engage with future material. For instance, Huber et al. (2024) and Sayed et al. (2023) may have investigated sophisticated models predicting students' engagement levels, dropout rates, or task completion likelihoods.

The capability of AI to anticipate student needs is crucial. This encompasses not merely understanding where a student might face challenges but also recognizing their preferences and learning styles. Through the analysis of past and present behaviours, AI can recommend real-time content adjustments, thereby enhancing engagement and accessibility. Insights from Cascella et al. (2023) and Hassan et al. (2019) likely delve into how adaptive learning algorithms customize the difficulty level and content type to align with the learner's progress.

Gamification elements—such as points, badges, and leaderboards—achieve greater effectiveness when aligned with learners' motivations. AI-driven analysis, potentially detailed by Duggal et al. (2021) and Oliveira et al. (2022), enables the optimization of these elements based on individual and collective behavioural patterns. Consequently, rewards can be personalised, challenges can be aptly adjusted for difficulty, and feedback can be strategically timed to simultaneously motivate and educate.

Leveraging insights from AI analytics, educators can refine their teaching strategies. This refinement extends beyond modifying gamified content to include adjusting pacing, focusing on specific topics, and even altering classroom activities to better meet learners' needs. Research by Ahmad et al. (2022) and Rodrigues et al. (2021) may have explored how these insights contribute to more effective teaching methodologies and improved educational outcomes.

4. Conclusion

Integrating artificial intelligence into gamified learning platforms has notably enhanced educational practices between 2019 and 2024. Studies pinpoint critical utilization sectors of AI such as customization, adjusting complexity, encouragement, and feedback, forecasting analyses, and insights based on data, showcasing a broad spectrum of applications that uplift educational experiences. Gamification strategies augmented by AI have been shown to boost both learning outcomes and participation in educational frameworks by tailoring to the unique needs of each learner, providing feedback promptly, and encouraging students through customized challenges and incentives.

The primary goal of merging AI with gamified elements in educational scenarios is to foster more customized, dynamic, and immersive learning journeys that address students' varied requirements. This fusion seeks to utilize the extensive data generated in educational environments to uncover insights about learners' behaviours, preferences, and achievements, thus facilitating more impactful and streamlined educational programs.

In summary, the review of existing literature underscores AI's significant potential and value to educational gamification, offering perspectives for researchers, educators, and policymakers at the intersection of AI and education. The evidence points towards an increasing trend in employing AI in educational contexts, signalling a future where personalized, adaptive learning settings are commonplace, thereby making the learning experience more engaging and effective worldwide.

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Leveling Up Learning: Game Based Learning Initiatives in Canadian Higher Education

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Abstract: Game based learning (GBL), the use of game design elements within non-game contexts such as education, became increasingly popular in the early 2000s, yet empirical evidence about the benefit of games on student learning remains inconclusive. The potential impact of GBL can be influenced, for example, by design elements, context, and discipline. In Canadian higher education, GBL may be housed within departments, the library, or centres for teaching and learning. At our institution, GBL initiatives have only recently begun to surface; for example, the Department of English and Drama has recently launched a games studies minor for undergraduate students, the library has an extensive collection of video games available to borrow, and the academic skills centre has a large collection of board games that are used primarily for social game cafés. While opportunities for curricular connections may exist, our academic skills centre currently lacks staff who have both capacity and expertise in GBL pedagogy. Exploring possibilities for expansion, we aimed to understand the landscape of GBL initiatives across Canadian post-secondary institutions. To achieve this aim, we conducted an environmental scan of over 100 Canadian post-secondary institutions, gathering data such as the existence of GBL programs, category and level of programming (curricular, co-curricular, or research), initiative types, research development, faculty involvement, and availability of additional resources. Findings indicate inconsistencies in definitions used to promote GBL and a concentration of GBL initiatives at the curricular and research levels. The majority of GBL in Canada is led by faculty through course and degree-level programs at both undergraduate and graduate levels. This research gives us insight into GBL program development, challenges, and opportunities for higher education in Canada and globally.

Key Words: Game Based Learning, Game Enhanced Learning, Gamification, Pedagogy, Higher Education

1. Introduction

Game based learning[1] (GBL), the use of game design elements within non-game contexts (Deterding et al, 2011) such as education, became increasingly popular in the early 2000s. GBL approaches have been suggested to positively transform student learning (Gee 2004). It has been argued that games—board games, video games, multi-player role-playing games—require players to use complex thinking skills and to develop argumentation skills (see Gee 2003; Steinkuehler & Duncan 2008). Further, GBL can be beneficial in promoting social interaction as students may be motivated to learn and can explore goal-driven challenges (DeLisi & Wolford 2002). GBL may also help encourage students to share, discuss, and apply knowledge within peer learning groups (Prensky 2006).

Recent research in GBL has focused on a multitude of topics, including use of augmented reality in language acquisition (Hung & Yeh, 2023); the use of games to promote mental health and well-being (Sort et al, 2018); and the use of GBL in flipped classrooms (Hung, 2018). Research has also shown that GBL is not limited to one discipline in higher education. Studies in GBL have been situated in fields such as pharmacy (Bangalee et al, 2021), theology (Oliver, 2018), and business (Emblen-Perry, 2018). Further, these studies have pursued the understanding of GBL through various theoretical frameworks including, constructivism (see e.g., Chan et al, 2017) and activity theory (see e.g., Ek-Ming, Mingfong, & Shao-han 2013). While there has been a plethora of published research, empirical evidence about the benefits of GBL on student learning remains inconclusive on account of influences such as learning context, discipline, and game design elements (see, e.g., Huang et al, 2020; Karakoç et al, 2020).

In Canadian higher education, GBL may be housed within departments, the library, or centres for teaching and learning. At our institution, GBL initiatives have only recently begun to surface; the Department of English and Drama has recently introduced a games studies minor, the library has a new collection of video games available for lending, and the academic skills centre has a large collection of board games used primarily for social game cafés. To determine the possibilities for GBL program expansion at our institution, we determined it was necessary to understand the context of GBL in general and, more specifically, in Canadian post-secondary institutions. Since GBL has not gained much attention in our own institution, we were curious about the

[1] Game based learning is used here, but other related terms include game enhanced learning and gamification.

existence of GBL programming elsewhere in Canada. We thought that by looking at Canadian higher education institutions, we would gain insight into the opportunities for GBL programming in our institution.

In this paper, we report our methods and findings from an environmental scan of over 100 Canadian post-secondary institutions. We then discuss these findings, paying particular attention to the opportunities for GBL program development and the needed support for such development. We end with a presentation of limitations and suggestions for future research.

2. Research Question

Given the lack of research about GBL programs in Canadian institutions of higher education, we were guided by the following research question: What GBL programming exists in Canadian post-secondary institutions?

3. Context

The first author—Jordana Garbati—is the director of the academic skills centre at our institution. As director, she oversees the academic programming of the centre. She began in this role in 2022 and prior to this time, one staff member was primarily responsible for initiating the development of the centre's GBL initiatives. With his retirement, there was a void in GBL programming. At the time of this research, the one initiative that the centre continued was the game café. Game cafés are primarily social in nature where students gather in a large community space for a few hours to play board games. One centre staff member coordinates about a dozen cafés throughout the academic year. While opportunities for curricular connections may exist, our academic skills centre currently lacks staff who have both capacity and expertise in GBL pedagogy. As we thought about GBL opportunities for our own institution, we thought it was important to learn from GBL initiatives across Canadian post-secondary institutions. The second author—Nicole Skrepnek—was completing a Master of Teaching at our institution at the time of this research. We previously completed a pilot study where we employed an environmental scan to identify GBL programs in one province only.

4. Methods

An environmental scan provides a means to identify and assess a given situation or context, so we used this method to identify current practices and programs in GBL across Canada. To begin our cross-Canada environmental scan, we adopted the methods that we used in our pilot study of one province. We identified all accredited post-secondary institutions in Canada (see UniversityStudy.ca). We documented and organized data by province and by institution. We collected information in two ways. First, we accessed the official websites of each institution. We then inputted keywords into the website's search bar to conduct a search of each institution's website. Keywords used were: game-based, game-based learning, gamification, gamified, game-enhanced learning, game-enhanced pedagogy, games, board games, video games, serious games, and jeux serieux and jeux de société (for French-language institutions in Quebec). Second, we used the Google Search Engine. Here, we inputted the full name of each institution along with keywords used in the first approach. This dual approach search method ensured comprehensive access to information online. With these two approaches, we gathered data from a range of webpages and documents. These included: webpages of the institutions; published faculty research articles; records from academic symposia organized or advertised by the institutions for faculty professional development; course offerings and syllabi; workshop resources; inventories of games; faculty-student projects; graduate student publications (e.g., thesis submissions); and links to external webpages published by the institutions for faculty professional development or to promote awareness of GBL initiatives.

We collected and organized our data in one, shared Google Sheet with one tab for each province and territory in Canada. We documented the following information for each institution: name of institution; website URL; identification of GBL programming; categorization of program: curricular (e.g., course, program, major/minor), co-curricular (e.g., game café, game night), or research initiatives (e.g., faculty research); existence of a related GBL definition (e.g., GBL, game-enhanced learning, gamification); type of GBL initiative (e.g., teaching strategy, research project, game night); research; stakeholder groups (e.g., faculty, undergraduate and graduate students, campus partners; and resources available (e.g., funding opportunities, technological infrastructure). We collected descriptive statistics about number of initiatives per category.

These methods allowed us to systematically capture and organize a large quantity of data collected from institutions' websites.

5. Findings

5.1 Higher Education in Canada

Canada has 10 provinces and three territories. Provinces and territories are responsible for all levels of education, including post-secondary education. In Canada, post-secondary institutions include universities and colleges. In universities, students typically earn a three- or four-year bachelor's degree, and in colleges, students typically earn a one- or two-year diploma or certificate. This study collected data from accredited post-secondary universities (see University Study, 2024). Table 1 shows the number of universities in each province and territory in Canada.

Table 1: Universities in Canadian provinces and territories

Region	Province	Number of institutions (n=108)	Number of institutions With GBL Initiatives (n=75)
West Coast	British Columbia (BC)	12	10
Prairie Provinces	Alberta	9	8
	Saskatchewan	6	4
	Manitoba	6	4
Central Canada	Ontario	34	21
	Quebec	26	21
Atlantic Canada	New Brunswick	4	2
	Nova Scotia	9	3
	Prince Edward Island (PEI)	1	1
	Newfoundland and Labrador	1	1
The North	Yukon	0	0
	Northwest Territories	0	0
	Nunavut	0	0

All 10 provinces have universities with number of universities ranging from one (e.g., Prince Edward Island/PEI and Newfoundland and Labrador) to 34 in Ontario. The three territories (e.g., The North region) have no universities. Provinces with the highest number of universities and GBL initiatives are Ontario (34 and 21, respectively), Quebec (26 and 21, respectively), British Columbia/BC (12 and 10, respectively), and Alberta (9 and 8, respectively).

5.2 Adoption and Integration of GBL

Provincial variation exists in the adoption and integration of GBL across Canadian post-secondary universities. The data collected from the environmental scan indicates a robust trend towards embracing GBL, with many provinces adopting game-based pedagogy within their teaching and research frameworks. British Columbia and Alberta are the two provinces that are leading in the adoption rates. In British Columbia, 10 out of 12 (83.33%) of institutions reported the existence of GBL initiatives, with projects ranging from curricular program integrations (such as the OMEGA+ program housed in Athabasca University) to game-based faculty research. Alberta showed a slightly higher adoption rate, with 8 out of 9 (88.89%) institutions reporting the existence of GBL initiatives, ranging from faculty integrating GBL pedagogy into their classrooms to internal grants being utilized to fund institution-based GBL projects, such as the Educational Gaming Fund housed in MacEwan University (MacEwan, 2024). Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland exhibit varying degrees of GBL adoption within their respective institutions

(see Table 1). As noted in Table 1, the latter provinces range in GBL existence, from 3 out of 9 (33.33%) institutions in Nova Scotia and 1 out 1 (100%) institution in Prince Edward Island.

5.3 Defining GBL and Gamification

The conceptualization of GBL across accredited Canadian universities is varied across the country. In provinces such as Ontario, Saskatchewan, British Columbia, and Alberta, universities explicitly separate GBL from gamification, with formal definitions underscoring the application of game principles to enhance educational experiences. These definitions commonly highlight the motivational aspects of games, such as their ability to captivate and sustain student interest, thus enriching the learning journey. For instance, in Ontario, the University of Waterloo defines GBL as "involving the design of learning activities so that game characteristics and principles are inherent within the activities themselves" (University of Waterloo, 2024). This is contrasted with their definition of gamification, which is described as "the integration of game elements like point systems, leaderboards, and badges into conventional learning activities to increase engagement and motivation" (University of Waterloo, 2024). In Saskatchewan, definitions also emphasize integration, but with a focus on the seamless inclusion of games in learning. The University of Saskatchewan defines GBL as "the integration of games into the learning experience. It includes a spectrum of approaches that range from high-fidelity simulation to gamification, which is the integration of classic game elements into traditional learning activities'' (University of Saskatchewan, 2024); it defines gamification as "the integration of classic game elements into traditional learning activities'' (University of Saskatchewan, 2024). In British Columbia, universities present a similar bifurcation in definitions. For example, The University of British Columbia defines GBL as "the integration of games or gaming mechanics into the educational experience" (UBC Blogs, 2024), highlighting a direct application of gaming elements in teaching. Meanwhile, Vancouver Island University provides a more detailed description of gamification, noting it as "the integration of game-like elements into the design of your course that integrate rewards for students as they engage with the topics of your course" (Vancouver Island University, 2024). In stark contrast to universities in these four provinces, universities in Quebec, New Brunswick, and Nova Scotia present a lack of definitions for GBL and gamification; in fact, none of the universities in these provinces provide a definition of gamification.

The environmental scan showed variances in the presence of GBL definitions amongst regions and institutions. For instance, in British Columbia, 1 out 12 (8.33%) institutions provided a definition of GBL and gamification. Similarly, in Alberta, 1 out of 9 (11.11%) institutions provided a definition of GBL, and 2 out of 9 (22%) provided a definition of gamification. In Saskatchewan, 1 out of 6 (16.67%) institutions provided a definition of GBL and gamification. Manitoba, Quebec, New Brunswick, and Nova Scotia, all lacked explicit definitions of GBL or gamification; none of the institutions in these provinces provided clear. In contrast, Ontario, of the 34 institutions, 4 (11.76%) provided a definition of GBL, and 8 (23.53%) provided a definition of gamification.

5.4 Curricular Applications

Data collected from the environmental scan show that the curricular integration and application of GBL can be understood through two perspectives: macro and micro. The macro perspective on GBL integration encompasses institutional-level efforts, including comprehensive curriculum design, structured program and course development, and overarching institutional support. This approach reflects a systematic incorporation of GBL into the educational fabric of the institution. Conversely, the micro perspective focuses on individual faculty initiatives and course-specific efforts. This includes the integration of gamification methods, such as the use of GBL platforms, game labs, and other innovative teaching tools within the classroom. This perspective largely highlights the contributions of individual educators and their localized applications of GBL to enhance student engagement and learning outcomes.

The application of GBL within curricular initiatives varies amongst institutions and provinces. Curricular integration is notably prominent in British Columbia and Alberta, where 66.67% of institutions in each province include GBL initiatives within their curricula. In British Columbia, the Advanced Game Development Program - Diploma (96 credits) at Kwantlen Polytechnic University (2024) gives rise to programs that directly support and encourage the use of GBL in academia and career advancement. This program not only teaches game development but also incorporates industry standard GBL practices and tools (such as game rendering, programming, etc.), preparing students for careers in the gaming industry (Kwantlen Polytechnic University, 2024). Data from British Columbia institutions, such as Simon Fraser University, show that faculty have reported that incorporating gamification within lessons enhances student learning and engagement, even when no academic grade is assigned (Simon Fraser University, 2024). Alberta's curricular integration is equally robust,

featuring programs such as game design minors and courses emphasizing game-based pedagogy to foster academic success. For instance, Athabasca University houses the OMEGA+ project, where students in the Master of Science in Information Systems program have created the platform to help other learners "develop their metacognitive skills through gaming" (Athabasca University, 2023). Additionally, in Nova Scotia, Saint Mary's University provides resources and instructional guides to faculty that encourage the incorporation of GBL and "Game Maps" directly into their course webpages via the Brightspace Learning Management System (Saint Mary's University, 2024).

In contrast, provinces like Saskatchewan, Manitoba, and Nova Scotia show lower rates of classroom integration, with many institutions lacking structured initiatives; instead, there exists individual faculty efforts and ad-hoc applications of game-based tools. For instance, in Saskatchewan, 66.67% of institutions have the existence of GBL initiatives, primarily emerging through isolated faculty-procured course descriptions and projects rather than institution-wide programs. For example, at St. Thomas More College, Dr. Saeed Moshiri (professor) integrated the MobLab online learning platform into his course ECON277.3 as a response to the COVID-19 pandemic drastically limiting in-person and face-to-face interactions that could take place amongst students (St. Thomas More College, 2020). This platform allows students, in various streams of social science, to run experiments to determine the cause-and-effect of variables, similarly to how "explorations" are conducted directly in the field (St. Thomas More College, 2020). Manitoba's integration efforts are similarly limited, also with 66.67% of institutions having the existence of GBL initiatives, with resources largely stemming from faculty research and serious game certificates, such as the one offered at the University of Winnipeg as part of Continuing Education (University of Winnipeg, 2024). Nova Scotia, having 33.33% of institutions with GBL initiatives, have yet to see a broad adoption or a systematic approach to integrating these methods into their educational framework, with initiatives largely consisting of co-curricular blogs, student research, and Brightspace Learning Management System toolkits.

5.5 Student Engagement

Student engagement within GBL initiatives varies across educational levels and provinces. In British Columbia, both undergraduate and graduate students are involved in GBL initiatives, with 58.33% of undergraduate students and 50% of graduate students participating. These initiatives range from graduate student research to faculty integrating gamification strategies into courses. Alberta shows similar trends, with 77.78% of undergraduate students and 55.56% of graduate students involved in GBL initiatives. Examples include GBL introduced within faculty of law classrooms at the University of Alberta (2020) and simulated field trips for students in the Department of Geoscience at the University of Calgary (2022). Ontario also reports good engagement with 52.94% of undergraduate and 23.53% of graduate students participating. For instance, WoodsworthONE courses at Woodsworth College at the University of Toronto, offer students the opportunity to engage with courses that are central around class discussions and participation, while integrating GBL strategies (University of Toronto, 2024). In contrast, Manitoba, New Brunswick, Nova Scotia, Saskatchewan, and Quebec report lower student engagement with undergraduate student involvement ranging from 0% to 57.69% and graduate student involvement ranging from 0% to 16.67%.

5.6 Co-Curricular Initiatives

Data show that GBL at Canadian universities extends beyond curricular applications. Co-curricular initiatives offer additional opportunities to engage with educational content in innovative ways. Co-curricular GBL initiatives are notable across several provinces, each showcasing diverse approaches to enhancing learning experiences. For example, in Alberta, institutions have implemented GBL within co-curricular settings. For instance, The King's University (2024) offers a recreational gaming club facilitated by the Students' Association (TKUSA), providing a platform for students to explore and engage with gaming as a learning tool. In Ontario, there are multiple co-curricular GBL initiatives. Carleton University has curated an academic library collection comprising over 400 video games and 50 board games, which primarily supports learning in computer game development and is accessible to students across various disciplines (Carleton University 2024). The Health and Wellness Lounge, housed within the University of Ottawa (2024) incorporates Virtual Reality (VR) and video games to promote student mental health and wellness. Additionally, the University of Toronto Mississauga (2024) offers an extensive board game inventory suitable for interdisciplinary study and hosts Game Cafés through the Robert Gillespie Academic Skills Centre (RGASC), fostering interactive and engaging learning experiences. In Quebec, the Université du Québec en Outaouais (2024) supports co-curricular GBL initiatives by maintaining a board game collection within its library, which students can access to enhance their learning

through gameplay. Conversely, provinces such as British Columbia, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland exhibit limited co-curricular GBL initiatives. Institutions in these regions primarily focus on curricular or research based GBL applications.

5.7 Research Applications

Research applications of GBL, while less prevalent than curricular integrations, are notable within certain provinces. In Alberta, 55.56% of institutions engage in GBL-related research. Noteworthy projects include a Scholarship of Teaching and Learning (SoTL) study conducted by faculty at Mount Royal University, which investigates the impact of an online role-playing game on adult criminal justice students at a western Canadian university (Fantazir & Bartley, 2021). Additionally, research at the University of Lethbridge focuses on updating a web-based card game used for teaching programming, cybersecurity, and software development (Tareque, 2021). Ontario also demonstrates considerable research integration, with 35.29% of institutions involved in GBL-related research. For instance, Eunsik Kim, a researcher at the University of Windsor's Faculty of Engineering, applies gamification strategies to provide virtual rewards for social isolation competencies and tasks such as social distancing, handwashing, and self-isolation during and beyond the COVID-19 pandemic (University of Windsor, 2020). New Brunswick, where 50% of institutions engage in GBL-related research, also showcases faculty-led initiatives. At Université de Moncton, Caitlin Furlong and colleagues have highlighted the use of technology-based games to enhance student motivation within mathematics (Furlong et al., 2018). However, other provinces like Saskatchewan, Manitoba, Quebec, and Nova Scotia show little to no research development, with research engagement ranging from 0% to 22.22%. Most initiatives in these regions stem from graduate student research. For example, a graduate student at Acadia University in Nova Scotia authored a paper on the use of games as a tool for teaching programming concepts to fulfill degree requirements (d'Entremont, 2015).

6. Discussion

While all the Canadian universities in our data set included instances of GBL, their approaches varied widely from the definitions used to the programs offered. The lack of consistency in terminology or presentation of definitions is surprising as this could indicate weakness and uncertainty within the field of GBL. The number of terms used—GBL, game-enhanced learning, gamification, serious games—created some complication in our data collection approaches, which could also indicate a lack of clarity for students and administrators. A clearer description of the terms, their uses, purposes, distinctions could lead to a more unified approach to program administration.

Our environmental scan shows that GBL initiatives primarily exist in curricular and research endeavors led by faculty. Many readers may not be surprised by this. The possibilities, however, to work with other campus partners on GBL are great. Libraries, students' associations, and academic skills centres could be ideal partners and leaders in GBL, and it seems that their value has not yet been tapped. That said, if institutions wish to expand GBL initiatives, our data show that faculty involvement is likely necessary.

There is great variation in existence and type of GBL initiatives across Canadian provinces. British Columbia, Alberta, and Ontario, for example, show a variety of initiatives in our identified categories whereas there was more variation of offerings in other provinces. This may because these are the provinces with the highest number of universities and show high faculty participation. Further, universities in these provinces may have more GBL courses, programs, and research initiatives than in other provinces because of funding and student enrolment.

7. Limitations

There are two primary limitations of this research. First, in terms of data collection, we collected data solely from published information provided by the institutions. We recognize that the published information may not capture all GBL initiatives within each institution. In addition, since each institution adopted different ways to present their GBL activities, we may have missed information in our website search. Second, we were limited by the information available and accessible on public websites. This meant that if a website did not have a "search" feature, we had to try to locate the needed data by other means. We also encountered broken links or pages that were redirected incorrectly, which resulted in missing data.

There is value in extending this research by conducting qualitative research (e.g., interviews, focus groups) with those involved in GBL to learn more about their programs.

Second, we limited our search to universities in Canada. To get a better view of the landscape of GBL in Canada, it would be interesting to also include colleges. This might give researchers and administrators a more comprehensive view of the place of GBL in higher education in Canada. To begin, an environmental scan could be completed. This work could be extended through qualitative research approaches as noted above.

8. Conclusion

This research contributes to our understanding of GBL in Canada. There are several practical outcomes of this research. First, it is the first environmental scan of GBL in Canada that is publicly available. Faculty and administrators can now use this scan as they explore GBL opportunities in their institutions. Second, we have identified a need for those involved in GBL to increase awareness by defining GBL more explicitly and clearly. Third, we have proposed that to increase GBL initiatives, faculty involvement is necessary, but cross-campus partnerships would bring additional opportunities.

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Serious Games for Vocational Training

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Abstract: The research project 'SG4BB' (Serious Games for Vocational Education and Training; abbr.: VET) has developed an integrated platform for the description, search, retrieval, integration, and utilization of educational games. This paper summarizes project outcomes, including platform concepts, software components, and – as focus – practical insights derived from a case study involving the educational game 'Corrugated' as simulation and training environment for service technicians. SG4BB has followed a user-centered design in an interdisciplinary project team: Two learning providers specified their requirements for VET in their specific application domains. Based on those requirements, game developers, learning solution providers and researchers for VET have conceptualized and prototypically implemented both an integrated learning platform (SG4BB platform) and two case studies of Serious Games for VET: 'Corrugated' for service technicians and an IT security game. The platform follows a process pipeline: For search and retrieval of educational games for VET, an application profile for VET based on the standardized 'Serious Games Metadata Format' (DIN/SPEC 91380) has been elaborated. This format builds the semantic basis for the metadata-based catalog system 'Serious Games Information Center' (SG-IC) with filter functionality for VET. Learning providers and developers can use the SG-IC portal to describe and promote their educational games, enabling users to identify suitable games for their learning needs and integrate them via learning infrastructure. Educational games can interact with the backend (Learning Management System and Learning Record Store) through a middleware based on the xAPI standard, allowing for personalized gameplay and data collection for game-based learning analytics. The final evaluation of the SG4BB project focused on the utilization of the educational game 'Corrugated', targeting problem-solving skills for service technicians in the corrugated cardboard industry. Data from 26 participants playing the game for 60 minutes, along with problem-solving tests and user experience feedback, were analyzed to validate game-based assessment and to assess learning impact. Initial results reveal insights into specific game missions, playtimes, and success rates, indicating that participant behavior during gameplay influenced perceived learning progress, leading to varied learning paths. This paper provides valuable insights and technical information for VET practitioners on using educational games for training. Game interactions and learning outcomes can be monitored via a dashboard within the learning infrastructure, offering visualizations for user behavior (during play) and (learning) progress.

Keywords: Serious Games, Vocational Education And Training, Metadata, Middleware, Case Study and Evaluation.

1. Introduction

Stakeholders in continuous vocational education and training are required to provide appropriate and suitable (digital) learning opportunities that can be used to develop the needed skills induced by technological change and thereto affected changes in type of jobs, skill needs, task content and other economic effects (Frey and Osborne, 2017). In light of this, serious games have enormous potential, as they can simulate complex real-life situations without disrupting operations, but in a playful and motivating way, and with adaption to the individual needs of the users. The problem is to find high-quality learning games for a specific job and skill level, and to integrate them in an existing learning management system.

In this contribution we investigated the practical question of which serious games exist for diverse occupational fields, what quality they possess, and how they can be integrated into professional development. We developed an innovative and standardized system to find appropriate games matching the skill needs, job tasks and interests of potential users/customers in continuous vocational education and training (Rotter et al, 2022; Göbel et al, 2018).

2. Project Description and use Case 'Corrugated'

Within the research project SG4BB (Serious Games for Continuous Vocational Education and Training) funded by the German Ministry for Science and Education, a platform has been developed based on existing components to discover, integrate, test, and evaluate appropriate serious games and playful learning offerings in vocational education and training: the Serious Games-Information Center (SG-IC, a classical web-based information system in form of a portal) and its underlying Serious Games Metadata Format (SG-MDF; DIN SPEC 91380, as semantic basis for the description and retrieval of serious games) are evolving into a search engine for target group-specific description and search for suitable learning games in VET on the level 4 to 7 of the European Qualifications Framework (EQF; European Union, 2017). Figure 1 illustrates the process pipeline for the usage of the SG4BB platform.



Figure 1: SG4BB process pipeline: Input parameters for application fields and user characteristics, search and retrieval of appropriate educational games based on metadata, integration of educational games into learning infrastructures, usage and evaluation of learning effects.

Through the search engine, educational stakeholders (e.g. teachers, coaches or trainers in VET settings, end users/learners etc.) can identify suitable game-based learning opportunities for their target groups in their specific occupational fields. Users as well as educational providers can download these educational games via a marketplace and integrate them into their own learning management system (LMS). The components of the platform, including the technical interfaces based on standards (xAPI) between the SG4BB middleware, the LMS, and the game, were tested through the collaboration of research, development, and practice using the serious game 'Corrugated'. The insights of the project are presented in the next sub-chapters.

2.1 Target Group Learner in Vocational Training

The goal was to develop a concept for the recommendation of relevant educational games in VET. Therefore, a literature review of established and well-founded national and international classification systems was conducted to identify fitting criteria and databases (Rotter et al, 2022). The research focus was on continuous vocational education and training in Germany, but with correspondence to international systems, such as International Standard Classification of Occupations 2008 (ISCO-08). Matching criteria were derived to propose appropriate educational games for VET, tailored to the potential users' professional context and educational aspirations. This process resulted in a collection of occupational fields as defined by the German Federal Institute for Vocational Education and Training (BIBB; Tiemann, 2018), and main activity as defined by the microcensus, the largest annual household survey of official statistics in Germany, annotated with metadata and a matrix, mapping occupation fields with educational games. Now, educational stakeholders (i.e. learning providers, coaches, or individual learners) can use the search engine to find appropriate game-based learning offerings tailored to specific occupations or job tasks.

As a result, we developed the application profile 'vocational education and training' as an added 'variant' of the SG-MDF. Hereto, serious games are matched with a database of occupational fields (or major occupational fields) as defined by the Federal Institute for Vocational Education and Training (BIBB; Tiemann, 2018), and main tasks and duties as defined by the microcensus.

2.2 Content Discovery via SG-IC

The Serious Games-Information Center (SG-IC, see https://seriousgames-portal.org/) is a web-based portal providing a free search engine that has been completely redesigned by the Serious Games research group at TU Darmstadt to incorporate the 'application profile for vocational education and training", tailored to the characteristics and needs in the field of VET. This profile is an extension of the underlying Serious Games Metadata Format (SG-MDF, DIN SPEC 91380), which serves as the semantic basis for describing and retrieving serious games via the SG-IC (Göbel et al., 2018) or other systems and portals.

The SG-IC can be used to formulate queries for serious games or educational games designed for game-based learning, applying filters such as specific occupational fields, primary activities, target age groups, or game genres. The retrieval process generates a list of candidates — educational games that meet the query's criteria

— presented in the SG-IC. Interested educational providers and individuals can then analyze these candidates in detail, accessing all available metadata information in the standardized SG-MDF format for each game.

2.3 Download and Integration via Middleware

Within the distribution section of the SG-MDF, users can access information on where the original games are available, including potential downloads from Skillfire.info or other platforms. Educational providers can integrate these games into their learning environments, provided they operate their own LMS and use the SG4BB plugin (middleware) developed in the project for integration. For example, in SG4BB, an interface has been established between the SG-IC and the 'Skillfire' platform, a 'steam-like' distribution platform for game-based learning and training material.

The Skillfire marketplace offers both free and paid (gamified) learning offerings for vocational education and training, facilitating integration into moodle-based LMS via SG4BB middleware with license management capabilities. Skillfire.info has transitioned to the new domain, serving as gamified learning platform in the Business-to-Business (B2B) sector. Additionally, a mobile app ('skillfire app') under the previous domain www.skillfire.io will focus on training personal and professional soft skills for end-users in the Business-to-consumer (B2C) sector.

MasterSolution, an IT service provider, has developed a middleware (SG4BB plugin) for connecting gamified learning applications to LMS using the xAPI standard. This middleware is freely available and can be accessed via MasterSolution's Git repository, linked on the SG4BB website. Detailed guidance on integrating and using the middleware by educational providers is available in project documents, i.e. 'Deliverable D4' (particularly Section D4.2 xAPI for the integration of learning games into LMS). Additionally, 'Deliverable D5' outlines the development process for development studios creating gamified learning offerings, emphasizing the design requirements for xAPI integration into the LMS.

2.4 Testing and Rating

The components of the platform, including the technical interfaces based on standards (xAPI) between the SG4BB middleware, the LMS, and the game, were tested through the collaboration of research, development, and practice using the serious game 'Corrugated': In the first development cycle, integration with the moodle-based LMS was tested; subsequently, the game was expanded and finally tested. Core activities of the SG4BB project focused on the development and testing of AI-supported (personalized, adaptive) playful learning offerings. Therefore, a requirements analysis was conducted in the first project phase to determine the needs of application partners and address open technical issues of technology providers. The outcome of this phase leads to a requirements specification, a concept for iterative and agile development and testing, which serves as the basis for networking and further development of the components of the SG4BB platform. The project proceeded iteratively in two development cycles following the paradigm of agile software development.

2.4.1 Use Case 'Corrugated"

In order to facilitate a deeper understanding of the individual components of the platform, including the technical interfaces and their interactions, 'Corrugated' ('SG4BB Corrugated Service Game') has been selected as a case study. This use case involves the examination of a prototype of a serious game, providing insights into the tested elements of the platform. . Initially, a target group-specific needs analysis was conducted to identify specific requirements and preferences of individuals within the target audience. The collected data, impressions, and requirements were integrated into the game's prototype conception, design, and content development. The prototype was developed iteratively in close collaboration with game developers (Nurogames), vocational education and training scientists, teaching staff, and subject matter experts from practice (UEBZO, BHS Corrugated) to ensure alignment with learning objectives and player experiences. The game concept is based on the theoretical framework of competence-based knowledge space theory (CbKST; Kickmeier-Rust et al, 2016) and evidence-centered design (ECD; Mislevy et al, 2003). A domain-specific competence model was created to enable personalization and adaptation within the learning game, structuring prerequisite relationships among learning content, competency facets, and gameplay behavior (learning progress). This approach should facilitate a non-invasive measurement of player actions within the game.

Corrugated is a single player 3D simulation game designed for the corrugated board industry, developed for mobile devices, and released in 2023 as a free app on common app stores (App Store - iOS and Google Play Store - Android). Players learn the game mechanics through a tutorial level at the beginning. Educational providers

can integrate the game into mobile devices via the SG4BB plugin integrated into their LMS interface, making it suitable for online training programs. This allows both learners and trainers to monitor learning progress and performance, even though the game can also be played independently without LMS integration. To effectively engage with the game, players require basic knowledge of corrugated board systems and manufacturing processes.

Players receive various missions simulating disruptions in the production process of a corrugated board system, requiring problem-solving skills for resolution. The overarching goal ('characterizing goal') of the game is to foster domain-specific problem-solving abilities in preparation for real-world training on corrugators. The game offers three difficulty levels, each designed in collaboration with training staff members to ensure appropriate challenge levels. Each mission is tailored to specific problem symptoms and appropriate maintenance tasks, reflecting real-world scenarios encountered by technicians in the corrugated board industry. The target audience for the game primarily includes inexperienced technicians specializing in maintenance and repair in the corrugated board industry. The game is classified within the domain of vocational training, specifically categorized under the VET application profile for technical occupations (main vocational field; Tiemann et al, 2018) focusing on monitoring, control of machines, plants, technical processes (activity field) (Hall and Rohrbach-Schmidt, 2020, 38).

2.4.2 Evaluation Studies

The system components and implementations of the SG4BB prototypes were tested in two iteration cycles. In the first cycle, an initial game version (version 1.5) was integrated into a training course on the moodle-based learning infrastructure using the SG4BB plugin and initial web services via xAPI standards and a learning record store (LRS) connection. This testing aimed to assess the correct functionality of all elements implemented in a test system environment from both a technical and user-friendly perspectives. Additionally, the study sought to identify gameplay barriers related to usability and playability issues, such as poor controls and interfaces, which can significantly impact the user experience (IJsselsteijn et al, 2007).

In a mixed method approach, representative participants (n=11) provided feedback on the game and its overall concept, including game design, selected content, and gameplay experience during a moderated test session. Participants played the game for 30 minutes while using the think-aloud protocol method, and their thoughts, feedback and interactions were recorded through audio and screen recordings. After gameplay, specific aspects of the user experience were explored in-depth through focused interviews to identify potential weaknesses and gameplay barriers. Finally, a semi-standardized questionnaire was used to collect data alongside demographic information.

Key findings highlighted the helpfulness of the tutorial at the beginning of the game, user-friendly game design, and ease of use as positive aspects. However, participants encountered significant difficulties with the first mission due to its non-intuitive nature, which required collection and evaluation a predetermined amount of information deemed relevant, not meeting user expectations. Participants expressed a desire for more supportive feedback on their performance during this phase. The feasibility of evaluating the test environment in a self-directed setting, where participants could download and test the game on their own mobile devices, was not examined due to technical restrictions of the test system.

Based on the results of the first iteration, the insights from these findings and potential improvements were deliberated and implemented. This involved rectifying bug fixing, adjusting incorrect content, expanding the player's scope of action when seeking information, and integrating additional educational feedback and assistance. Moreover, adjustments were made to refine the research methods used in the final evaluation study.

The final evaluation study emphasized user acceptance and learning effects, centered around the concept of a quality label for serious games (Caserman et al, 2020). Fundamental quality criteria encompass aspects related to the game itself (usability, user/game experience), learning outcomes, and the alignment between these aspects within integrated gameplay, utilizing suitable technology that is appropriate for the specific learning environment. Special attention was directed towards AI-supported algorithms for personalization and adaptation: Do these approaches function effectively, and are they perceived positively by users?

For the evaluation, a separate course was created within the productive learning management system of the training provider, where the evaluation tools and access to the game were integrated via the SG4BB middleware. Participation was possible in both German and English and was voluntary, with agreement from supervisors during working hours. Interested service technicians of the value partner were enrolled in the LMS course and

received all instructions and guidance for the testing process there. We offered two test conditions: a) moderated in-person at a scheduled time using test devices, and b) online self-directed at any time using one's own mobile device during the testing phase, whereby the last setting reflects the realistic depiction of digital training offered and conducted within the company. Each test session was designed for 90 minutes, including instructions and clarification regarding study participation, anonymity and data protection, completion of pre- and post-game problem-solving tasks, a 60 minutes gameplay, and completion of an online questionnaire. The collected data was assigned using a personal code. In addition, audio and screen recording were conducted in the moderated test session to aid in data evaluation.

In order to investigate learning effects, we created six single-choice problem-solving tasks corresponding to the tasks, difficulty levels and objectives in the game. Four of them were anchor tasks, which were included in both the pre- and post-game test. To evaluate participant's experience with the game and the perception of learning, we developed and used an 18-item questionnaire oriented on the serious game evaluation scale by Fokides et al (2019), a validated instrument to assess the players' experience and perceptions towards serious games. Participants responded on a five-point Likert scale, from strongly disagree (1) to strongly agree (5).

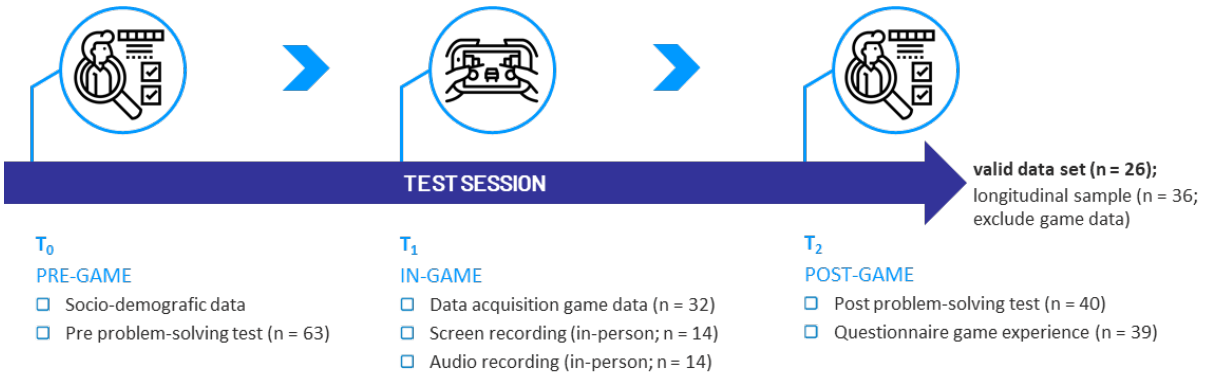


Figure 2: Data acquisition workflow and response statistics

Figure 2 depicts the workflow of the data acquisition and response statistics. We collected data from a longitudinal sample of 36 participants, predominantly male (n = 35), who played the game and completed both a pre- and post-game problem-solving tests along with an online questionnaire. The majority of participants (n = 22) engaged in the self-directed digital session, while the remaining 14 attended in-person. Over 50% of the participants were under 30 years old (n = 19), and 45% (n = 16) reported having no or less than one year experience with a corrugator plant, representing very well the target audience. However, 10 cases could not be included in the game analysis because these participants were not connected to the LMS during the gameplay despite receiving an alert message, resulting in no interaction data being transmitted to the LRS. For analyzing the game interactions, the longitudinal sample size shrinks to 26 participants.

The data analysis provides insights into specific in-game performances. We examined data related to the following: total number of missions (successfully) solved, total number of skill (facets) scores, playtimes and duration. These data form the basis for further investigations and calculations. Initial evaluation results support the assessment that the characterizing goal provides an enjoyable player experience for inexperienced professionals, with the game's progression positively impacting learners by offering varied learning paths across difficulty levels. This assumption could be supported by the results from the game experience questionnaire. In average, the computed mean scores for all questionnaire items were high ($M = 3.6, SD = 1.02, n = 36$), indicating that participants generally enjoyed the game. Additionally, we observed that many participants who engaged in online self-directed testing continued playing the game independently after the testing session. The comprehensive findings will be elaborated in a subsequent publication.

Figure 3 shows a dashboard with a learning analytics module enables user-friendly visualization of learning activities and outcomes. This allows displaying key metrics and information directly within the LMS.

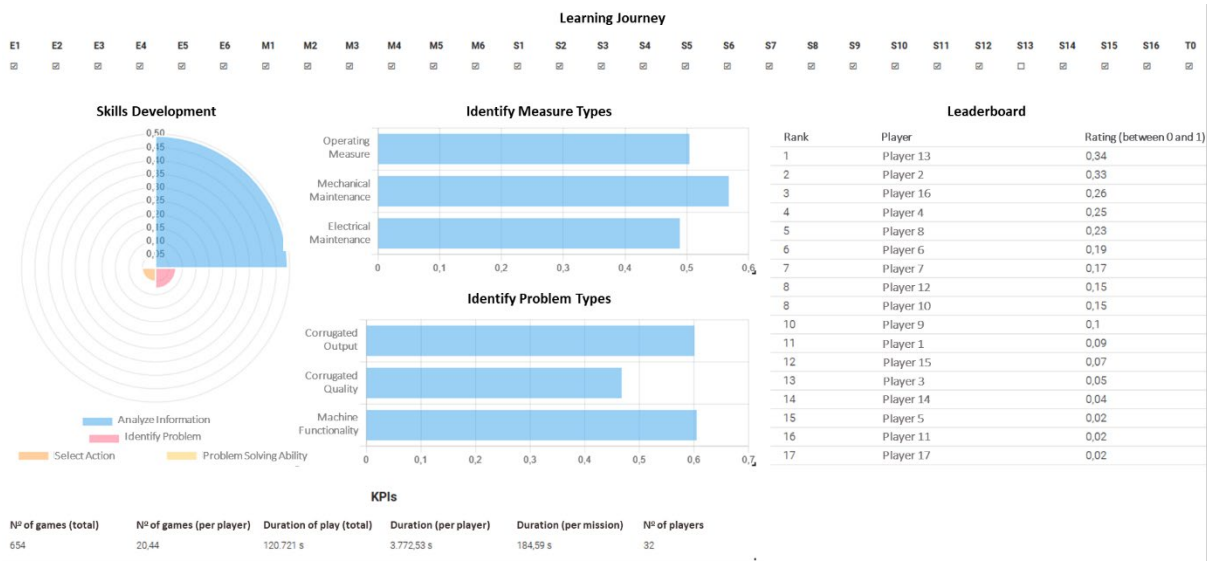


Figure 3: Dashboard with key metrics (i.e. gameplay results, learning progress).

The study also identified areas for improvement within the game, providing valuable insights for future development efforts. However, it was observed that the game's appeal may diminish over time and with increased experience if missions are repeated excessively.

Corrugated was acknowledged by the RAL Serious Games Quality Community as an exemplar of best practice in the field of a gamified learning offering for service technicians in the corrugated cardboard industry.

As a result, the game was described and classified in the SG-IC using the subject-specific application profile 'vocational education and training' of the SG-MDF. As the classification system enables a categorization between the dimensions 'occupational fields' and game-based learning opportunities, Corrugated can be located and found by potential users/educational providers according to its respective occupational field, main activity and industry focus.

3. Conclusion and Critical Reflection

The development and implementation of the Serious Games-Information Center (SG-IC) and associated Serious Games Metadata Format (SG-MDF) within the SG4BB project have successfully enabled the creation of a comprehensive search engine tailored specifically for vocational education and training. This novel platform facilitates the identification and integration of suitable game-based learning opportunities into VET settings, benefiting educational stakeholders by providing targeted, occupation-specific educational games. The platform's robust technical interfaces and middleware, tested through practical collaboration using the 'Corrugated' serious game, demonstrate its readiness for integration into existing learning management systems. The comprehensive analysis of the evaluation results appears to provide promising findings, suggesting valuable insights and implications for further research and practical applications in the field. Such advancements signify significant progress towards enhancing continuous vocational education and training through engaging and effective game-based learning solutions.

In reflecting on the outcomes of the game evaluation and development process within the scope of the project, several key lessons have emerged. Most relevant, these lessons underline the importance of methodological rigor, interdisciplinary collaboration and effective project management among learning providers, subject matter experts and game developers. Second, due to the small sample size, for sure the results of the game evaluation do not have statistically relevance and need to be cautiously examined and interpreted. With respect to the development of new educational games, two major lessons learned should be mentioned: First, it is crucial that the intended learning effects and evaluation/testing methods are clearly specified at the very beginning of a project. This enormously helps the game developers to design a game, and subsequently facilitates game and learning analytics at the end for testing and evaluation purposes. Second, more technically oriented, game developers (especially game developers which are typically focused on the development of entertainment games) need to be supported with practical information (technical specification, manual, 'cookbook') how to build the educational games. This considers both content-related aspects (e.g. knowledge spaces and logical

orders/sequences in the presentation of individual learning tasks and modules respectively educational game situations and game levels based on existing curricula etc.) and technical and conceptual aspects referring to the implementation of the game middleware and, practically speaking about the definition and frequency of interactions between a game and the backend of the system (LMS, Learning Record Store): when and how often should be passed 'which' information from the game to a LMS/LRS? Again, this underlines a strong collaboration among all involved parties in the collaborative, interdisciplinary educational game development process.

Overall, the project has established a comprehensive process pipeline and individual components for the development, provision, and utilization of gamified learning offerings in vocational education and training. The involved partners have gathered valuable experiences, particularly in the realm of gamified content delivery and integration with learning management systems, based on the xAPI standard.

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What is "Learning" in Serious Game Jams? A Systematic Literature Review

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Abstract: Game jams, events where participants collaboratively create games within a limited time frame, have gained popularity as engaging and educational activities. Numerous studies highlight learning as a significant motivator for participation, positioning game jams at the intersection of pedagogy, design research, and game studies. A systematic literature review (SLR) using the PRISMA 2020 method was conducted to explore the state-of-the-art in game jams and game-making co-creation practices amongst Cultural Heritage Institutions, Creative Industries, Higher Education Institutions, and Youth Citizens in the context of X project. Out of the 68 eligible sources, 10 explicitly addressed the learning goals associated with game jams and constitute the sample of this study. The present article focuses on exploring what conceptualizations of learning can be found in the sources and how that learning process was structured throughout the game jams; specifically, what participants are learning, the methodologies employed, and how the learning was measured. A comprehensive understanding of the educational potential of game jams is important for game jam organisers as well for formal, non-formal and informal Education. The results show that although some articles use game analysis or questionnaires to measure learning, these results are not analysed or presented in depth. Furthermore, it could be noticed that serious game jams, explicitly designed to teach something, usually featuring more time consuming, due to the specific nature of an added layer to game jam: a serious theme that needs to be learned by the participants but also reflected in a game for educational purposes. This underscores the potential use of (adapted) game jams to promote learning regarding social issues, culture, or science in an engaging and dynamic way. This article reflects on those processes and the different conceptualisations of learning that can be found in sources that tackle this topic with regards to Serious and Cultural Game Jams.

Keywords: Game-based Learning; Game Jams; Serious Game Jams; SLR

1. Introduction

Learning is a multifaceted process, shaped by several foundational theories: behaviourism, cognitivism, constructivism, humanism, and connectivism. Constructivism, particularly highlighted by theorists Vygotsky and Piaget, provides valuable insights when it comes to games. Piaget's cognitive constructivism focuses on the individual's construction of knowledge, asserting that humans must actively create their understanding (Piaget, 1953). In contrast, Vygotsky's social constructivism emphasises learning as a social activity, relying heavily on collaboration and interaction (Vygotsky, 1978). Recent research underscores the integration of game analysis and production in education, enhancing contemporary media literacy and other skills (Costa et al., 2020; De Freitas et al., 2013). Studies show that games can support multiple literacies (Gee, 2008; Buckingham & Burn, 2007) and foster creativity (Caperton & Sullivan, 2009). Parekh et al. (2021) explored how Systems Thinking and Model Building for Learning could engage young people in producing games on complex scientific themes. In a workshop with youth,, a board game about water pollution was developed. The ideation process involved participants using Model Building to grasp the scientific concepts before designing the game. They simplified the science behind water pollution and applied it to their game design, aiming to disseminate knowledge effectively. Considering this, the present study is part of a broader systematic literature review (SLR) on game jams and collaborative game-making practices across various sectors, including Cultural Heritage Institutions, Creative Industries, Higher Education Institutions, and Youth, within the framework of EPIC-WE project. The research aims to explore learning through Serious Game Jams (SGJs) by addressing these questions: 1) What are the conceptualizations of learning according to SLR sources? 2) How did organisers structure the learning process?

1.1 Related Literature

Game jams have been emerging as an innovative tool for learning, due to its potential for networking skills, adaptability, as well as the ability for innovation and creativity in game-making. These events are known for their time-constrained characteristics, ranging from 24-28h, where participants gather in groups to develop games relating to a specific theme (Kultima 2021). Kultima (2021) observes that for many jammers, the interest in

participating in game jams lies in the ability to expand the design and game-making process, a crucial skill in the context of commercial game development, not typically cultivated in traditional educational settings. Arya (et al., 2013) also emphasises that this flexibility is valuable not only in game development but also as an opportunity for jammers to develop innovative and more efficient methods of organisation and brainstorming that align with the time constraints faced. Beyond the development of game making skills, a new type of game jam, usually described as Serious Game Jam (SGJ), which has been organised by DiGRA JAPAN (Digital Games Research Association) since 2014, focuses on exploring the use of games as a tool for learning about social issues, such as gender inequalities (ref), cultural heritage (ref) or science (ref). Here, a 'serious' thematic constraint is added in comparison to events such as the Global Game Jam (GGJ), that also have a thematic constraint though normally unrelated to the topics approached by SGJs. When considering SGJs, which explore more complex themes, some studies, which will be further analysed in the present paper, emphasize the importance of preparing the theme with the participants, engaging them in extra educational activities and giving them time to internalise it.

2. Method

This article features a selection of sources stemming from the results of a Systematic Literature Review (SLR) conducted under the EPIC-WE project that followed the PRISMA 2020 guidelines (Paget et al., 2021). The review gathered sources from three scientific databases (ACM Digital Library, b-on, and JSTOR); declaring as 'external sources': items from four other digital libraries where the agreed upon search formula could not be used, and individual articles that were either selected from the project's original proposal or suggested by project partners. All the sources had to have been written in English. For the search time frame, the articles should be published between February of 2002 (since the first game jam had been organized) and February of 2023. The search formula used in the scientific databases is shown below:

- ("game jam*" OR "game mak*") AND ("youth" OR "young" OR "teen*" OR "adolesc*") AND ("culture" OR "cultural" OR "communit*" OR "innovation")

Exclusion Criteria	Name	Description
Ex.C. 01	Revision by peers	Not peer-reviewed
Ex.C. 02	Publication Date	Published before 02/2002 or after 02/2023
Ex.C. 03	Language	Not available in English
Ex.C. 04	Availability of Full Text	Full text is not available
Ex.C. 05	Document Duplication	Duplicate record
Ex.C. 06	Ongoing	Describes a project that is ongoing
Ex.C. 07	Not Related	Theme is not relevant to the review
Ex.C. 08	No Game Jam	Does not mention game jams
Ex.C. 09	No Game Development	Does not mention game development
Ex.C. 10	No Youth	Focuses on ages below 16 and above 25 years old or does not specify
Ex.C. 11	No Culture	Does not mention cultural themes and/or heritage
Ex.C. 12	No Innovation	Does not expore practices that are explicitly innovative

Figure 1: Exclusion Criteria for the SLR screening process

The first screening of the SLR (title and abstract) using Rayyan software identified 1,455 sources, including 87 from external sources. The exclusion criteria are shown in Figure 1. Cohen's kappa for this screening, calculated on 12% of the records, was 0.74, indicating "substantial" correspondence (O'Connor & Joffe, 2020), with an average agreement rate of 95.57% and a disagreement rate of 4.43%. The second screening (full text) was conducted with *NVivo 14*, resulting in 82 articles, with 68 included in the review. No automation tools were used. This screening's Cohen's kappa was 0.76, also indicating "substantial" correspondence, with average agreement and disagreement rates of 98.12% and 1.88%, respectively. From the SLR, 10 sources were selected to be analysed in the context of this paper, and were codified as "learning in serious or cultural game jams." This paper will analyse these sources regarding their conceptualizations of learning, descriptions of the learning process, and the logistics of the SGJs they report on.

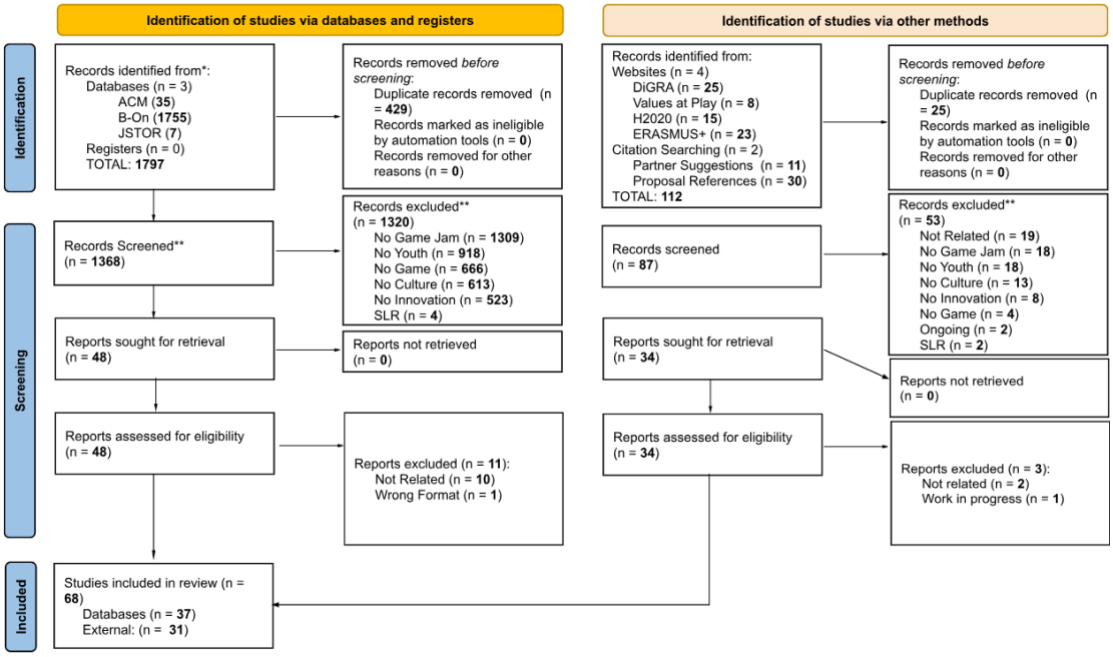


Figure 2: PRISMA2020 flow diagram including sources from both scientific databases and external sources.

3. Results

From the 10 sources selected and analysed in this article, represented in table 1, eight of them were codified as referring to conceptualizations of learning, but only one of them specified a learning paradigm, namely, the constructionist approach (Study 7). Most of the conceptualizations of learning found were related to game jams – for example, collaborative and cooperative learning (Study 4). Furthermore, seven articles were codified as "measuring learning", although this is not discussed or analysed in depth in most articles. The learning process and the logistics behind the serious game jams are described in five articles, focused mostly on the time of the jam, the learning activities prepared, and the relationship between facilitators and participants.

Table 1: 10 selected sources for analysis that address learning in game jams

Nº	Reference	Serious Game Jams Logistics	Main Ideas
1	Arya et al., (2019)	Pré-event workshops and educational activities Week-long game jams	The authors develop the "GGJ-Next Curriculum" adapted for educational purposes, focused on learning.
2	Aibara et al. (2022)	The SGJ operation organizes the logistic of the game jam in 3 phases: 1) the preparation phase 2) the lecture phase 3)the development phase	The authors present the SGJ operation manual, adjusting the game jam logistics to serious themes.
3	Aibara et al., (2020)	The 8th SGJ was divided into two sessions: a study session, with lectures about the theme delivered by specialists and a development session, focused on the game-making	The authors noted the difficulty in adapting the logistics of the GGJ to the specificities of the SGJs, given the different objectives of each. They highlight the importance of preparing a manual to guide the organizers of SGJs.
4	Contreras-Espinosa & Eguia-Gomez, (2022)	Four dimensions of learning in game jams: 1) cooperative; 2) project-based; 3) problem-based; 4) collaborative;	The authors highlight game jams as great opportunities for the cultivation of essential skills, embodying principles of co-creation, co-production, and co-design.

5	Danilovic et al, (2022)	A game jam aimed to explore the lived experiences of participants with opioid addiction, focusing on inclusivity for marginalised groups, by inviting these populations to take creative control of the game production process.	The authors highlight the transformative potential of game design in fostering community, resilience and self-insight among young-adults grappling with addiction.
6	Laiti et al. (2021)	A five day cultural game-jam had a cultural program of two days to get acquainted and involved with the Sámi culture. The theme of the jam was defined together with the participants. The game jam took place in a cultural center.	The authors shed light on the role game jams can have in passing down traditional knowledge, using the case of Sámi Game jam as a tool for the revitalisation of indigenous history in the context of Sámi culture.
7	Petri et al., (2019)	The article argues that game jams are well-suited for constructionist learning, providing a context where students can work as a team to solve challenges and expand their knowledge.	The authors introduce the constructionist approach, connecting it with game jams, advocating for an active and experiential way of learning.
8	Preston (2014)	Preparation on the theme and support began a week before the start of the jam. Experts were present throughout the last day to do follow-up sessions. Information leaflets on the subject were made available at the facility during the entire event.	The author recommends logistical specificities to be taken into account in the case of Serious Game Jams.
9	Ramzan and Reid (2016)	The NPJ benefited from a team of researchers working with developers, allowing for a diverse range of expertise to be shared. This collaboration allowed developers to utilise researchers' knowledge for prototype design and development, while researchers' work was translated into games through effective communication.Having key stakeholders may have generated a different breadth of prototypes due to the addition of new expertise, perspective, and agenda	The authors developed the noPILLS Jam (NPJ) focused on water pollution solutions. The games, targeting various audiences, reflected the potential of game jams in generating rapid prototypical evidence for research initiatives.
10	Schrier et al (2021)	The game jam aimed to enhance perspective-taking, identity exploration, and connection to others through game design, encouraging students to express themselves creatively.	The study discusses the implementation of a game jam in public schools in Nigeria, focusing on identity exploration and perspective-taking for students, teaching empathy and compassion.

3.1 Game Jams for Learning

In recent years, there has been a growing acknowledgment of the intertwined relationship between learning and enjoyment, a concept elucidated by study 1. The authors posit that the human brain is inherently wired to derive pleasure from the act of learning, suggesting that they are symbiotically linked. Many studies highlight game jams as valuable learning opportunities, with learning being a primary motivator for participants. Study 7 introduces the constructionist approach, connecting it with game jams, advocating for an active and experiential way of learning. According to this framework, learning is most effective when individuals construct personal knowledge through engaged participation, rather than passively acquiring information. This approach of hands-on experiences fosters creativity, independent thinking and problem-solving skills.

Study 4 states that the type of learning that takes place in game jams does not differ much from the one that occurs in typical educational environments, identifying four types of learning: cooperative, project-based, problem-based and collaborative. Cooperative learning happens through task division among participants, especially in teams with diverse skills, requiring autonomous work while maintaining team cohesion and collaboration. Project-based learning involves participants solving their challenges with facilitator support, fostering autonomy and frustration management. This aligns with problem-based learning, characterised by creative problem-solving for new challenges. Lastly, collaborative learning, one of the most identified types of learning in game jams, concerns the process of learning through collaboration between two or more participants

to achieve a common goal: creating a game. This process is present throughout all the game jam, and doesn't relate only to participants, but the facilitators, who also engage in processes of collaboration, particularly during pitch sessions.

When it comes to learning in SGJs, study 9, through the "noPILLS" game jam, explores the theme of water pollution, with three games produced. One of them, Sewer Seeper, focuses on water filtration, with the main goal being to shoot the micro polluting elements that appear and threaten the environment. Along with players learning about micropollutants as they eliminate them, a quiz is introduced between levels to test the knowledge acquired. This study introduces the concept of learning extending beyond the game jam, when games are made publicly available. Study 5 highlights the transformative potential of game design in fostering community, resilience and self-insight among young-adults grappling with addiction. Study 10 explores the use of a game jam to learn about empathy, with two games being developed: Forgiveness, which focuses on exploring conflicts and learning to forgive others, and Togetherness, which focuses on tolerance, acceptance and perspective taking. Another growing field explores game jams' potential to teach and produce culture. Study 6, involving the Sámi Game Jam, aimed at revitalising indigenous Sámi culture, produced six cultural games. For example, Lost Memories presents the player two conflicting worlds: the cultural traditions that represent the Sámi community and their heritage, and a new modern world, which implies leaving behind their memories, traditions and history. Another game, Rievssat, puts the player in the role of a Northern Finnish ptarmigan bird whose habitat, that used to provide safety and a home, becomes increasingly dominated by colonising forces, leaving it uninhabitable and the bird feeling alienated from his birthplace. The authors considered that the production of culture happened in a literal sense, reflecting the way Sámi Game Jam successfully served as a tool for cultural revitalization. Considering the sources analysed, it's possible to identify a common notion: that game jams have the potential to be dynamic learning ecosystems where participants engage in multiple learning processes – ranging from game making skills to learning about cultural heritage.

3.2 How was the Process of Learning Structured?

When considering the specific goals of SGJs, it's important to adapt the game jam format to the learning outcomes desired. Study 3 notices that the conventional framework for Global Game Jams (GGJs) is not a good fit for SGJs. When comparing the logistics of both, the authors call attention to the differences in theme and the games' design. While in GGJs the participants are free to interpret a general theme as they wish, and develop games for entertainment, in SGJs the theme is usually followed by lectures with specialists and the pressure of dealing with a real-world issue. This is reflected in the game design, as participants need to conduct research and share ideas and doubts with specialists to develop a game that is entertaining, but also educative, which makes it the key process of the entire event. While in GGJs there is a theme revealed to the participants at the beginning of the game jam, followed by the game design, in SGJs the theme is revealed through several means, and includes preparation such as live lectures on the topic. After knowing the theme, for the participants to start the game design, they need to research extensively about the theme, which requires a greater effort and time than in GGJ. Taking this into account, study 3, which implements the 8th SGJ, inspired by the SGJ operation manual (see study 2) was divided into two sessions: a study session and a development session. In the first stage, a workshop was organised by a specialist and a presentation of the theme was made, allowing participants six days to reflect on the theme and to do their own research and prepare for the game ideation. Study 8 explores the logistics of SGJs through the noPILLS Jam, which focused on health. A week before the jam, participants attended a lecture by a health expert, which allowed the participants to gather more knowledge about the topic, ask questions and autonomously do a follow-up of the theme. After the start of the jam, experts were also present on the last day to provide support. In addition, throughout the game jam, information leaflets on the subject were made available at the facility, which the participants found very useful. The author emphasises the importance of having experts present throughout SGJs to foster collaboration and enhance learning. Although follow-up sessions with experts were beneficial, most teams were focused on completing their games due to the time constraints, neglecting deeper reflection on the theme. Therefore, the author suggests preparation before the jam to allow for more time and dedication to the theme. Additionally, evaluating games based on their educational value alongside typical criteria encourages participants to focus on developing games with educational purposes, not just on design and playability. Based on the experience, . The author proposes a model for SGJs that includes extensive expert access before and during the jam, through workshops, information sessions, and participation in pitching and presentation sessions. The importance of facilitators is also explored in study 9, where the authors, through the lessons learned from the noPILLS game jam, already mentioned, emphasise the importance of collaboration and the benefits of having topic experts as facilitators. These experts transferred their knowledge to participants, who then expressed it through their games. Study 1 adapted game

jams for educational purposes, especially for youth, resulting in the "GGJ-Next Curriculum, that explores the learning outcomes that should be achieved during game jams. This curriculum targets cognitive outcomes (creativity, innovation, problem-solving, logical thinking), skill-based outcomes (programming, design, narrative, audio, visual arts), and affective outcomes (motivation, confidence, friendship, networking, fun). They found that adapting the GGJ for younger participants enhances learning by addressing their needs. For educational game jams, the authors also recommend pre-event workshops and activities weeks before the jam and suggest week-long jams to produce more games. Study 6 highlights the importance of preparing the theme and creating a learning environment in game jams, as shown in their game jam focused on Sámi culture. There was a focus on preparing the theme, enabling participants to get involved and take ownership of the topic, and fostering communication, sharing and learning with and from representatives and participants of Sámi culture. By the start of the jam, participants were expected to be familiar with the theme, allowing for greater exploration of Sámi culture. The event lasted 5 days, with the traditional 48-hour format, but with three important variations: before the start of the jam, a cultural program was held, which included two days at the beginning to get acquainted and involved with Sami culture, culminating in a day dedicated to Sámi culture. Throughout the event, it was a priority to include representatives of Sámi culture among the participants, as their lived experiences and knowledge were essential for the creative and narrative process, and for interpreting and using their culture in the games appropriately. The importance of “feeling” the culture reflected on the choice of the facility - the game jam took place in a cultural center (Áilegas), but at the same time there was a traditional Sámi tent (lávvu) which served as a place for daily reflections, pitching sessions and follow ups (ibidem). This approach shows that SGJs, which aim for educational purposes, need to meet different participant needs, allowing more time for internalising and learning without the typical 48-hour pressure.

4. Discussion

The learning process in SGJ’s must be adjusted to the needs of the theme and the participants. In this sense, study 2 presents the SGJ operation manual, which states the importance of going beyond the 48-hour format, preparing and evolving the participants on the theme. Study 8 advocates for pre-jam preparation through lectures and workshops to facilitate meaningful reflection and suggests evaluating games based on their educational value alongside traditional criteria. Similarly, study 6 emphasises theme preparation in a Sámi culture-themed jam, extending the event to include cultural immersion activities. In both studies, the extended format and expert involvement enhanced the participants' understanding and self-confidence in exploring the themes. These findings underscore the transformative potential of structured learning within serious game jams. When considering how learning is assessed in serious game jams, some studies measure it by the number of games created as a result of learning, while others conduct pre and post-game jam surveys to track changes in the awareness of the issue, but the results are never explored. For example, in study 6, with the Sámi Game Jam, the authors did follow-up questions throughout the event, to see if the participants were managing to familiarise themselves with the topic. These questions focused on the educational aspects of the game jam, especially regarding Sámi culture and the participants' expectations for the educational impact of their game – however, the results are not addressed by the authors. Subsequently, a textual analysis of the games was also carried out, with the aim of understanding the educational impact of the game and measuring the occurred learning. In the “noPILLS Game Jam” (study 9) the learning process stems from the way all games were "considered as successful demonstrations of the potential that serious game jams can offer in developing rapid prototypical evidence for research initiatives" p. 541. However, there is no measurement of learning, as the authors acknowledge that no research has been done to confirm the validity of this learning, and that this is only an assumed outcome of the project. This lack of measurement and description of the learning processes found in the articles reflects the need to reinforce the importance of this process when it comes to SGJs. Due to the complexity of organising, preparing and ensuring not only that the learning of the theme happens, but also that the game-making reflects that while contributing with new knowledge, a bigger and clearer communication of the process, challenges and achievements between different organisers may contribute to a stronger framework and outcomes related to SGJs. Furthermore, since the articles focus on learning, there should be a deepening and exploration of this thematic, given that some articles do not refer to any theory or conceptualization, using the term in a generalised way. For the future, to inform the learning process, this article suggests a bigger focus on measuring the learning outcomes beyond the number of games produced, and making those results available and discussed in the article. To talk about learning outcomes, one must know 1) what was the participants’ initial educational level on the subject; 2) what instruments must be used considering the needs of each team and subject; and 3) what are the expected outcomes.

Some limitations in this study can be found. The first limitation stems from the fact that the articles analysed come from an SLR with a more general theme, as part of a broader project, not taking into account other articles that could be relevant to discussing this thematic. The second limitation comes from analysing only 10 articles, which is not representative of the broader research done in the topic of learning in Serious Game Jams. For the future, it is recommended to create a framework adapted to SGJs, which considers specific educational approaches used in the context of these game jams, the expected learning outcomes, how to prepare the theme and the participants, and which methodologies should be used to measure the success of this learning process.

5. Conclusion

Considering the first research question, "What are the conceptualizations of learning according to SLR sources?", through the analysis of the sources, it was possible to conclude that there isn't a unique approach to learning applied to game jams – instead, the authors highlight the multiplicity of formats of learning and conceptualizations that can be thought of when talking about game jams. Study 7, for example, introduces the constructionist approach to game jams, highlighting how they provide a context for participants to construct their knowledge in collaboration and interaction with others. Furthermore, the results found that some articles referring to learning in game jams do not specify any educational approach or theory, reinforcing the need to define clearer specific approaches. Considering the second research question, "2) How did organisers structure the learning process?", when analysing the logistics of SGJ's, most articles reinforce the need to prepare the topic with the participants, extending the usual time-frame, introducing experts on the topic as facilitators, and doing educational activities. Given that it is expected that in SGJs participants will not only be able to present a playable prototype, but that this prototype will reflect a real social problem, there is an added responsibility to treat the topic with time and less pressure.

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Design and Development of an Immersive Virtual Reality Serious Game With Biofeedback for Physiological Regulation: Alice, Beyond Reality

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Abstract: The adolescence period is characterized by significant changes in individuals' lives, which can lead to various emotional and behavioural problems. Therefore, it is important for young adults to have tools for self-regulation, understanding, and controlling their physiological symptoms. Integrating these tools as gamified elements into new technologies is a way to engage a younger audience. In recent years, the effectiveness of immersive Virtual Reality has been repeatedly demonstrated in fields such as Psychology and Education. The combination of this technology with biosensors enables individuals to be aware of their real-time physiological states. This physiological monitoring can lead to adaptations in applications based on the individual's emotional state, for example. This work describes the design and development of an immersive Virtual Reality game whose main interaction is through biofeedback. The game is called "*Alice, Beyond Reality*", and its objective is to help young adults learn to self-regulate their physiological responses. The game draws inspiration from the well-known story of "*Alice in Wonderland*". In this story, the Queen of Hearts has transformed all the characters into cards, and the players must help them escape before it's too late. To achieve this, the players are guided by the White Rabbit through different levels where interaction through physiology is key. For instance, the players must learn to increase and decrease their heart rate to solve puzzles that allow them to progress to the next level. Throughout the game, gamification elements such as points, progressive difficulty, and various challenges are included to motivate the players to continue advancing in the game. Through the biofeedback system, the players become aware of their physiological changes to control them voluntarily. In the final screen, the players are shown their progression throughout the game so they can recognize their evolution. In the near future, an initial validation with users will be conducted to assess the usability and functionality of the game.

Keywords: Biofeedback, Heart Rate, Immersive Virtual Reality, Serious Game, Physiology

1. Introduction

The adolescent period is characterized by significant changes in individuals' lives: physical and psychological maturation, changes in social relationships, brain transformations, etc. (Crone and Dahl, 2012). These changes can lead to difficulties in attention management, emotions, and behaviour. Such difficulties may escalate into more serious situations such as aggression or substance abuse, among others (Iannattone et al., 2024). Therefore, it is important for young adults to have psychological tools like self-regulation to use when needed.

The self-regulation of physiological state serves as a valuable mechanism within the organism, facilitating the management of situations characterized by high levels of anxiety or stress or negative emotions (Goessl, Curtiss and Hofmann, 2017). This process entails the attentive monitoring of physiological signals, the comprehension and management of emotions, and the adjustment of bodily responses to achieve an optimal state wherein negative emotions, such as anxiety, do not become incapacitating (Gratz and Roemer, 2004). Biofeedback systems help individuals train the voluntary capacity to control some physiological functions such as breathing (Aritzeta et al., 2022). Heart rate (HR) variability emerges as the most frequently utilized parameter in biofeedback applications aimed at self-regulation, given its intimate connection with respiratory processes (Lehrer and Gevirtz, 2014). Deep breathing technique, for instance, increases oxygen levels in the blood and stimulates the vagus nerve, resulting in longer intervals between heartbeats (Toussaint et al., 2021).

Gamification is a technique that involves incorporating game elements into non-game contexts (Deterding et al., 2011). This technique has gained popularity in the field of mental health in recent years. The inclusion of game elements such as rewards or challenges in therapeutic situations encourages individuals to become more engaged (Khaliq, Fowles and Moore, 2018). Games that combine some form of learning with gamification are referred to as Serious Games (SG) (Carrión et al., 2020). Gamification elements such as trophies or scores can create a sense of challenge and excitement that boosts attention and enhances cognitive engagement. The use of these elements fosters positive emotions that improve learning rates and cognitive skills (Christie et al., 2019).

In the field of Psychology, SG can be designed to achieve various objectives, including promoting techniques to mitigate and manage symptoms related to mental health issues. Among these techniques are breathing exercises and meditation (Alqahtani and Orji, 2020).

Immersive Virtual Reality (iVR) can be defined as a virtual experience in which the individual is completely immersed thanks to a Head-Mounted Display (HMD) (Suh and Prophet, 2018). This sensation is enhanced by the sounds played on the HMD and the feeling of control over the application though controllers or trackers (Murcia-López and Steed, 2016). In recent years, iVR has become increasingly popular across various fields, not just in entertainment. For instance, its significant potential has been observed in the field of education (e.g.,Checa, Miguel-Alonso and Bustillo, 2021). Similarly, numerous benefits have been discovered in the field of Psychology.

For example, iVR can assist individuals in confronting their fears in a controlled environment (e.g., Bzdúšková et al., 2022) or promote anxiety reduction (e.g., Bozdogan Yesilot, Ciftci and Ozcelik, 2021; Ziegelman et al., 2021).

iVR has been combined with biosensors to monitor user physiology in real-time. For example, one study found that individuals had better stress resilience when their heart rate data was displayed to them while they played and interacted with the game through biofeedback (Maarsingh et al., 2019). In another study, researchers found that biofeedback in iVR was effective for learning breathing techniques (Blum, Rockstroh and Göritz, 2020). Besides, the use of biosensors enables application customization as it adjusts to the needs of each user. This customization facilitates task focus, enjoyment of the experience, and enhances results. Individuals also prefer customization as it offers them a greater degree of control over the application (Alqahtani and Orji, 2020).

The present work is structured as follows: Section 2 explains the methodology followed for the creation of the serious game. Subsequently, Section 3 outlines the design and development process of the application. Finally, in Section 4, conclusions are drawn from the work, and future lines of research are proposed.

2. Methodology

For this work, a methodology proposed for the development of serious games in iVR has been followed (Checa and Bustillo, 2020). This methodology proposes different phases for creating a serious game in iVR. In the first phase, Pre-design, the target audience and the needs and objectives that the game aims to fulfil should be identified. It is also necessary to decide on the technology that best fits the research proposal. In the second phase, called Design, all the necessary materials for the game, such as assets or environments, are created. In this phase, the narrative and level structure, interaction mechanics, game objectives, etc., are also decided and developed. Finally, during the Evaluation phase, a validation must be designed to check if the educational objectives proposed in the Pre-design phase have been met. This last phase will be carried out in future research.

The project has been developed under the framework of established theories. Firstly, the Flow Theory has been employed, which posits that individuals seek to achieve final goals when they are engaged and motivated in an activity (Csikszentmihalyi, 2014). For this theory to be effective, there must be a balance between difficulty and challenge. The Reinforcement Theory has also been employed, which explains that extrinsic gamification mechanics such as rewards or rankings positively influence learning outcomes (Berkovsky, Freyne and Coombe, 2012).

Furthermore, other research has been taken into account for making more specific decisions within each of the sections. According to a research, the duration of gameplay should be short so that individuals can quickly appreciate their progress (Khaliq, Fowles and Moore, 2018). Likewise, increasing their motivation and helping them stay focused on tasks helps them achieve better outcomes. This is also positively influenced by the customization of applications and their adaptation to the needs of each individual (Cheng and Ebrahimi, 2023b). A biofeedback system aids in this customization of the application in real-time, adapting to the needs of each user.

On the other hand, navigating through a fantasy world generates a state of flow and concentration that allows players to feel immersed to the point of losing self-awareness and track of time. This state of flow enables players to set aside real-life concerns and focus on the intervention to address, for example, their physiological symptoms (Cheng and Ebrahimi, 2023a). To prevent players from being distracted by the use of new technologies, it is advisable to include a tutorial level where they can learn the game mechanics and avoid the novelty effect (Miguel-Alonso et al., 2023).

Regarding relaxation techniques, deep and conscious breathing has been shown to have a positive impact on factors such as stress and anxiety. Additionally, it is an easy-to-perform technique that can be used across various populations of individuals (Toussaint et al., 2021).

3. Alice, Beyond Reality

A serious game in immersive Virtual Reality named "*Alice, Beyond Reality*" has been developed, featuring its primary interaction through users' physiology with a real-time biofeedback system. In Figure 1, the design and development process of the application is illustrated according to the parameters outlined in the Methodology section.

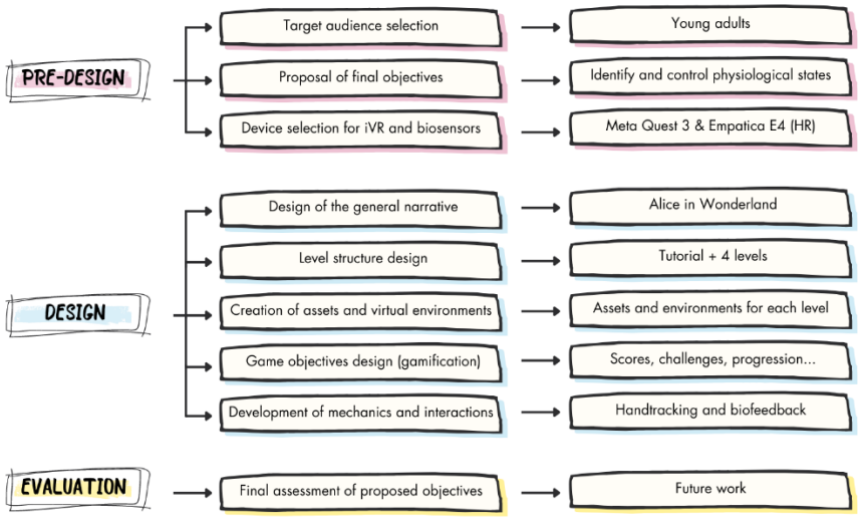


Figure 1: Summary of the game design and development process

The selected target demographic comprises young adults aged 15 to 20 years who lack understanding of how to manage their physiological state. On the other hand, the purpose of this study is to assist these young adults in becoming aware of their physiology and teaching them how to regulate it.

The game narrative draws inspiration from the story of *Alice in Wonderland*. As it is a well-known tale, the player is already familiar with the background from the beginning of the game. In this narrative, the Queen of Hearts has transformed all the characters into cards, and the player must assist them in escaping before it is too late. To achieve this, the player must overcome a series of levels with the guidance of the White Rabbit, where interaction through the player's physiology is the key.

3.1 Software and Device Selection

The game has been developed using the following software. Blender was employed for the creation of 3D assets. Photoshop was utilized for the creation of textures. Finally, Unreal Engine was used for the creation of environments and the programming of mechanics and interactions. These software tools were chosen due to their previous experience within the research group.

The game has been designed for use on the Meta Quest 3 device, although it could be utilized on any device that supports hand-tracking. Regarding the selected biosensor, the Empatica E4 wristband has been employed. The Empatica E4 wristband enables the collection of various raw physiological data, such as electrodermal activity or blood pressure volume, and can connect in real-time with the game engine. However, in this game, only the data related to heart rate is utilized.

3.2 Level Design

All the scenarios have been designed with a visual style that departs from realism. The textures evoke watercolour paintings, and the assets exhibit a slight fantastical character (for example, clocks that run backward). The scenarios have been designed so that the user can play within a real physical space of 2 square meters. This has been done to eliminate the need for players to move using controls, providing them with the sensation of actually moving within the virtual room. The interaction with virtual objects is accomplished

through a hand-tracking system integrated into the HMD instead of using controllers. Hand-tracking has been chosen as the main mode of interaction to make gestures such as grabbing and releasing objects feel more natural. Otherwise, the total duration of the game is approximately 25 minutes to ensure that the gameplay is sufficiently engaging, and that the player does not experience fatigue from the iVR device. In terms of audio, sounds have been incorporated to enhance the players' experience and immerse them further into the environment. Firstly, ambient sounds tailored to each level have been created to enhance the sense of immersion. These sounds align with the game's narrative, reflecting the tone and atmosphere of each level. Secondly, there are dynamic sounds related to the player's behaviour. For example, gratifying sounds play when actions are successful, and alert sounds signal if game objectives are not met. Additionally, these feedback sounds will be complemented with visual cues for individuals with hearing impairments.

The game is structured as follows: 1) a tutorial level for users to learn basic interactions and establish their individual baseline, 2) four levels with different environments and challenges where biofeedback plays a fundamental role, and 3) a final screen displaying the progress and results for each user.

3.2.1 Level Tutorial

The player emerges in a forest surrounded by trees, as can be seen in Figure 2.A. There is a picnic bench and various objects, including a key that opens a door located in one of the trees. The player has time to explore how the mechanism of picking up objects works and can practice with those placed on the bench. If the player is unable to do so independently after a few minutes, an off-screen voice will provide instructions on what needs to be done. When the player opens the tree door, the scenario changes as the player enters Wonderland.

As a transition between levels, a black environment will open up where cards fall around the player.

When the player enters Wonderland, a new level begins in a nearly empty room, as shown in Figure 2.B. In that room, there is a card with a printed white rabbit that can only move its eyes and mouth. The White Rabbit explains that "they are all trapped in Wonderland" and reveals the evil plan of the Queen of Hearts to turn everyone into cards. Subsequently, the White Rabbit seeks the player's aid in searching for and saving the characters throughout the different levels.

The White Rabbit warns the player that the rooms are aware of how people feel when they enter them: they use the player's heart rate information to alter the environment, making it more challenging to escape Wonderland. Additionally, the White Rabbit gives the player a gift: a watch that displays real-time heart rate. This watch makes it easier for the player to recognize a state of calmness or agitation. The purpose of using this watch is for the player to learn how to consciously regulate the physiological state. To achieve this the White Rabbit teaches the player what happens when body movement is increased (heart rate increases) and then demonstrate the effects of deep and conscious breathing technique (heart rate decreases). Following this brief introduction, the adventure through Wonderland starts.

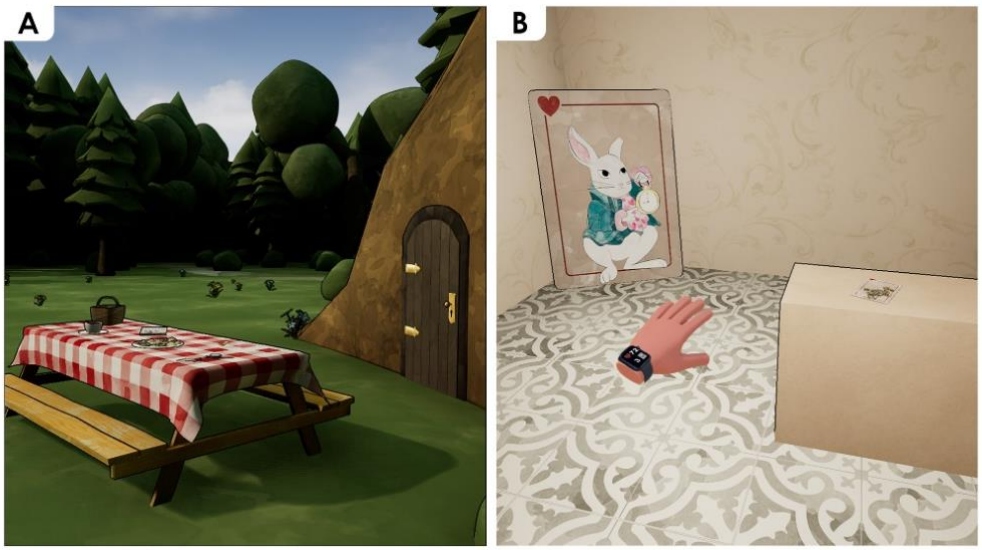


Figure 2: Overview of the tutorial level: the initial screen with the picnic bench (A); and the tutorial and first interaction with the White Rabbit (B).

3.2.2 Level 1

In the first level, the player appears in an exceedingly large room. Within this room, there is a tea table with various items on it: plates, cups, teapots, cookies, etc, as shown in Figure 3.A. The player needs to do exactly the same as in the tutorial level: increasing the heart rate to grow in size and be able to search for a key in the room; and breathing deeply to reduce the heart rate, become small again and exit through a small door.

Apart from searching for the key, the player is also able to find some character cards hidden in the room. Each time a character card is found, the number of cards collected throughout the game will appear on the watch. The White Rabbit's card is present in this and the other levels to assist the player in case they are unsure of what to do or need some form of help.

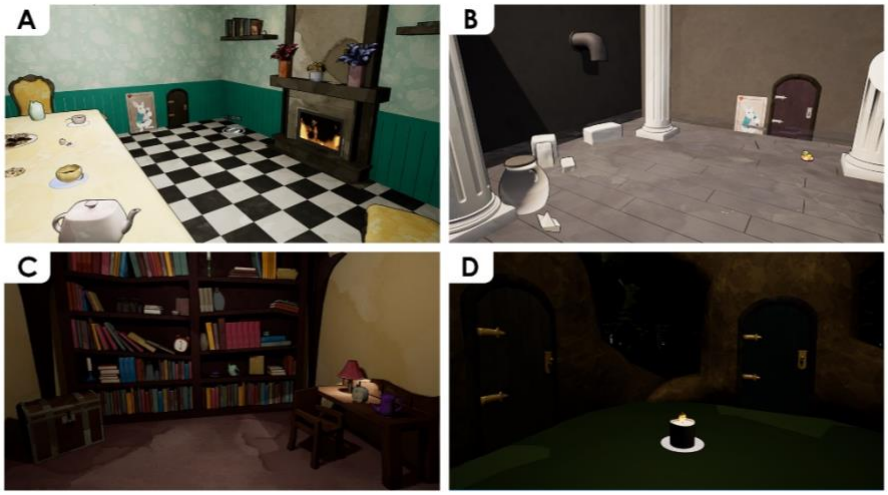


Figure 3: Overview of the game levels: initial level (A); level 2 (B); level 3 (C); and final level (D).

3.2.3 Level 2

At the beginning of this level, the player appears in a room with water on the floor, as can be seen in Figure 3.B. In the background, the sound of falling water is heard. The water level on the floor rises as time passes. The player must search the stage for some cards and a key to exit before the water reaches head level.

To successfully complete this level, the player must stay calm to slow down the rising water. If the heart rate increases, the water will rise rapidly, giving the player less time to play. If the water reaches the player's head, the level will restart, giving the player the opportunity to practice controlling their physiology despite the stress of the situation. The player can request assistance from the White Rabbit whenever necessary so they can successfully complete the level.

3.2.4 Level 3

In a room filled with objects and numerous keys, the player must search for the correct key to unlock the door and exit the room. The player won't have any clues; there will only be a timer clock with a countdown, and the sound increases with each passing second, as shown in Figure 3.C.

The player must maintain a state of calm despite the countdown timer to ensure that time does not run out. If time runs out, the level will restart, providing the player with the opportunity to learn how to control their physiology in order to progress to the next level. As in the other levels, the player can also search the environment for character cards and ask the White Rabbit for help at any time.

3.2.5 Level 4

The player appears in a clearing in the middle of the forest at night, surrounded by trees with doors, as can be seen in Figure 3.D. In the middle of the clearing, there is only a candle that slightly illuminates the surroundings. The candle's appearance is influenced by the player's HR: if it remains steady, the candle will shine brightly. In case the HR fluctuates, the candle will lose intensity, and the player won't be able to see the surroundings clearly.

The player must maintain balance while searching for the exit. Only one of the doors contains the clue on how to exit the adventure to the final screen.

3.2.6 Final Screen

The player reappears in the initial forest with the picnic bench, as if the adventure never existed. On this screen, the player's progress in the game, the saved character cards, and the number of times help has been requested are visible. Additionally, the White Rabbit running through the forest and disappearing among the trees can be observed. When the player wishes, the game and the adventure will be concluded.

3.3 Gamification Elements

Throughout the game, various gamification elements have been incorporated. Below is a list of these elements.

3.3.1 Points and Badges

Players must search for character cards throughout the levels. These cards are badge-shaped and collectible. The more cards they manage to obtain, the higher their score will be.

3.3.2 Levels and Difficulty

Levels increase in difficulty as the player progresses through the game. The first level replicates the same interaction as in the tutorial level, while the last one requires the player to figure out what to do on their own.

3.3.3 Narrative and Challenges

There is a narrative that drives the progression of the game. Additionally, various challenges are included to prevent the game from becoming monotonous.

3.3.4 Progression

In the final screen, the players are shown their progression throughout the game so they can recognize their evolution. Specifically, the relationship between the stressors in the game and the player's physiological control required to overcome them will be displayed.

The difficulty of the levels and the various challenges can induce stress in players. Although these situations might seem counterproductive, it is essential to include challenges where players can apply what they have learned throughout the game. For instance, in Level 2, the rising water will likely make players anxious, leading to an increase in their heart rate. However, the challenge in this level is to try to reduce their heart rate despite the stressful situation. These types of scenarios mirror real-life situations, where the true effectiveness of this application in teaching users how to regulate their physiology will be tested.

3.4 Biofeedback System

For the creation of the biofeedback system in this game, the Empatica E4 wristband has been utilized. The wristband transmits real-time data and connects to the computer via Bluetooth. An application programmed in C# has been developed, serving as an intermediary between Unreal Engine and the Empatica data acquisition service in real-time. The code of this application implements a TCP/IP socket client connecting to a remote server (E4 Streaming Server) and also acts as a server to receive data from Unreal Engine. This code utilizes the official documentation of the wristband (https://developer.empatica.com/windows-streaming-server.html).

Within the Unreal Engine project, a blueprint has been created that requests information from the wristband. Specifically, it instructs the wristband to acquire only heart rate data. The heart rate data is obtained from the Blood Volume Pressure measurement (BVP) provided by the wristband at a frequency of 64 Hz and is acquired using a photoplethysmogram. To calculate the HR value, the application uses the interval between peaks of the BVP signal, also known as the Inter-Beat Interval (IBI). The formula for calculating HR is as follows: 60/IBI (in seconds). The result is the number displayed to the player on the virtual smartwatch and used by the application. The tutorial level's duration will be utilized to establish each player's physiological baseline, serving as a reference throughout the game because it is assumed that during the tutorial level, players are in a neutral state between relaxation and arousal.

Throughout the levels, an average of the most recent HR values is calculated, to create a *dynamic baseline* for each player. The biofeedback system compares the current HR with the dynamic baseline value to determine if the goals set for each interaction are achieved. These goals have been programmed as percentages to adapt to each player's baseline. For example, if the HR is more than 110% of the dynamic baseline, the goal is considered achieved. This system for obtaining HR from BVP data using the Empatica E4, and its classification of emotional states through various percentile thresholds, is similar to that used in a study aimed at detecting real-time stress by exposing individuals to both stressful and non-stressful situations (Campanella *et al.*, 2023).

4. Conclusions and Future Lines

A serious game in immersive Virtual Reality, functioning through biofeedback, has been designed and developed. This serious game called "*Alice, Beyond Reality*" aims to teach players to regulate their physiology through gamified educational content. In this way, by incorporating a familiar narrative and engaging gameplay mechanics, the players can learn to understand and control their own physiology, specifically, their heart rate through breathing.

In the game, various gamification elements have been included, such as scoring, diverse objectives, progressive difficulty, and a summary of progress during gameplay. Additionally, a tutorial level has been created to mitigate the novelty effect of the Virtual Reality device.

In the near future, an initial validation with users will be conducted to assess the usability and functionality of the game. Following this validation, any identified areas for improvement will be addressed, leading to a subsequent large-scale validation to gather data on the learning outcomes related to self-physiology management. The validation will be conducted with a large group of young adults, specifically university freshmen, divided into three groups. One group will use the VR application with real biofeedback, another group will use the VR application with a fake or placebo biofeedback system, and the third group will receive lessons on the relationship between the use of breathing techniques and their physiological state. All three groups will undergo several tests to determine which group has learned the most about physiological control, with the expectation that the group using VR with real biofeedback will show the most improvement.

In the future, the possibility of incorporating additional physiological data into the biofeedback system will be considered to enhance the complexity of the game. With this data, complex algorithms can be trained to learn from users' physiological responses, enabling the prediction of user behaviours.

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Tiers of Engagement: Achieved Learning From Business Simulations Reflected in Economics Students' Experiences

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Abstract: This article investigates the impact of a business simulator in an online economics course, focusing on the relationship between student engagement and reflections on learning. Utilizing a mixed-methods approach, our study analyzes responses from 328 students who used the "Hubro Business Simulator" in a flexible online bachelor's program in economics and administration. Students provided reflections on the simulator as a learning activity, application of theoretical concepts and practical relevance. Qualitative analysis of 1640 responses further explored the depth of students' reflections, categorized into different tiers of engagement based on their responses. This analysis builds on Self-Regulated Learning (SRL) and motivational theory. The study sought to determine whether students reporting higher levels of engagement exhibited deeper metacognitive reflections compared to their less engaged peers. Findings support a link between the level of engagement and the depth of reflection. Students with higher engagement levels were more likely to reflect on specific ways in which the simulator had supported their learning and understanding of theoretical concepts. This paper discusses the limitations and implications of these findings for enhancing game-based learning interventions, emphasizing the need to foster higher engagement levels to improve educational outcomes in online learning environments. The study contributes to the literature on game-based learning by providing a large empirical study on how business simulators can foster higher-order thinking and deeper learning reflections among economics students. It also highlights the role of engagement in using business simulators as learning tools, offering insights that could improve the learning design and implementation in similar online and flexible learning program contexts.

Keywords: Game-based Learning, Engagement and Motivation, Self-regulated Learning, Online Education, Business Economics Education, Business Simulators.

1. Introduction

In recent years, especially after the pandemic, online education has received more focus in Norway (Breiby et al 2022). Our case is an online bachelor program in business economics and administration. Our students participate through online platforms. The students have a need for flexibility. As a result, activities such as groupwork, discussions and internships are not feasible.

This necessitates alternative activities for student-engaged learning. We therefore use the "Hubro Business Simulator" where students manage a startup company. Throughout the simulation, students were also given custom made narrative assignments. These were made by the course instructor to fit the narrative of the simulation. The assignments were closely linked to the course curriculum, and the normal course work. The reasoning for this was to see if the students could connect the practical tasks in the simulator to the theoretical assignments. To further integrate the simulator into the course, students were given an assignment to reflect on their learning process.

In this article, we analyse the data, looking at students' level of engagement with the simulator and their displayed level of reflection on their own learning.

Our research question is: Are the students that report a high level of engagement operating on a higher taxonomical level when they reflect on how the simulator has impacted their learning, compared to students that report low levels of engagement?

2. Theoretical Background

2.1 Game-based Learning

Games for learning is a potential way to promote increased learning through higher levels of engagement (Schwartz and Plass, 2019). There have been some studies on the Hubro Business Simulator at Norwegian universities. Baksaas and Nygård (2021) find that it can provide deep learning in accounting courses. Hovland et al (2023) find no cognitive effects on quantitative measurements of grades and knowledge tests, but that

students express increased term- and method learning, and positive experiences and motivation. Skjelbred and Daus (2022) presents an RCT that found no evidence that high satisfaction corresponded to game effectiveness.

The use of games in economics education has seen an increase in recent years. Platz (2022) is the first systematic review of learning with digital games in economics programs and synthesizes the results from 20 intervention studies. It examines the effect games have had in comparison to other mediums, and which elements have had an impact on learning. Platz remarks that there is a large variation in effect sizes but concludes that evidence supports that games can be an effective form of learning for economics. She draws attention to results for content knowledge and higher-order thinking skills. An interesting finding is that the effects of GBL on motivation are unclear, but motivation as a factor for learning is supported. Platz points at this dilemma, as motivation is central in GBL-literature. She points out potential in relation to increased challenges to drive engagement and flow, or fostering intrinsic motivation through autonomy.

2.2 Engagement

In higher education, engagement often means engagement with the university, course or program. Our focus is on students' engagement with the simulator as a learning activity, that takes place in the overall context of their scholarly activities.

Kuh (2009) defines engagement as a *"term usually used to represent constructs such as quality of effort and involvement in productive learning activities".* Lu (2020) states engagement is important for online students' course connection and learning. He points out that the course instructor plays a role in facilitating engagement through substantive feedback. Martin and Bolliger (2018) state that student engagement can lessen the feeling of isolation in online courses and improve academic performance, and that engagement is critical for success and reducing the drop-out. Meyer (2014) describes an indicator of engagement from the National Survey of Student Engagement: The level of academic challenge that requires effort to overcome. Sub-categories to this indicator include higher order learning, reflection, integrative learning, learning strategies, and quantitative reasoning. This means engagement is important in online education to ensure student success, learning and completion of the education.

We focus on engagement in the context of a simulation game. According to Plass et al. (2015), engagement occurs inside the context and rules of a game setting. Engagement is also affected by the participation of the user (Salen & Zimmerman, 2004, as cited in Plass et al (2019)). Engagement comes from the individual that is engaging with a game, created by interest and motivation when interacting with the game (Schwartz and Plass, 2019). However, the most important element of engagement is defined by activity. Engaged users are actively taking part in a process of making meaning of the game and tasks therein. (G4LI, n.d., as cited in Schwartz and Plass, 2019). Schwartz and Plass conclude that engaged individuals are exerting some kind of effort and based on this define engagement as *"the active and focused investment of effort in a game environment"* (Schwartz and Plass (2019, pp 55). In the context of our study, we consider engagement to be the active effort, and quality of this effort, students have put into making meaning out of, and make use of the business simulator in their learning processes.

2.3 Motivation and Self-Regulation of Learning

Our approach for analysing the collected data builds on theories of motivation and self-regulated learning (SRL).

Deci and Ryan (2000) examine the motivational causes for actions. They distinguish between intrinsic motivation (doing what is inherently interesting or enjoyable) and extrinsic motivation (doing something because of an outcome or external factors). Furthermore, they say that intrinsic motivation can be seen as residing inside a person. Although, intrinsic motivation can also be seen as residing between a person and a task. This means that someone can be intrinsically motivated for certain tasks, but not for others. Finally, Deci and Ryan (2000) state that intrinsic motivation, in self-determination theory (SDT), cannot be created directly, but be facilitated or catalysed by providing situations where people can express it. We focus on intrinsic motivation relating to engagement with the simulator.

To closer examine how students' engagement with the business simulator impacts learning, we turn to SRL as a conceptual framework. Efklides (2011) concisely refers to SRL as "the setting of one's goals in relation to learning and ensuring that the goals set are attained". Panadero (2017) states SRL is central to "understand the cognitive, motivational, and emotional aspects of learning". His review examines the major models of SRL that have gotten traction in research. He finds that, in general, the models group the different subprocesses students perform

into phases: Preparatory, performance and appraisal. Our study focuses on appraisal aspects, which in the various models involves processes of how students regulate and adapt, (self-)reflect and apply metacognitive strategies in their regulation of learning. Miele and Scholer (2018) conceptualize two metamotivational process-loops in which learners monitor or control their task motivation.

Our survey was not an explicit instrument to measure SRL, but the qualitative data offers a view of how students reflect on the business simulator as a learning activity. Drawing on the SRL literature, we have looked for statements that deal with themes related to the appraisal phase of SRL to assess the level of reflection.

3. Methodological Design

Our study combines quantitative and qualitative data in a concurrent triangulation design. This approach uses complementary data on the same topic to get a deeper understanding of the studied problem (Almeida 2018). Because the aim of our study is to explore the relationship between engagement and level of reflection, we consider this design to be appropriate for our data collection.

Our data was gathered through an online survey. The survey was framed as a reflection assignment for students to complete after finishing the simulator. The first part recorded demographic variables (age and gender). Respondents could answer "other" on gender, but there were no such responses. The second part consisted of four quantitative questions where the students rated the simulator's usefulness in achieving four learning outcomes on a scale from 1 (low) to 5 (high).

The final part consisted of five open-ended questions asking respondents to reflect on the simulator as a learning activity (reported in Table 1). By allowing the student to formulate their answers freely, we aimed to collect data that represented their actual experiences with the simulator. In total there were 1640 comments. These comments make out the main part of our data analysis.

There were 365 responses, with 328 consenting to being used in research. The quantitative data was analysed by measuring the mean, and standard deviation (SD) in the answers.

A large part of our study involves analysis of the qualitative reflections. Based on the theory outlined above, we attempted to identify signs of engagement and motivational type. We used SRL to guide our analysis of the level of reflection. In doing this we aimed to illustrate the tiers of engagement and corresponding reflection on learning in the context of game-based learning and simulator games. Finally, we analysed the quantitative data of each tier to determine if students on higher tiers of engagement and reflection reported higher scores on the learning outcomes.

As our data is self-reported, there are risks related to validity. Based on Gonyea's (2005) criteria for validity of self-reported data, we consider the data to be generally valid for our study. In the context of the simulator, the questions are clearly phrased and unambiguous, and relate to a recent experience and context familiar to the respondents. The open-ended questions gave opportunities to provide feedback related to their individual experience at their preferred level of detail. The survey is anonymous with a long response time, preserving privacy and avoiding pressure. Respondents also had to explicitly give consent for their responses to be used for research. We will further discuss possible limitations of the data later.

4. Empirical Findings and Analysis

Table 1: Categories in reflection assignment

Category	Query
Reflection	Write what you liked/disliked with the simulator. What could we have done to make the simulator more useful for your learning?
Collaboration	The simulator can also be used in groups where several people take part in each company. 1) Would you have preferred to use the simulator in collaboration with other students? 2) Do you think collaboration in groups would improve the learning outcomes?
Learning outcomes	What do you think you learned by taking part in the simulation?
Practical relevance	1) Did you gain an increased understanding of how theory and practice are connected in business economic analysis? 2) How could the simulator be improved in this regard?
Simulation as a learning activity	What do you think about this activity as a way of working?

4.1 Summary of Aggregated Findings

The qualitative comments were analysed by categorizing what we could interpret as the meaning of the comments and performing a frequency analysis. A significant number of respondents appreciated the simulator, noting the engaging and realistic nature, although some expressed concerns regarding time demands, oversimplification of real-world scenarios, and lack of clarity. A preference for traditional assignments was noted by a small minority. The simulator enhanced reported understanding of business concepts such as accounting and market dynamics. While the simulator was used individually, opinions on hypothetical collaboration were mixed. Many recognized potential benefits of collaboration and discussion, but few wanted to work in groups, citing concerns about coordination or a preference for working alone. Comments highlighted requests for guidance and feedback. Some also wanted integration with other courses. Positive remarks were made about the interactive elements of the simulator, the ability to observe the consequences, and comprehensive understanding of business, aligning well with the course curriculum.

4.2 Analysis of Engagement, Motivation, Reflection and Learning

Drawing on the theory presented on engagement, motivation, and reflection, we defined criteria and indicators for our categorization of the variables, shown in the tables below.

Focusing on the appraisal aspects of SRL, we applied the concept of metamotivation. Scholer et al (2018) describe "metamotivation as the processes by which individuals monitor and control their motivational states in order to achieve their goals". Miele and Scholer's (2018) metamotivational model of motivational regulation builds on SDT. It attempts to illustrate the process of students' awareness of their level of motivation (i.e. motivated "enough" or "in the right way"), arguing that motivation regulation is tied to tailoring the level of motivation to the demands of the task. They suggest that extrinsically driven students might be as highly motivated in tasks as their intrinsically motivated peers but find the tasks less engaging thus with less complex, creative and flexible effort. Furthermore, they provide a list of relevant feelings that signal high or low levels of different motivational components (e.g. confidence/frustration for self-efficacy, or enjoyment/boredom for intrinsic value).

We categorized engagement as low (1), medium (2), and high (3). We used the same scale for assessing level of reflection. We categorised motivation as extrinsic (1) or intrinsic (2). As classifying motivation can be challenging, we assessed if there was a considerable intrinsic component present in the response, or if it was strictly extrinsically motivated. We reiterate that the score assigned to each variable was based on the interpretation of the researchers using our defined criteria, and not a measurement of SRL. Both researchers analysed the data and discussed uncertain classifications. Therefore, results might not accurately represent the actual engagement, motivation, and reflection, but what we could assess and categorize from the data in the responses.

Table 2: Criteria for categorization of engagement level

Engagement indicators:	Quantity of effort (comments about desire to complete or finish the simulator, how many things they have tried/done), quality of effort (comments about whether the simulator "fits" their motivation for engaging in the task, how thorough they have been in the task), exploration of the simulator, mastery of the simulator.
High:	High quantity and quality of effort put into exploring and mastering the simulator.
Medium:	High quantity or quality of effort put into exploring or mastering the simulator, but not both.
Low:	Low levels of both quantity and quality of effort put into exploring and mastering the simulator.

Table 3: Criteria for categorization of primary motivation type

Motivational indicators:	Joy, interest, external pressure, rewards or outcomes.
Intrinsic:	Presence of comments indicating joy from, or interest in, the simulator.
Extrinsic:	Presence of comments about instrumental use of the simulator, focus on external factors (rewards, outcomes), time/effort expenditure.

Table 4: Criteria for categorization of reflection on learning

Level of reflection on learning indicators:	How the students describe their experience with the simulator, their perceived learning from it, and insight regarding their learning process. We differentiate between how detailed and deep their thoughts about the simulator and their own learning are as described below.

High:	Reflects on what they have learned, but also how they learned, and what could facilitate more learning. Relating their learning to larger contexts.
Medium:	Reflects on what they have learned.
Low:	Reflects on what tasks they have done and if they have learned/not learned (e.g. answering "yes" or "no" without further specifications).

We categorised based on assessed levels of engagement and motivation. Categories were high, medium, and low engagement, where each category of engagement had sub-categories for motivation. This resulted in six tiers. No respondents were categorized as having high extrinsic engagement. This row is therefore left out. We counted the number of responses in each category, calculated mean levels of reflection and reported learning outcomes, and SD for each category. We also report mean SD of age, and gender distribution.

Figure 1 shows that 61% have been categorized as showing medium engagement, with the largest tier being medium intrinsic engagement, followed by high intrinsic engagement and medium extrinsic engagement.

The mean level of reflection appears to increase with higher levels of engagement and intrinsic motivation. The SD on reflection varies from 0.5 to 0.76, which is moderate to high. This indicates a moderate to high variance within each tier. The mean of reported learning also increases with higher engagement and intrinsic motivation. The SD for this is also moderate to high, indicating similar variance. Intrinsic motivation seems to influence engagement. We see that most responses we have coded as showing intrinsic motivation are categorized in medium to high tiers of engagement. Furthermore, we see that age does not vary in any significant way between tiers. The SD is not high considering the range of ages, and similar between tiers.

Regarding gender differences, we see some differences for each tier. Especially the percentage of men and women in each tier. These percentages are based on how many men or women are present in a tier in relation to the total population. 28% of men are categorized as having high intrinsic engagement vs. 20% of women. We see that a larger percent of men is categorized in the higher tiers, while a larger share of women is categorized in the lower tiers.

Engagement tiers	Distribution of students	Mean level of reflection	Standard deviation reflection	Mean of reported achievement of learning outcomes	Standard Deviation LO	Mean of age	Standard Deviation age	Percentage Men	Percentage of men	Percentage women	Percentage of women
High Intrinsic Engagement	23%	2,49	0,58	4,07	0,60	29,22	6,77	52%	28%	48%	20%
Medium Intrinsic Engagement	45%	1,75	0,69	4,01	0,66	29,31	7,35	47%	48%	53%	43%
Medium Extrinsic Engagement	16%	1,68	0,58	3,90	0,62	30,96	6,39	40%	15%	60%	17%
Low Intrinsic Engagement	2%	1,71	0,76	3,21	0,64	27,29	7,30	29%	1%	71%	3%
Low Extrinsic Engagement	13%	1,28	0,50	2,60	0,84	30,28	9,63	26%	8%	74%	17%

Figure 1: Results of data analysis

Categorizing by intrinsic motivation and level of engagement separately, we can see from Table 2 that in the overall population of respondents, a larger percentage of men tends to be intrinsically motivated and engaged by the simulator.

	% men	% women
Intrinsic motivation	78%	66%
High engagement	28%	20%
Medium engagement	63%	60%
Low engagement	9%	20%

Figure 2: Division of motivation and engagement by gender

4.3 Visualizing the Tiers of Engagement

In this section we visualize the data showed in the earlier chapter in figures.

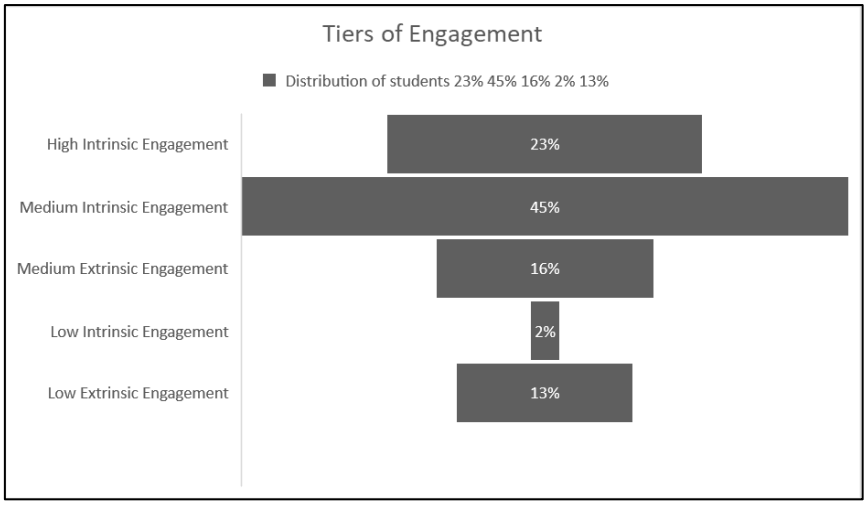


Figure 3: Tiers of Engagement

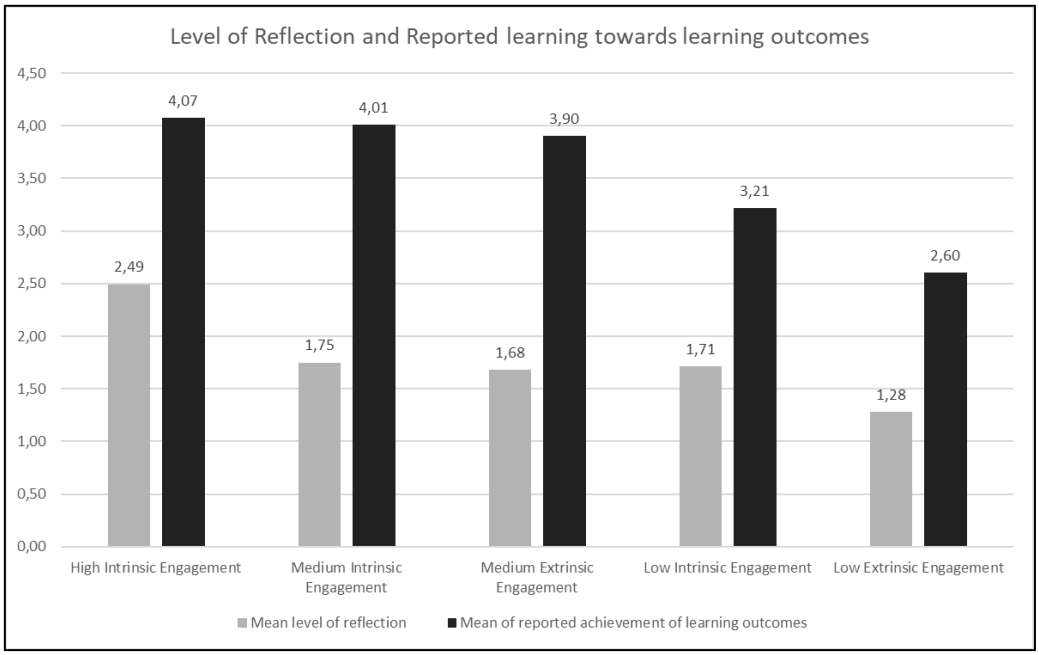


Figure 4: Level of reflection and reported learning

5. Limitations and Discussion

5.1 Limitations

This study is based on self-reported data. Although we believe we satisfy the criteria for validity proposed by Gonyea (2005), there are challenges with self-reported data and he therefore recommends that self-reported data should be combined with more objective data to increase validity. Our study would be stronger if we had measured motivation and engagement with instruments designed for this purpose. While our analytical framework has been designed to identify the presence of engagement and motivation, it is based on our interpretation of the data and application of the criteria, which weakens the validity. We consider the responses to be valid and representative of students' experiences, as discussed in the methods section, but we acknowledge that our analytical approach opens for errors of interpretation. In addition, there are potential confounding variables that can impact our findings and transferability to other contexts.

The study was made in the context of a fully online program, with a student population that has chosen the program due to the high level of flexibility, often combining it with full-time employment. As we see in their reflections on possibilities for collaboration, this impacts what they see as preferable or practically feasible. Similarly, the simulator was a mandatory assignment. As such, as a learning activity that differs from 'traditional'

assignments, the students' views could be impacted by not conforming to their expectations for an online program. This could also be seen in relation to the variance in age. Some respondents in the higher age groups are possibly not interested in digital games. These variables could impact students' motivation for the simulator.

Prior knowledge could also have an impact. Some students had prior experience with the simulator from a different course, which could have influenced their experience with the simulator (e.g. having mastered the simulator as a game, putting less effort into it as a learning activity for this course). Some students also reported experience from working in business, which could impact their views on the simulator's realism or relevance to working life.

5.2 Discussion

We aimed to examine if higher levels of reflection on learning could be found with students who were highly engaged by the simulator, compared to students showing low levels of engagement. As our survey was not intended to measure the level of engagement and motivational types, we had to develop an approach for analysing and coding our data. Our analysis indicates that there seems to be a connection between levels of reflection on learning and engagement, with high engagement corresponding with more complex reflections on learning. Intrinsic motivation seems to influence the level of reflection and engagement. This matches established theory. The tier of low intrinsic engagement breaks with this trend. This tier represents only 2% of the responses and could be an example of imprecision in our data analysis method. If we presume it to be valid, it could mean that intrinsic motivation is more intricately tied to reflection, than engagement itself. Nevertheless, intrinsic motivation appears to be key in attaining high engagement, as intrinsically motivated students populate most of the higher tiers of engagement.

The respondents have a varied demographic makeup. Within the tiers the average age and variance is similar. There is a relatively higher share of men in the intrinsic high and medium tiers of engagement. In the lower engagement tiers, there is a larger relative share of women. Our data has not revealed any specific insight on the gender gap, but this might link up with other studies, such as Riemer and Schrader's (2015) finding that women reported higher general negative affect towards GBL.

Students report they understand more of the context of working in a business, and the link between curriculum and "real" businesses. Some reflect on how this understanding affected their following work in the course. The simulator feeling realistic matches the results reported in Baksaas and Nygård (2021) and Hovland et al (2023).

The simulator itself is simplified in relation to reality. The most reflected students report that they see the connection between theory and practice, but also the shortcomings of the simulator. This points to how engaged students who want a more a complex and challenging simulator can see the shortcomings because they are on a higher reflection level. We expected that highly reflected respondents could report lower levels of achieved learning, as they might be more critical to the simulator's ability to provide insight due to the abstractions. While critical reflections on realism are present in the responses, the highly engaged and reflected students still reported the highest mean achieved learning outcomes. This could mean that awareness of the abstracted reality of the simulator is not a hindrance for learning, provided that students are sufficiently motivated to go beyond the simulator in their learning.

68% exhibit criteria signifying intrinsic motivation, and medium or high engagement. Returning to Miele and Scholer's (2018) concept of metamotivation (are the students motivated "enough" and/or "in the right way") brings some insight. Some comments that shed light on motivation revolve around interactivity and being able to make decisions and experiencing consequences. There's reflection on learning from effort put into exploring the simulator and making use of the information provided by in-game reports. The activity was individual, but when reflecting on the potential of collaboration, students express that group discussions would be useful for learning. Even so they prefer individual use. This is not surprising, as the program is online and flexible. The students are motivated to use the simulator, but not to use it in a less flexible context that would require more coordination.

Furthering reflection on metamotivation, a question is if some of the students who reach medium, but not high, engagement does so because they found the simulator to be lacking in challenge or realism. Could challenge and realism be a ceiling for engagement by limiting the feeling of meaningfulness? Although some comment on the simulator being too complex for an introductory course, others state that they found it helpful for grasping the course basics. Platz (2022) points out that GBL research on such design elements are hard to generalize and compare, with more studies needed. Our analysis has not resulted in strong findings on this point, but we can

see from some comments that highly engaged students seem to want more complexity and challenge. This suggests that challenge and complexity/realism could be a driver for engagement, but there could be individual differences (possibly related to type and amount of motivation) between students on what they deem complex or challenging enough to be engaged. Explaining why some are highly engaged by the simulator's current challenge and complexity (but want more), and some do not reach the higher tiers of engagement because of a lacking level of challenge and complexity. At the same time, the simulator must also not be too complex. This is an area where a deeper analysis of the qualitative responses might shed more light.

Comments relating to technical or practical issues with the simulator are recurring. Seen from a motivational perspective, it could point to such issues as external factors that inhibit the students from expressing their intrinsic motivation, i.e. reducing both the quality and amount of their motivation to engage with the learning activity and obscuring the connection between the simulator and the curriculum. Issues reported deal with how the simulator is introduced, the allotted time, feedback and guides for use. Among these we also find reflections that go beyond instrumental concerns about making it easier or taking less effort to complete. From these comments we can see potential for helping students reach higher tiers of engagement. By reducing frustration, we could potentially prime students to better experience the simulator as a meaningful learning activity by making the usefulness for learning more apparent. Additionally, opportunities for challenge could be included for the students who feel that the simulator is too simple to further their learning.

Some students reflected on how the additional narrative tasks they had to complete were useful for their learning. These assignments were added by the instructor to expand the simulator to also include theoretical tasks and terminology in a practical context. Many responses reflect on how this added realism or helped with visualizing or fostering understanding of concepts. Comments on the same relationship from lowly engaged students report that they didn't see connections between the theoretical curriculum and the practical tasks. These reflections are also coded as low. This could show that engagement is important to see the connections, and therefore reach a higher level of reflection.

6. Conclusion and Future Work

Our study shows that the students in the highest tier of engagement express higher levels of reflection on their learning than the respondents in the lower tiers. The middle tier, both intrinsically and extrinsically motivated, express lower mean levels of reflection (1.75 and 1.68 on a scale of 1-3 compared to 2.49 for the highest tier). This shows that engagement is important for students' perceived learning in our context: An online business simulator game as a learning activity. The qualitative data provides insight into several factors relating to the respondents' reflections. There is a large degree of variance within each tier. The high and medium level reflections contain a broad display of metacognitive thinking about the simulator as a learning activity. The comments highlight the importance of appropriate challenge and opportunities for the players to find the simulator meaningful. Intrinsic motivation seems to be a key component in reaching the highest tier of engagement.

The lowest tiers of engagement display a low level of reflection (1.71 and 1.28). The intrinsic motivated tier corresponds to only 2% of the respondents and could be reflective of methodological weakness in our analysis. When providing reflections beyond one-word responses, their concerns revolve primarily around issues connected to effort and technical/practical issues.

Our analysis indicates that the intrinsically motivated students have been more engaged and found the simulator meaningful. It is important to create opportunities for students to express their intrinsic motivation. With a heterogenous student population with a high need for flexibility, this could necessitate more focus on options to customize the simulator to fit their optimal level of complexity. Arenas for students to discuss the tasks could also be useful, provided it matches their needs for flexibility.

Based on our work so far, we see the use for a more precise measurement tool in future data collection. This will provide the opportunity to closer examine various motivational components connected to the students' self-regulation of learning, as well as possibly shedding more light on the relationship between intrinsic and extrinsic motivation on reflection. We also see the potential in reducing frustration and improving the integration of the simulator in the course to better enable students to see how it can be a meaningful part of their learning process and motivate them to reach a higher tier of engagement. The qualitative comments also point towards questions that could benefit from further inquiries. This includes the effect of the narrative assignments that expand on the simulator, realism, and complexity/challenge.

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Integration and Promotion: Integrating Sustainability Research into Computer Science Teaching through Serious Games Assignments

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Abstract: "Serious Games" is a final-year 20 credit point module, undertaken as the default optional module for students on Undergraduate courses entitled BSc Computing and BSc Computer Science (Games Technology) at Nottingham Trent University, UK. The module focuses on developing students' critical evaluation skills, enhancing their ability to design and implement solutions for a real-world design brief, working with clients and making final products accessible to a broad target audience. Historically this was achieved through engagement with a single client, often via a wider research project or local educational establishment of some sort. More recently, the module has retained two client project briefs, which the students are then empowered to choose between. With each client brief the module team has sought to add extra value for the students. For the previous two academic years, the module team has partnered with Green Academy, a strategic team within the University whose priorities include stimulating pedagogical innovation and practice sharing within the area of sustainability and pioneering a shared understanding of sustainability education. The resulting partnership has introduced a brief for students which combines vital industry skills with sustainability literacy. Working with and alongside the students who are undertaking the module, the module has developed Serious Games on a diverse range of local and global sustainability issues and has exposed students to university research culture and our sustainability research specialisms. It has also necessitated that students engage with and contextualise the United Nations Sustainable Development Goals and the UNESCO ESD competencies which they are tasked with integrating into their design solutions. The long-term intent of this partnership is for these design decisions to be utilised in the Green Academy's ongoing strategy to further enhance the University's pedagogical framework and sustainability education offer, and to improve the provision of Serious Games for use by clients outside the University. This report is a synoptic overview of the module design and insights from the two-year partnership as well as how these observations have been leveraged to improve the design and delivery of the module for future clients and students.

Keywords: Serious Games, Interdisciplinary, Student-led Design

1. Introduction

As a module undertaken by students seeking to complete courses in and receive awards for BSc Computer Science (Games Technology) and BSc Computing, the current and ongoing primary objective of the module is to provide students with experience of working with real-world clients and creating prototypes to meet client briefs. Clients may take the outputs forward, either deploying them within their workplace, or developing the prototypes further, potentially alongside the students. The tangible benefits of this model are clear to students; they create a piece of project work that has focus, utility, and is easily understood by a potential employer. Their output can demonstrate that they not only have the technical ability to provide a working prototype, but that they are also able to understand and work effectively to a client brief with all the important transferable skills and competencies inherent in that scenario.

Clients are selected for the module on a year-by-year basis, with clients approaching the Serious Games module team or vice versa when a synergy of aims is identified. Contact between the team and Green Academy was first established early in 2022. Discussions quickly developed into the two teams working together to create a coherent brief which would meet the existing aims of the module and the aspirations of the Green Academy. The key initial aspiration for Green Academy was an experimental one; to explore whether students could develop a viable serious game prototype to teach other students about sustainability. The teams also both wanted to provide through the brief an opportunity for Computer Science students to enhance their sustainability literacy and be exposed to university research culture; a unique feature of Higher Education which is sometimes inaccessible to students. To our knowledge the module does constitute a pioneering model within the Higher Education sector in the way it has approached embedding sustainability within the context of computing courses and game design.

1.1 Core Module Learning Outcomes

As part of the Computer Science (Games Technology) and Computing courses, the Serious Games module requires that students, regardless of the brief they select, demonstrate that they are able to:

- Research and investigate previous Serious Games in the selected sector (Parallel Products), and analyse their positives and drawbacks, and utilise knowledge derived from this in their design.
- Communicate with their client regularly, refining the brief and matching their design to it as close as possible.
- Gather feedback from their clients, peers and potential end users, and use this to refine their design
- Investigate the brief beyond the information given, including researching traditional non-games based pedagogy.
- Tailor the game to the entire projected userbase, being aware of the variety of disabilities and disorders that they may have.

Accessibility is an important element of the module which focuses on a "one size fits all" universal design philosophy (Gillern and Nash, 2023). Students need to ensure that design is as accessible as possible, especially as clients often supervise learning for a small number or even majority of students who have a cognitive or physical disability. Given the rapid increase in students (Hubble and Bolton, 2021) and Staff (HESA, 2024) with declared disabilities, especially cognitive and learning difficulties such as Autism Spectrum Disorder, Blindness, Dyslexia, and Physical/Motor impairments, these themes also tend to resonate with students, with many having diagnoses of or experiencing one of these conditions, or having class mates or close friends who do.

1.2 Green Academy Brief

Green Academy provided a brief for students to *create a game based on an area of NTU sustainability research*. Students were advised that the game should:

- Be engaging, accessible, informative and inspire further exploration by those who experience it.
- Make reference to the UN Sustainable Development Goals (https://sdgs.un.org/goals).
- Help players facilitate one or more of the UNESCO ESD competencies (AdvanceHE, 2021).

Students were given the following user considerations:

- Your game should work for short-term development; open ended simulations will not work, unless there is a natural stopping point to enable students to return to the game later.
- Game play time should be a maximum 10-15 minutes so that it can be used within lectures and tutorials followed by critical discussion and exploration of learning.
- It must be easily accessible to both students and academics on multiple types of software and be able to be used within the university IT systems e.g. a browser based game.
- People should *want* to play it, so an elements of creativity, fun and excitement are important. We want the game to be memorable and offer critical perspectives.

Green Academy attended near the beginning of the module to deliver a workshop where they launched the brief and led students through a series of discussion activities which introduced fundamental concepts of sustainability such as the United Nations Sustainable Development Goals, also known as the 'SDGs' or 'Global Goals' (https://sdgs.un.org/goals) and planetary boundaries (Richardson et al 2023). Students were prompted to consider how a serious game could facilitate the development of sustainability competencies such as problem-solving, self-awareness or systems thinking (AdvancHE, 2021) within the player and what could 'go wrong' with such a game, so that they might avoid pitfalls associated with sustainability games and serious games in general (Ouariachi, Li and Elving, 2020; Watt and Smith, 2021).

Students were provided with a Google drive containing information folders for six different research projects led by NTU staff (and in one case co-led by a fellow NTU student from the School of Animal, Rural and Environmental Sciences). Each folder contained relevant research papers and one or more recordings of the researchers speaking about their research with the intention that this would enhance the sense of personal connection with the researcher. Students could browse each folder before deciding on one or more research projects upon which to base the game. The research projects were as follows:

- Climate change communications and politics (Poberezhskaya and Bychkova, 2021).
- Arctic lakes and carbon (Stevenson et al, 2021).

- Climate reporting by large companies (Pavlović and Miler, 2022).
- Climate change and biodiversity in 'winterbourne' chalk streams (Sarremejane et al, 2021).
- Citizens, environmental sustainability and local democracy - Nottingham's Carbon Neutral 2028 strategy (Henn and Arya, 2023).
- Local planning for climate change (Haupt et al, 2021).

Green Academy was invited back to attend several formative feedback sessions throughout the year to receive presentations from the students on their work so far, and to catch and advise on any potential flaws in the idea based on their specialist knowledge. Later in the year Green Academy also invited to observe the final demonstration of the prototypes, and finally to sit in on the final assessment session and provide feedback to inform student outcomes (though these were determined by the core module team in all cases).

2. First Year (2022-3 Academic Year)

In the first year of this collaboration, the cohort was split into two separate groups – 12 Games Technology Students and 15 Computing students. Alongside the brief provided by Green Academy, the Serious Games Team also partnered with a local Special Educational Needs specialist school, who requested a number of highly accessible games to assist their students with travel, cooking, and other elements of self-care.

Students were encouraged to use whatever development environment they were most comfortable with. Sessions teaching and supporting the students in using the Unity engine were held throughout the year, which was the development environment most students used. The students on the Computer Science with Games Technology course had previous Unity experience from their second year “Games Programming” module. While the remaining students taking this module also had programming experience, Unity can be time consuming to learn for those with no games development experience. Students were therefore encouraged to use freely available open-source assets where possible and were not assessed on the technical complexity of their games as much as they were on the “core idea”.

The final games were evaluated by a five-member panel consisting of module staff and other specialists in the field of Games Based Learning. The average grade awarded was used as a starting point, with the grade being elevated if the panel felt it was appropriate to combat the natural trend towards more moderate grades that tend to emerge because of taking the average of a grading panel.

3. Observations

Contrary to expectations, students responded better to more structured weekly sessions, than to the less teaching intensive teaching approach offered in the second term. The team’s aim was to enable them to embody their games design at their own pace, where coding support was offered when needed, in a less "hands on approach". The pressures of other competing coursework deadlines exerted a deleterious effect here in students' game production schedule. As a result, students voluntarily put themselves under crunch development conditions, which resulted in the final products being more variable in overall quality.

Further, many students were confused by the dual brief nature of the assessment, and a few attempted to meet both briefs. This resulted in a number of games that were not appropriately designed, though as they were required to submit their report for assessment at the end of the first term, most of these cases were caught, and students supported in reworking their design to clearly align with one brief or another.

Student feedback highlighted two primary issues with the scheduling of sessions.

- Students felt that the Unity Development sessions came too late in the year, preventing the students from managing their workload well and causing, in effect, crunch development.
- Students felt like that they did not have sufficient reason to come into sessions, as there was no obvious positive impact from doing so.

4. Second Year (2023-4 Academic Year)

In the second year, the cohort was one merged group of 21 students, of which 10 were on the Computing course, and 11 were on the Computer Science (Games Technology) course. Alongside the brief provided by Green Academy, the Serious Games Team also partnered with the Trent Institute for Learning and Teaching (TILT), who

requested a number of games to boost the internal provision of legally required training (specifically regarding the PREVENT duty, Safeguarding and British Values).

In response to student feedback and to try and maintain engagement, the entire module was more rigorously planned from the start. As highlighted by the previous cohort, Unity Tutorial Sessions were moved earlier in the year to accommodate students who had not used the tools before, and Research and Design focused labs were more evenly distributed throughout the year. The students were given a very clear format through which to log the feedback they obtained, and a number of formative feedback points were explicitly embedded into the teaching calendar. Sessions were also not only tied to the learning outcomes, but also very explicitly to the assessment. Further, students were always given an outlook of the next few weeks, informing the students of what they should be working on.

Entering the second term, we received a lot of student feedback through multiple channels from the Computing cohort that they felt like they needed more programming support earlier in the year. Thanks to flexible working and scheduling arrangements organised by the Team, we were able to rapidly adjust, integrating extra support Surgery sessions, and shifting Tutorials earlier in the year to compensate. The cohort responded very warmly to our proactivity in this manner, and engagement remained very high.

While moving the programming support sessions earlier in the year had a positive impact overall, some students found themselves scaling back their ideas based on what they thought they would be able to implement, rather than forming their ideas around the client's brief. In future years, students will be encouraged to "dream big" then implement as much functionality as they are able to, and explain any "out of scope" functionality during their demo.

We also arranged an explicit "Playtesting Day", where first year students were invited to trial some of the cohort's games and provide detailed feedback. The students were taught a rigorous playtesting process used in the games development industry, focused on making the test as unbiased and rigorous as possible.

- Designing the playtest to be playable with minimal instruction, utilizing Signifiers correctly.
- Preparing a cheat sheet and any emergency helpers in advance.
- Preparing questions in advance (Lemarchand, 2021).

This event ended up being far more popular than predicted, with nearly 70 first year students taking various courses throughout the department showing up for the playtesting session. This naturally caused some organisation issues, but most students benefitted greatly from this session, from finding bugs, gaining accessibility feedback or general enjoyability feedback.

The assessment was undertaken in a similar manner this year – though one extra component that was added was a formal structure for recording and proving feedback had been collected and utilised.

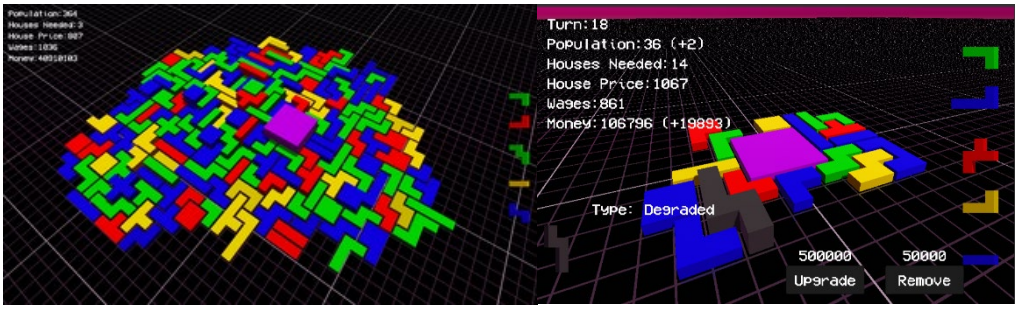
5. Outcomes

Despite some differences outlined previously in the delivery of the module over the two years of the Green Academy brief, both years resulted in several excellent student outputs. As the module allowed students to personalise their output in terms of an aspect of sustainability of their choice, the resulting prototypes were diverse in theme as well as format including for example a climate negotiation simulation, a game about a CEO seeking to contribute to sustainability before they retire and several games which involve players making decisions about alternative energy options. A number of the demonstration games have been adopted by Green Academy for use in training and events both to educate about sustainability issues and showcase how sustainability can be contextualised effectively across different academic subject areas. A selection of games are described below to illustrate the breadth and depth of student response to the brief.

- Winterbourne Babysitter: Based largely on Sarremejane et al's research (2021) on winterbourne chalk streams, Winterbourne Babysitter focuses on themes of Partnerships for the Goals (SDG 17) and the conservation of species, through a narrative resource-based game. The player uses time in a "non-Drought" phase to construct materials which must be used in a "Drought" phase to preserve eggs of various mythological species who have been placed in their care. Once enough time has passed, assuming the player has performed well enough, some researchers arrive to create a more sustainable future for the ecosystem. The endearing characters including various creatures and an NTU Professor from the real-life research project make for an engaging game play which educates players about a little-known aspect of UK conservation activity.



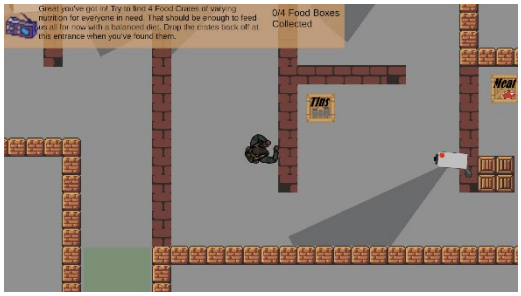
- System Sprawl: Based on themes of Sustainable Cities and Communities (SDG 11), System Shock is an abstract puzzle game where the player is tasked with placing colored pieces, representing different zones of a growing city, into a grid such that all area types have access to other area types which they need in order to run. As opposed to an active learning approach, this design attempts to inspire the player to think about how cities are built and grown, and adopt strategies to ensure resources, especially energy and other utilities can be used effectively and efficiently. An elegant composition, the game is at once compelling for the player due to the classic puzzle aspects and also visually articulates the complex predicament of trying to allocate finite resources for a growing population.



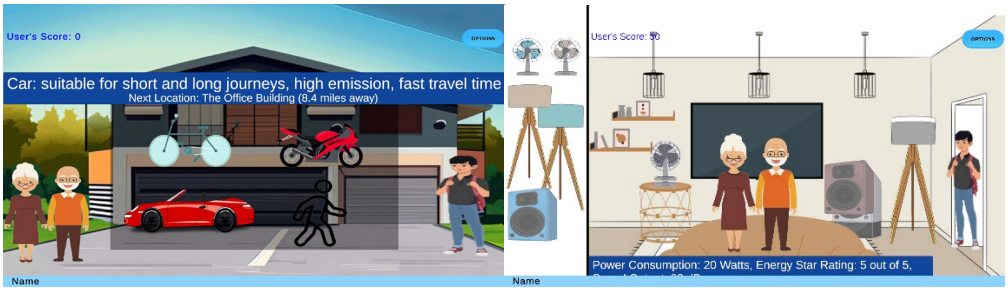
- Kobold Mining Corps: This clicker game incorporates fantastical lizards representing low-income nations and money-eating dragons symbolising high income nations. Focussing on SDG8 – decent work and economic growth – as well as broader themes of climate justice and geopolitics, the game facilitates both short term and long-term thinking and explores how the strength of individual workers can be multiplied. This game also focused on enabling the end client to enhance and customise the game via an easily edited modular design, requiring little programming experience.



- Environmental Vigilante: The game is set in a climate dystopia and explores social sustainability issues connected with SDGs 1-3 – No poverty, zero hunger and good health and wellbeing. The character is presented with several tasks to complete to ensure the safety and health of local citizens. One such task revolves around a food bank (a charity food donation point); a nod to the fact that the city where our university is located – Nottingham, UK – has one of the highest uses of food banks in the country.



- Energy Expedition: an interesting feature of this game is that it revolves around an intergenerational conversation about sustainability issues with a prospective university student and their grandparents as the main characters. The grandparents send the student around the local town on a sustainability discovery adventure, educating them along the way about ways to be more sustainable within your individual sphere of influence, for example the student is faced with decisions about selecting the most sustainable options of electrical appliances for their move to university. The game focusses chiefly on SDG 7 – affordable and clean energy – with the wider them of intergenerational learning which is a key tenet of our university sustainability strategy.



6. Ongoing Pedagogical Outcomes

Whilst students were very engaged throughout the year, there were a number of students who struggled with the module's apparent process on "reporting" over programming, in spite of the fact that there is no explicit requirement for programming to be taught or assessed under the module's agreed Learning Outcomes (with programming skills being assessed elsewhere on both sources). In particular, this caused a rift between the Games Technology Students, who had already had significant Unity experience in a second year module, and the Computing Students, who had not. The group who had already undergone teaching of the Unity Engine prior to the module, on average, scored 74% (SD 20%), with 8 of them (72%) attaining a 2:1 or better, whereas the group who had not, on average, scored 76% (SD 16%), with 7 of them (70%) attaining a 2:1 or better.

The appropriate test to determine if these two groups varied significantly is the Mann-Whitney U test, suited to comparing two relatively small sets of data. The U value for the Games Technology group was 53.5, and for the Computing group, 56.5. To disprove the null hypothesis that there is no impact of course on student outcomes, the lower of these would have to be less than 26 ($P<.05$). It seems relatively safe to say that the current provision enables Computing students to perform just as well as their peers in Games Technology – in fact, the statistics this year suggest that the Computing students performed better. Of course, the team is planning on monitoring this difference in years to come, especially considering how provision may be adjusted if the cohort size requires that the groups be split once more. For now, however, the balance of provision shall be left as is.

Therefore, it suggests that the purpose of the report is not strictly clear to the students, as while the report contents cover most of the learning outcomes, the report in and of itself is not, barring that for producing quality written work. Some students have explicitly expressed that the report is redundant. Furthermore, from the perspective of the final year as a whole for both modules, there are few explicit assessments of speaking skills outside of this module. Combined with very positive feedback with regards to the clients being present during their final demonstration, as well as concerns over AI use and workload, this assessment element is currently being changed to a full presentation component with a small written context document or brochure. This also has the effect of reinforcing the idea of communicating with a client in a clear manner, one of the key learning outcomes of the module.

The Playtesting Session, despite ending up being less effective than it could have been due to unexpected numbers and timetable complications, still showed great use and promise to the students. In future years, this session will be extended to a full day, with the testers being straddled throughout the day. Similarly, the structured feedback log will be maintained, as not only were students more clearly able to identify what feedback they had received and used, they were more likely to go out of their way to solicit feedback from their clients, their family and their peers.

The confusion found by the students in their first year was less pronounced this year, indicating that the extra clarifications embedded within the teaching content and the mark scheme helped students differentiate between the two briefs and create a more targeted and focused product. Whilst it's possible this could be further alleviated by mandating that students fill in a form declaring which brief they are following; it appears that this would likely inhibit the students by requiring them to commit to an idea that may not work early on.

Students fed back that they did not feel like there was enough opportunities for them to exchange ideas and help each other to work. This may be alleviated in future years by introducing sessions based on Beichner's SCALE-UP project – giving each student some time to head a roundtable discussion on their design ideas and concepts, either prior to or during the development of the student's first pitch session. (Beichner et al. 2008)

Sustainability based teaching is going to remain embedded into the module, particularly focusing on intersectionalities between equality and environmental sustainability, themes that are going to remain very relevant heading into the briefs to be used in the 2024/5 academic year. There are plans to remain in contact with Green Academy and other departments in the university to enhance teaching on the module and courses, including clear plans to resume a direct partnership in later academic years.

Going forward, the module team is attempting to work alongside their clients and their user groups in order to create highly specific briefs and goals for teaching to address gaps in their current curriculum. The module team has already been through an intensive co-design session with a local user group of SEN students and their teaching and support staff, to prepare the assessment specification and brief for the next academic year.

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Fun and Functional: Using Non-Digital Games to Promote Maths Engagement in Pre-service Teachers

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Abstract: Humans naturally engage in playful activities throughout their lives and play serves as a fundamental mechanism for cognitive development as well as the development of essential soft skills such as teamwork, decision-making, leadership, and communication. Recognizing this innate predisposition for play, educators are increasingly embracing gamification strategies into their classrooms. More attention has been driven to digital tools such as platforms Kahoot! and Duolingo which gained popularity and demonstrated the potential of game-based learning to increase engagement and knowledge retention. However, concerns about digital screen time fuelled a renewed interest in non-digital activities, including educational games. Non-digital games are often more accessible and affordable, making them suitable for schools with limited resources. Research suggests that non-digital games can effectively promote collaboration, communication, and critical thinking skills. In addition, they offer flexibility to teachers to adapt rules and scenarios to specific learning objectives and student needs. Recognizing the benefits of employing games as a pedagogical strategy, the first author of this study opted to incorporate game-based learning strategies into her classes, on a regular basis. Throughout the semester, various non-digital games were implemented, inspired on well-known classics such as memory card games, Monopoly and Pictionary. These games were carefully designed to address specific mathematics topics identified as either the most relevant or those where students revealed more difficulties. The participants in this study were pre-service pre- and primary school teachers enrolled in a maths undergraduate course. Since these students are future educators, the games served a dual purpose: improving current learning experiences and providing teaching resources for their future classrooms. At the end of the semester, a survey was conducted to evaluate students' perceptions towards the use of games in the mathematics teaching-learning process. In this paper we describe some of the games used in this study and analyse the results of the survey. Previous studies reveal that students generally welcome the incorporation of games, perceiving them as effective tools for enhancing motivation and promoting positive learning outcomes. Our findings corroborate these studies.

Keywords: Educational Games, Gamification, Non-digital Games, Mathematics Education, Pre-service Teachers.

1. Introduction

Mathematics is present in almost everything that surrounds us. Although not everyone is always aware of it, it is a fact that the world we live in has always depended and will continue to depend, increasingly, on mathematics (Pais and Hall, 2019; Yadav, 2019). Unfortunately, the scenario in most mathematics classrooms in Portugal is not stimulating. The mathematics experienced by students is boring and monotonous (Alien-Fuller, Robinson, and Robinson, 2010; Grootenboer and Marshman, 2016). In an era of so many transformations, changes are also needed in the teaching and learning processes, namely, of mathematics. It is necessary to develop "powerful and challenging" mathematical tasks, "to captivate students and boost their learning" (ME, 2021).

Changes are needed in the teaching/learning processes, and it is necessary that the role of both teachers and students adapt to the demands of today's society. Active, cooperative, and participatory learning methodologies should be privileged, which promote, through interaction, voluntary, active, and conscious learning (Pais, 2023).

In this context, one of the strategies that has been used with good results is gamification, where games are not considered as a merely playful activity, but can be seen as resources that stimulate visual and intellectual contact with different contents (e.g. mathematics, language or history) and facilitate the learning process (Sailer and Homner, 2020; Dinata, 2021; Pais and Hall, 2021; Morando and Turconi, 2022).

2. Gamification

Gamification is an active educational methodology that uses elements, designs, mechanics and rewards from games or video games, adapted to a non-game environment such as the educational context (Kapp, 2012). This methodology provides a better experience in the learning process, promoting the interest of the students and involving them in this process, which has a positive impact on their results (Dinata, 2021; Morando and Turconi, 2022).

The learning mechanisms based on gamification are related to the student's motivation (Ryan and Deci, 2017), which is often associated with the factors of novelty, challenge, competition, fun and pleasure (González-Cutre et al, 2016). In this context, learning becomes enjoyable and not a duty or obligation. Several studies (McGonigal, 2011; Kapp, 2012; Hamari, Koivisto and Sarsa, 2014) highlight the positive impact of adopting gamification strategies in the teaching/learning process, both on student motivation and on the development of soft skills such as teamwork, creativity, decision making, leadership, communication, and critical thinking (some of the main skills mentioned by the World Economic Forum (2020)). Additionally, using gamification in education has other widely recognized advantages, such as: making learning more fun and interactive, creating an addiction to learning, stimulating brain connections, and allowing the establishment of relationships with the real world (Kapp, 2012; Pais and Hall, 2021).

Non-digital games, in particular, have additional benefits (Ramo, Knaul and Rocha, 2020), including: improving social relationships, promoting team spirit, cooperation, face-to-face interaction and communication with others, and providing a "relief" from the digital world and screens.

3. Educational Games for Mathematics Classes

Didactical games can be powerful tools in the classroom, transforming the classroom into a dynamic and engaging learning environment. To be effective, they need to be designed strategically. The following aspects should be considered when creating a game for mathematics classes:

- Alignment with the curriculum: Games should directly address topics and address student misconceptions identified through their mistakes. This clarifies doubts and focuses learning on challenging areas.
- Building automaticity: Games should include a myriad of exercises, thereby developing the essential automatisms crucial for mastering maths concepts.
- Active and enjoyable learning: By incorporating game elements, students actively engage with the content in a supportive and fun environment. This fosters a dynamic learning experience.
- Inclusive learning environment: Random elements like dice rolls or bonus points ensure everyone has the chance to succeed and contribute, regardless of skill level. This builds a collaborative and supportive classroom atmosphere where all students feel valued. It also adds excitement and teaches valuable life skills like adaptability and resilience.
- Simultaneous engagement: Effective games keep all students involved, even when it's not their turn. Non-playing teams can verify moves and answers, fostering collaboration and a sense of shared responsibility.
- Simple rules: Clear instructions ensure students understand the game mechanics quickly, allowing them to focus on the learning objectives. The game should be challenging enough to be interesting but not so difficult that it discourages participation.
- Adequate pacing: Maintaining the right pace keeps students engaged and motivated throughout the learning experience.
- Rewards and Penalties: Rewards, even small ones, incentivize active participation and a desire to excel. Penalties for random answers encourage students to approach the game seriously and strategically. A balance between rewards and penalties promotes both engagement and valuable lessons about focus and responsible decision-making.

The last two authors of this paper have a long experience in designing didactical games, targeting a wide range of educational levels (from primary school to university), in a diversified range of educational contexts (formal such as schools and prisons, and informal such as museums and botanical gardens) and, in some cases, taking into account students with special needs (La Fortuna, Morando and Spreafico, 2022; Morando and Turconi, 2022; Morando and Spreafico, 2023).

4. Methodology

4.1 Methodological Options

The research question underlying this study is how the incorporation of non-digital educational games in maths classes can enhance student motivation and engagement in learning mathematics.

In this perspective, a mixed case study was developed (quantitative and qualitative, based on a logic of complementarity), grounded on a pragmatic paradigm and case study design (Yin, 1994; Ponte, 2006). The teacher responsible for the course in question is simultaneously one of the researchers of this study.

In order to develop this experience, the techniques of inquiry, direct observation and analysis of documents were applied, and the following instruments were used: field notes and final questionnaire.

The main objective of the questionnaire was to assess students' perceptions regarding the use of educational games in the classroom. The questionnaire was created using Google forms and answered online by 44 students. This was a convenience sample, as participants were easily accessible to researchers. Statistical analysis of the data, specifically descriptive statistics, was performed using Excel.

4.2 Description of the Study

This case study was conducted during the first semester of the academic year 2023-2024 and involved the 1st year students enrolled in the course "Mathematical Concepts I" (Conceitos de Matemática I) of the undergraduate program "Basic Education" (Licenciatura em Educação Básica) at the University of Aveiro, Portugal. This three-year program prepares pre-service teachers for pre-school to the 6th year.

The course consists of two weekly face-to-face classes (one 2-hour sessions and one 3-hour session) and had a total of 28 sessions. Out of the 65 enrolled students divided into two groups, only 51 attended the classes (6 dropped out, and 8 only took the exams).

The topics of the course are numbers and operations. In the first part of the course different numeral systems are addressed and the students learn how to represent (and convert) numbers in different numeral systems and bases. The four basic operations are explored (addition, subtraction, multiplication, and division) and their algorithms are detailed not only in the decimal system but also in other bases. The second part of the course is devoted to elementary number theory: multiples/divisors, divisibility rules, prime number decomposition and applied problems are addressed. The third and last part of the course is related to decimal numbers (focusing on rational numbers), exploring the four operations both with fractions and/or decimal representations. Problem solving is also addressed using different approaches with a strong emphasis in the use of diagrams, following Singapore's bar model methodology.

Recognizing the benefits of games as a pedagogical strategy, the first author of this study integrated game-based learning strategies throughout the semester. Specifically, sixteen class sessions incorporated educational games. The activities were strategically placed in the middle of classes to serve as a mid-point break while still enhancing learning.

In total, eight different games were played, two of which were created in five different versions, addressing different mathematics contents. The time allocate to the games in class varied between 10 and 30 minutes, though most of the games were played for 15-20 minutes. All games were played in teams and most of them involved three to four teams, requiring several replicas to be played simultaneously. The games were designed to be diversified in many ways as shall be described in the next section.

5. The Games Played

All games applied in this study have been designed by the authors of this paper, in accordance with the principles described in Section 3. The authors chose to use only non-digital games for two key reasons. Firstly, the course itself is designed with a paper-and-pencil focus, aligning with the educational environment these pre-service teachers will likely encounter. Secondly, the instructors identified a need to address basic maths skills in many students and felt this could be best achieved without resorting to digital tools.

This section describes a selection of the most popular games, chosen in accordance with the students' preferences shown in the bar chart of Figure 6.

5.1 Garden Animals

The most preferred game was "Garden Animals" which focuses on developing mathematical communication skills and deals with simple operations and comparing quantities. It is intended for two teams of 2 to 4 players each.

Materials needed:

- One deck of 40 cards featuring images of garden animals (see Figure 1 (left) for some examples).
- One deck of 24 cards containing numeric conditions (e.g., "There are more snails and bees together than there are caterpillars").

Game Instructions:

- Display four cards from the image deck face-up on a table.
- Teams take turns drawing a card from the conditions deck.
- Each team has a limited time (one minute) to identify the image cards that satisfy the drawn condition.
- Correctly identified image cards are collected by the team.
- If the opposing team spots a wrongly collected card, it is returned to the table, and the playing team receives a penalty point.
- Once the team declares there are no more matching cards or the timer runs out, the empty spaces are filled with new image cards from the deck.
- The game ends when there are no more image cards left to display or after a predetermined time limit.
- The team with the most collected image cards wins.

5.2 Maths Monopoly

The second most preferred game was "Maths Monopoly" which draws inspiration from Monopoly. It can be adapted to different contents and in this case, we explored the properties of the arithmetic operations such as commutativity, associativity, and the existence of a unit element. It's designed for 2 to 4 teams, with 2 to 3 players per team.

Materials needed:

- "Title Deed" Cards (deck of 40): These cards feature numerical sets coupled with arithmetic operations (e.g., "The set of even numbers with addition").
- Board Cards (deck of 24): one "Start" card, five cards saying "Chance"; four cards saying "Closure"; seven cards saying "Commutativity and Associativity"; seven cards saying "Other properties".
- Chance Cards (deck of 12): These contain random bonuses (e.g., "Draw two cards of your choice").
- "Money" Cards (three decks):
    - Closure Cards (deck of 24): These represent closure properties (e.g., "The set is closed for the operation").
    - Commutativity and Associativity Cards (deck of 48): These represent properties (e.g., "The operation is associative").
    - Other Properties Cards (deck of 48): These represent other mathematical properties (e.g., "The operation has a unit element, and it is in the set").
- Dice (two) and tokens (one per team).

Game Instructions:

- Place six "title deed" cards face-up in a rectangular grid (2 rows x 3 columns).
- Shuffle the board cards and randomly arrange them face-up around the rectangle, placing the "Start" card in a corner (Figure 1 (right)).
- Place all team tokens on the "Start" card.
- In turns, teams draw the dice and move their token the corresponding number of spaces around the board. Depending on the landed card, a card is drawn from the respective deck. Chance cards must be placed back in the deck. The other cards are kept.
- A "title deed" may be bought if a team is playing on its turn and has gathered three "money" cards that match the title. One of the cards must be a closure card. For instance, a team can buy (collect) "The set of integer even numbers with addition" handing in the cards "The set is closed for the operation" "The operation is commutative" and "The operation has a unit element, and it is in the set".

- The game ends after a predetermined time and the team with more title deeds wins.

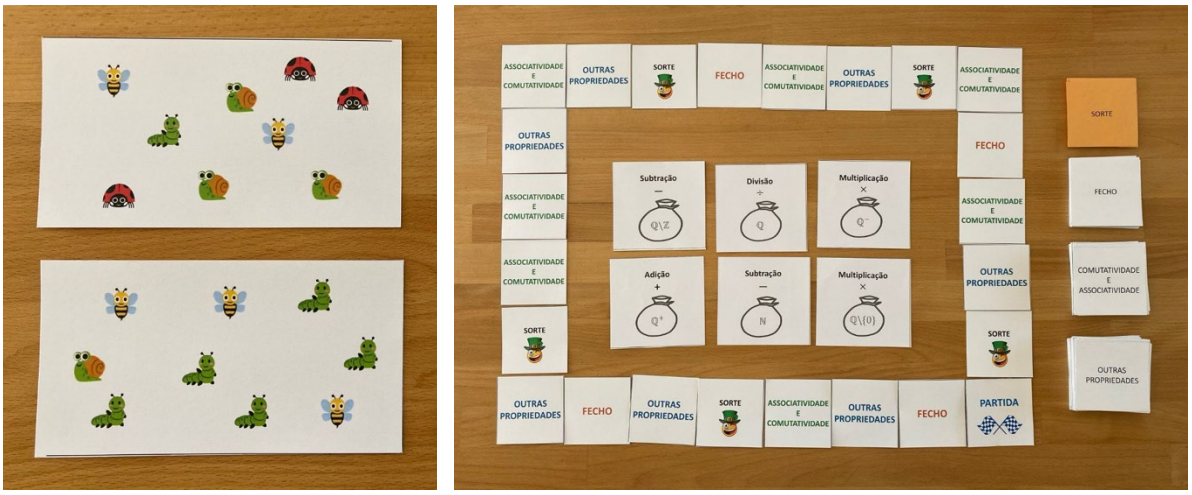


Figure 1**: Photos of "Garden Animals" (left) and "Maths Monopoly" (right).**

5.3 Mysterious Divisor

The third most liked game was "Mysterious Divisor" which explores prime factor decompositions and divisibility. It is designed for two teams of 2 to 4 players each.

Materials needed:

- Two identical decks of 20 cards featuring numbers and their prime factor decomposition (e.g., $1144=2^3$x11x13).
- One deck of 20 cards containing numeric conditions (e.g., "N is multiple of 26")

Game Instructions:

- Each team receives one of the identical decks and spreads it face-up on the table.
- Afterwards, each team draws one card from the conditions deck and reorganizes its deck by placing all number cards that satisfy the condition on the left-hand side of the table and all other number cards on the right-hand side. All cards must remain visible.
- Once ready, each team observes the other team's cards and tries to guess the drawn condition.
- Teams earn one point for correctly identifying the opposing team's condition.
- The game ends when there are no more condition cards left to draw and the winning team is the one with most points.

5.4 Boxes Game

This game is a fun activity that gets teams moving around the classroom! It's designed for the whole class, divided into four competing teams.

Materials needed:

- Five boxes placed around the room. Each box should be labelled with a different number range.
- Four decks of 20 cards. Each deck should be a different colour, but all decks should have the same contents. Each card must represent a number (it can be a numerical expression, a numeral in a certain numeral system, an equation with a single solution, etc.)

Game instructions:

- Divide the class into 4 teams.
- Each team chooses one member to be the messenger. He is responsible for placing the cards in the correct boxes.
- The remaining members must look at the cards and find the destination boxes.

- Teams have five minutes (or another pre-fixed time limit) to place the largest number of cards in the correct boxes. The time limit should be tight enough that players can't place all the cards. This encourages strategic thinking about which cards to analyse first.
- At the end of the game, each box is checked for correct and incorrect cards:
    - Each correct card earns the team 1 point.
    - Each incorrect card costs the team 1 point.
    - The team with the most points at the end of the game wins.

In this game the cards had numbers written in different bases and numeral systems (Roman, Egyptian, and Babylonian).

5.5 Decimal Numbers Pictionary

"Decimal Numbers Pictionary" takes inspiration from the classic game Pictionary and is designed for teams of 3 to 4 players.

Materials needed:

- Several identical decks of cards containing rational numbers in decimal form (terminating decimals).

Game Instructions:

- Distribute one deck of cards to each team.
- Each team chooses a member as the guesser (which can change every time a new card is drawn).
- The remaining team members draw a card from the deck and read the number on the card aloud, in its full form.
- The guesser writes the number down back in decimal form (e.g., the card has the number 23.5096; the readers say "twenty-three units, five thousand and ninety-six ten thousandths"; the guesser writes 23.5096).
- Each correct guess earns the team one point.
- The game ends after a predetermined time and the team with most points wins.

5.6 Open Middle

This game draws inspiration from the open middle maths problems available at https://www.openmiddle.com/. The proposed challenges all require selecting digits to place in blank spaces, without repeating any (e.g., Maximize $\square\square + \square\square$, using the digits 1 to 9 without repeating). It is designed for 2 to 4 teams of 2 players each.

Materials needed:

- A deck of chance cards with five types of cards: "all teams play" (most common card); "only your team plays"; "only the other teams play"; "earn one point"; "lose one point".
- A deck of challenge cards with solutions on the back.
- A timer.
- Paper and pencils for each team/player.
- Beans (points).

Game instructions:

- Each team takes turns drawing a card from the deck of chance cards.
- If the drawn card indicates a game for one or all teams, the team draws a card from the deck of challenge cards.
- Set a timer for one minute (or the time limit stated on the card).
- All teams try to solve the challenge using paper and pencil, if necessary.
- At the end of the timer, the teams flip over the challenge card to reveal the correct answer.
- Each team that correctly solved the challenge earns one point.
- After a pre-establish game time, the team with the most points wins.

The game was played in five class sessions and the topics covered were addition and subtraction of integers, hours and minutes, divisibility rules, mixed numbers, and fractions.

6. Survey Results

At the end of the semester, students completed a four-part questionnaire. The first section focused on participant characterization, the second section addressed the use of games in class, the third section (not analysed here) covered assessment methods, and the final section dealt with general course evaluation.

Regarding participant characterization, student ages ranged from 17 to 54 years old. The majority (81.8%) were between 17 and 19 years old, with only eight students (18.2%) aged 20 or older. Most students were full-time students (86.4%), while the remaining 13.6% were working students. The gender breakdown was heavily skewed towards females (95.5%), with only two male students (4.5%). This is usual in the "Basic Education" degree.

The second section of the questionnaire first asked students if they liked playing educational games in the classes, through a five-point Likert scale. As Figure 2 shows, there were no negative responses.



Figure 2: Pie chart of responses for the first question of the second section.

Further on, students answered four questions concerning educational games in maths classes. The responses are summarized in Figures 3 and 4.

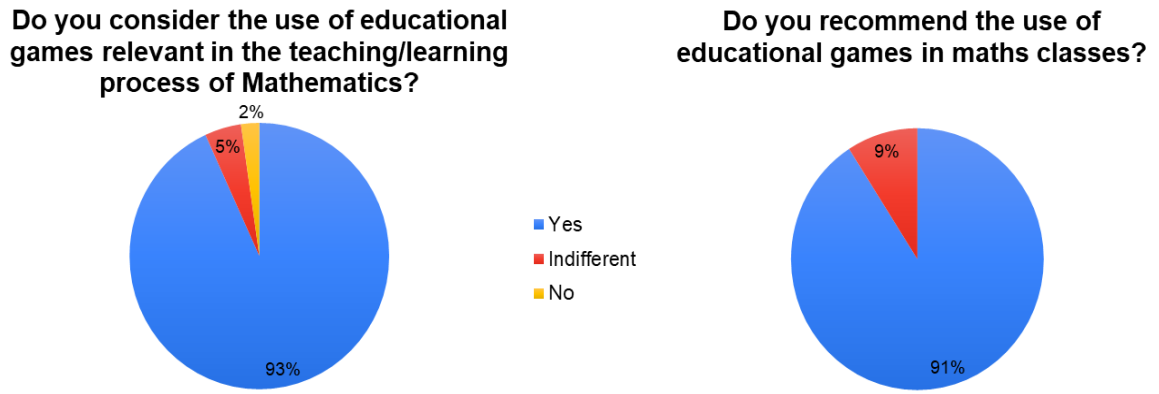


Figure 3: Pie chart of responses (Questions 2 and 3).

Figure 3 indicates strong student agreement that games are a valuable resource in the teaching/learning process. Additionally, students recommend using educational games in maths classes.

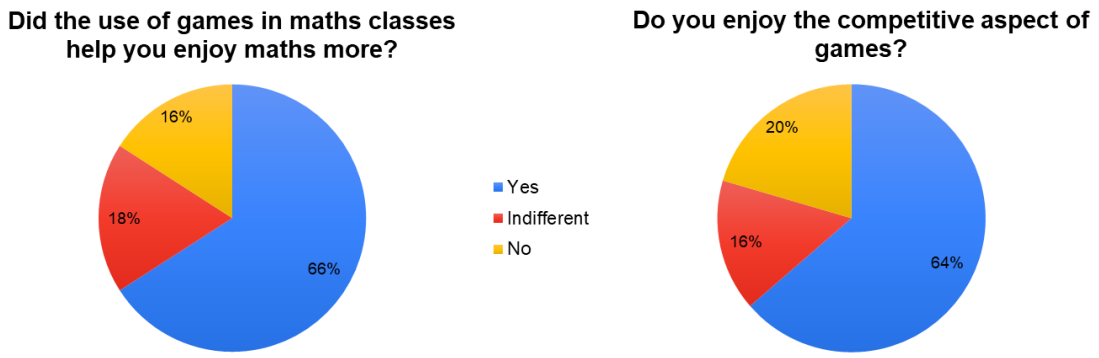


Figure 4: Pie chart of responses (Questions 4 and 5).

Figure 4 (left) shows that most students (66%) enjoyed maths more due to the use of educational games in class. However, the competitive aspect of gamification has varying appeal. While 20% of students reported disliking it, another 16% remained neutral.

Students rated their agreement with a set of statements concerning the use of educational games in class using a five-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree). The results are presented in the heatmap of Figure 5, which also includes the mean and standard deviation (SD) of the responses.

The use of educational games in maths classes contributed to:	**1**	**2**	**3**	**4**	**5**	**Mean**	**SD**
making learning more interesting.	0	1	4	14	24	4,4	0,8
making learning more interactive.	0	0	4	9	30	4,6	0,7
making classes more stimulating.	0	0	6	13	24	4,4	0,7
involving the students in the learning process.	0	1	2	15	25	4,5	0,7
increasing student motivation.	0	3	5	14	21	4,2	0,9
a more positive view of mathematics	0	0	8	17	18	4,2	0,8

Figure 5: Heatmap of responses related to the use of games in maths classes.

As Figure 5 shows, very few respondents disagreed with any of the statements. "Total agreement" was the most frequent response for all statements, reflected in a mean agreement level above 4 and a small SD. The heatmap allows us to conclude that the use of educational games generally contributed to motivating students, making the learning process more interactive, and engaging students in the teaching/learning process.

Students were asked to select which games they liked better (they could choose more than one). The answers are given through the bar chart of Figure 6.

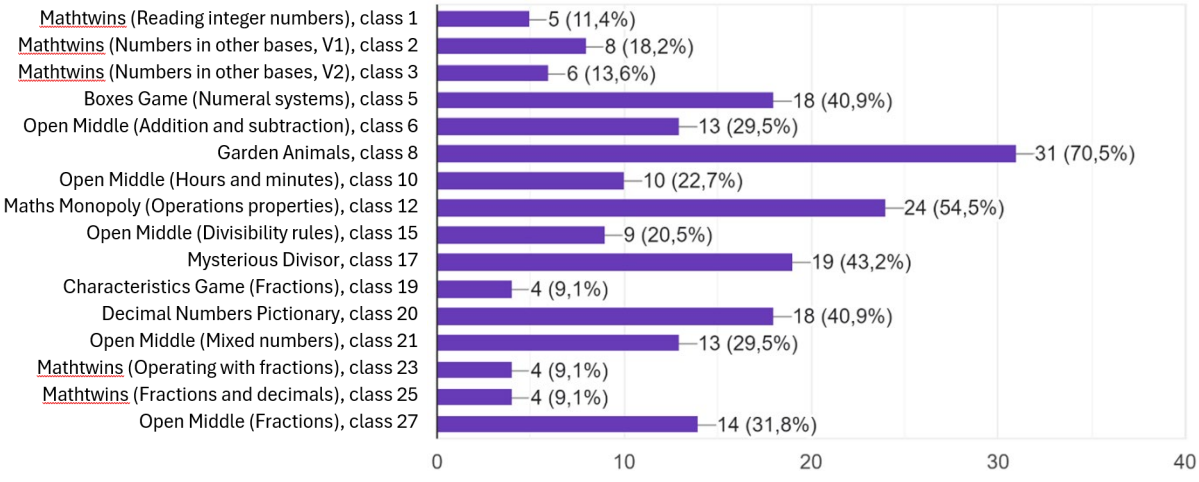


Figure 6: Bar chart of preferred games.

To gain a deeper understanding of student perceptions regarding the competitive aspect of games, they were asked to rate their agreement with a set of statements on a five-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree). The results are presented in the heatmap of Figure 7.

I consider that the pressure of competition contributes to increasing:	1	2	3	4	5	Mean	SD
my responsiveness.	3	4	8	18	11	3,7	1,2
my motivation to succeed.	3	5	7	15	14	3,7	1,2
the fun with the activity.	3	4	7	12	18	3,9	1,2

Figure 7: Heatmap of responses related to the competitive aspect of games.

Analysing the results of Figure 7, we see less consensus in opinions, reflected in an increase of the SD and a decrease of the mean responses. This aligns with the findings from Figure 4 (right-hand pie chart), where 36% of the students didn't have a positive opinion. Not everyone thrives in competitive environments, and although a minority in this group, they should not be neglected. One solution involves grouping these students together and facilitating non-competitive gameplay. The teacher successfully employed this strategy to accommodate students' diverse preferences.

In the final section of the questionnaire, students were asked to assume the role of the teacher and outline what they would maintain and modify for next year's course. Regarding what they would maintain, seven students said they would keep everything as-is. Educational games received the strongest attention, with another 26 students advocating for their continued use. Two students did not respond, while the remaining suggestions focused on other resources and methodologies employed in the course.

When asked about potential modifications, 17 students felt nothing needed to be changed. The remaining students suggested adjustments to the pace of content delivery or the need for breaks during class. No modifications related to gamification were proposed. It's important to note that the games were played mid-class, and complete breaks were not permitted. The teacher agrees with the students who highlighted the need for breaks, particularly during the 3-hour sessions.

7. Conclusions

This study investigated how educational non-digital games in maths classes can contribute to increase student motivation and engagement in maths learning. The results demonstrated that students not only enjoyed playing the games, but also reported feeling more involved in class and motivated to learn. These findings were supported by both questionnaire responses and the teacher's field notes taken during class observations.

Games offer both a leisure aspect and a competitive element. While most people enjoy the leisure side, not everyone embraces the competitive nature of games. In this study, none of the students reported disliking the educational games played throughout the course. However, 20% did indicate a preference for playing without competition. To accommodate these varying preferences, we recommend adapting the game rules for different student groups. For most students, a point and penalty system can provide a welcome challenge. However, others may benefit from a more collaborative setup that removes the competitive aspect. Ultimately, the teacher's role is to tailor the game format to best suit the players.

Students in this study not only found educational games to be a valuable tool for the teaching/learning process, but also recommended their use in classrooms. The participants, pre-service teachers enrolled in a mathematics undergraduate course, not only strengthened their own understanding of mathematical concepts through these games, but also gained valuable teaching resources for their future classrooms.

In summary, using non-digital educational games to promote maths engagement in pre-service teachers was found to be both fun and functional.

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Playing to Collaborate: Using Cooperative Board Games to Experience and Reflect on Collaboration in Upper Secondary Education

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Abstract : There is a growing interest among researchers in using board games for supporting learning in school contexts. Co-op board games is a relatively new and promising type of games, which seems well-suited for improving students' collaboration skills. In this paper, we explore how two groups of Danish high school students interact when playing two different co-op games, *The Mind* and *Forbidden Island*, and how they reflect upon their shared game experiences. The data collection is based on video observations of group interaction and student interviews, which use stimulated video recall. In this way, we are able not only to describe the students' perceived outcomes of the gaming activities, but also their in-game practices. Our data analysis is informed by microsociological perspectives (Goffman and Collins), which are used to map the group interaction rituals and social norms of the students' gaming encounters. Based on the data analysis, we identify two analytical themes, which concern the students' use of verbal and non-verbal communication practices as well as their socialisation processes. The findings suggest that co-op games may be used as a valuable educational tool for qualifying high school students' collaboration skills as well as strengthening their group relations. The students especially valued playing *The Mind,* which they tried playing for multiple game rounds. Based on these findings, we discuss recommendations for the further use and study of co-op board games in educational settings.

Keywords: Co-op; Board Games; Microsociology; Collaboration; Communication; Socialisation.

1. Introduction

There is a growing interest among researchers in using board games for supporting learning in school contexts (Bayeck, 2020). This rising interest in the educational use of games can partly be explained by the fact that board games have developed from being a niche interest with few well-known titles such as *Chess* or *Tic-tac-toe* into a mainstream global market with thousands of new titles coming out each year (Naghikhani, 2024). Paradoxically, this wide variety of games may also make it difficult for educators to use board games to get an overview of what games to be used, how to use them, with what groups of students, and for what educational purposes.

In this paper, we wish to focus on the use of leisure co-op (cooperative) board games as a particular game format, which may have learning potential for improving student collaboration. We have chosen this focus for two reasons. First of all, we believe that the use of board games, and co-op board games in particular, offer a rich and focused approach to learning and reflecting on complex aspects of collaboration and communication, which are key skills in most educational systems (Bayeck, 2020). Moreover, we believe that leisure games may offer more engaging forms of learning than what can often be achieved through educational games.

Despite the growing interest in using board games in education, we lack more detailed knowledge on how such games are enacted and experienced by students. Consequently, this study pursues a microsociological approach to understanding how students interact during co-op board gameplay, and how they reflect upon their game experiences in relation to the norms and roles of everyday school collaboration. This brings us to our research question: How do upper secondary students interact, negotiate, and reflect upon co-op board games as a tool and activity for qualifying collaboration?

2. Cooperative Board Games and Student Collaboration

According to an international survey conducted among teachers, Danish school children are among the most frequent collaborators in terms of working in groups or in pairs (OECD, 2019). There may be many benefits from student collaboration in school contexts such as shared knowledge construction or possibilities for exploring multiple perspectives through group dialogue. At the same time, there also exist several challenges in student collaboration such as asymmetric participation or difference in communication and collaboration skills. Consequently, groups of students often end up working together more *in* groups than *as* groups (Howe & Abedin, 2013).

Parallel with the widespread practice of student collaboration, there is a high interest among Danish children and youth in playing analogue and digital games, both inside and outside school contexts. According to a large-scale survey of Danish students (N=3000) in grades 5 and 7, one of the primary reasons for playing together is linked with social relations and friendships (Hanghøj & Ejsing-Duun, 2023). This demonstrates how social aspects are crucial to most gaming experiences (Gonçalves et al., 2023).

Despite these overlapping tendencies, there exists relatively few studies on the use of co-op board games in school contexts. A recent study by Sousa et al. (2023) offers a quantitative analysis of 25 Portuguese high-school students' experiences of 5 different co-op board games. However, this study only provides limited insight into how the games were played, and how the students reflected on their game experiences in relation to everyday school practices. This calls for more qualitative approaches to the process of playing and reflecting on co-op games in educational settings.

3. Case Description

In this section we will briefly describe the two co-op games, *The Mind* and *Forbidden Island*, used in the study as well as the context for the study. The two games were studied as a part of a municipal development project entitled "Conquer the Cooperation" (in Danish: "Spil Samarbejdet Stærkt"). The aim of the project was to investigate the extent to which cooperative board games can strengthen students' understanding of academic cooperation at upper secondary school. The project is based on a collaboration between researchers from Aalborg University, the non-profit organisation The Board Game Bureau (BrætspilsBureauet), and two high schools in Copenhagen. The financial support comes from the Frederiksberg Foundation, a fund under Frederiksberg Municipality.

The project was carried out in spring 2024 in 6 classes with a total of 167 students (ages 17-19). The main activity in the project involved a visit to a class by a game facilitator, who conducted a 90-minute workshop, which divided the students into groups of four. Each group played the two co-op board games. After finishing each game, the groups discussed their game experiences and how they related to everyday cooperation in class.

The workshop's first co-op game was *The Mind* (Figure 1), which is a card game with 100 cards, each of which has a number from 1-100. In the first round, each player gets one card, so in groups of four students, there will be four cards in total. The players must lay down the cards without communicating, so that the lowest comes first and then they follow chronologically. In round 2, each player gets 2 cards, so the group now has 8 cards in total. In each round, the players get an extra card, and the players win if they manage to complete round 8 using 8 cards each. The game invites the students to develop non-verbal forms of communication to sense each other.



Figure 1: *The Mind* (Copyright: Pandasaurus Games).

The second game, *Forbidden Island* (Figure 2), is a turn-based tactical game in which players can communicate verbally. In the scenario, players must try to escape from an island that is constantly in danger of being flooded. All the players flee together or drown together. The players can escape only when they have collected four treasures. The treasures are claimed by redeeming five identical treasure cards. Along the way, the players can give each other treasure cards, ensuring that single players acquire cards faster to redeem a treasure. It does not matter who collects the treasures. During the game, players can choose to give cards to each other or counteract the flood. Each player is given a role from the start, which possesses some special abilities. The game calls for joint discussions of each player's actions and what might be the best tactical action to take.



Figure 2: *Forbidden Island* (Copyright: Gamewright).

In summary, the two games were chosen according to three criteria. First, the games had to be simple, as there was limited time for learning how to play them. Secondly, the games were chosen to explore *different game mechanics* – e.g. *The Mind* requires individual players to co-create a linear number sequence with direct consequences if they succeed or fail, whereas *Forbidden Island* relies on several different mechanics when drawing cards and moving player tokens, where it is harder to detect direct consequences of the individual player's actions. Thirdly, the two games enabled quite *different communication patterns* as *The Mind* relied on non-verbal group communication, whereas *Forbidden Island* required the players to verbally communicate and agree on shared decisions.

4. Theoretical Perspectives

In order to study the interaction and situated norms of cooperative board gaming, we will pursue microsociological perspectives on gaming (Kirschner, 2021). Microsociology focuses on small-scale, everyday interactions between individuals or small groups, interpreting how these interactions influence larger societal patterns. More specifically, we will draw on the work of Goffman (1961, 1974) on gaming encounters, and Collins' (2005) theory of interaction rituals.

According to Goffman (1961), gaming encounters can be seen as a particular form of *focused gatherings*, where gaming participants orient themselves toward each and follow the norms and rules of the specific gaming situation. Goffman (1961) also describes the *interaction tension* in gaming encounters as the game participants may be engaged in different ways during gameplay – e.g. some may be spontaneously engrossed, whereas others may be bored. Moreover, games often involve a risk of losing *face* (Goffman, 1955), e.g. when the individual player, either through his action or that of people closely related to him, fails to meet essential requirements placed upon him by virtue of the social position he occupies.

Furthermore, gaming encounters always involve specific *framings* (Goffman, 1974), which refer to the participants' mutually negotiated experiences and social norms of the game. As an example, a game session may be framed by the participants as being casual or serious. Similarly, game activities imply different framings (involving different norms and meanings), when enacted inside and outside school contexts (Hanghøj et al., 2018).

Building upon the insights of Goffman, Collins (2005) has developed a theory of *Interaction Ritual Chains*, which assumes that successful rituals create symbols of group membership and pump up individuals with emotional energy, while failed rituals drain emotional energy. Collins identifies four key ingredients for successful social interactions: *bodily co-presence* (physically assembling in the same space); *barrier to outsiders* (a sense of who is taking part and who is excluded); *mutual focus of attention* (awareness of each other's attention, focusing on a common object); and *synchronisation* (common mood or emotional experience) (Collins 2004). Correspondingly, Collins emphasises four outcomes of interaction rituals: *group solidarity* (a strengthened

feeling of group membership through shared experiences), *emotional energy* of a group (the positive or negative feeling that motivates a ritual participant toward action), *group symbols* (actions, artefacts or jargon that act as symbol carriers), and *moral standards* (shared norms and values that promote a sense of "rightness" in adhering to the group). Even though Collins does not write about board games, we agree with Stromberg (2009) that his theory of interaction rituals can also be used to describe how game participants may be able to create emotional energy through group interaction.

5. Methodological Approach

The study adopted focused ethnography as our methodological approach to documenting the students' interaction during gameplay and their following evaluation (Knoblauch, 2005). Focused ethnography is an applied and pragmatic form of ethnography that explores a specific social phenomenon as it occurs in everyday life. The focused ethnographic approach is characterised by limiting itself to a short time frame, relying on audiovisual collection techniques, gathering a large amount of data, and focusing on communicative elements. This approach seemed relevant as it was not the project's intention to follow the everyday life of a high school class over a longer period. Instead, we wanted to focus on very specific, limited elements, namely the students' game practices and their considerations about the potential of board games to enhance collaboration. We ensured focused data through our video observation of the game sessions as well as the subsequent interviews.

Our study was conducted in one of the 6 classes in the development project, where 8 students gave consent and volunteered to participate in video observations and interviews. A researcher had visited the class two weeks before the project and informed them about the upcoming workshop and the possibility of participating as informants. The 8 students were divided into two groups with an equal number of women and men. Figure 3 provides an overview of the informants' anonymized names. Students at the same line were interviewed together.

Table 1: Overview of informants.

Group A	Adam (M)	Beate (F)
	Chris (M)	Diana (F)
Group B	Elin (F)	Frederik (M)
	Gustav (M)	Hannah (F)

The eight students, as well as the rest of the class, conducted the workshop in the same room, which was also their usual classroom. The two groups that we observed were placed at the back of the room, where the cameras were set up (Figure 4). One camera filmed the tabletop where the game was placed, and the other two cameras filmed two students from each group.



Figure 4: Camera setup. Two cameras each focusing on a couple of the plates. One camera aiming at the table.

The video observation gave essential insights into how the students negotiated the collaboration during the game as well as their post-game discussion. The analysis was inspired by a multimodal approach, where both the spoken word as well as gestures and the role of the artefacts can give insight in the social relations (Davidsen & Ryberg, 2017). The multimodal understanding of communication was especially important in relation to the game *The Mind*, where the students were not allowed to communicate verbally. In our analysis, the verbal as well as non-verbal communication were included in our understanding of the collaboration.

After the workshop we processed the video data and began the analysis. We decided the topics for the student interviews and chose video sequences to play at the interviews. Two weeks after the workshop, we conducted the interview. The informants were asked the same questions, which were divided into three themes: 1) their experience of playing *The Mind*, 2) their experience of playing *Forbidden Island*, and 3) their thoughts about what they might learn about collaboration from the boardgames.

We choose to interview the students in mixed gender couples. We hoped that hearing each other's thoughts would inspire further reflections. To help facilitate the recall of events and reflections, the interviewer had placed the two board games on the table. At the interview, the students saw a two-minute scene of themselves playing the board game, prior to questions about the experiences related to the board game.

When addressing the third topic – what they might learn from the board games – we had written down quotes from the students during their post-game discussions, which reflected their game experiences. In the interviews, each student had to select a quote, which he or she thought came the closest to their own experience and then comment on it. Examples of the quotations: “The games can help us get used to each other's way of collaborating” and “In the game, no one knows the answer, but if you are confident in your answer, you can convince the others, even though no one actually knows what is correct.”

The combination of video observation and interviews allowed us to both follow the players’ negotiations as it happened and return to scenes that the students discussed post-game and in the interviews. This enabled us to compare observed behaviour with expressed reflections. Having transcribed and coded the data, we performed a thematic analysis that identified analytical themes through patterns of variation across the different data types (Braun & Clarke, 2006).

6. Analysis

Based on our thematic analysis, we identified two analytical themes: 1) *Learning to collaborate: Verbal and non-verbal communication*, and 2) *Learning to socialise: Make or break for all*. Each theme is based on data from the video observations as well as interview data.

6.1 Learning to Collaborate: Verbal and Non-Verbal Communication

The first analytical theme concerns the students’ verbal and non-verbal communication during gameplay as well as their post-game reflections on the same topic. More specifically, the theme concerns the communicative skills that the students needed to use during gameplay, and how this related to everyday forms of student collaboration.

Based on the different mechanics of the two games, the students’ communication patterns differed substantially across the two game sessions. When playing *The Mind*, the students had to be silent as the game only allowed them to communicate through eye contact and bodily gestures when gradually putting their handheld cards on the table in varying tempos. During the game, Elin laughingly encouraged the others to read the number in her eyes, and then she tried to draw the number with her eyes by moving her pupils. The others gave up laughing at their attempts to read the number she visualized. In this way, each student group’s interaction ritual relied heavily on bodily co-presence and mutual awareness (cf. Collins, 2005). Moreover, the students’ focused group interaction created high emotional intensity. Once a game round had been won or lost, this could be seen in loud emotional outbursts among group members – e.g. by spontaneously clapping their hands or making whooping sounds that reflected their wins and losses (cf. Figure 5).



Figure 5: Players clapping and cheering after completing a game round in *The Mind*.

When playing *Forbidden Island*, the interaction and communication patterns in the groups were quite different. In contrast to the rhythmic patterns in *The Mind*, where group members shifted between being silent and engaging in loud outbursts after each game round, the students would talk more or less constantly when playing *FI*, which lasted for about 30-40 minutes. Even though the game was turn-based, the group members discussed collaboratively before agreeing on the best move for each player (cf. Figure 6). In this way, there was less emotional intensity in the room, but constant verbal negotiation, which weighed different strategies, possible moves, and their consequences.



Figure 6: Players discussing and instructing the next player's move in *Forbidden Island*.

In the post-game interviews, the students commented on how their game experiences (especially from playing *The Mind*) required them to "read the other players' body language and eyes" (Elin) to avoid losses. Moreover, the students also described how the games made them reflect on their everyday communication and collaboration in school. One student, Elin, described how the game made her think about her own approach to collaboration, where she would often be (too) talkative:

> *So, normally I talk a lot, so the thing about not being allowed to say anything, I just had to get used to that, where there are others who might be used to being completely silent. In other games, you must communicate a lot verbally. And then it can be a challenge for them, so you can also develop those skills and get used to the fact that it is not dangerous to say something, nor is it dangerous to say a little less*.

This example shows how the students used their game experiences to reflect on different forms of "interaction tension" (cf. Goffman, 1961) and social norms that accompany different types of collaboration, both during gameplay and student work. Student collaboration as well as co-op gaming both require participants to align their social norms and find ways to reduce tensions in their interaction to make sure that the communication flows. As the quote shows, this implies that group members should neither be allowed to take too much space nor be too passive. Through such reflections, the students pointed out a learning potential in co-op board games in terms of becoming more aware of how and when group members should take the floor in student collaboration. Moreover, another student mentioned how co-op games could be used for "tuning in" to each other when doing group work or help to prepare for oral group exams (Chris). In this way, the co-op games could

be used to learn communicative and social skills, which was not only relevant to the game, but also everyday forms of student collaboration in upper secondary education.

6.2 Learning to Socialise: Make or Break for all

Playing co-op games provides the participants a way of socialising which is different compared to other game types. Many games include a clear distinction between winners and losers among players. Co-op-games are unique in the sense that there seldom is an internal division. Instead, the players participate as an entire group, who will make it to the victory or break and loose. In this analytical theme, we will investigate how the group participants socialise and contribute to a shared mood (cf. Collins, 2005) in the groups, and afterwards how the co-op-setup reflects the individual player's facework.

Even though co-op games do not encourage internal competition, locked situations can still arise, where the players' mutual assessments and decision-making may come into conflict. Such a situation arises at one point during the game session with *The Mind* (cf. Figure 7). The three players Elin, Frederik, and Hannah are in a situation where one of them must play the next card, but none of them want to. Elin and Frederik sit next to each other. Frederik puts his card on the table, presses his lips together in a smile, stares at Hannah, and folds his arms. Elin glances sideways at Frederik, presses her lips together, places her card on the table, puts her hands under the table, and smiles at Hannah. From Hannah's perspective, she sees two smiling teammates across from her, who have put down their cards on the table without showing any initiative to place their cards on the pile. Seconds pass. Hannah laughs. Elin and Frederik smile. Visibly pressured, Hannah throws her card onto the pile. It turns out to be the right move. Seconds later, the remaining players place their cards on the pile in the correct order, and the game round is won.



Figure 7: Elin with her arms crossed. Frederik with hands under the table. Hannah must take the next move.

The preceding tense situation triggered a shared mood, which in some games could have been a negative experience or cause tension. But with Elin and Frederik's comical imitation of each other's refusal to play their cards, they ease the situation's potential serious pressure on Hannah. In other situations, Hannah's action could be seen as a loss, as she is pressured to act against what she thinks is in their common interest. However, within the contexts of the co-op game, Hannah's yielding to the pressure turns out to be in the group's common interest in terms of making progress in the game. Her action triggers a positive shared energy that has a group-building effect (cf. Collins, 2005). So, what in other games could be seen as Hannahs individual defeat ends up being a collective victory; also for Hannah, who is celebrated for having yielded at the right moment.

During *The Mind* game sessions, the groups often found themselves locked in situations like the one mentioned between Hannahs and her teammates. In the succeeding interviews, the students commented on these situations. Chris explains that as a player you can only see your own card, which makes you believe you know how the cards should be played. However, the individual player does not have all the facts. Other players have their own cards and information exclusive to them. As a player, you need to count on the other players' insights. Diana and Chris elaborate further on this:

> *Diana: Everyone needs to participate for us to move forward. So, you have to look, okay, Chris is just sitting back completely, and Beate, she's ready, and if you also have low cards yourself, then you have to follow along. This is also generally true in group work, where you can see that some people might be more reserved with their answers, and then there are those, who just say something even if they have no idea whether it's right or wrong, just to say something. So, actually it is important to get everyone to speak up.*
>
> *Chris: I also think exactly what you said about being reserved. If you think about it in the context where Beate has low cards, but you also have low cards yourself. But you still have to make a decision about whether to wait or not, because you can sense that we are somewhat in the same number range, so you don't know, you have to either break through or hold back a bit.*
>
> *Diana: It's about actually daring to come forward with your point and without it being at the wrong time.*

As Diana and Chris explains, you cannot choose to not play your cards in *The Mind* as this will make the entire team lose. Everything depends on each player's active throwing of cards on the pile. Transferring the situation to group work, Diana and Chris also explain that when you work together, you need to dare to continue even though you get stuck.

As the locked situation with Hannah and the game-enhanced participation explained by Diana and Chris suggest, the students experience that playing co-op games may both have a group building effect and being able to support the development of group solidarity (cf. Collins, 2005). According to Diana and Chris, there are a lot of competitive persons in their class. In this way, they perceive co-op games as being particularly relevant in a high school setting to counterbalance the high focus on competition.

The discussion of competitiveness recurs in other interviews. Interestingly, several of the informants begin by stating that they are not competitive people, only to later change their statements to say that they are competitive people. This shows how there was a tendency for the informants in their facework (cf. Goffman, 1955) to distance themselves from the role of a competitive person. Being competitive is not perceived positively by the informants, as the role is associated with behaviour that can seem exclusionary and demoralising. Normally when playing board games, the competition might cause tension between the playing students. Hannah says:

> *Playing might be more fun, when there is a winner and a looser, but it can also quickly get out of hand. Some people get upset, or it ends badly, especially if you're in a class with many competitive people*".

Here Hannah emphasises that playing games involves a risk of reducing the sense of security within the group. From this perspective any board game might not necessarily support the development of group solidarity. However, the co-op games are *framed* (cf. Goffman, 1974) differently, as the players' competitiveness do not seem to be triggered when they are playing against the game itself. In Gustav's words: "You are not face to face against another person. The co-op board game is just pieces and cards." Thus, this game format does not trigger what he describes as his competitive mentality. According to Chris, he is a competitive person and is eager in securing that he or his teammates are making the best moves. However, he finds that his competitive nature is not triggered in the same way in the two games:

> *When it comes to competitive people, in* Forbidden Island *you wouldn't notice mistakes right away. If you spend the wrong card, it will bite you later, whereas in* The Mind *you can more directly and concretely see if you played a card too late or too early*.

Chris had to put more effort into facework and tolerate his own or others' unfortunate moves in *The Mind*, whereas in *Forbidden Island*, he finds himself being a bit more reserved.

On the one side, the students experience how competition may spark competitive energy and excitement. On the other side, competition also comes with a risk of damaging the relationship in the group. When Hannah is asked whether she would prefer to put the co-op games aside in favour of more risky and fun competitive games, she answers:

> *No, I don't think so. I think it (co-op-games) provides something different. I may not find it as exciting, but it contributes to cooperation and communication. I believe it offers many more positive qualities than if we were playing against each other*.

From Hannah's perspective the goal of playing co-op games is not simply having a fun time in class, but just as much as a way of learning to cooperate. In this way, she frames co-op games as having a clear educational value, even though they may be less fun than competitive games. In summary, the findings of this analytical theme indicates that co-op-games can serve as a tool for supporting group solidarity through shared moods and increased emotional energy. Using co-op-games may diminish the risk of conflict. Moreover, competitive players might have an easier time controlling possible losses.

7. Discussion

The analysis shows how the students actively engaged in the co-op games by interacting verbally and non-verbally with each other during the game sessions when negotiating their moves. Through mutual awareness, the students contributed with high emotional energy to the shared non-competitive mood of playing together as groups against the co-op games. The emotional intensity among group members was particularly high when the students played *The Mind*. Moreover, the analytical themes show how the students' reflected on their gaming activities in relation to the skills needed for everyday forms of student collaboration as well as different possibilities of supporting group socialisation in upper secondary education. Taken together, these findings indicate how the students frame co-op board games as valuable pedagogical tools, which can create mutual engagement among group members, which may potentially both support collaboration and socialisation processes.

Our study is based on a microsociological approach to mapping students' gaming interaction patterns as well as contextualising their post-game reflections. This approach allowed us to document detailed aspects of the student group's in-game communication patterns, and how the students related their gaming experiences to their everyday collaboration and socialisation practices in upper secondary education. There exist relatively few studies, which maps students' gaming practices through a microsociological lens – for exceptions, cf. Wisittanawat & Gresalfi (2021) and Hanghøj (2008). In this way, our study provides new microsociological findings and perspectives on how local gaming processes and interaction norms can be linked to everyday study practices.

However, there are also obvious limitations to our study. First, the students were only allowed to play the two co-op games for a relatively short time. This was particularly problematic with *Forbidden Island,* which the students were barely able to finish, before being asked to discuss the game. Based on the students' excitement with playing *The Mind* several times, which allowed them to discuss, reflect on and improve their strategies, it is highly likely that the students would also have benefitted from replaying *Forbidden Island*. Moreover, we were not able to explore how the games could have been adopted in everyday educational practice as this was beyond the scope of the development project, which formed the context of our study. In this way, we have not been able to validate the students' claims regarding the potentials of the co-op board games in terms of supporting collaboration and socialisation. This points to the need for more longitudinal studies of how co-op games may help to develop local practices.

8. Conclusion

The aim of this paper was to explore how upper secondary students interact, negotiate, and reflect upon co-op board games as a tool and activity for qualifying everyday forms of student collaboration. Analysis revealed that the students became actively engaged in playing the co-op games, employing different strategies and modes of verbal and non-verbal communication. Moreover, they reflected on how the gaming experiences related to their own roles during student collaboration, and how co-op games may be especially suited for socialising students into new classes, which is a vulnerable and mandatory process for all Danish upper secondary students. Based on these findings, our paper points to the need for more research on the process of playing co-op games, and how this may help qualify everyday forms of student collaboration and group formation.

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StaffsVerse: Building a Metaverse Campus Utilising the Unreal Editor for Fortnite

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Abstract: In pursuit of redefining the conventional campus introductory experience, this paper presents the development and implementation of the StaffsVerse project - a virtual campus immersion tool. Designed as a Metaverse representation, the StaffsVerse project intends to transform the physical campus of Staffordshire University into an interactive digital environment. Its purpose extends to serving as a versatile tool for remote education delivery, virtual campus tours, public science outreach, and facilitating a seamless transition for students into the university community. Through immersive digital engagement, the StaffsVerse project seeks to bridge the gap between remote learners and the campus environment while facilitating a smooth integration into academic and social aspects of university life. In contrast to previous implementations of virtual campuses, the StaffsVerse project is unique in leveraging the capabilities of Unreal Editor in Fortnite (UEFN). This approach enables the development of highly detailed, interactive, and engaging environments within the expansive Fortnite ecosystem. The project's primary objective is to harness the infrastructure and extensive user base of one of the world's most widely played multi-platform games, thereby ensuring a low barrier to access. Therefore, this paper will explore how the UEFN system's adaptability can effectively create an accurate virtual replica of the physical Staffordshire University campus. The key contribution of this paper includes an overview of the design and developmental journey of the StaffsVerse project. The evolution of the project will be outlined by discussing the two pivotal iterations of the game-based implementation and explaining the decision-making process that led to the resulting version. The examination extends to the unique features of the UEFN build, addressing the inherent challenges and opportunities specific to the platform. Furthermore, specific game-based decisions are discussed, such as replicating essential campus locations, integrating interactive features, and incorporating elements unique to the virtual environment. The paper will discuss the specific educational opportunities UEFN offers, including the potential for enhancing student engagement through gamified campus experiences, insights into creating a Metaverse university campus, and contributions to the growing discourse on the intersection of game-based virtual environments in learning.

Keywords: Metaverse, Student Engagement, Virtual Worlds, Onboarding, Virtual Campus

1. Motivation

Student demographics have driven transformational thinking in how educational services are delivered and experienced. This shift is particularly critical in higher education, where traditional methods often limit accessibility and fail to engage a technologically proficient student body. The advent of virtual environments and digital platforms presents an opportunity to redefine engagement paradigms.

Student transition is a known challenge in higher education. University is for many individuals, their first time living away from home. It requires adapting to new ways of learning, and increased autonomy, and this transition can create challenges. Typically, universities have used welcome (“fresher”) weeks to support this adjustment. But this often only begins once the student has arrived on campus. Other institutions have explored using their VLE to provide some pre-enrolment transition activities, but these often suffer from limited participation.

There is also the challenge of location acclimation. Most students will find themselves getting lost in their first few weeks of study while they try to learn to navigate a large campus. While many institutions offer “open” days and applicant sessions, these only provide a small opportunity to experience the campus. However, in recent years, due to the cost-of-living crisis, an increasing number of students are struggling to attend these sessions. For this reason, traditional campus tours and orientation processes can be intimidating and inaccessible for many potential students, especially those from international or remote backgrounds.

By creating a metaverse version of the Staffordshire University campus, the project aims to democratise access to campus experiences, allowing students to explore and interact with the campus environment from anywhere in the world. The Staffsverse project leverages the interactive capabilities of UEFN to create a dynamic learning

environment that goes beyond static online courses and video lectures, offering real-time interaction and exploration of educational content.

The choice to use Unreal Editor in Fortnite (UEFN) for developing StaffsVerse is driven by the popularity and extensive reach of the Fortnite platform. Fortnite's global popularity ensures that the virtual campus is accessible on a platform many students are already familiar with and enthusiastic about. This approach not only lowers the barrier to entry by using a familiar interface but also taps into the engaging and interactive elements of gaming to enhance the learning and orientation process.

Finally, the development of StaffsVerse is motivated by a forward-looking vision for the future of education. As digitally capable individuals become the primary demographic in educational institutions, there is a growing need to incorporate technology not just as a tool, but as an integral part of the campus infrastructure. A student's online engagement will need to offer an experience that compliments the physical resources of the institution.

2. Background

In the evolving landscape of Higher Education (HE), the shift towards virtual environments is driven by the need to adapt to the changing demographics and technological proficiency of students (Díaz et al., 2020). The StaffsVerse project, leveraging Unreal Editor in Fortnite, exemplifies this transformation by offering an immersive, interactive virtual campus that enhances the introductory and ongoing campus experience for remote learners. This exploration discusses the transformative impact of digital platforms in HE, and explores the development and utility of virtual campuses, the integration of gaming elements for learning, and the significant potential of metaverse technologies to enhance both academic learning and social connection in university settings.

2.1 Virtual Campuses and Online Tours

Virtual campuses have been a part of the educational technology landscape for over two decades (Anderson et al, 2020). One of the earliest and most notable implementations of virtual campuses occurred in environments like Second Life, where institutions such as Stanford University and the Open University established virtual campuses (Rymaszewski, 2007). This initiative was specifically designed to ease the transition for incoming students by creating a virtual replica of the campus environment. As part of their introduction to university life, students navigate through various interactive tasks and scenarios that simulate real-world campus activities. Studies from this period, such as those by Dalgarno (et al., 2010), have emphasised the importance of these interactions in creating engaging learning environments that extend beyond traditional classroom settings (Dalgarno et al, 2010; Jin et al., 2022).

As technology evolves, the focus of research shifted towards the immersive capabilities of technologies such as Virtual Reality (VR) (Heise et al., 2021). Recent advancements have seen the development of VR tours and interactive maps that enhance the induction process for new students. These tools serve not only to introduce students to campus layouts but also to significantly lessen the anxiety associated with navigating a new and often overwhelming physical environment (Concannon et al., 2020; Hawes & Arya, 2023). Research by Montana (et al., 2019) highlights that these virtual introductions can greatly ease the transition for incoming students by reducing initial stress and building familiarity, which in turn helps in smoothing their integration into their university life (Montana et al., 2019; Di Natale, 2024).

Moreover, these virtual experiences are increasingly recognised for their potential to make campus tours accessible to all, which can be particularly beneficial considering barriers that might prevent prospective students from visiting campuses (Baguma & Wolters, 2021; Dwyer et al., 2023). As institutions continue to explore these technologies, the emphasis is on creating more inclusive, engaging, and supportive virtual environments that cater to a globally dispersed student demographic. This shift not only reflects an adaptation to student needs but also aligns with broader educational goals of increasing accessibility and reducing barriers to higher education.

2.2 Transitional Games

Within the dynamic and evolving landscape of Serious Games (SG), where the integration of play and learning extend beyond mere entertainment to educational and therapeutic applications, a distinct category emerged - Transitional Games. Defined as "A subset of Serious Games, with the aim of supporting an individual through a period of transition, whether it be emotional or physical" (Threlfall et al., 2022). These types of games are

meticulously designed to assist individuals as they navigate significant changes in their lives, which can range from entering new educational environments, adjusting to different social settings, moving through different life stages, or recovering from physical or mental health conditions.

Transitional Games uniquely blend the engaging elements of gaming - such as storytelling, interactive gameplay, and immersive environments - with the structured support needed to facilitate a smooth transition. By focusing on both the emotional and practical aspects of change, these games provide a valuable resource for learning and adaptation. They do this by creating scenarios that mirror real-life challenges, thereby offering players the opportunity to practice responses and strategies in a controlled, risk-free setting.

This innovative approach allows players to develop necessary skills and coping mechanisms that can be critical during times of change. By fostering a deeper connection to the experiences faced during transitions, Transitional Games contribute significantly to the field of SG. They not only entertain but also empower individuals, helping them to face their real-world situations with confidence and a stronger sense of preparedness (Threlfall et al., 2022).

2.2.1 Examples of Transitional Games

Transitional games represent a dynamic subset within the field of SG, specifically designed to aid individuals during significant periods of change. These games effectively address various transitional needs, from easing students into university life to supporting young individuals in managing mental health challenges. The breadth and impact of serious gaming as a transformative educational and emotional support tool are clearly demonstrated through these applications.

2.2.1.1 Campus Quest

In response to the challenges new students face when transitioning to higher education, Curtin University teamed up with 2and2 to create Campus Quest, a gamified environment that allows players to get a glimpse of university life (Tutty & Leslie-McCarthy, 2012). This game targets young people from diverse backgrounds - including low-socioeconomic, regional, and indigenous communities. In the game, players strive to excel academically while managing four critical metrics: time, income, research, and social life. By engaging in various quests, each impacting these metrics differently, players gain insights into essential aspects of university life, such as securing housing, finding part-time jobs, and navigating support services.



Figure 1

The game's design simulates the delicate balance required in university life, where students must adeptly juggle academic responsibilities with social activities and financial management (Tutty & Leslie-McCarthy, 2012). Success in the game depends on maintaining a sustainable balance among these aspects, reflecting the real-life strategies that can help students thrive in higher education settings. Through this interactive experience, Campus Quest goes beyond mere entertainment; it serves as a practical tool that prepares students for the multifaceted challenges of university life. The transition from secondary to higher education is not just a change in academic setting but a significant life event. Campus Quest incorporates pedagogical principles that teach players about balance, resource allocation, and time management, key skills that support a successful adaptation to higher education.

2.2.1.2 SPARX

SPARX represents an innovative approach to mental health designed specifically for young people navigating the emotional transitions associated with adolescence to early adulthood. Developed through a partnership between the University of Auckland and the New Zealand Ministry of Health, SPARX is an interactive computer gam grounded in cognitive-behavioural therapy (CBT) principles to help teenagers manage symptoms of depression and anxiety (Merry et al., 2012; Lucassen et al., 2021). Within the game, players embark quests within a fantasy world where they are tasked with restoring balance to a virtual environment clouded by negative thoughts. As they advance through various levels, players face challenges that teach vital coping strategies, including breathing techniques, the identification and restructuring of negative thought patterns, and participation in activities that foster positive emotional growth.



Figure 2

The game structure allows players to learn at their own pace within a safe and engaging environment. Each level is designed to build upon the previous one, ensuring a gradual increase in skill and understanding. The game's narrative and challenges mimic real-life situations that might trigger stress or anxiety, providing players with practical skills they can apply in their daily lives (Merry et al., 2012; Lucassen et al., 2021). This helps to facilitate a smoother transition through potentially turbulent times by equipping players with the tools they need to manage their mental health effectively.

SPARX is exemplary of a transitional game as it aims to mitigate the emotional challenges of transitioning into adolescence and beyond. It serves not only as an educational tool but also as a therapeutic intervention that promotes mental well-being in a format that is accessible and relatable to young people. By blending therapeutic principles with engaging gameplay, SPARX effectively prepares its players for the emotional aspects of growing up, making it a critical tool in the landscape of educational and supportive serious games (Merry et al., 2012; Lucassen et al., 2021).

3. Universities and the Metaverse

The rise of the metaverse marks a significant evolution in the digital landscape, offering universities innovative ways to create, interact, and engage. As an advanced virtual environment, the metaverse provides persistent, immersive, and interactive experiences that goes beyond the capabilities of earlier virtual learning environments (Tan et al., 2022). Universities are increasingly drawn to these platforms for their potential to not only replicate physical spaces but also to foster new educational standards and enhance student engagement (Zhang et al., 2022).

Metaverse platforms allow universities to create dynamic virtual campuses that facilitate a range of interactions—from academic lectures to social gatherings—thus extending the traditional educational environment into a more flexible and accessible digital realm (Wang et al., 2022). These platforms support a variety of learning activities that can adapt to different learning styles and needs, thereby offering a more personalised educational experience. Research by Lee et al. (2021) emphasises how the metaverse can transform pedagogical approaches, allowing educators to implement experiential learning, simulations, and real-time collaboration on a global scale (Lee et al., 2021).

The StaffsVerse project, utilising the Unreal Editor in Fortnite, exemplifies this innovative approach by integrating the educational framework within a platform widely recognised and used by students around the globe. This not only reduces the technical and financial barriers to entry but also capitalises on the engaging and

interactive elements inherent to modern gaming environments. Furthermore, the StaffsVerse initiative is illustrative of how universities can leverage popular culture and technology to enhance educational accessibility and engagement. The use of a well-known gaming platform helps to bridge the gap between recreational and educational activities, attracting students who might not otherwise be reached through traditional methods. This approach also taps into the collaborative and competitive spirit of gaming to foster a deeper connection with educational content, encouraging more active participation and retention of information.

In conclusion, as universities continue to explore the metaverse, the potential for these platforms to revolutionise education becomes increasingly apparent. The metaverse not only supports the replication of physical campuses in a digital format but also encourages the development of innovative teaching methods and new forms of academic and social interaction. This shift towards immersive digital education platforms like the StaffsVerse project represents a forward-thinking approach to education, promising to enhance learning experiences, increase accessibility, and prepare students for a future where digital and physical realities are increasingly intertwined.

4. Pilot: The Mars Campus

Implementing the StaffsVerse campus was done in two phases. We initially constructed a pilot to explore several key questions, specifically regarding scalability and user experience. This Campus pilot was the “Staffordshire Mars Campus”, pictured in Fig.1.

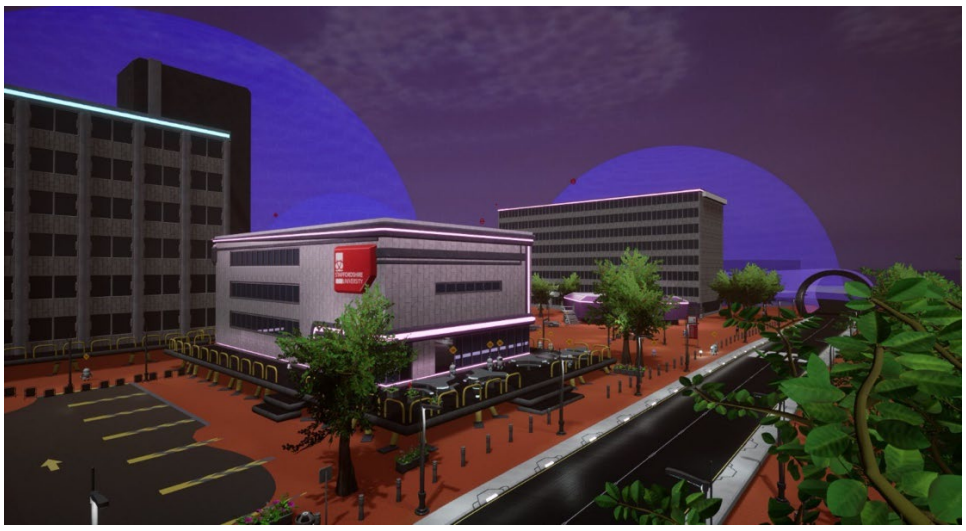


Figure 3: The Staffordshire Mars Campus. Pictured from left to right is the Melor, Beacon, and Flaxman buildings.

We made a number of design decisions in the implementation. Most notably, we chose to implement the campus as a creative “interpretation” rather than a true to life representation. We made the choice for two main reasons.

1. It enabled us to focus on the general navigational experience, avoiding unnecessary detail.
2. It facilitated a low-resolution rendering style that would be more efficient to deliver.

For this we chose the theme of a university on Mars and used that narrative direction to influence the visual elements of the implementation. However, although the visuals were a creative interpretation, the environment was implemented at a 1:1 scale implementation of the real-world campus. This meant that all the virtual features were in the same positions (and size) as their physical counterparts, this ensured that the navigation experience was analogous to navigating our Stoke-on-Trent campus.

We used this pilot to explore a number of technical challenges, but critically how to deliver a large-scale open world environment to multiple concurrent users. The aim of the pilot project was to create a live world that users would be able to login, interact with other players and engage in activities in real-time. Development of a bespoke implementation of a metaverse like application whereby potentially 100s of users can access the platform at any given time possess a huge technical and costly feat to ensure a smooth uninterrupted and secure play experience.

Historically, peer-to-peer (P2P) networks were a popular choice for hosting multiplayer games. However, over the years, the approach has fallen out of fashion. In a P2P setup, the responsibility of managing connections falls directly on the user. This requirement can prove technically daunting for average players who may lack the necessary expertise particularly when network configuration such as port-forwarding is required.

Moreover, P2P networks are inherently fraught with security management challenges. The decentralised nature of these networks, while offering certain benefits, significantly complicates the implementation of effective security measures. As a result, these networks are more vulnerable to attacks and breaches, which can compromise user data and game integrity (Glazer & Madhav, 2016).

Additionally, the structural attributes of P2P networks facilitate easier game outcome manipulation, making cheating a more prevalent issue. Players can exploit the network's vulnerabilities to alter game data or disrupt other users' connections, which undermines the fairness and competitive spirit of the gaming environment (Yahyavi & Kemme, 2013).

Given these issues, the gaming industry has gradually shifted towards more centralised (client server) network models (Lindner, 2023). These alternatives not only relieve the user from the burden of network management but also enhance security protocols and provide a more controlled and equitable gaming experience. This transition reflects an ongoing effort to address the intrinsic weaknesses of P2P networks while embracing the technological advances that promote a safer and more enjoyable multiplayer gaming landscape.

Games as a Service style games that can be updated in real-time require the use of dedicated servers, which allows developers to add new features to the application on the back end to add more playable content (Vaudour & Heinze, 2019). By focusing on this model for StaffsVerse events could be created around key points of the academic year such as open days, Welcome Week and large-scale events. This would enable the development of an ever-evolving environment where students could gain an understanding of these events at their own pace.

Commercial games and metaverse applications typically achieve this by hosting portions of the game in the cloud using solutions such as Amazon GameLift (Amazon) and Azure PlayFab (Microsoft). However, this comes with a significant cost, both in the rental of cloud computation and the cost of maintaining a self-managed system. This approach has the benefit of being able to rapidly spin-up additional servers should capacity be required.

However, these systems are primarily funded by the users themselves. Specifically, as players purchase or subscribe to a game, their contributions directly finance the necessary server capacity (Davidovici-Nora, 2013). This financial model aligns the scalability of the system closely with user growth. moreover, as our objective was to provide this service free of charge, we faced challenges in achieving the same financial sustainability. Following a detailed cost analysis, it became clear that hosting on a commercial cloud server was not a financially viable option for our project.

Another issue that was present was ensuring accessibility of the software. We developed this platform for Windows and targeted lower-end graphics cards. However, we could not guarantee the potential player base had access to the required hardware. Developing the application for more platforms such as consoles (PlayStation, Xbox and Switch) and mobile devices (iOS and Android) would only add to the increasing cost of development and maintenance.

In response, we explored alternative funding models and cost-effective hosting solutions that could support our vision without compromising service quality. This included considering partnerships and seeking sponsorships to offset operational costs, thereby ensuring the longevity and accessibility of our service. However, the release of the Fortnite Creator programme provided a suitable alternative.

5. Building Fortnite Maps in UEFN

5.1 What is UEFN?

Unreal Editor for Fortnite (UEFN), is the PC-only software used for creating custom experiences in the Fortnite ecosystem (Epic Games[1], 2024). UEFN provides a 3D viewport workstyle which will be familiar to developers who are used to working with Unreal Engine and the standard Unreal Editor.

UEFN allows developers to create Islands which Fortnite players can access through the Fortnite game client.

UEFN runs on Unreal Engine 5 (UE5), providing access to Unreal Engine's powerful rendering systems including Nanite and Lumen with preset islands delivering the Fortnite lighting aesthetic straight out the box. The toolset delivers a very familiar experience with most toolsets including Niagara (particle systems), the Material Editor, Sequencer (cinematic animations) and Control Rig (skeletal mesh animation), and the Landscape sculpting tools being available in UEFN.

The one key difference between UEFN and UE5 is the lack of script editing in Blueprints. Instead, opting to provide pre-set building blocks for games from "Fortnite Creative known as Devices" (Epic Games[1], 2024) which can be expanded with the Verse, a new programming language from Epic Games which has debuted in the UEFN ecosystem.

Fortnite is a Free-to-Play Game with no upfront cost to install the game or access User Generated Content (UGC) such as our virtual campus experience. Additionally, the wide array of possible hardware that Fortnite can be installed on reduces the need for purchasing of new systems to interact with the experience.

5.2 Rationale of using Fortnite to build a Virtual Campus

UEFN offers multiple key benefits compared to using UE5. Distribution of the project is important to its success, "UEFN is designed to create experiences for Fortnite. This means every experience you create is published to the Fortnite ecosystem, reaching a built-in audience of millions." (Epic Games[1], 2024), this means there is a high potential that applicants and students will at least have some level of familiarity with Fortnite's gameplay and menus, improving accessibility to the virtual campus experience.

5.2.1 Device Support

Fortnite itself is available for download on a wide array of devices, so instead of being restricted to a PC-only experience with UE5 (console release requires additional hardware and licensing), a UEFN developed experience can be released onto everything from PC to mobile devices (Epic Games[2], 2024), including both 8th generation consoles including Sony's PlayStation 4 , Microsoft's Xbox One, and the Nintendo Switch, and 9th generation games consoles including the PlayStation 5 and Xbox Series X/S devices.

Fortnite can be played on mobile devices natively using Android systems or via game streaming services (Epic Games[3], 2024) including Xbox Cloud Gaming, which offers access to Fortnite for iOS users on iPhone or iPad, and Nvidia Geforce Now which provides expanding the userbase for Fortnite to additional users include those with Chromebooks and a variety of TVs.

5.2.2 Decreasing Development Time

UEFN provides a significantly shorter pipeline of development due to having a large selection of features and functionality already in place, reducing the need to develop significant parts of the project.

This includes the core mechanics such as inputs, cameras, movement, interaction, and weapon-based combat to create third person games. The ease of access to a third person game template is ideal for the virtual campus experience although we made the decision to remove the default weapons from the experience.

These elements contribute to shorter development times for game developers, Bungie co-founder Alex Seropian setup Look North World to exclusively make games in Fortnite (Ferdinand, 2023), in discussion with YouTube channel GameDevAdvice *(2024)* stated "we've been going for six months, we've we just released our third game", highlighting a severely reduced development cycle time compared to normal games development which can take two to seven years to develop (Juegoadmin, 2023).

5.3 Overcoming the Technical Challenges by utilising UEFN

As well as mechanics already being setup and ready to use, certain technical challenges have been solved ahead of development, removing the need for lengthy, complex development processes to meet the requirements of the virtual campus experience including online gameplay, distribution, user management, and platform specific engine development.

5.3.1 Network Replication

UEFN removes the need for the development of network programming and dealing with replication of entities across networks due to built-in networking code which is running inside the Fortnite Framework. Fortnite

already supports up to 100 concurrent players on an Island (Epic Games[4] ,2024) with full replication of players, the world and actors within it.

5.3.2 Distribution

Islands created in UEFN are accessible from the main menu of the Fortnite game client by entering an island code in the search tool or by selecting featured islands from the graphical interface. Islands are downloaded via the game client and matchmaking is launched once complete.

5.3.3 User Management

Utilising the Islands system in Fortnite means all user management including login / join and logout / leave as well as having built in communication systems such as chat, parties, and friends etc.

5.3.4 Source Control

A bonus of UEFN is the inclusion of Unreal Revision Control allowing teams to work collaboratively on projects and reduces risk of lost work. Unreal Revision Control includes an Auto Checkout feature which, when enabled, locks assets the moment they are modified to prevent concurrent changes and merge conflicts. (Epic Games[5], 2024)

5.4 Insights from Implementation

During development of the UEFN version of the project, we identified the following approaches to assist with creating the virtual campus experience:

UEFN has a limitation on the size of the island, with a download size limit for users of just 400MB. With the need to focus on accurately representing the buildings and the location of the Stoke-on-Trent campus, we decided to weight our custom assets for the island to be meshes as opposed to textures or materials. To do this, we utilised existing textures and materials from Fortnite with tweaks and colour tints which also assisted the team in achieving the Fortnite art aesthetic. The memory usage of the project at time of writing is shown in Fig.2, currently using around a quarter of the available resources with most of the new assets in place.

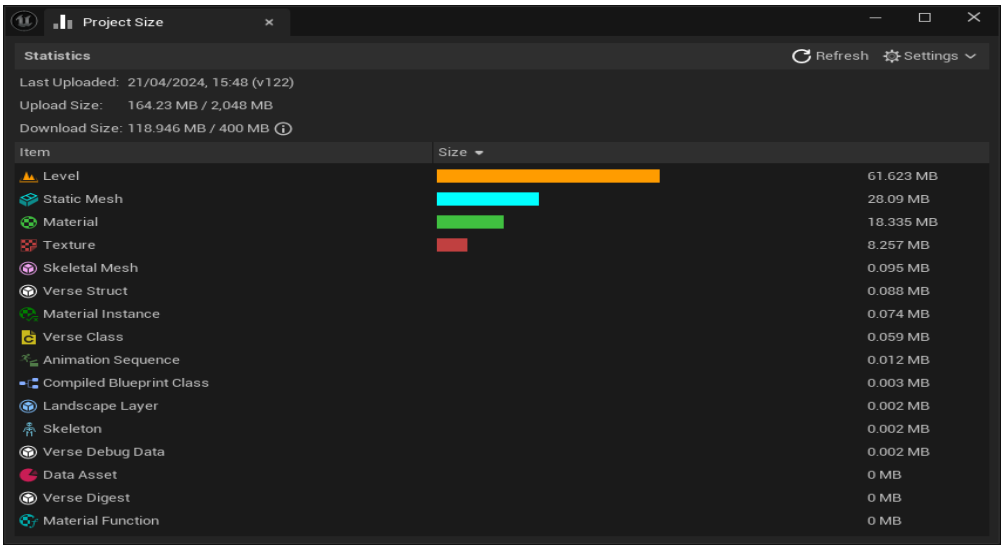


Figure 4: Screenshot of Project Size dialog of the StaffsVerse Island in UEFN

To maintain the technical consistency of Fortnite and allow us to use existing art assets and modular building pieces, all buildings were constructed using new assets, built to the same modular piece size as the existing Fortnite assets. All modular pieces were built around a base dimension of 512cm x 16cm x 384cm with some deviation allowed for unique assets or assets which required a particularly difficult form to achieve whilst maintaining those base dimensions. Trims were also created with sizes of 32, 64, 128, 256 etc. to facilitate further decoration of campus buildings.

Based on our experience, we highlight the following as key insights:

- Fortnite / UEFN provides an ecosystem which will speed up project development due to the built-in solutions for user management, networking and distribution.
- The third person gameplay mechanics of Fortnite are ideal for location exploration experiences.
- Utilise existing assets in UEFN to keep Island Size low using existing textures to maintain the Fortnite art style and matching dimensions to make better use of existing meshes.

6. StaffsVerse

Overview of the metaverse campus



Figure 5



Figure 6



Figure 7



Figure 8

7. Conclusion

In conclusion, the StaffsVerse project represents a significant step forward in the integration of virtual environments within higher education. By leveraging the capabilities of Unreal Editor for Fortnite (UEFN), this initiative not only offers a novel solution to the challenges of student onboarding and campus familiarization but also redefines the educational landscape by providing an immersive, accessible, and engaging digital experience. The successful implementation of the StaffsVerse campus underscores the potential of the metaverse to transform traditional educational models, bridging the gap between physical and virtual learning spaces. Furthermore, the project demonstrates how modern gaming platforms can be harnessed to create dynamic educational tools that are both cost-effective and widely accessible.

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What Matters to Patients: Community-Engaged Design for Healthcare-Related Serious Games

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Abstract: Narrative-based serious games are accessible, engaging technologies that connect users' lived experiences to pedagogy. Despite having patient-centered goals, most narrative-based serious games are not designed alongside patients and communities, limiting their likelihood of acceptance, uptake, and impact. Literature reveals that many serious games intended for patients merely evaluate efficacy with end-users after game deployment and with a lack of consistent participatory design. This work aims to describe a patient-centered participatory approach to game development to teach self-advocacy skills to patients newly diagnosed with cancer. First, characters were developed based on panels that included patient advocates, cancer survivors, clinicians, and researchers. Second, storyline development created realistic story arcs, decision-points, and consequences based on qualitative interviews with patients, patient advocates, and cancer survivors. Third, game evaluation metrics (e.g., 1st vs. 3rd person perspective, game fail states that incentivize replaying the game, and provision of implicit or explicit feedback) were developed based on accessibility, usability, and patient preferences. Based on patients' insights, we implemented changes accordingly to maximize the game's efficacy and collected qualitative data on patients' assessment of the game's accessibility, relevance, and impact. During initial game development, patient and advocate feedback built relatable characters with a particular focus on providing sensitive information (e.g., palliative care) and inclusive storylines (e.g., diverse family situations). Following a prototype, patients and advocates suggested refinements to characters and additional storylines, including common and/or distressing experiences related to pain management, family dynamics, financial struggles, and disrespect from healthcare providers. Participants in a randomized trial of the game (N=34) found the scenarios relevant and realistic. Patients reported increased comfort speaking up, seeking support, and interacting with their families and healthcare team after playing the game. Our process demonstrates the essential role patients can inhabit in the development of narrative serious games, particularly in how patient input permeated every aspect of Strong Together's development, from initial design to evaluation. Such integration allows for adjustments to address patient concerns and refine patient-relevant metrics.

Keywords: Serious Games, Self-Advocacy, Healthcare, Cancer, Participatory Design

1. Introduction

Storytelling is a, if not the, primary universal method available to humans looking to explore the affective side of their lives. Especially in cases of hardship, we understand our experiences through stories (Bruner, 1991), may they be our own stories or the stories of others through which our own experiences resonate. Through these lenses, we come to understand ourselves and the world around us: self-image, motivation, ideology, the sciences, et cetera. Why do research papers include introduction sections? They frame the narrative of the paper for an audience to consume it more easily: the utility of storytelling.

Narrative-based serious games take advantage of that utility towards several educational and transformational goals. In a literature review of narrative in serious games, Naul and Liu (2019) highlight narrative as essential in offering highly motivating fantasy that is intertwined with pedagogical content, and they further explore the benefits of empathetic game characters in further immersing the player in the learning environment and altering their considerations when making in-game decisions, especially when players see aspects of their own experience in the characters. The narrative sets base context for the procedural rhetoric of a game, providing an affective layer to what the systems of player choice and game response are communicating (Bogost, 2007).

Narrative-based games are an attractive intervention for patient populations living with chronic conditions. These individuals often have high disease burden, including symptoms and side-effects related to their disease and treatment. This simultaneously makes educational interventions necessary to teach them ways to manage

their illness, but also difficult because they have limitations to their time and energy. Currently, there are over 32 million cancer survivors worldwide, making it one of the most common chronic conditions and one that contributes heavily to disability and healthcare costs (Chan & Nekhlyudov, 2023). For example, some of the most frequent unmet needs of individuals living with cancer include managing their fatigue, pain, and neuropathies. Yet, healthcare providers infrequently discuss these concerns, and engagement in traditional interventions is time-consuming (Schmidt et al., 2022; Lewandowska et al., 2020; Maqbali et al., 2021). Narrative games such as visual novels may address these concerns in an approachable, impactful medium and allow individuals from a variety of backgrounds in game and technological literacy to get the information they need in an engaging, efficacious manner.

While serious games are created with end-users in mind, they rarely include end-users during development, instead involving them during testing after game deployment (Khaled & Vasalou, 2014). We argue that the inclusion of consistent participatory design in the iteration cycle of the game design enhances the quality of the game and provides a pointed approach that directly impacts the users they are created for. Khaled and Vasalou (2014) argue that fluency in both domain content and game design is imperative for the attainability of serious games. This work aims to introduce and exemplify a patient-centered participatory approach to serious game development to teach self-advocacy skills to women newly diagnosed with gynecologic or metastatic breast cancer.

We propose the following major contributions:

- We introduce, exemplify, and advocate for a patient-centered participatory approach to serious game development.
- The design and evaluation of Strong Together, an efficacious serious game intervention aimed at promoting self-advocacy skills among patients newly diagnosed with cancer.

2. Related Works

Participatory design is a user-centered approach that involves end-users in the design and development process of software applications (Chen et al., 2020). In healthcare, participatory design has gained significant attention due to its potential to improve the usability, effectiveness, and acceptance of software tools among healthcare professionals and patients (Donetto et al., 2015). The complexity of healthcare environments, coupled with the diverse needs of stakeholders such as clinicians, patients, and administrators, underscores the importance of incorporating participatory design principles to promote collaboration, empathy, and co-creation, leading to solutions that better align with users' real-world needs and workflows.

For decades, system and software designers have employed participatory design methodologies within healthcare applications. Examples of participatory design include involving clinicians in the design of electronic medical record (EMR) applications (De Croon, Klerkx and Duval, 2014), telemedicine applications (Clemensen et al., 2017), clinical information system design (Pollack et al., 2016), medical artificial intelligence (AI) (Rodrigues et al., 2022), and surgical tools and procedures (Jamjoom and others, 2022). Recently, healthcare-related patient-centric systems, applications, and educational platforms began to employ participatory design frameworks such as the "Think-Aloud Protocol" (Fanfarelli, 2021) and co-design workshops (Alvarez et al., 2019) to allow users to verbalize their thought processes while interacting with prototypes, thus providing insights into potential usability issues and s fostering a sense of ownership and engagement.

A large body of research indicates numerous benefits of employing participatory design in healthcare software development. These include increased user satisfaction (Harper & Mustafee, 2023), reduced errors and inefficiencies (Tian et al., 2021), improved patient outcomes (Dykes et al., 2014), enhanced adoption rates (Rushton & Corrigan, 2021), and better alignment with clinical workflows. Additionally, participatory design fosters an equitable, collaborative culture that values end-user perspectives and promotes continuous improvement.

When it comes to game development, participatory design is usually limited to playtesting (Pietriková & Sobota, 2022), the part of game development lifecycle where representatives of the target audience (i.e., potential users) play various prototypes of the game to help identify technical issues, potential problems with game mechanics, or disconnects in storylines. It is exceedingly rare to find examples of games (either digital or analog) where future users participated directly in the creation process.

Serious games (SG), unlike their entertainment counterparts, often require a design approach that is more focused on co-design. SGs, defined as games designed for purposes other than mere entertainment, have gained traction in healthcare for their potential to engage users, promote behavior change, and enhance learning outcomes. SGs have diverse applications in healthcare, ranging from patient education (Damaševičius, Maskeliūnas & Blažauskas, 2023; Arif et al., 2024) and rehabilitation (Mitsopoulos et al., 2023) to medical training (Lin et al., 2023) and therapeutic interventions (Ahmed et al., 2023). For instance, virtual reality (VR) games are used in physical therapy for motor skill rehabilitation, while interactive simulations are employed for surgical training and procedural skill acquisition. Gamified mobile apps are also utilized for health promotion, disease management, and medication adherence among patients.

A growing body of research demonstrates the effectiveness of SGs in achieving various healthcare objectives. These games have been shown to improve patient engagement and motivation (You et al., 2023), enhance learning retention and skill acquisition (Chittaro, 2023), facilitate behavior change (e.g., smoking cessation (Aigner et al., 2023), weight management (Pervanidou et al., 2023)), and contribute to better clinical outcomes (e.g., reduced pain (Suleiman-Martos et al., 2022), improved adherence to treatment regimens (Maurin et al., 2020)).

The design and development of SGs in healthcare require careful consideration of user needs, objectives, and evidence-based strategies. Gamification elements such as rewards, challenges, feedback mechanisms, social interactions, and empathy play a crucial role in maintaining user engagement and fostering learning and behavior change but must be designed within the cultural assumptions and values held by those individuals. That is why participatory design approaches, such as co-design workshops, iterative prototyping, and usability testing, are integral to creating effective serious games.

3. Designing Strong Together

A panel of patient advocates (n = 2), clinicians (n =2), and nurse researchers (n = 2) worked alongside SimCoach Games' team of designers (n = 3), artists (n =1), and writers (n = 2) to create the characters within the Strong Together game in iterative steps. Each of the three characters was designed with sufficient backstory and depth to demonstrate familiar yet accentuated aspects of women with cancer. For example, one character is an over-committed retiree with strong social support, a second is a younger single mother with minimal family support, and the third is a middle-aged woman balancing a busy career and family obligations. We developed characters to highlight various common experiences that can make self-advocacy difficult in the context of cancer. We knew that users may not identify with each character, but their experiences were common enough that users could grasp the learning objectives.

After the characters were developed, the same panel of patient advocates, clinicians, nurse researchers, and gaming professionals met to map the learning objectives of Strong Together (e.g., specific self-advocacy skills) onto the characters' storylines. We gave each character central self-advocacy struggles that are the focus of their interactions and decision points. But we also interwove all learning outcomes into each storyline so that all learning objectives were present with varying degrees of depth. The panel's goals were to make realistic challenges, decision points, and consequences that reflected real-world patient experiences. We carefully reviewed the language, tone, and wording to reflect what women with cancer likely experience. A primary concern was that the negative consequences associated with selected poor decisions did not overwhelm or upset users while still providing upfront preparation for challenges they would likely experience in the future. We were careful not to include sensitive or overwhelming information (e.g., prognostic information) and touched on the availability of palliative and supportive care services lightly with extensive input and consensus-building from the panel.

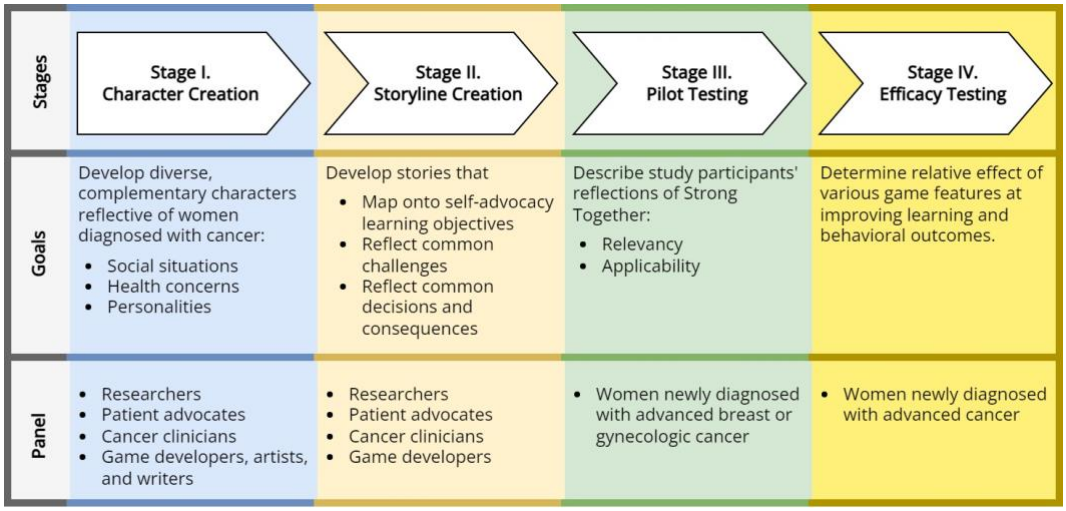


Figure 1: A summary of the participatory design process taken by our team during the development of Strong Together, in four stages.

3.1 Describing Strong Together

Strong Together is a single-player 2D visual novel developed in Unity for deployment on mobile devices. It is designed to encourage self-advocacy skills and explore realistic challenges and decisions taken on by its desired audience of players: patients newly diagnosed with cancer. In the game, players experience five stories starring three characters, and each meant to explore different archetypes of patients (shown in the top-left corner of Figure 2), featuring narrative-changing decisions in healthcare, domestic, and workplace settings, encountering hardships related and unrelated to care.

3.2 Identifying Key Features

Following the initial development of Strong Together, our team was invested in clearly articulating core design approaches and assumptions that went into its development by synthesizing insights from the patient advocates and the team of SimCoach Games designers, developers, and artists. Our team found it necessary to analyze the process of design components of the game as they are different from narratives and characters that were directly inspired by the patient advocates. In discussion with SimCoach Games' employees, we hoped to discover the assumptions that went into Strong Together's design but went unsaid. We asked questions about components of the game that, if removed, would "break" it. Three key features stood out as worthy of future evaluation: first-person perspective, implicit audio-visual feedback, and soft fail states. In these three features, we see a set of assumptions worth challenging and hypotheses worth testing, which may help us more precisely evaluate Strong Together in future work.

Though plot and decision points that reflect patient experiences were obvious inclusions from patient advocate perspectives, a more subtle detail of Strong Together's narrative is its perspective. Across the five stories, players make decisions while inhabiting one of three pre-written characters, each having their own specific backgrounds and personalities. The alternative, that players instead play from a first-person perspective, i.e., they are playing as a version of themselves that is experiencing the game's set of narrative experiences, was potentially desirable to patient advocates but not the preference of our designers, who preferred the narrative specificity of Strong Together's third-person perspective.

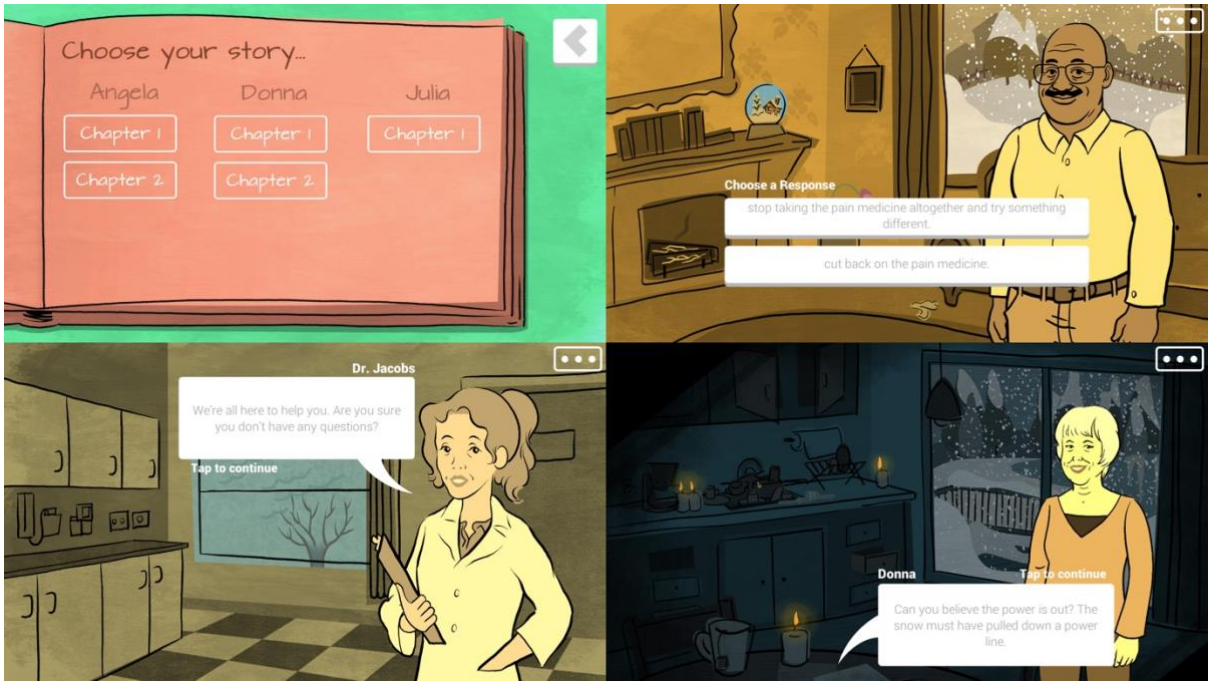


Figure 2: Four screenshots from Strong Together. Top-left shows the chapter-select screen where players choose which story to play. Top-right shows a decision point where the narrative will branch according to the player's choice. Bottom-left shows a game state where the player has made choices that have negatively impacted the player-character's well-being, which is implicitly conveyed to the player through a lack of foliage out the window and a reduction in color saturation. Bottom-right shows a scene of the player-character experiencing hardship that is not directly related to their illness, in this case, a power outage.

The implicit feedback system might be the most subtle among the three features. In addition to dialogue that conveys plot points relevant to the player-character's physical and mental well-being, behind-the-scenes the game quantitatively tracks this status as a numerical quality-of-life score, ranging from 0 to 100. Colors, foliage, and weather reflect the character's well-being, with low quality of life indicated by color desaturation, foliage loss, and worsening weather (e.g., increasing cloud coverage or rain). Improvements in the quality of life are subtly communicated through opposite aesthetic changes. However, there is much concern that users may not notice or appreciate this feedback in its subtlety. An alternative feedback scheme, such as displaying the player-character's quality of life through an on-screen health bar, may be perceived differently.

Similarly inspired by concerns about users being unable to notice or appreciate game mechanisms, we shifted our focus to the game's soft fail states, which may have disincentivized replaying sections of the game. To ensure comfort for cancer patients experiencing the player-character's stories, our team crafted narratives that contained only soft forms of failure, which have both emotional and mechanical implementation. In terms of the former, even the worst health outcomes were described as relatively mild, and choices are often recoverable, allowing any poor decision to be countered later by a better decision. A potential problem with both implementations is they likely discourage replaying the game, which may be less beneficial for learning self-advocacy skills. An alternative feature of Strong Together could utilize less recoverable fail states with more intense health outcomes, explicitly encouraging users to learn from mistakes and recover through replaying.

4. Methods

Women diagnosed with advanced gynecologic or metastatic breast cancer in the past three months were recruited from an academic cancer center in Pittsburgh, Pennsylvania. Participants were part of a larger randomized clinical trial (NCT03339765) evaluating the initial efficacy of the *Strong Together* serious game. Participants were randomized to receive the intervention and completed one-on-one semi-structured qualitative interviews with a research assistant at the end of the three-month intervention period. Three trained research assistants were not members of the game development team and were otherwise unbiased towards the evaluation of the intervention. These research assistants conducted interviews over the phone or in-person

depending on patient preference. We audio-recorded all interviews and transcribed verbatim by TranscribeMe.com with no identifiable information included.

We extracted participants' responses to selected interview questions that aligned with the purpose of this manuscript for the analysis including participants' reflections on how Strong Together reflected their experiences and taught them self-advocacy skills. The analysis consisted of simple descriptive content analysis by two coders utilizing Microsoft Excel. Two coders independently reviewed and coded the transcripts and subsequently met to discuss the discrepancies and achieve consensus. Initially, coders developed a preliminary codebook, which they utilized to code 20% of the transcripts to calculate the inter-coder reliability and refine the codebook. The coders repeated this process to achieve satisfactory inter-coder reliability (O'Connor and Joffe, 2020), which was .72 in this study. The resulting codebook was then applied to complete the analysis.

5. Results

A total of 34 participants who completed the interviews were included in the analysis. Participants' demographics are listed in Table 1. The average age of the participants was 59.4 years (SD = 13.0), with the majority self-identifying as White (85.3%). Two themes were identified: (1) Realistic and Engaging Storylines and (2) Learning Outcomes from Strong Together.

Table 1: Participant Demographics (N=34)

	Mean (SD)	N (%)
Age	59.4 (13.0)	
Years of formal education	14.0 (3.1)	
Current relationship status		
Married or living with a partner		23 (67.6)
Never married		5 (14.7)
Separated, divorced, or widowed		6 (17.7)
Racial identity		
White		29 (85.3)
Black		4 (11.8)
Asian		1 (2.9)
Latina ethnicity		1 (2.9)
Current employment status		
Employed		9 (26.4)
Unemployed		1 (2.9)
Other		3 (8.8)
Unknown		21 (61.9)
Difficulty paying for basic needs ("somewhat" or "extremely")		14 (41.1)
Current income does not meet basic needs		6 (17.6)

5.1 Realistic and Engaging Storylines

Most participants (n = 26) found various storylines and challenges in the serious game to be realistic and reflect their everyday experiences facing cancer. These challenges include finances, symptom management, nutrition, family matters, and others. Participants who didn't fully relate to the storylines indicated they already had a strong support system or had not experienced the portrayed challenges (n = 6). Additionally, 7 participants noted that they found the storylines reasonable and applicable to other individuals with cancer at different stages of life and cancer journey. Participants predominately (n = 21) reported enjoying the game. However, a few participants (n = 3) expressed that while they enjoyed the serious game, they did not always agree with the proposed best solutions.

> *They were realistic, when I went through them, the one with the single mother, I could relate to that because that's me, but they hit all the different scenarios of people in their life, whether they are younger or older or married or not, or have children.* – Patient 24

> *Angela's [game character] dealing with the fatigue and trying to take care of her daughters and her house and everything, you can relate to that real easy…. You could say, "Yeah. Okay. I really was tired." I understand why she would call off a day of work and finally ask Kat to help her.* – Patient 23

5.2 Learning Outcomes from Strong Together

Through their experiences with Strong Together's storylines, many participants (n=27) noted positive changes in their attitudes towards self-advocating. These behavioral and emotional changes made many participants feel more comfortable asking for help and speaking up about their discomfort or other issues they experienced. For these participants, they contextualized their improved attitudes and behaviors in relation to their healthcare team and social network.

> *I guess, don't be afraid to ask questions was the main thing. Because I always feel like we could be annoying to the doctors, nurses. You're always afraid you're imposing. And it did show you that that's what they're there for.* – Patient 10

Some participants (n=7) noted how the various storylines reassured them by reinforcing that they were already correctly advocating for themselves by speaking up and seeking more information about their condition.

> *I feel like I was already an informed decision maker; it just reinforced how I was already feeling.* – Patient 11

The 7 participants who experienced little to no significant changes in self-advocacy after engaging in the serious game cited that the lessons conveyed through the storylines were ones they already knew or followed. Some (n=4) also mentioned that they had a pre-existing support system in place already, whether it be a partner, family member, or friend. However, despite these 7 participants having minimal changes, they did not mention having any strong dislikes regarding Strong Together. Indeed, 4 participants with no significant changes either stated that the storylines were realistic and relevant to their own experiences or acknowledged that Strong Together could be applied to other cancer patients.

6. Discussion

Strong Together exemplifies a participatory design approach that is uncommon in the world of serious games, particularly those in healthcare (Khaled & Vasalou, 2014). This patient-centered approach began during initial game development stages and was then assessed systematically through qualitative interviews during a clinical trial. Over the course of the 34 interviews conducted, we distilled several lessons regarding patient-focused serious game design. Foremost among these was engaging with participants regarding their experiences inside and outside the game. Their statements showed that most participants found the storylines and scenarios realistic and relevant to their own lives, a detail of upmost importance given the prominent role of realistic life scenarios in the efficacy of narrative game-based interventions (Zhou et al., 2019).

Through sensitive discussions around these experiences, we found how these scenarios helped participants stay engaged with the characters and game. Due to the painstaking nature of serious game development and qualitative testing, however, this type of feedback loop early in development is rare and requires commitment from all stakeholders, as demonstrated in similar patient-centered design processes in non-game applications (Wolpin & Stewart, 2011; Ector et al., 2020). Conducting interviews and extracting key lessons from the feedback leads to the further development and enhancement of specific game and story features, which in turn leads to more testing. Participants must also commit to engaging with the story and playing through the various scenarios to understand the goals of Strong Together. Through this patient-focused approach to design, we can begin to create more effective serious games that align with the needs and preferences of their players, adding to a growing literature that suggests a strong utility of patient-centric design in supporting greater uptake and efficacy in healthcare-related interventions (Wolpin & Stewart, 2011; Ector et al., 2020; Verwij et al., 2023).

In this work, we described the process by which we analyzed the design procedures of Strong Together to reach three core features of the game that may contribute to its efficacy: a third-person perspective, implicit aesthetic feedback, and soft fail states. We are presently continuing this work with a proper evaluation of those three

features (Healy et al., 2022), for future publication. We have implemented three alternative versions of Strong Together that subvert those features: a first-person perspective, explicit feedback, and hard fail states. This work is essential in reaching greater specificity in which features of Strong Together contribute to its efficacy, potentially verifying our design and analysis procedures.

7. Conclusion

In Strong Together's design and evaluation, we present two core contributions: methodological and practical in the design of serious games. First, we described our application of participatory design throughout multiple game development stages, representing the consistent involvement of end-users and stakeholders during key decision points during the game's conceptualization and deployment. Second, we highlight features of the Strong Together game that contribute to end-users' uptake of the learning objectives. Based on the feedback from participants, we encourage other serious game developers to follow similar participatory design steps to ensure the relevancy and applicability of games to the perspectives of the end-user.

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Game-based Learning for History: Student Perceptions and Preferences

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Abstract: With the rapid development of games in the 21st century, the panoply of games on history shows a wide variety. Backstories from most historical eras have been implemented in different game genres and modalities. Furthermore, a growing number of studies have pointed to the didactic potential of historical games as learning tools. This study aims at investigating university students' perceptions of gaming and their game preferences, with a particular focus on history. The research question to answer was: "What types of games do history students play, and how can games, in their view, contribute to learning in their subject?" Educational action research was used as the overall strategy in a study where data was collected from five different university course groups in general history at the basic level. Students answered questionnaires with open ended questions about gaming preferences and their perceptions of games. The answers were then analysed in an inductive thematic analysis. Findings show that the students play a mix of analogue board games, digital games and hybrid forms. In the transmedial array of games available, important genres include role playing games, strategy games, quizzes and first-person action games. The students frequently provide arguments for the use of games in history education, and they give reasons why they find a particular game useful for this purpose. They describe how these games have a potential to add value to history education. To some extent, they also discuss how this can be implemented. In conclusion, the authors argue that so-called technology tree games are particularly relevant to learning history from a structural perspective, while RPG:s can strengthen interpretive approaches through a subjective historical experience.

Keywords: Game-based Learning, History, Strategy Games, Technology Tree, Role-playing Games

1. Introduction

While different types of gaming have been around for thousands of years, digital games are a major part of modern culture to the point that games are now surpassing traditional entertainment media such as television and cinema. The majority of the population are in fact gamers, and games have become a frequently used learning tool in many subjects (Juul, 2009; Hellerstedt & Mozelius, 2020). Within the field of history education alone, a wide range of historical eras have been used as the setting for many different game genres and modalities. The idea of using games in history education has been discussed in academic research since at least the 1990ies and early 2000s (McCarty, 2001; Squire, 2003). Game-based learning for history education can be designed around tailored serious games, or with commercial-off-the-shelf (COTS) games. Examples of COTS games which have been used in history education are the series Age of Empires (Weir and Baranowski, 2011), Europa Universalis (Koabel, 2017) and Assassin's Creed (Looije, 2018).

In an earlier study, history teachers' gaming preferences were explored and also which games that could be integrated into curricula and lesson plans (Mozelius et al., 2017). This study aims at investigating university students' perceptions of gaming and their game preferences, with a particular focus on history. The research question to answer was: "What types of games do history students play, and how can games, in their view, contribute to learning in their subject?"

This article will present an action research study of the gaming preferences of history students at a Swedish university as expressed in questionnaire responses. After a short background and presentation of methodology, an analysis will follow, highlighting the game genres mentioned by the students and their reasoning around the educational benefits and uses of games, as well as potential challenges. In the final section, we will provide our conclusions from the study and some prospects for future work.

2. Games for History Education

The game most frequently discussed in research on games for history education is the Civilization series, originally developed by Sid Meier (with Bruce Shelley) in 1991 (Squire 2003; Fogu, 2009; Guys, 2012; Ford 2016). The basic concept and many central game mechanics from Civilization have been copied many times, while the Civilization series is still currently popular. The game can be said to have spawned a genre of its own, called "4X" (eXplore, eXpand, eXploit, eXterminate), describing the games' overall focus. One often discussed and copied element of the game design of this genre is the technology tree. A technology tree is a form of flow chart,

illustrating a civilization's progress in terms of technological, scientific, economic or cultural innovations. As we have shown in a previous literature study (Hellerstedt & Mozelius, 2023), researchers have pointed to the potential of strategy games in general and the 4X genre in particular in explaining causal mechanisms and structures in historical societies and their development. The interplay between factors such as economy, trade, science, diplomacy and conflict have been regarded as valuable features for history education, as has the technology tree concept. (Fogu, 2009; Guys, 2012; Wainwright, 2014; McCall, 2016; Hellerstedt & Mozelius, 2023). Learning and playing this type of game can, however, require many hours and has been recommended as an extra-curricular activity (Wainwright, 2014; McCall, 2016; Mozelius et al., 2017), while "the classroom instead serves as a venue for presentation, discussion, and analysis" of games (Wainwright, 2014, p. 581).

Previous research also describes the successful integration of game-based learning in history courses where game playing was combined with themed and detailed instruction (Squire, 2003; McCall, 2016). Wainwright (2014) describes how this can be done in a history class at university level. In this model, various aspects of history and how it is represented in the game mechanics were discussed critically and compared to the theories of prominent historians and social scientists.

From a critical perspective, many strategy games with historical themes have been considered to reinforce a Eurocentric narrative of world history while also suffering from gender bias. 4X games in particular often have an emphasis on war, competitive scientific development, international trade and aggressive expansionism. They sometimes also leave out highly controversial historical facts and developments (Fogu, 2009; Ford, 2016, Slocombe, 2019).

The aim of this study is to investigate university students' perceptions of gaming and their game preferences in general, with a special focus on games that involve history. As part of the HistoTree project, the study will also inform the implementation of games in future history courses at Miun in Sundsvall/Östersund, a largely distance based university in Northern Sweden. The research question that guided the study was: "What types of games do history students play, and how can games, in their view, contribute to learning in their subject?"

3. Method

This study was carried out with an action research approach. Action research has been presented as a practical but systematic approach "that enables teachers to investigate their own teaching and their student's learning" (Nolen & Putten, 2007, p. 401). Action research can be divided into various types, where this study was conducted in the British tradition of action research that has been described by Norton (2009, p. 71), as being something "that links research to improvement of practice and is education orientated". The research question to answer was: "What types of games do history students play, and how can games, in their view, contribute to learning in their subject?" The authors' overall objective is that the research results should have a positive impact on the future design of the involved courses.

One of the authors has also been a teacher in some of the course groups that data were collected from, while collaborating with other teachers at the department to include additional groups. Data were collected by questionnaires distributed in five different university course groups during the 2024 spring semester. Three courses can be classified as introductory, while the two other courses require prerequisites. With respect for personal integrity, respondents have been kept as anonymous as possible during the research process. We obtained 35 responses in total. The number of active students was 48, giving a response rate no less than 72,9%.

The questionnaires included six questions: 1. Do you play games of any kind regularly? 2. Which type of game do you play? 3. Do you believe that games can teach us anything about history? 4. If so, which games can, in your opinion, do so? 5. Do you play any games with a historical basis, in content, theme or aim? 6. Is there anything in the game/games that you believe can be particularly valuable for learning, and if so, what? The questionnaires were distributed through the course platforms and the students had several weeks (during the course of the spring term) to answer them.

3.1 Data Analysis

Data were analysed in an inductive thematic analysis according to the seven-stage approach recommended by Norton (2009). In a first stage of immersion, data were read and reread with the idea of getting familiar with topics and themes in the questionnaire answers. During this iterative reading, analytic ideas and suggestions for themes were written down as memos. In the following stage of a more detailed close reading the suggested themes and topics were revised to create preliminary categories. A third stage comprised deleting some of the

preliminary categories "to get rid of any categories that have only one or two examples in them, or any that overlap considerably with other categories" (Norton, 2009, p. 119).

This was followed-up by a fourth stage where remaining, relatively small and overlapping categories were merged to more substantial categories. This work continued in the fifth stage with a general rereading of the answers to check and revise themes and how they had been grouped into categories. Stage six looked at interrelations between the categories remaining from the previous, where authors also discussed potential super- and sub-categories for a taxonomy structure. Finally in the last stage, the remaining categories that contribute to answering the research question were presented, including quotes from respondents' answers, in an effort to achieve what (Norton, 2009, p. 120) calls an "analytical narrative".

4. Results and Discussion

The analysis shows that two broad game genres are particularly relevant to the teaching and learning of history in the eyes of the students: strategy games and role-playing games. The students specified several different learning affordances: games can motivate and facilitate the learning of basic facts, such as geography, dates, events and biographies of famous personalities. On a more advanced level, games are well suited for teaching structural explanation. However, they can also, according to the students, provide historical empathy and a subjective experience of the past. Table 1 summarizes the number of mentions of particular game titles, sorted by broad genres or types. Often, the same respondent has mentioned several titles.

Table 1: Games and game genres mentioned by respondents as *recommended* for history education

Genre/*Title*	Number
Strategy	**25**
Age of Empires	4
Civilization	5
Europa Universalis/Svea Rike	6
Crusader Kings	3
Victoria	1
Hearts of Iron	2
Total War	1
Civil War (Grand Tactician)	1
Last Train Home	1
Romance of the Three Kingdoms	1
RPG	**10**
Assassin's Creed	5
Pentiment	1
A Plague Tale	1
Kingdom Come	1
Disco Elysium	1
Ghost of Tsushima	1
Board games	**4**
Pen & paper RPG	**3**
Quiz	**3**
Trivial Pursuit	2

Genre/*Title*	Number
Smart 10	1
FPS	**2**
Battlefield	2
Chess	**2**
Educational games	**2**

4.1 Game Genres

The majority of respondents say they play on a regular basis, and they discuss a great number of games in their answers. Seven say they do not play regularly, although two of those still mention favourite games, indicating that they are at least occasional gamers or used to be in the past. Among games *played*, six mention first-person shooters (FPS), such as Counter-Strike (CS), and six mention strategy games among the games they actually play. However, no one mentions CS in the column for games that can *teach history*. Overall, a plethora of genres and a few specific games are mentioned in the games played category. 23 out of 35 mention computer/console games, either a specific title or, more often, generically.

The major genres mentioned as games that may teach history (*games recommended*) are computer strategy games (25), computer RPG:s (10) and board (4) and quiz games (3). Historical FPS:s (2) are also mentioned. In the *recommended* category answers are more specific than in the games played category. Strategy games mentioned include Civilization (5), Europa Universalis (5), Crusader Kings (4) and Age of Empires (4). 1990-ies Swedish language game Svea Rike, the pre-cursor of Europa Universalis and Crusader Kings, is mentioned once. Among computer RPG:s the Assassin's Creed series (5) is the most common, but a number of lesser-known titles are mentioned as well, such as medieval adventures A Plague Tale and Pentiment. Four mention board games (only one mentions specific titles, omitted here). Also mentioned are Chess (2), Trivial Pursuit (2) and quiz game Smart10 (1). Chess is mentioned by one respondent for training generic competencies like memory rather than any particular historical skills or knowledge. Three mention pen-and-paper role-playing games. Two respondents specifically mention computer games with a non-European setting as games recommended. It should be noted that the category "educational games" (2) refers to purpose designed games for education, as opposed to the other categories, which all refer to various types of commercial (off the shelves) games. The responses do not specify any particular educational games, hence the somewhat generic category.

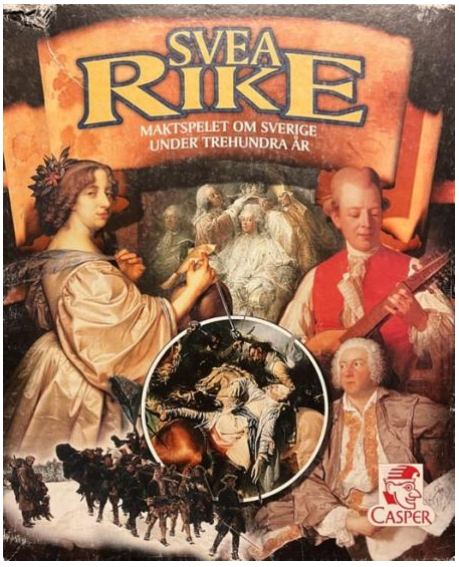


Figure 1: Original board game version of Svea Rike (1996). This game was subsequently developed into a digital game series. The computer game Svea Rike III was then retitled as Europa Universalis, itself the first in a successful series of games. Photo courtesy of Oskar Sjöström.

4.2 Learning Affordances

33 out of 35 respondents say that they believe games can teach history. The question therefore is rather what and how students may learn from games. Fortunately, many of the respondents were quite enthusiastic about this portion of the questionnaire and provided extensive discussions of this topic.

That games can draw students into history as an academic subject is perhaps the most obvious benefit of games for learning history. The fact that games with a historical setting can inspire and motivate was mentioned explicitly by six respondents, one even calling them a “gateway drug” to historical study. Another obvious positive outcome of gaming, although perhaps less often discussed, is the fact that games can teach basic facts (9). Historical geography is a particularly interesting aspect, which was stressed already in Kurt Squire’s seminal study on Civilization (Squire, 2003). Many of the games discussed above are set in the Middle Ages or the early modern period. The map of the world looked very different in those periods, and territories changed hands following conflicts and complex dynastic entanglements, some of which had massive consequences reaching down to the present day. Games such as Europa Universalis can provide students with an introduction to these aspects, and board and computer games alike have unique features which facilitate learning them. The medium is, at its best, well suited to visualizing geo-political relations and trade, but also timelines and various layers of dynamic historical development. It is important to point out that the respondents in this study often play both board games and computer games, not exclusively one or the other. Furthermore, the most common strategy games, the Civilization series and Europa Universalis and Crusader Kings, were either wholly or partly developed from board games. The basic mechanics are often similar, and while computer games can be said to benefit from impressive graphics, computing power, music and other advanced technical features, board games tend to be conducive to social interaction and a sense of community.

As already mentioned, nine respondents stress basic factual knowledge, which can be gathered from games in a variety of ways. This includes things such as famous or less famous events, biographies of historical figures, dynastic history and historical geography. Respondents often connect this type of learning to quiz games. Others point to games which include a “database” of factual historical information (in the AC series, like the “Civilopedia” included in the Civilization series since the early 1990-ies). This mechanism, which integrates factual knowledge into the game for a more directly didactical purpose, has been analysed and discussed as 'Tangential Learning' (Portnow & Floyd, 2008; Rath, 2015; Mozelius, Fagerström & Söderquist, 2017). While many respondents thus regard games as a valuable source for basic factual knowledge, many also mention the risks of game developers taking liberties with these facts. At least four discuss the problem that games often adapt historical facts to facilitate game play and commercial success. Others explicitly reject this however, stating that this is fine so long as the non-historicity is made clear. Interestingly, a similar point has been made by researchers. The important thing is not necessarily historical correctness, but the ability of the games’ mechanics to illustrate historical causality, social structure and explanation. This is especially true for higher level education and the teaching of historical theories (e. g. Fogu, 2009, Wainwright, 2014, Hellerstedt & Mozelius, 2023).

This leads on to the next important learning potential, which regards insights into “integrated relations of cause and effect”, as one respondent terms it, or “processes and connections” as another calls it. This is mentioned explicitly by four respondents. It seems logical to connect this type of deeper learning to strategy games of the 4X type, many of which implement the technology tree-mechanic in one way or another. Games such as Civilization are based on the interplay between variables such as production, trade, taxes, intellectual innovation etc, which in combination will produce different outcomes. Games of a more diplomatic/conflict orientation, such as Europa Universalis, provide an overview of complex causal interactions in a slightly different area.

Yet another and quite different aspect, which is mentioned by nine respondents, is the value of a subjective experience of history. This is described as games providing an understanding of “how life was lived in the Middle Ages”, for example. It ties in with an actor’s perspective and immersion into the historical game world, including “the communication with real or fictious people”. The game Pentiment (released in 2022) is lauded by one respondent for its game-world inspired by medieval manuscripts, early prints and woodcut illustrations. The game is set in early 16th century Germany and involves an apprentice illuminator investigating a murder mystery. Respondents describe this aspect with terms such as insight or empathy (Sw. *inlevelse*, similar to Ger. *Einfühlung*) or immersion in the “atmosphere” of a period. This aspect is clearly connected to the RPG genre. In this way, the respondents describe games as a gateway not only to factual knowledge, theory or causal explanation, but to *experiencing* history as well. In this aspect, respondents describe how the potential of digital games can be utilized in a different and complementary area compared to strategy games. Through immersion, interactivity,

communication and interpretation, it can provide the feel for everyday objects, practices and ways of living. Such aspects are often lost in grand strategy games with a God's eye view perspective.

5. Conclusion

It is evident that the responses point to two major potentials in using games in learning history at the college/university level: 1. training the use of structural concepts and explanatory analysis and 2. providing an immersive, subjective experience. Basic factual knowledge should not be underestimated, but these are the two areas in which games seem to facilitate the teaching of history on an emotionally deeper or theoretically more advanced level. The two are connected to the two major game genres: strategy games and RPG:s. The two areas are distinct, if not entirely incompatible – a good strategy game can presumably provide an immersive atmosphere and a compelling narrative too, although this feature is more strongly related to RPG:s. The strategy games Europa Universalis/Crusader Kings, for instance, include a dynastic perspective, incorporating marriage alliances and the education of children as part of the strategic game. From an analytical perspective, the skills involved are different, with one corresponding to a structural view of society, and the other focused on individual actors and subjective experience. They therefore seem to train two different sets of skills: historical empathy and structural explanation. They seem to be the 'sense and sensibility' of the historical gaming world. But the two also correspond well to the two main strands in modern historical research: the first directed towards history as social science (social and economic history), the second resembling history as an interpretive humanities discipline (cultural and intellectual history, the history of religion, etc.).

Of course, factual errors or biased misrepresentations of historical figures, events or social conditions are a problem for all the aspects mentioned. The respondents to the questionnaire did not specifically mention problematic biases regarding gender or race and themes such as colonial, Eurocentric perspectives, although these are some aspects commonly discussed in studies of GBL and history (Ford 2016). The reason for this may partly be that respondents were not asked to discuss the strengths and weaknesses of one particular game. As has already been mentioned, they do also discuss games with a non-European setting (such as Ghost of Tsushima) and games that have been developed outside North America and Europe (such as the Japanese game series based on the medieval Chinese novel Romance of the Three Kingdoms). With such games becoming more popular in the West, perhaps a Eurocentric bias may be somewhat less of a problem than it has previously been.

6. Future Work

We plan to build on the results from this study and the results from the previous literature study by Hellerstedt and Mozelius (2023). In combination, these will provide a knowledge base regarding best practices and the specific preferences of Swedish students. During the 2024 autumn semester students on various courses in history will be assigned game playing with content aligned to the actual course syllabi. The students will evaluate the games and summarize their analyses in short essays. This will be the next step in the HISTOTREE project that is described in the section below.

Acknowledgements

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Primary Education's Stakeholders Behavioural Intention to use Prospective Game-based Learning for Waste Awareness

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Abstract: Despite some efforts to design games to raise primary school students' awareness of the waste problems, there is a lack of research studying the directly involved stakeholder's behavioural intention to use the games. Prior studies have explored the users' games acceptance of the games that have already been developed. However, we believe that understanding the user's acceptance from the beginning of the game design process is also crucial. This research investigates the factors that influence the behavioural intention to use prospective game-based learning (GBL) for waste awareness among primary school parents, teachers, and students. An online survey based on the UTAUT 2 was distributed to each stakeholder, supplemented by a video demonstrating an Augmented Reality-based mobile game interaction scenario. The sample of participants included 135 parents, 47 teachers, and 129 primary school students from Malang, Indonesia. The internal consistency of game acceptance from the surveys was evaluated through Kruskall Wallis. Results show that Effort Expectancy is the factor with the highest acceptance value while Facilitating Condition has the lowest value. The three stakeholders argued that the prospective GBL seems easy to play and learn, but in contradiction, the adults are concerned that they cannot assist in teaching how to use the game and cannot provide the necessary technology. The cultural background seems to influence user game acceptance. Indonesians are known to be quite open to new technologies like GBL, although the facilitation condition might be low. Furthermore, there are some significant differences between the student-parent and student-teacher groups, but not in the parent-teacher group. Findings indicated that Indonesian teachers are more ready to adopt GBL than students and their parents. By understanding the perceptions and attitudes of these groups, educators and researchers can develop strategies to address any concerns or doubts they may have and promote the benefits of GBL.

Keywords: UTAUT 2, Games Acceptance, Behavioural Intention, Waste Awareness.

1. Introduction

Game-Based Learning (GBL) has emerged as an innovative pedagogical approach that forces the engaging nature of games to enhance learning outcomes. Recent studies show that using GBL potentially improve student's learning outcome compared to traditional teaching learning method (Acquah and Katz, 2020; Byusa, Kampire and Mwesigye, 2022). Despite numerous studies indicating that GBL can increase learner's performance, understanding its acceptance among parents, teachers, and students as direct stakeholders, particularly in specific cultural contexts like Indonesia, remains underexplored. In Indonesia, where cultural values and school curricula somewhat different from those in other parts of the world, it becomes imperative to study the acceptance and readiness of stakeholders towards GBL. This is especially important because, based on our careful observations, studies on technological readiness and acceptance in the Indonesian context often yield uniformly positive results without offering comparative insights among different stakeholder groups. In addition, the geographical diversity of the Indonesian archipelago presents challenges, as some students have limited access to the technology and facilities necessary for effective learning.

While previous research has often examined the acceptance of GBL by students, teachers, and parents separately (Bourgonjon *et al.*, 2010, 2011, 2013), our study seeks to integrate these perspectives. By exploring the connection of these stakeholders' different perspective, we aim to provide a more comprehensive understanding of the factors that drive the acceptance of GBL in Indonesia. This research aims to investigate the factors that influence the behavioural intention to use game-based learning for improving waste awareness among these three stakeholder groups in Indonesia. Notably, we have only come across two studies in our journey to find research that compares the level of games acceptance among them. In Yong's and colleague's research from Malaysia about parents, students, and teachers views in the use of digital games in learning

mathematics (Yong, Gates and Harrison, 2016), shows that students were supportive and positive towards it but not with their teachers and parents. In their study, the students' focus their affective aspect towards learning, while the teachers and parents are concerned with the practicality and effectiveness of using Math computer games for learning, but they do not perceive learning as an activity that should be fun. Other study from China (Xie, Wang and Hooshyar, 2021) revealed that teachers' and parents' perceptions toward digital GBL were shown to be significantly correlated with each other. There is a possibility that parental pressure may contribute to the teacher's lack of empowerment in classroom, even though the students show highly optimistic perception with GBL (Xie, Wang and Hooshyar, 2021). These two studies show that students are more ready to learn using digital games compared to adults, echoing with three studies by Bourgonjon and colleagues that exploring students, parents, and teachers (Bourgonjon *et al.*, 2010, 2011, 2013) acceptance in GBL, although they did not continue their studies to correlate those three results.

This study was part of a larger project researching how games can enhance primary student's waste management awareness. This paper represents the initial phase of our primary research, focusing on understanding user's technology acceptance before moving on to game design process. Unlike most previous studies that explored stakeholder game acceptance after the development of games, our research aims to assess the readiness of parents, teachers, and students to adopt GBL from the beginning. By exploring the perspectives of these three key stakeholder groups, this research aims to provide a comprehensive understanding of the factors that may facilitate or hinder the adoption of game-based learning, in the case of Indonesia.

2. Previous Studies on GBL's Acceptance

2.1 Factors Influencing User Acceptance in Game-Based Learning

Compared to teachers and students, parents' acceptance of GBL is less studied, possibly due to underestimating the importance of their perspective in education (Hillier, Milne and Aurini, 2019). Some parents seeing GBL as an opportunity to make learning more interesting and interactive for their children (Rosyati *et al.*, 2020; Amzalag, 2021), while others may be more skeptical, concerning whether children truly acquire knowledge when playing video or have concerns about the potential negative effects of excessive game play (DeCamp, 2019; Xie, Wang and Hooshyar, 2021; Hidayat, 2022). The top three factors influencing parents' games acceptance namely learning opportunity, game experience, subjective norms, social influence, and cultural background (Nikken and Jansz, 2006; Bourgonjon *et al.*, 2011; Yong, Gates and Harrison, 2016; Lin, Li and Yang, 2018; Xie, Wang and Hooshyar, 2021). In our prior research, encompassing a sample size of 42 parents, the findings revealed that issues related to screen time management, facilitation conditions, and limited opportunities for social interaction significantly influenced their perspectives on GBL (Hidayat, 2022). When parents hold negative views or disapprove of a particular technology, it is highly probable that their children's acceptance of games will be impacted as well (DeCamp, 2019).

On the other hand, the successful implementation of GBL heavily relies on teachers' perceptions and attitudes, as they play a crucial role in executing learning games (Hanghøj and Brund, 2010; Chee, Mehrotra and Ong, 2015). Teachers serve as instructional designers when incorporating GBL into their classrooms (Pedler, Hudson and Yeigh, 2020). Their perceptions and openness of new teaching methods and technology could lead and impact to their instructional strategies (De Grove, Bourgonjon and Van Looy, 2012; Stieler-hunt and Jones, 2015; Rasmitadila *et al.*, 2020). They also need to be comfortable with the idea of giving up some control over the learning experience (Acquah and Katz, 2020; Luo, Brown and O'Steen, 2021) as GBL often involves a more student-led approach to education. Key factors influencing teachers' adoption of GBL include facilitation conditions, gaming experience, and challenges during the preparation phase (De Grove, Bourgonjon and Van Looy, 2012; Ucus, 2015; Bandara, 2018; Ibrahim, 2018; Alizadeh *et al.*, 2021; Siburian and Mahmud, 2022). Several other factors are also very important to look at, such as perceived usefulness, personal gaming mindset, parent's involvement, learning opportunity, teacher's skills, and personal positive belief in GBL (De Grove, Bourgonjon and Van Looy, 2012; Ucus, 2015; Huizenga *et al.*, 2017; Bandara, 2018; Ibrahim, 2018; Alhebshi, 2020; Alizadeh *et al.*, 2021; Siburian and Mahmud, 2022)

Furthermore, understanding students' acceptance of GBL is essential for effective implementation and maximising its potential as an educational tool (Byusa, Kampire and Mwesigye, 2022). The perception of GBL by students can significantly impact their level of engagement (Armier, Shepherd and Skrabut, 2016), motivation (Liu, Liu and Yue, 2021; Byusa, Kampire and Mwesigye, 2022), and overall learning experience (Bourgonjon *et al.*, 2010; Janakiraman *et al.*, 2021). Factors influencing students' game acceptance include perceived usefulness,

perceived ease of use, perceived enjoyment, learning opportunity, gender, and usability (Bourgonjon *et al.*, 2010; Martí-Parreño, Galbis-Córdova and Miquel-Romero, 2018; Huang, 2019; Wang, Wang and Jian, 2020; Liu, Liu and Yue, 2021; Udeozor, Russo-Abegão and Glassey, 2023). Several other factors, including learning opportunity (Bourgonjon *et al.*, 2010; Beavis, Muspratt and Thompson, 2015; Martí-Parreño, Galbis-Córdova and Miquel-Romero, 2018) and usability (Saleh, Prakash and Manton, 2014; Beavis, Muspratt and Thompson, 2015) exert an influential effect on students' acceptance of GBL. Only two studies from (Beavis, Muspratt and Thompson, 2015) and (Ninaus *et al.*, 2017) had primary school students as their research subjects. However, some students may be hesitant to embrace GBL, particularly if their parents and teachers are still unaware with the beneficial of games (Piller, 2016).

2.2 Recent Studies of Utaut 2 in Games Study

The Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2), an extension of the original UTAUT model, includes additional constructs like Hedonic Motivation (HM), price value, and habit, along with the original constructs of Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC) (Venkatesh, Thong and Xu, 2012). It has served as a baseline model for new technologies and has been valuable in understanding technology adoption (Yein and Pal, 2021). In the case of the use in games research, Ramírez-Correa et al. (2019) argued that UTAUT 2 is better and suitable model to analyse online game use, although with certain changes, compared to Theory of Use and Gratifications or the original UTAUT. This model has been successfully used formerly in the online games sector, but we have not found in our review other works that have applied the UTAUT 2 model to GBL for primary school education. Ibrahim and colleagues' study with the utilisation of extended UTAUT for game-based learning seem to be the closest work (Ibrahim and Jaafar, 2011) even though their study occurred before the establishment of UTAUT 2. They add two new factors to the origin UTAUT with Enjoyment and Learning Opportunity but eliminate Facilitating Condition. Other recent work from Udeozor et al. (Udeozor, Russo-Abegão and Glassey, 2023) whom employed UTAUT 2 based survey and interview to investigate the factors affecting the adoption of digital games for engineering education also seem similar to our works. While the UTAUT 2 model has been widely used in various technology adoption studies, its application in the context of game-based learning, particularly among adolescents, remains relatively unexplored. To date, only one study we found that implemented UTAUT for primary school student's participant, however, this study focused on an online homework platform rather than on game-based learning. They (Chen *et al.*, 2024) extend UTAUT model by incorporating perceived playfulness, perceived interactivity, and flow experience into a theoretical framework for understanding the behavioural intention to use online homework platforms. Result shows that PE, EE, SI, and Flow Experience significantly impact elementary school students' behavioural intention toward online homework platforms. Perceived playfulness and perceived interactivity indirectly affect students' behavioural intention through the mediating effect of flow experience.

3. Methodology

This study was conducted in several phases (figure 1). The research began with the exploration of technology acceptance model that suitable most to our study. We decided to adopt UTAUT 2, but we exclude Price Value and Habit from our study since we did not evaluate user acceptance of published games; rather, we created a conceptual game from the interaction scenario video (Figure 2). After several iterative discussions about the questions with researcher's team, we got each 14 questions for students encompassing six factors, with two questions per factor except for facilitation condition and behavioural intention which include three questions, and each 12 questions for teachers and parents encompassing six factors, with two questions per factor (For a detailed breakdown of the survey results, see Appendix [https://shorturl.at/yYoGR]). This questionnaire is divided into two parts: the first section covers demographic questions, which include the participant's gaming experience and habit, while the second section focuses on game acceptance question. The survey was not formally tested for validity and reliability with the experts, due to constraints related to time and the challenging conditions imposed by the COVID-19 pandemic. However, to ensure that the child participants would understand the task, we conducted a pilot test like a trial with a sample of eight private primary school students, aged 7-12, to confirm clarity and eliminate any potential ambiguities. While we found that all students understood and easily completed the 7-point Likert scale surveys, it is acknowledged that the absence of formal validity and reliability testing represents a limitation of this study.

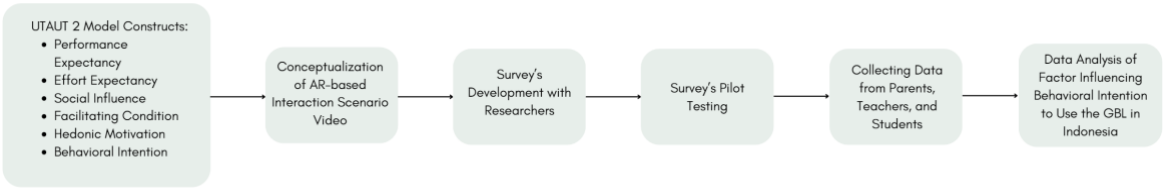


Figure 1: The data collection phases



Figure 2: The interaction scenarios video

Moreover, each group has different questions approach, in which, parents' acceptance of GBL refers to their willingness to support and engage with the use of games as a learning tool for their children, teachers' acceptance of GBL refers to their willingness to teach with the use of games as a teaching tool for them and learning tool for their students, while students GBL acceptance refers to their willingness and enthusiasm to participate in and engage with the use of games as a learning tool. Furthermore, the final phase involved analysing the collected data using Kruskall-Wallis.

4. Findings: Behavioural Intention to use the GBL

4.1 Performance Expectancy

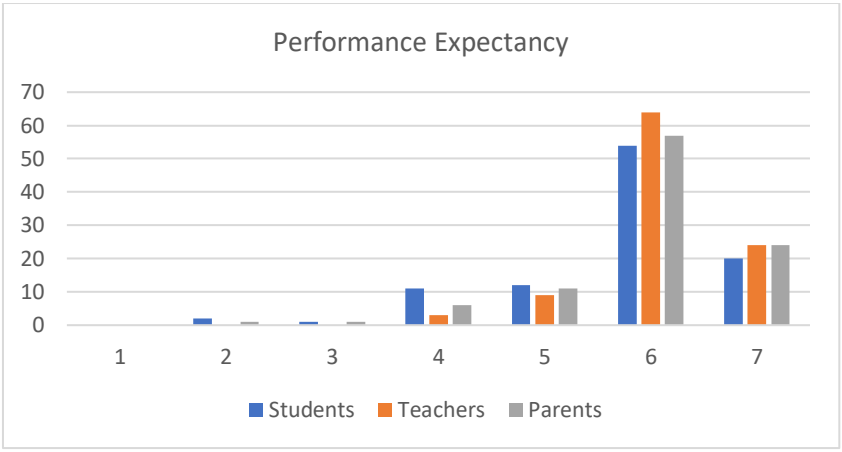


Figure 3: Frequency of responses for PE for students, teachers and parents

Figure 3 shows the frequency of response for the samples of students, teachers and parents for the variable PE. To check for differences between groups, we performed a Kruskal Wallis nonparametric test for independent samples. The test revealed statistically significant differences for PE between groups of students, teacher and parents ($H(2)=9.92$, $p=0.007$). Concerning the sample of students, they are the ones who have lower distribution values of PE, with an average of 5.4 and a standard deviation of 1.2. When we compare students with teachers

and parents, post-hoc Mann-Whitney tests using Bonferroni-adjusted alpha level of 0.17(0.05/3), showed a difference between students and teachers U(NStudents=129, NTeachers=47, z=-38.05, p=0.029) and between students and parents U(NStudents=129, NParents=135, z=-27.94, p=0.026). It is clear from Figure 3 that teachers and parents have a higher frequency of the higher scale values (6 and 7) than students. Teachers have the higher average value (6) and the lower standard deviation (0.7) followed by parents with an average of 5.7 and a standard deviation of 1.1. Between parents and teachers there was no statistically significant difference (U(Nparents=135, NTeachers=47, z=10.11, p=1)). In general, we can see that all of the groups have high values of PE, with averages above 5, however students have the more heterogeneous results, thus are the ones with more doubts about their PE.

4.2 Effort Expectancy

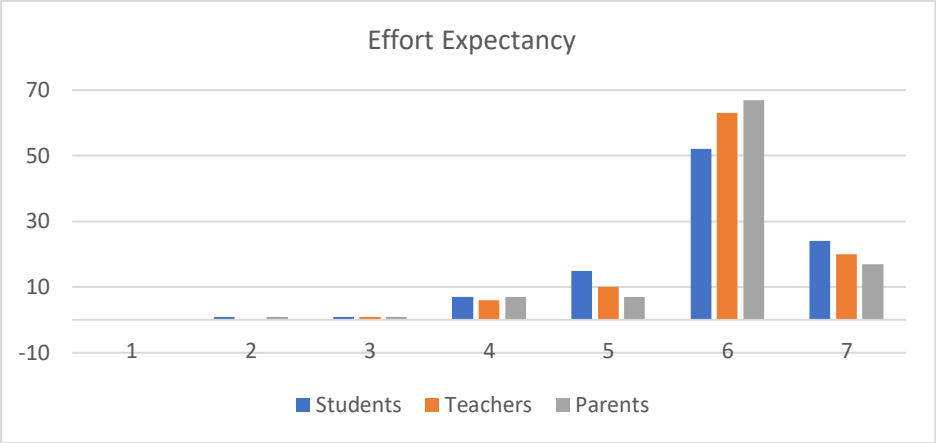


Figure 4: Frequency of responses for EE of students, teachers, and parents.

Figure 4 shows the frequency of response for the samples of students, teachers, and parents for the variable EE. The Kruskal-Wallis test showed no statistical differences in EE between student, teacher, and parent groups (H(2)=1.91, p=0.384). In this factor, students, teachers, and parents have Mean value distributions that are not too far apart, being 5.6; 5.8; and 5.7, respectively. Teachers have the lowest standard deviation (0.7) but with the highest value, followed by parents (0.9), and students (1.0). Overall, it becomes evident that all groups have high levels of EE, with average values exceeding 5. This proves that all three groups believe that the games interaction scenario video we provided, even with Augmented Reality technology, appears to be uncomplicated and easy to understand.

4.3 Social Influence

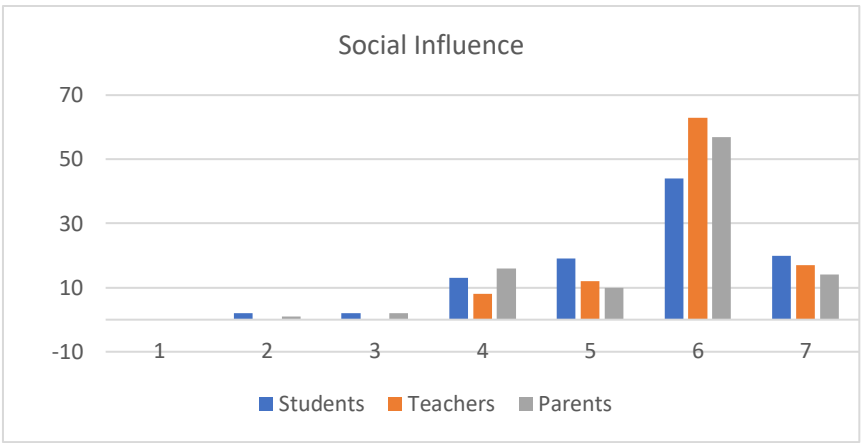


Figure 5: Frequency of responses for SI of students, teachers, and parents.

Figure 5 shows the frequency of responses for SI of students, teachers, and parents. The statistically significant differences between the groups are clear in this factor (H(2)=6.24, p=0.044). To discover the differences and comparisons among each sample, we employed the post-hoc Mann-Whitney test. There is a statistically

significant difference between students and teachers even after adjusting for multiple tests using the Bonferroni correction, the significance remains below 0.05 (U($N_{Students}$=129, $N_{Teachers}$=47, z=-36.23, p=0.044). However, in parents and teachers' comparison, the initial value is 0.032 and it indicates significance difference. But after adjusting for multiple tests using the Bonferroni correction, it increased (U($N_{Parents}$=135, $N_{Teachers}$=47, z=31.64, p=0.095). This means that, while there is some evidence of a difference in perceptions between parents and teachers, the difference might not be statistically significant when considering the multiple tests conducted. Furthermore, as shown from Figure 3, students and parents exhibit a more diverse range of values compared to teachers.

4.4 Facilitating Conditions

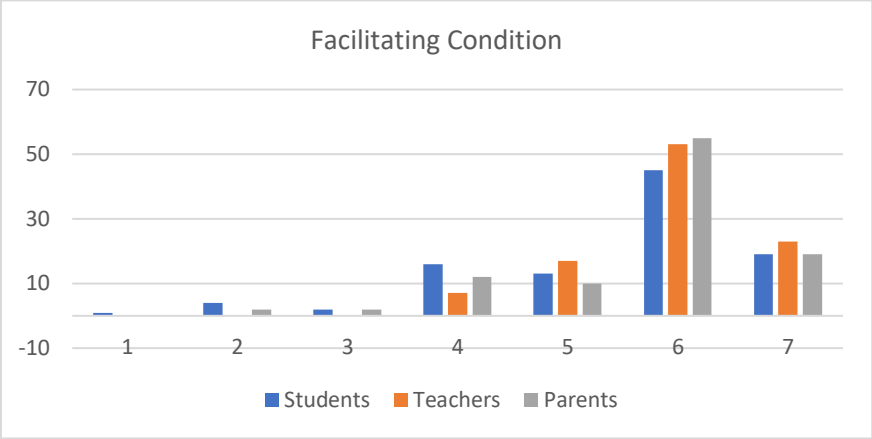


Figure 6: Frequency of responses for FC of students, teachers, and parents

In this factor, the Kruskal-Wallis non-parametric test shows that there is statistically significant difference between three groups (H(2)=15.08, p=0.001). The student's group has the broadest distribution of values compared to the other groups, with an average of 4.97 and standard deviation of 1.3. Consistent with the previous factors, we conducted a post-hoc Mann-Whitney test using a Bonferroni-adjusted alpha to examine the relationships. It was found that there is a statistically significant difference in the relationship between students and parents U($N_{Students}$=129, $N_{Parents}$=135, z=-31.91, p=0.01) and between students and teachers U(NStudents=129, $N_{Teachers}$=47, z=-52.27, p=0.02) Conversely, there is no statistically significant difference in the views of parents and teachers regarding FC U($N_{Parents}$=135, $N_{Teachers}$=47, z=-20.36, p=0.53). Relatively, all groups display a positive attitude towards the FC factor with average values above 5. However, in this factor, the Mean value for students is the lowest (4.97).

4.5 Hedonic Motivations

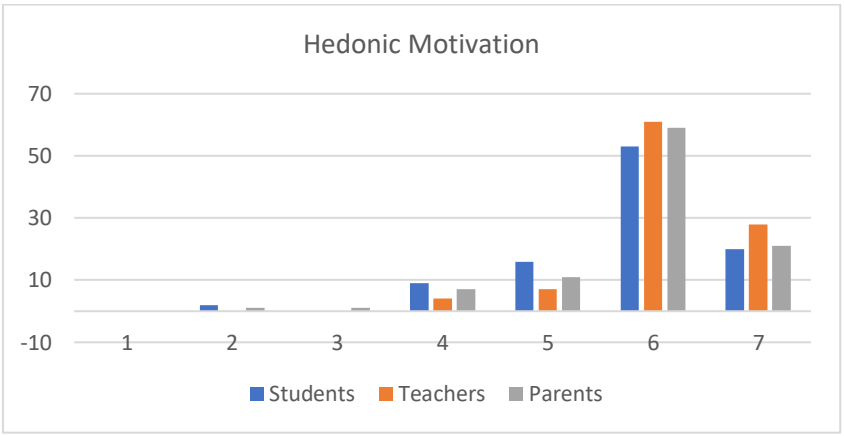


Figure 7: Frequency of responses for HMs of students, teachers, and parents

Based on the results of the Kruskal-Wallis test for the HMs factor, a statistically significant difference was identified among the three groups (H(2)=10.78, p=0.005). When comparing the three groups—students,

teachers, and parents—using post-hoc Mann-Whitney tests with a Bonferroni-adjusted alpha level, the p-value (Sig.) for the comparison between students and teachers was found to be 0.001. After adjustment for multiple tests, this value becomes 0.004. Both values fall below the significant level of 0.050, denoting a statistically significant difference in HM between students and teachers $U(N_{Students}=129, N_{Teachers}=47, z=-47.51, p=0.004)$. Conversely, the p-value for the comparison between parents and teachers stands at 0.040; after adjustment for multiple tests, it rises to 0.119. This adjusted value exceeds the significance level of 0.050, indicating that, when accounting for multiple tests, the difference in HM between parents and teachers is not statistically significant. Within this factor, teachers have the highest Mean value among the six factors we tested, displaying an average of 6.05 with a standard deviation of 0.69. Moreover, while teachers and parents generally expressed positive views toward HM, students appeared somewhat less enthused.

4.6 Behavioural Intention to Use GBL

Figure 8 illustrates the frequency of responses from the samples of students, teachers, and parents concerning the variable of BI. Upon examining the differences between the students, teachers, and parents groups, we found no significant differences in BI ($H(2)=4.16, p=0.128$). However, the mean values for BI in both the teachers' group (with an average of 5.58 and a standard deviation of 0.89) and the parents' group (with an average of 5.13 and a standard deviation of 1.2) are the lowest among the other six variables. This suggests that some parents might still be hesitant to permit their children to regularly use digital GBL (or on a daily basis), while certain teachers remain sceptical about the potential of GBL as a tool to augment learning activities and are uncertain about its implementation in schools. Nevertheless, on average, all groups displayed high values for BI, with Mean values exceeding 5. Thus, the average sample across the three groups demonstrates positive acceptance of this variable.

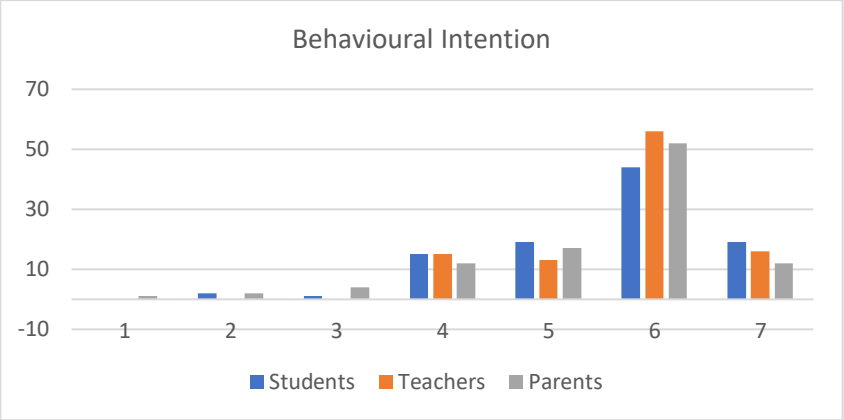


Figure 8: Frequency of responses for Behavioural Intention of students, teachers, and parents

5. Conclusions

Significant differences were found in the PE factor between student-teacher and student-parent relationships. Teachers and parents were confident in the potential of GBL to motivate and engage students, while some students were skeptical about its ability to deepen their understanding of environmental issues. This highlights the need to integrate LO into research on GBL's effectiveness. No significant differences were observed in the EE factor, as all groups found the GBL concept user-friendly. Positive perceptions from parents could ease teachers' concerns about GBL implementation. For SI, all groups generally felt supported in using GBL, although some doubts persisted due to the novelty of GBL in Indonesian schools. Some students may still feel the uncertainties about whether their parents or teachers would permit the use of GBL. Conversely, the teacher's group, which has the highest value, seems confident that both their colleagues and the students' parents would agree with the utilization of GBL in classroom. FC factor received the lowest scores, indicating doubts about having adequate tools for GBL, especially given restrictions on smartphone use in schools. Demographic data revealed that most students lacked personal mobile phones, relying on parents or siblings, which could limit parental support in resolving game-related issues. This indicates that some students may still have hesitation about whether they possess the necessary tools and if their parents or teachers can assist them when they encounter challenges with this technology. Conversely, the highest value for FC is still held by the teachers, who believe that they can support students in using GBL and that schools will provide adequate facilities for it. The

factor HM showed a significant relationship between students and teachers, with both groups finding GBL fun. However, some students found the concept less entertaining. It seems that teachers believe the game concept we introduced is highly entertaining, which would enhance their enjoyment when employing it for teaching. While for students, they might want to have more entertaining GBL. It is contrasting with findings from (Yong, Gates and Harrison, 2016; Xie, Wang and Hooshyar, 2021), where adults had lower confidence in GBL. Furthermore, factor BI showed no significant differences among groups, though parents had the lowest mean values, reflecting concerns about daily digital game use.

Remarkably, the interesting discovery in the case of Indonesian primary school was that adults showed a higher level of confidence in using games to improve students' learning experience than the students. This result could be attributed to cultural factors or their previous experiences with technology. Indonesian adults may have a greater appreciation for the potential educational benefits of GBL, viewing it as a valuable tool for enhancing learning outcomes, particularly in the context of environmental education. While the students may feel a lack of familiarity with GBL's effectiveness, or they just want a more fun games. It has come to be understood that parents and teachers never prohibit children from playing games, especially for educational purposes, but ensure that their responsibilities as students take priority overindulging in games. These insights could contribute for educational game designs area, to meet the needs and expectations of different stakeholder groups, particularly in primary school. Game designers should address the specific concerns of students perspectives, since they are the end-user of the GBL.

Furthermore, teacher's strong BI to use the game plays a crucial role in determining what kind of technology will be used in the classroom, as the teacher acts as a facilitator. Future research needs to gain a deeper about what technology that teacher's familiar with. While teachers might be confident in their abilities to use games to teach, as seen in the interaction scenario video, they might run into problems when using this strategy in the actual classroom. By understanding the perceptions and attitudes of these groups, educators and researchers can develop strategies to address any concerns or doubts they may have and promote the benefits of game-based learning.

Acknowledgement

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Community, Socialisation, and Empowerment in Cultural Game Jams with Youth Citizens

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Abstract: This paper examines social and collaborative elements of Cultural Game Jams developed and implemented in the large-scale Europe Horizon research and innovation project, EPIC-WE: *Empowered Participation through Ideating Cultural Worlds and Environments* (2023-2026). The project explores and develops transdisciplinary collaboration and co-creation across cultural heritage institutions, creative industries, higher education institutions, and youth citizens (ages 16-25) towards Cultural Game Jam interventions across three European sites: Óbidos (Portugal), Hilversum (Netherlands), and Aarhus (Denmark). The Cultural Game Jams are held at cultural heritage sites and are aimed towards value-sensitive game design and youth empowerment. This paper explores Cultural Game Jams as a potential format for enabling and developing youths' empowered participation, communality, and cultural socialisation by analysing the first Cultural Game Jam (2024). Framed by a Design-Based Research methodology and guided by experimental and short-term ethnography and design experiments, the analyses draw from qualitative empirical material, e.g., interviews, participatory observations, field notes, and the Cultural Game Jam participants' reflective process and design documentation. The analyses illustrate how co-creating games within cultural heritage contexts can develop youth perceptions of community, cultural socialisation processes, and individual/collective empowerment. Furthermore, the paper offers insights into the co-creation of games as new expressions of cultural heritage through epistemic collaboration and cultural participation in game jams while discussing possibilities for enabling new experiences of empowered participation, social learning, and community among youth citizens.

Keywords: Cultural Game Jam; Youth Citizens; Transdisciplinary; Epistemic Collaboration; Empowered Participation.

1. Introduction

Game jams are accelerated, social game-making events characterised by their relatively short time span, creative design constraints, and the public dissemination of created games, game concepts or game prototypes (Kultima, 2015; Fowler et al., 2016). Though participants in game jams emphasise different features as most exciting or relevant, e.g., enabling creativity and innovation or socialising, communities, and learning (Kultima, 2015), there is a lack of research detailing how game jams might foster empowered participation along with experiences of communality and socialisation beyond networking and elements of joyfulness and fun (Lai et al., 2021). While game jams generally revolve around a specific theme or constraint and might emphasise social topics and purposeful and serious approaches, technological challenges, or game typologies (e.g., Boulton et al., 2018; Lai et al., 2021; Abbott et al., 2023) less is known about game jams connected to culture and cultural heritage. However, isolated examples of 'purposeful game jams' can be located, with, e.g., the Sámi Game Jam addressing Indigenous culture and diversity (Kultima and Laiti, 2019) and cross-cultural online game jams across countries (Park et al., 2023). Generally, scholars find that cultural diversity and inclusivity "is still lagging behind its ever-diversifying reality" in the global game industry (Park et al., 2023, p. 2), calling for new approaches towards more culturally explorative, diverse, and sustainable game-making practices and experiences that also address the participants individual and social values that permeate and guide game-making. Hence, game jams that are set and enacted through culture and within cultural heritage spaces to produce games *through* and *for* culture are a novel format that this paper's underlying research and development project seeks to develop and examine.

This paper studies social and collaborative elements of Cultural Game Jams (CGJs), which is a game jam format developed and implemented in the large-scale European research and innovation project EPIC-WE that builds on transdisciplinary collaboration and co-creation across cultural heritage institutions (CHIs), creative industries (CIs), higher education institutions (HEIs), and youth citizens (YCs; age 16-25) towards CGJ interventions across three European sites: in Óbidos (Portugal), Hilversum (The Netherlands), and Aarhus (Denmark). CGJs, held in cultural heritage sites, focus on value-sensitive game design and youth-empowered cultural participation (Nørgård & Holflod, 2024). Drawing from the first project intervention, this paper examines the participating youths' experiences of value-sensitive game-making in diverse communities and cultural participation and socialisation (understood as individual and collective processes of acquiring knowledge of cultural histories, traditions, identities, and values), leading to the following research question guiding the present paper: *How can*

Cultural Game Jams enable youth experiences of empowered participation, communality, and cultural socialisation?

The paper first examines social, communal, and relational perspectives on game jams, addressing CGJs and their potential in youth cultural empowerment. It then outlines the design-based research methodology used in EPIC-WE and presents findings from the first CGJ, discussing the potential for social learning, novel communities, cultural playfulness, and youth empowerment.

2. Social, Communal, and Relational Perspectives on (Cultural) Game Jams

In recent years, game jams have emerged as a novel method and approach for introducing youth to diverse educational, cultural, and societal topics (Fowler et al., 2016; Lai et al., 2021) while serving as platforms for research and innovation (Kultima and Laiti, 2019). Despite this, they remain relatively unexplored (Kultima, 2021). Game jams are social, collaborative events where participants come together to ideate, develop, and prototype games within a limited time frame (Kultima, 2015). The goal is to foster creativity and rapid game (concept) development (Meriläinen et al., 2020). These events vary in duration, typically spanning from a few hours to a weekend, encouraging focused development without excessive planning. Participants come from different backgrounds and thus integrate experiences and competencies across disciplines, e.g., design, technology, programming, or visual arts, providing relevance in the enculturation of aspiring game developers who might look towards entering the industry (Kultima, 2015; Olesen and Halskov, 2018).

Game jam events furthermore promote fellowship and community, providing a platform for skill development, learning, and feedback (Kultima, 2018, pp. 146-147; Meriläinen et al., 2020). As a format and experience, game jams are thus collaborative, social, and communal places and spaces for rapid game ideation and development, enabling the potential of enculturation in, particularly, game industry domains. However, even after 'Two Decades of Game Jams' (Lai et al., 2021), there is still a lack of knowledge about how participating youth experience elements of sociality, relationality, and communality that extend beyond themes of social networking (Arya et al., 2015), social capacity building and social capital (Fowler et al., 2016), and social skills as a learning outcome (Aurava and Meriläinen, 2021).

A *CGJ*, a game-making format developed in EPIC-WE, integrates values-sensitive design (Friedman and Hendry, 2019) to innovate game ideas and prototypes within cultural heritage spaces. Unlike traditional game jams, these events emphasise creating games *as*, *through* and *for* culture and transforming cultural heritage using arts, archives, and local cultural collections. They aim to enable youth participation in cultural and societal domains, featuring collaborative work over a short period (36-48 hours) connecting four thematic categories of Games, Culture, Citizenship, and European values, which are 1) human dignity, 2) freedom, 3) democracy, 4) equality, 5) rule of law, and 6) human rights (Lisbon Treaty, 2007). These CGJs moreover address themes of diversity, inclusion, intergenerational perspectives, and cultural and societal challenges, which scaffold the participants to reflect on and enact new modes of social, communal, and empowered participation in game jams. Finally, CGJs follow four taxonomical phases: Experience, Play, Imagine, and Create (EPIC phases), leading youth through cultural game-making. The underlying WE Dimensions (Worlds and Empowerment) guide processes, focusing on empowering youth towards exploring new cultural and gaming worlds. In each phase, the participants reflect on their collaborative game development and thematic, cultural, and value-sensitive exploration and design through writing Game Logs.

3. Methods: Cultural Game Jams as Design-Based Research Interventions

Framed by a Design-Based Research (DBR) methodology (McKenney and Reeves, 2019) and drawing from experimental and short-term ethnography (Pink and Morgan, 2013; Estalella and Criado, 2018) and design experiments (Brown, 1992), this study examines diverse qualitative empirical material from a CGJ intervention. The data includes in-situ vox pop interviews, participatory observations, field notes, and the youth participants' reflective processes and design documentation during the CGJ.

EPIC-WE is situated in an ecosystem with different sectorial partners collaborating to design, develop, and implement DBR interventions within a quadruple helix innovation ecosystem, a strategic model for university-government-industry-public interactions and collaborations (Carayannis and Campbell, 2012), where CIs, CHIs, HEIs, and YCs collaborate on interventions with both scientific and innovation goals. DBR emphasises the interaction between developing theoretical insights and practical solutions in real-world contexts, closely involving stakeholders from and within the specific domains and contexts the interventions are designed

towards and address (Barab and Squire, 2004; McKenney and Reeves, 2019). This approach is applied explicitly to the co-creation of CGJs as design experiments (Brown, 1992) that involve cross-sector partnerships between CIs, CHIs, and HEIs, whereas YCs become epistemic and practical partners during the interventions by problematising and co-creating the field of CGJs together with the different partners, drawing inspiration from experimental collaboration (Estalella and Criado, 2018).

This paper primarily draws on the first intervention of the project by examining a two-day CGJ at the ARoS Art Museum in Denmark and the participating youths' (n=23), primarily students, experiences of collaboration, social engagement, and communality. CGJs engage youth citizens in creating games with material inspiration from cultural heritage through value-sensitive design processes and collaboration with peers from diverse backgrounds to co-create games that reflect and emphasise culture. The inspiration from tangible cultural heritage, such as artworks and artistic installations in the museum, along with more intangible cultural heritage, such as the European values also influencing the youths' ideation and design processes, led to different and novel approaches to collaborative game design processes of re-thinking, criticising, and transforming cultural expressions through game. In this process, the youth participants thus take on roles as both game-makers and culture-makers within cultural heritage domains. Through CGJs, the project aims to enable youth to experience and cultivate empowered participation and a stronger sense of belonging in culture and cultural heritage. By inviting them to be partners in culture-making and game-making, the overarching emphasis is on supporting them to explore and navigate cultural and societal challenges with curiosity, creativity, agency, and imagination - thus becoming empowered participants in culture and society.

A pilot game jam was also tested earlier in the project with 40 youth students (ages 17-18) (Eriksson, Holflod and Nørgård, 2024). During the *CGJ*, 23 youths (ages 15-25) co-created game prototypes drawing on cultural heritage and artworks as materials, imbuing and reflecting on their game-making processes, design and prototyping with European values. As a DBR intervention inspired by short-term ethnography, it is conceptualised as an intense and participatory inquiry through the intervention time and space (Pink and Morgan, 2013) by co-creating and accelerating the research process through intervention design and facilitation.

3.1 Data Production and Analysis

The empirical material produced during and after the CGJ employs a multi-method approach, incorporating in-situ vox pop interviews (Bayne and Gallagher, 2021), participatory observations and observation notes, and documentation of participants' reflective processes in game-making and design. At the outset of the CGJ intervention, we conducted vox pop interviews, seeking brief 5–10-minute insights from all youth participants about their motivations and expectations for the event. We asked questions like "What motivates you to be here today?" and "What do you expect from the game jam?" The researchers documented the participants' responses immediately after the vox pop interview. Researchers observed the game-making processes throughout both days of the CGJ, applying an observation grid to document the dynamics of youth participants' teamwork, collaboration, and participation. They also observed the facilitation and structure of the event, the participants' vocal reflections on the process, and the conditions and potentials for cultural reflectivity and empowered participation. An integral part of the CGJ involved documenting the youth participants' iterative reflections, game ideas, and game-making processes through the Game Logs. This documentation captured their thoughts on how their participation intersected with cultural heritage and European values in the context of game creation. The table below visualises the characteristics of the CGJ regarding organisation and details of the participating youths' backgrounds.

Table 1: Cultural Game Jam Details

	Cultural Game Jam 2024
Organisers Government - Cultural heritage Industry - Games University - Research	 ARoS – Aarhus Art Museum (CHI) Filmby Aarhus (CI) Aarhus University (HEI)
Venue	ARoS – Aarhus Art Museum
Duration of CGJ	2 days
Facilitators	2 art/museum guides (culture-making); 4 coding/game design guides (game-making)
Public - Number of youth participants	23

	Cultural Game Jam 2024
Age distribution	15-27 Avg: 21.4 SD = 3.33
Gender distribution	M: 10 F: 7 Other: 6
Number of games created	5
Distribution of participants by field of interest	Arts & Culture: 1 Game-making/Games: 8 Game-making/Sound design: 2 Art-making/Visuals: 7 Creative programming/Technology: 3 Idea Management/Design processes: 2

The analysis of the empirical material draws from thematic analysis and is guided by an emphasis on the researcher's reflexive positioning as both a condition and an asset in constructing themes and analyses across the empirical material (Braun and Clarke, 2022). In this paper, we accentuate two themes of participation created during the analyses: 1) Participation, communality, and empowerment in CGJs, and 2) Social learning and cultural socialisation in CGJs. These themes are interrelated, although different lenses through which we can understand the potentials and challenges of youth participation in CGJs.

3.2 Research Ethics and Data Management

Before the CGJ, all participants who signed up were provided with materials covering research ethics, GDPR, intellectual property rights (IPR), and general ethical considerations. These materials outline the formal procedural ethics of the project's research and interventions, including the participants signing declarations of informed consent prior to the game jam and IPR-related guidelines and agreements regarding game ideas and concepts that might be developed during the CGJ. Additionally, the project's framing within DBR emphasises the importance of participatory and relational ethics, thus highlighting how participation and representation are active democratic inquiries in the research and interpersonal relationships involving youth - and, therefore, inherently epistemic and interdependent connections. Finally, the project also had ethical consent from the ethical board at the university responsible for the present study.

4. Results: Exploring Youth Citizen Experiences of Cultural Game Jams as Social and Communal Spaces for Empowered Participation

The EPIC-WE CGJ was a two-day event in February 2024, where 23 youth participants collaborated on game-making *through* and *for* culture across diverse backgrounds and experiences at the ARoS Art Museum in Denmark. The HEI, CHI, and CI partners facilitated the event. In the following sections, we examine youth citizens' experiences of participating in the CGJ in Aarhus, their motivations to participate, their jam experiences, and their reflections on the CGJ and the cultural and value-sensitive game-making processes.

4.1 Lens 1: Participation, Communality, and Empowerment in Cultural Game Jams

During the first day of the CGJ, we performed 20+ in-situ vox pop interviews that generally display that the participants are motivated by an eagerness to explore both culture and games and test their different skills, particularly in the context of a CGJ. Moreover, they highlight the motivating factors of networking, potential career development, and exploring and innovating the intersection between games and culture. Through the interviews, participating youths express expectations of gaining new social and individual experiences while building relationships in a creative, collaborative environment. Regardless of background, they seek to expand their skills in game design, art, culture development, and programming. Common motivations include applying and extending existing skills in a different setting and exploring career opportunities. The communal and relational aspects of novel participation across disciplines and backgrounds are also highlighted as important. The community and socialising perspectives are, however, not only about meeting new people in a novel situation but also a vocal desire for a sense of community situated within a unique *game jam feeling*. This resonates with other research on game jam experiences that highlight the prevalence of perspectives on community and belonging as central motivating themes in participating across disciplines and cultures and towards building social capital (e.g., Fowler et al., 2016; Park et al., 2023). To exemplify this, one youth participant with a programming background emphasised "the communal elements of creating together, experiencing the game jam feeling and involvement, and being motivated by the process of creating something

new and different from others" in a vox pop interview. This message of communality and exploring new interplays between games and culture resonates across the vox pop interviews, with another youth from a game-making background articulating "the intensity of creating something together, and thus also the communal and collaborative elements of participating in the game jam." Of particular importance - and highlighted in the participatory observations - is the disciplinary diversity, with youth participants coming from different backgrounds and disciplines, though they generally emphasise the same motivations of exploring "... a different experience by jamming with other people and taking her friends with her and meeting new people. To socialise - and being and becoming part of a community that enables new connections and relational experiences", as articulated by a participant with a background in culture and project management.

Throughout the CGJ, and across interviews and observations, general themes voiced by the participants were the motivations and desires to become part of a different community that emphasises relationality across cultures and hence longings for novel ways of connecting within cultural game-making and design communities. It further relates to elements of empowered participation with and through culture, individually and collectively, and how it might be enabled by CGJs as a communal and safe environment to "... learn from each other and socialise in open settings while enjoying the experience of meeting other young people in a cosy, informal environment that 'feels' safe." Hence, the game-making activities in CGJs might be recognised as playful events or playful learning spaces, mimicking the characteristics of playfulness that are procedurally constructed by the participants towards trustful relationships (Whitton, 2018), as 'magic circles' for both vulnerable and empowered social participation in culture, further influenced by the value-sensitive processes of collaborative game-making as a playful and experimental co-creation of objects (games) that mediates and strengthens cross-cultural communication and relationships (Holflod, 2023).

4.2 Lens 2: Social Learning and Cultural Socialisation in Cultural Game Jams

The participants in the game jam came from diverse backgrounds, including audio design, visual design, programming, game-making, escape room design, animation, and dramaturgy. This variety fostered a rich and dynamic environment where different disciplines could converge to ideate and create something new and different. For example, a youth participant with an artist background reflected on this interdisciplinary collaboration during an interview, stating, "I had a feeling that it was lovely meeting across disciplines and perspectives. At some point, I drew a square on a Post-it note, and later, it blew from the table to the floor. Even later that day, some of the group members saw it, picked it up, and were excited with potential ideas stemming from the simple drawing - and it created a nice experience of learning from each other's perspectives." It exemplifies and highlights the perceived and experienced value of collaborating across diverse perspectives to spark creativity and innovation during the game jam. However, this case was enabled through an unexpected or unplanned situation, which was not explicitly designed for.

During the CGJ, the youth participants approached cultural material - artworks, tangible cultural heritage, and European values - as materials for their design processes, resulting in different game concepts and prototypes. The five cultural games created during the CGJ are publicly available (https://itch.io/jam/epic-we-game-jam-01-aarhus/entries), and they display how the participants drew inspiration from national paintings and artists, emulating a vibe, aesthetic, or atmosphere or by creating new ways of interacting with and in the specific artworks. An example of this is the game "Roomination", wherein the player navigates and ruminates on the eerie, melancholic hallways of a Vilhelm Hammershøi (1864-1916) painting – and experiences freedom (as an incorporated European value) in its interaction design as something that can be strived for but quite difficult to reach. From a processual perspective, the participant's collaborative engagement through a more and more refined game idea was a medium for social learning and cultural empowerment across backgrounds and disciplines. They actively learn from and build upon cultural artefacts by choosing, adopting, and remixing specific artworks. Moreover, by exploring different disciplinary perspectives on the artworks, such as aesthetics or narratives, and integrating them into their games, they assert their creative agency and reinterpret cultural heritage in ways that resonate with themselves as cultural citizens in contemporary society.

Cultural integration and socialisation became a central focus during the CGJ, with participants keen on exploring the intersection of games, culture, values, and citizenship - and their individual and collective relationships with culture and cultural heritage. While a few participants focused on CGJ themes and examined the processes and methods involved, the overall interest was integrating cultural elements into their game designs. Several participants emphasised the significance of cultural diversity and exploration within the game development process - and how it changed their perceptions of the cultural collection and artworks and their experiences of being and becoming cultural citizens less foreign to cultural heritage than before. As such, the format of CGJs

scaffolded potentials for cultural socialisation, which relates to processes of social and cultural influence wherein the youth participants acquire culture and are thus socialised into culture otherwise foreign to them, affecting and shaping cultural identity and relationality - towards both games as culture and as a medium for ideating and experiencing new expressions of culture.

During the final exposition of the created game prototypes, the research team observed and participated with the youth participants. It became evident that many of them had undergone significant shifts in perspectives towards cultural heritage. The participants from cultural backgrounds voiced similar processes of becoming more receptive and sensitive to the potential of game-making as both an interest and cultural expression. In contrast, game-oriented youth participants discussed embracing cultural perspectives and expanding their understanding of cultural heritage. They were immersing themselves in tangible cultural heritage, e.g., artworks and cultural worlds, in new ways previously perceived as difficult or impossible for them, with both 'groups' of participants articulating becoming more open to different European values, how they influence us, and how they can change perspectives on culture and games. These changes in perspectives are not only conceptual or theoretical but also very actionable and practical by expressing and demonstrating changes in ways of thinking, voicing, and acting, leading to more empowered and engaged participation with cultural heritage, both *tangible*, like artworks, and *intangible*, like values (Eriksson, Holflod and Nørgård, 2024).

5. Discussion: Empowering Communities and Cultural Playfulness

This study illustrates how co-creating games within cultural heritage contexts can develop youth perceptions and experiences of community, sociality, and individual and collective cultural empowerment. Moreover, the experimental ethnographic and design-based perspectives support examinations of democratic inquiry (DiSalvo, 2022) with participating youth citizens who become both epistemic and practical partners (Estalella and Criado, 2018) during the CGJs by co-creating and problematising the field with different participants and stakeholders.

From the Sámi Game Jam (Kultima and Laiti, 2019), it was discussed that the participants reflecting during the jam on their thinking and views led to experiences of empowerment; they learned something about their identity and could thus deal with personal and collective culture differently. On a similar note, the CGJs led to youth participants experiencing their own culture and cultural identity as a polyphony of voices from games, culture, values, and citizenship permeating and empowering their participation with cultural heritage and towards emergent communities. As mentioned, the first CGJ drew from experiences with designing and testing the format during a pilot test, revealing several vital insights. It underscored the importance of carefully designing and planning how participants interact with cultural heritage and values in game design and conceptualisation, and it highlighted a need for deeper engagement with specific cultural heritage pieces to facilitate the ideation processes of creating games through culture within empowering spaces of being, becoming, and belonging.

5.1 Playing with Culture, Participation, and Communities

Though game jams are mainly viewed as game-making events that are experimental, creative, and social, play and playfulness as theories and practices might offer new perspectives to conceptualise and discuss the CGJ participant's experiences of relating and socialising across backgrounds, disciplines, and culture in experimenting and creative processes. A recent review on adult playful learning and collaboration found that tangible construction play, i.e., creating, making, building, or materialising things together, are mediums to collaborate across disciplinary boundaries and hold the potential to permeate boundaries when the objects (e.g., games) are mediating materials for externalising one's perspectives along with enabling new participatory and communal spaces (Holflod, 2022). As also highlighted in the analysis, the youth participants were creating together throughout the CGJ - both in diverse design and game-making activities and the game prototypes themselves, and these processes enabled safe spaces for participation. In play, the players continuously negotiate and frame - communicate and meta-communicate - the boundaries of play (Bateson, 1972). They, in other words, examine questions of 'what if' and 'what might be' in a relationship between a playworld and a 'real' world, wherein playful engagement with objects (e.g., artworks and material cultural heritage) can become intrinsically connected to individual and collaborative world-building through objects in play (Holflod, 2023). Here, approaching cultural heritage playfully aids in supporting the players to create, frame, and reconfigure their processes and situations, with cultural heritage collections as play objects becoming references to the real world (Fink et al., 1968), supporting the creation and safe space (Whitton, 2018) for collaborative learning, game design, and relationships across backgrounds.

6. Conclusion

This paper reports on and discusses findings from the first CGJ from a cross-cultural European research and innovation project, with multiple similar game jams planned for and held during 2024 and 2025. As such, clear limitations of the present study are its local emphasis and lack of testing across sites and contexts, but in alignment with a DBR framework, it explores and produces tentative local theories by examining limited manifestations of a phenomenon, leading to context-sensitive knowledge about a specific domain (McKenney and Reeves, 2019). It, moreover, leads to possible implications to scrutinise and reflect on regarding game jams in cultural places and spaces and how youth participants experience social, communal, and collaborative practices and learning within such formats and environments.

Throughout this paper, we have explored the interplays between culture and games within the format of CGJs with youth participants, presenting and discussing their motivations and experiences regarding social and relational perspectives, communities, enculturation, and empowered participation. CGJs contribute towards youths engaging with cultural heritage in new ways, which materialise in games and become new expressions of cultural heritage. Moreover, more playful entanglements with cultural heritage and play methods to ideate and design game concepts can support collaborative and co-creative practices and relationships through safe spaces and mediating materials. Though this paper disseminates themes of interest to game-based learning environments and formats such as game jams and hackathons - in cultural, educational, and social domains - more robust knowledge through multiple interventions and studies is essential. We thus hope that the present study can inspire others to develop and test related formats and concepts for the cultural empowerment of youth citizens through game-making.

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Harnessing the Power of Gaming to Influence Policies Addressing Climate Change

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Abstract: In this paper, the authors present the findings of an empirical case study examining the efficacy of the Games Realising Effective & Affective Transformation (GREAT) Case Study design process. The process is underpinned by an established Mixed Methodological Research (MMR) framework for eliciting the preferences of gamers and determining their priorities in climate change policies. Funded by the Horizon Europe programme, the GREAT Project examines the impact and affordances of games for social engagement. The project explores the innovative potential of games as new forms of dialogue between citizens and policy stakeholders. The games are used as tools for players to express their preferences and actively shape policy issues. We present the first case study on this approach, which is one of ten to be undertaken with various partners over the next two years to test and validate the methodology, investigate its potential, and present findings. In partnership with the popular PC & Console game Smite, by the Hi Rez, game development studio. The study involved stakeholders' participation in the co-creation of research questions, designed to influence the prioritisation of future climate policies. The activity was embedded the Smite game playing community via the Playmob platform in January 2024 and engaged over four thousand active players with a completed response rate of 58 %. Quantitative analysis of the data collected during this period will be presented by the authors. In summary, the engagement in and completion rates of the activity were high, validating the initial GREAT project approach. The methodological approach and the substantive data sets produced are of interest to any organisation considering engaging diverse groups active in gaming communities in the political process, including NGOs and policymakers. The project and methodology applied is at the core of this paper.

Keywords: Digital Games, Applied Games, Policy, Climate Change, Data, Games Base Learning, Society

1. Introduction

This paper Reports on the findings of an exploratory case study of a European Commission (EC) and United Kingdom Research and Innovation funded three-year GREAT project. The project involves seven partners across Europe and aims to enhance citizens dialogue with governments and policy agendas relating to actions to mitigate climate emergency, using the medium of gaming to facilitate this. The scope of the paper does not address the sustainability of the digital Games industry per say but how the industry and specifically the associated playful development techniques for player engagement could be meaningfully deployed to address wider societal sustainability challenges. The growth of digital games over the last decade has been a remarkable phenomenon and this raises important questions about the cultural role and meaning of games and the potential for games to be applied for learning or social good over and above their core purpose of entertainment. Collaborative virtual gaming environments can support a variety of pedagogic approaches and can be applied, for example, 'as both constructivist learning environments and as didactic instructional tools' (Whitton & Hollins 2008).

The digital games industry is now a larger economic sector than either of the music or film industries and is estimated to have generated $180.3 billion in the year 2021 (Wijman, 2021). There is no consensus on the positive or negative nature of the impact of games on wider society though much has been written about

specifically children's over exposure to screen time and the negative impact of social media and forms on wellbeing. 'Serious' or 'Applied' games are considered a major emerging technology anticipated to enter mainstream use, in wider society Steiner et al (2015) In parallel, the proportion of (EU) citizens declaring dissatisfaction with functioning democracy in their countries has risen markedly. The deterioration has been especially evident within high-income, consolidated democracies, where the proportion has risen from a third to half of all citizens." (Foa et al., 2020). Similarly, the rise of 'fake' news and distrust of news sources and 'scientific 'information is at an all-time low (United Nations 2021). This dissatisfaction and mistrust correlate with increased scepticism and has occurred in an environment where the volume of data generated through citizens everyday interactions and transactions with media is increasing. Analysis of data has increased to the point that it has significant impact, that social media is contributing to a polarizing society (Vrontis et all 2022). It is in this context that the GREAT project was established aiming to explore these dilemmas through applying games technologies, designed to achieve positive transformation, restore community engagement and satisfaction with democracy and democratic processes. It does this by contributing to the establishment of policy priorities for addressing the challenges presented by climate change and by utilising the opportunities presented by the collection and storage of citizen generated data to bring together communities, in an open, ethical process.

The first case study undertaken by the project is an exploratory study for the United Nations Development Programme (UNDP). The paper provides detail on the methodology applied to the project and how this is elaborated through a research cycle and the steps undertaken in the cycle to examine the problem space this is framed within the context of the overarching research questions to be addressed in the project followed by discussion and interim findings and conclusions of this, the first of a series of, case studies to be undertaken in the project.

2. Methodology

In this section the authors provide detail on the methodological approach adopted and how this is reflected in the selected methodology applied to the study. The challenge facing the project is to apply games not simply to promote learning or social attitudes, but rather to gain insight into the cultural role of games through case studies which establish a new communication channel between citizens and policy makers centred around transparency and actionable insights. The project is oriented to the goal of harnessing the cultural and communicative value of games to provide an opportunity for input and feedback for citizens who may not normally engage in socioeconomic debates, and new sources of insight for policy stakeholders. The games and interventions co-designed and implemented are not one-off solutions acting as research tools that explore the effectiveness of the approach, establishing a method and data sources for future adoption.

Project activities support scalability and adoption from the outset, with case studies which test the concept and apply it in authentic conditions at a scale of genuine value to the policy stakeholders. This undertaking is built on three well-founded assumptions:

1. Games constitute a rich source of data that can reveal a great deal about players' engagement, preferences, and attitudes. However, this is closely guarded by publishers and developers as a competitive advantage in optimising their games. This data constitutes a huge opportunity to draw out insights into social preferences and attitudes at scale, but this requires new methods of gathering, storing and analysing data, and new forms of engagement with stakeholders, together creating an engagement ecosystem.
2. Data analytics developed methods to extrapolate from online interactions to gain insight into citizens real-world experiences. The online interactions of game players generate a similar stream of data, and analytics methods can be adapted to reveal the connections between game-world interactions and players' engagement with and attitudes towards real world experiences and issues.
3. Policy stakeholders require informed insight into citizens preferences and attitudes. Policy stakeholders are open to and will engage with this input. This is supported by the active engagement of policy makers in the project and the participatory Citizen Science approach that engages all stakeholders from the onset.

The methodological approach is situated with an established interdisciplinary framework an adaptation of the Multi Interdisciplinary Research (MIR) (Tobi & Kampen 2018) framework to refine methods and instruments of research based on synthesis of established community intervention/ co design evaluative methods).

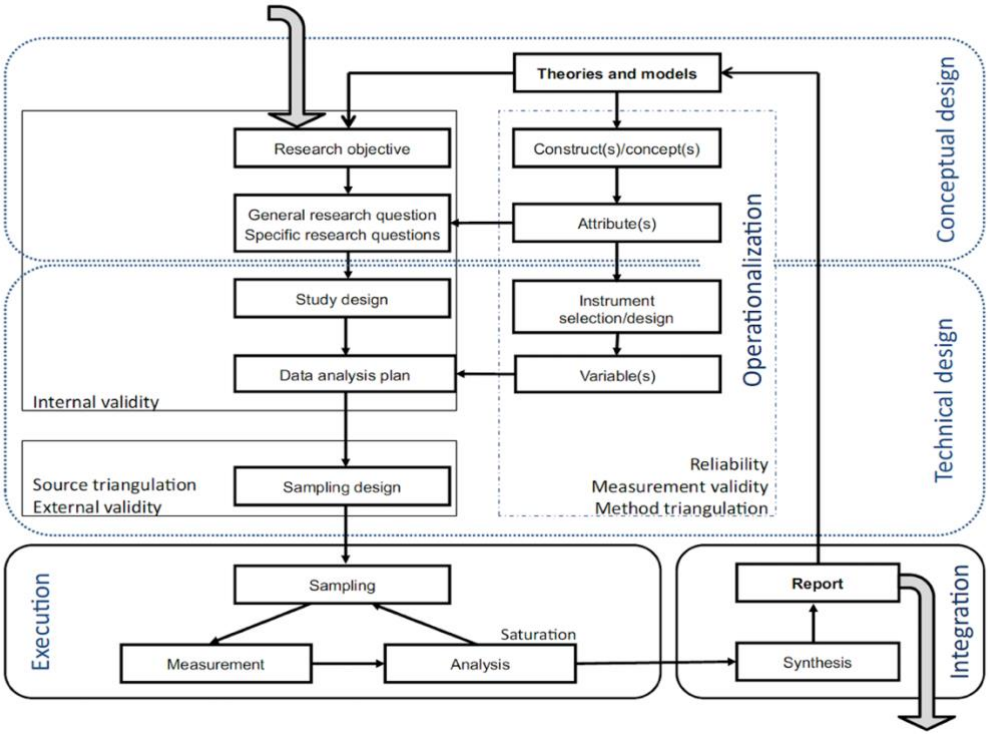


Figure 1: An adaptation of the MIR Framework (Tobi and Kampen 2018)

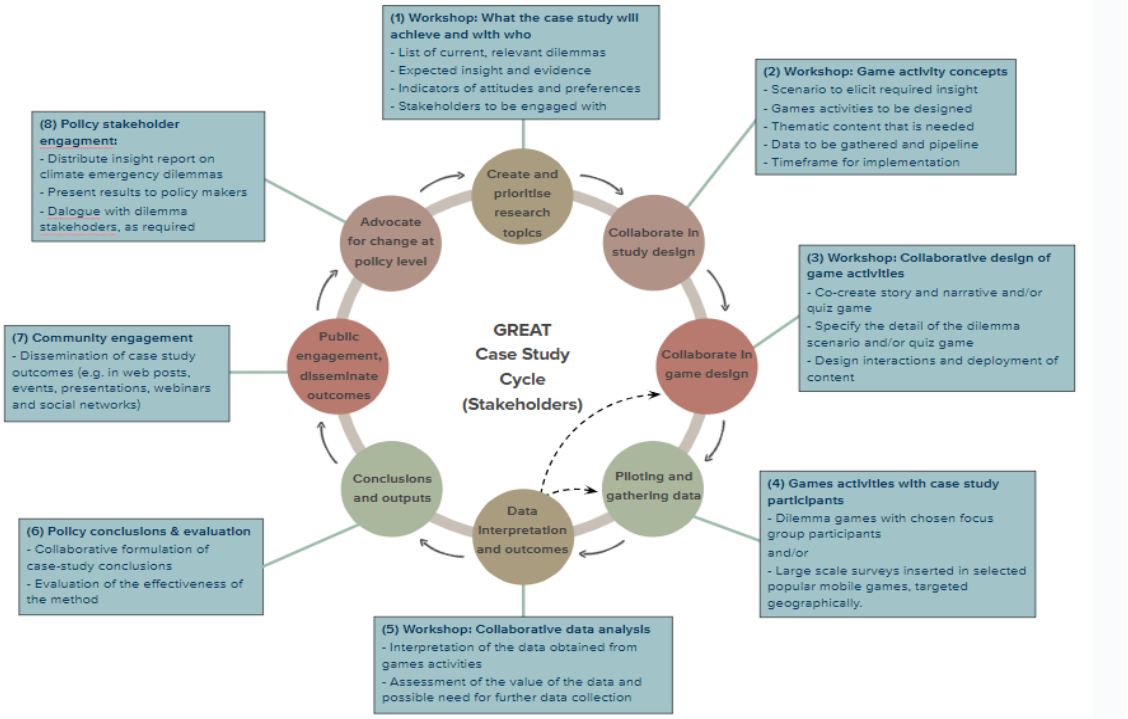


Figure 2: GREAT Case Study Cycle

The research question underpinning the initial steps of the case study displayed in this paper is: *How effective are games-based activities in eliciting, representing and communicating citizens' views on social dilemmas?*

This study utilizes the GREAT case study methodology [Figure 1 and Figure 2] which implements processes involving both policy stakeholders (UNDP) and citizens (Players). Thus, this methodology provides a link between policy and the public.

Table 1: UNDP exploratory Case Study Research Cycle Steps

Step 1: *What the case study will achieve and with who*	Participating stakeholders will participate in a workshop or equivalent activities to identify and prioritize the research topics.
Step 2: *Game activity concepts*	Participating stakeholders will join a workshop or equivalent activities to generate ideas for the game activity.
Step 3: *Collaborative design of game activities*	Participating stakeholders will engage in activities to co-create research questions based on strategic requirements
Step 4: *Games activities with case study participants*	Playmob quizzes embedded within the SMITE online game analysis of two methods 'paid for' (where links to the games are provided by paid advertising) and 'Non Paid' (where the quizzes are embedded directly in the gameplay).
Step 5: *Collaborative data analysis*	Data analysis undertaken using the collected data.
Step 6: *Policy conclusions & evaluation*	Formulate the conclusions that can be drawn from the results of Step 5.(outside the scope of this paper)
Step 7: *Community engagement*	Promote community engagement activities that are impacted by the policy dilemma and identify dissemination opportunities. (Outside the scope of this paper)
Step 8: *Policy stakeholder engagement*	Close the cycle by engaging with policy stakeholders, and in particular the policymakers who identified the dilemma addressed by the case study. (Outside the scope of this paper)

The GREAT case study methodology follows an eight-step process, each stage providing details for co-design and implementation. The work presented in this paper focuses on step 4, the remaining steps of the case study which are beyond the scope of this paper will inevitably close the loop on the cycle in future research, through detailed policy insights, policy stakeholder dissemination and the presentation of results directly to policy makers, the purpose of each step is listed in Table 1.

The project objectives and steps in the cycle determine the types of activities and participants to be involved in the co-design processes, i.e. citizens, domain experts, policy stakeholders and policymakers etc. The following section outlines the steps of the methodology in relation to the UNDP exploratory case study.

3. The Research Cycle Implementation

In this section we discuss the GREAT research cycle and how this was applied to the UNDP exploratory study.

3.1 Create and Prioritise Research Topics. (Step 1)

The research topics in the exploratory case study were developed by the United Nations Development Programme to address key themes identified in their organisation policy documents.

3.2 Collaborate in Study Design. (Step 2)

UNDP collaborated with the GREAT researchers to developing a set of questions to engage players in the climate change debate. The questions were a refined and improved version of questions previously developed in consultation by UNDP with key stakeholders for the Peoples Climate Change Vote and the University of Oxford using a polling method. The questions were refined by the GREAT team with input from partners ZSI and UoB.

The following research questions were developed to be embedded within the selected digital game (SMITE).

- What should the world do about climate change?
- To address the climate crisis, how should your country improve transport?
- To address the climate crisis, what should your country do about energy?
- To address the climate crisis, what do you think your country should do about nature?
- To address the climate crisis, what should governments do about farms and food?
- To address the climate crisis, what should governments do about the economy?
- How can your country better protect people from extreme storms, flooding, droughts, forest fires and other climate impacts?
- Do you think games can contribute to resolving climate change?
- In your view How do you think games could best help tackle climate change?
- What climate topics do you think games can best cover?

- Age.
- Gender.
- Level of Education.

3.3 Collaborate in Design of Games-based Activities. (Step 3)

In collaboration with UNDP stakeholders the game studio partner selected to be a collaborative partner for the UNDP GREAT case study was SMITE which provided free access to the game.

Smite was selected as the game had a high number of active users whilst not being of a scale that could present difficulties in terms of data management for this exploratory study. It was recognised the game had predominantly male players and future case studies aims to address gender balance in a more effective way.

SMITE is a game originally published in 2014 a free to play third person Multiplayer Online Battle Arena (MOBA) digital game developed and published by the Hi-Rez studios for multi platforms including the Microsoft X Box, Sony PlayStation 4, Nintendo Switch and Amazon Luna. In the game players control a 'god' 'goddess' or other mythological figures to participate in team-based combat activities using their tactics, approaches and ability to engage with other players and non-player characters (NPC) 'minions'. The game has multiple modes and supports an active e-sports community that participate in multiple global tournaments and currently has over ten million global players. The Case study explored two discreet approaches to embedding content in the online game SMITE. The first approach involved exploring the use of paid for advertising using 'google ads' embedded within the game. The second involved directly embedding the research questions into game playing experience.

Two alternative visual approaches were developed by Playmob to engage players. The visual approaches were designed in collaboration by the Playmob and Smite design team. The visual approaches were designed using themes from the game in which the activity would be embedded and to appeal to the SMITE community

3.4 Games Activities with Participants (Step 4)

The game participants were invited to respond to a series of questions relating to climate change.

3.5 Data Interpretation and Outcomes. (Step 5)

The responses to each of the research questions is provided herein:

Question 1 What should the world do about climate change?

2365 Responses 93.8% Engagements

Do everything necessary, urgently (1328) 56.2%

Act slowly whilst we learn more about what to do (835). 35.3%

Do nothing (210) 8.9%

Question 2 To address the climate crisis, how should your country improve transport?

2297 Responses 91.1 Engagements

Use more clean electric cars, busses or bicycles (1367) 59.5%

Transport goods on planes, ships, trains and trucks that run on clean energy (1101) 47.9%

Improve the design and planning of cities and rural communities (1463) 63.7%

None of the above (226) 9.8%

Question 3 To address the climate crisis, what should your country do about energy?

2255 Responses 89.4% Engagements

Use solar, wind and renewable power (1710) 75.8%

Waste less energy in homes, buildings and factories (1077) 47.8%

Stop burning fuels that pollute (1215) 53.9%

None of the above (231) 10.2%

Question 4 To address the climate crisis, what do you think your country should do about nature?

2221 responses 88.1% Engagements

Keep the Oceans and waterways healthy (1852) 83.4%

Conserve forests and land (1744) 78.5%

Support local communities, indigenous peoples and women that are environmental stewards (1104) 49.5%

None of the above (127) 5.7%

Question 5 To address the climate crisis, what should governments do about farms and food?

2205 responses 87.5% engagements

Use climate friendly farming techniques (1630) 73.9%

Reduce food waste (1639) 74.3%

Promote plant-based diets (691) 31.3%

None of the above (207) 9.4%

Question 6 To address the climate crisis, what should governments do about the economy?

2185 responses 86.7% engagements

Invest more money in green business and jobs (1439) 65.9%

Require more information on how products are made (1272) 58.2%

Make companies pay for their pollution (1520) 69.6%

None of the above (195) 8.9%

Question 7 How can your country better protect people from extreme storms, flooding, droughts, forest fires and other climate impacts?

2165 responses 85.8% engagements

Install more early warning systems for disaster (1436) 66.3%

Provide good affordable insurance (1233) 57%

Build infrastructure and conserve nature to protect lives and livelihoods (1607) 74.2%

None of the above (157) 7.3%

Question 8 Do you think games can contribute to resolving climate change?

2164 responses 85.8% engagements

Yes (1244) 57.5%

No (380) 17.6%

Don’t Know (542) 25%

Question 9 In your view How do you think games could best help tackle climate change?

2153 responses 85.4 engagements

Raise awareness of climate change (1509) 70.1%

Educate players on what we can do to take action (1305) 60.6%

Raise money for green projects (1435) 66.7%

Enable players to speak up on climate change (1009) 46.9%

None of the above (263) 12.2%

Question 10 What climate topics do you think games can best cover?

2151 response 85.3% engagements

Transport (379) 17.6%

Energy (670) 31.3%

Nature (615) 28.6%

Food and Farms ((408) 19%

The economy (421) 19.6%

Protecting people (335) 15.6%

All of the above (924) 43%

None of the above (227) 10.6%

Question 11 Age.

2147 response 85.2% engagements

Under 18 (102) 4.8%

18 – 35 (1822) 84.9%

36 -59 (224) 10.4%

60 plus (34) 1.6%

Question 12 Gender.

2147 responses 85.2% engagements

Male (1830) 85.2%

Female (191) 8.9%

X (161) 7.5%

Question 13 How old were you when you left education

2120 responses 84.1% engagements

Under 12 (20) 0.9%

12- 16 (83) 3.9%

17-19 (657) 31%

20 or over (803) 37.9%

Still in education (528) 24.9%

Never went to school (29) 1.4%

3.6 Conclusions and Outputs. (Step 6)

The analysis, conclusions and outputs from this study are currently being worked on and outside the scope of this paper which focusseds on the process and methodology applied.

3.7 Public Engagement and Disseminate Outcomes. (Step 7)

Outcomes of the UNDP exploratory case study will be disseminated through established academic publishing channels.

Advocate for Change at Policy Level. (Step 8)

Advocacy and policy interventions are subject to planning with UNDP and outside the scope of this paper.

4. Geographical Context for the Delivery of the Game

This exploratory Case Study was undertaken in a global, international geographical context specified for the delivery of the game. The data collected provides detail of the geographic location of the individual sessions undertaken by players in the game. Players of the SMITE game play on servers predominantly in the United States of America and this has served to highlight that in future studies, where distinct geographical focus may be required, targeted approaches will be taken by the project.

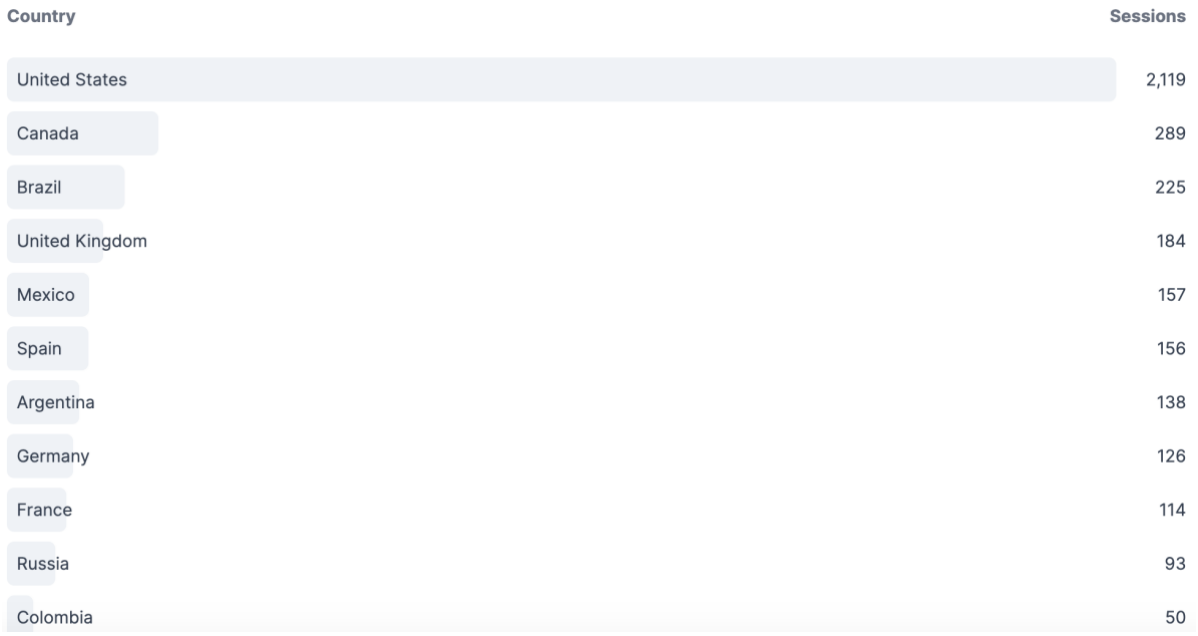


Figure 4: Geographical location

GREAT Project Research Questions.

The overarching research questions of the project were directly mapped to the UNDP exploratory case study activities to ensure alignment with the GREAT project objectives and are detailed in Table 2 below. This ensures that the project research questions are addressed within the case study.

Table 2: Mapping of Project Research Questions to the UNDP exploratory Case Study

GCS 1 United Nations Development Programme (UNDP) Mapping of the Case Study focus and contribution to the GREAT project research questions as proposed.	
Objective 1. Establish ways in which games can be designed to provide a link between citizens and policymakers.	
RQ 1.1: Which methods in digital games can be used to create an information exchange between attitudes and preferences of citizens on societal challenges (e.g., climate change) and policy makers working on these challenges?	Yes
RQ 1.2: How effective and efficient is the use of games in creating an information exchange between attitudes and preferences of citizens on societal challenges (e.g. climate change) and policy makers?	No
RQ 1.3: How can games be used to foster dialogue and collaboration on societal challenges (e.g. climate change)?	Yes
Objective 2. Understand the actual and potential impact that games can have on citizens' engagement in social issues and challenges, and on policy stakeholders' awareness of citizens' attitudes and preferences.	
RQ 2.1: What are the affordances of games in developing citizens' engagement with challenges and dilemmas arising from societal challenges like climate crisis?	No
RQ 2.2: What are the affordances of games in informing policy on the societal challenges like climate crisis?	?
RQ 2.3: What is the value to policy stakeholder groups of the information on citizens' attitudes and preferences generated through games-based activities?	No
RQ 2.4: What is the value to citizens of enabling them to engage in policy discourse through the design of and engagement in games-based activities?	No

GCS 1 United Nations Development Programme (UNDP) Mapping of the Case Study focus and contribution to the GREAT project research questions as proposed.	
RQ 2.5: How generalisable are the GREAT methods to other global challenges or other fields of research and innovation?	No
Objective 3. Provide practical guidance for games developers and policy stakeholders.	
RQ 3.1: Which are the key interventions in the GREAT method which lead to its effectiveness and efficiency?	No
RQ 3.2: Which variables need to be taken into consideration when adapting the method to new contexts?	Yes
RQ 3.3: What documentation and/or training is required for games developers, policy stakeholder groups?	Yes
Objective 4. Assess the benefits and risks to individuals and society of using games to promote engagement with societal challenges.	
RQ 4.1: What are the benefits and risks experienced by citizen participants, policy stakeholders, games designers and providers, as well as policy makers and organizations, when they participate in the GREAT method?	No

5. Discussion

Earlier project pilots carried out in the summer of 2023 and the design of the case study cycle steps made a start on addressing this question. If the method/methods as defined in RQ1.1 are characterised by the step cycle, then case study addresses this, though the early steps were not conducted exclusively by the GREAT project which developed the approaches and questions of earlier UNDP validated activities. The application of the Playmob approach using established digital games tested the method confirming an information an indication of preferences to policy makers was supported by the methods deployed in the case study.

The case study provides substantive quantitative data on those that were engaged and players that have completed surveys. The data provided in this paper suggests that the method is 'effective' though more detailed evaluative comparative study would be required to validate the method as being 'efficient'.

The UNDP exploratory case study does not provide any qualitative response to the research question.

In this case study the focus was on the use of games to foster dialogue and collaboration. There were two business models applied to foster dialogue and collaboration the first, Google Ads, being the purchase of advertising space (using google ads) the second, in-game rollout, engaging directly with games development studios to embed the approach within gameplay.

Table 3: Comparative engagement response rates Google Ads and In-game rollout

	Google Ads	In-Game Roll out
Reach/First page load	7,257	4,352
Engagement	398 (5%)	2,539 (58%)
Completion	179 (45%)	2,148 (84%)
Community Sign Up	18 (10%)	282 (13%)

The data relating to engagement and completion suggests that direct engagement in this case was more effective in fostering and supporting this dialogue. The data further suggests that games can be used as a medium for supporting dialogue. At least anecdotally the study does serve to identify affordances but does not provide substantiated evidence to support these, whilst the quantitative data generated is not compelling.

Data was generated that relates to citizens' engagement, however:

1. There is insufficient data to substantiate player engagement.

2. The case study question is not clear about the meaning of 'affordances', and if indeed this is a useful word to guide our inquiry.
3. There is a potential overlap with RQs 1.1, 1.2, & 1.3.

The Case Study involved discussion with stakeholders, though in this example most of the consultation occurred in earlier activities not managed by the GREAT project. The consultation with UNDP as sponsor of the activity provides limited evidence of sponsor engagement. In future Case studies, where practical and possible questions could be posed to UNDP on what 'value' in a qualitative sense they apply to the information provided to them via this activity and specifically examination of how this games-based activity data generated is used by them.The Case Study does not directly identify key interventions though game interventions within the GREAT method are, at least, implicitly identified in this Case Study access to large volumes of players for example could be construed as an effective characteristic of the intervention. Consultation and co-creation of engaging question sets could be considered likewise as could association with large scale successful commercial games. It will be possible to undertake a comparative study as part of the full UNDP Case study later in 2024 involving future refinements and improvements informed by this Case Study could be incorporated into the research cycle where applicable to ongoing activities with the GREAT Case study sponsors.

Each future case study undertaken by the project could produce a theory about the context (the characteristics of the participants, the circumstances) and identify the characteristics of project intervention that made it work or not work (i.e. an explanatory mechanism). These insights could be accumulated to suggest "use it, but when you do, be aware of these decisions you have to make". Further important insight could be attained through internal evaluation by the GREAT team and or supplemented by the documented reflections of stakeholders and sponsors Useful input could be obtained through the combination of citizen science approaches adopted in dilemma-based activities in the project with the Playmob method to produce rich quantitative data to supplement the large data sets produced through this method.

6. Conclusion

The UNDP exploratory case study detailed has provided valuable insight into the methodology and the research cycle to be applied in further case studies as they are undertaken in the GREAT project. The case study is focussed on a methodology to apply digital games to engage players in discussions focussed on climate change. Addressing the primary research objectives of the project the number of players responding directly to the intervention provides limited early indication of evidence of the efficacy of the approach. The response data is provided directly to the UN to help inform policy development.

The case study provided an opportunity to test two distinct approaches to working with games studios on a large scale. The case study provided evidence that working directly with the studios and embedding the activity within play is more effective in engaging players with the activity than using 'paid for' adverts within games.

Opportunity was provided to test the Playmob approach from a technical perspective, of server functionality and in the management of raw data. The case study did expose a deficiencies in the data in terms of its use for detailed analysis, this is being addressed by the GREAT data teams, reuse, interoperability of the data as it is currently formatted requires further work and standardisation, if the data sets are to be examined and used in other contexts or if the data sets are to be provided directly to the sponsoring stakeholder group for the activity.

The case study has been used in discussion with UNDP to inform the development of a future much larger scale implementation in partnership with several games and studios scheduled for late 2024. It is anticipated that recommended changes both to the methodology and technical improvements will be incorporated in this future activity.

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The Impact of Language and Social Communication on the Sense of Belonging among International Students Using ScLINGO Application

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Abstract: The UK's Higher Education landscape embraces global diversity, with the country ranking second as a destination for international students. However, limited research attention has been given to understanding the challenges faced by these students, particularly regarding language proficiency and cultural adaptation, which affect their sense of belonging. This study aims to address these challenges by investigating the impact of ScLINGO, a web-based gaming platform, on enhancing language skills and fostering social integration among international students, including those studying to become health professionals. Drawing on existing literature, the study seeks to fill this gap and promote sociocultural adaptation through a digital gamified language-learning tool. ScLINGO offers personalized bingo cards and interactive language exercises to familiarize players with everyday phrases and enhance language proficiency, encouraging both independent learning and collaborative interaction. The study navigates through three phases of game development, informed by insights and feedback from practitioners, students, and technology developers. By promoting cross-cultural competence and communication, the study aims to create a more inclusive higher education environment. ScLINGO's pilot phase addresses the rationale behind the game, building-up phases, and stakeholder feedback, anticipating its role in addressing cross-cultural maladjustment and facilitating effective support mechanisms for international students. Ultimately, the findings aim to contribute to the development of support systems facilitating international students' transition and adaptation to diverse cultural and learning contexts.

Keywords: Belonging, Communication, Gaming, International Students, Language

1. International Students and Language

International students are an integral part of higher education in the United Kingdom, comprising 20% of the total student population. According to Bolton *et al.* (2023), in 2021/22 there were 679,970 overseas students studying at UK universities. International students commonly encounter psychological challenges including acculturative stress, homesickness, loneliness, frustration, depression, isolation, and feelings of worthlessness (Tseng & Newton, 2002). Given their physical distance from family and friends, they often have less access to social support compared to local students (Bisadi *et al.*, 2013). However, fostering communication with peers and building a social network can help alleviate their need for social support (Poyrazli & Grahame, 2007).

Although studying in a cross-cultural setting may be valuable, international students may experience challenges and acculturative stress in adjusting to the new environment as it is a complex issue that depends on several factors. They may be vulnerable to stress, which refers to the physical, social, and psychological impact of adaptation to a new culture (Poyrazli and Grahame, 2007). They may experience homesickness and social isolation, a cultural difference and a lack of social support (Dee & Henkin, 199). They often feel overwhelmed by cultural differences (Özturgut, & Murphy, 2009). Examples of day-to-day needs and use of language are such as finding suitable accommodation, applying for social security ID, learning about the transportation system, adapting to local food and being familiar with the city and campus. Consequently, feelings of confusion, anxiety, sense of loss and isolation may arise. If not managed properly, international students' academic success, social wellbeing and psychological health could be in jeopardy (Hechanova-Alampay *et al.*, 2002). Additionally, they may face the fear of failure of academic achievement. Interestingly, many of these questions and challenges can be relived and resolved by the student asking his/her peers for help, however with the limitation of different language and/or accent these challenges persist. Heish (2007), noticed that international students kept silent in her American classes. The participant internalized a deficient self-perception as a useless person in her group discussions and perceived that a deficient identity was attributed to her. Studies that explore social connections within the campus commonly adopt the notion of belonging. Belonging involves feeling connected and the extent to which students feel personally accepted, included, and supported by others in the educational social environment (Goodenow, 1993). Research suggests the importance of establishing relationships with

international students so that other “good practices” may occur, where every location has a range of spoken languages or dialects. Therefore, students need an icebreaker when they start university life away from their mother tongue. The icebreaker supports them in acclimating to the new linguistic environment, fostering connections with peers, and building confidence in social interactions.

2. The use of Amification in Educational Settings Across Different Cultural Contexts

Gamification has emerged as a transformative approach in educational settings, leveraging game design elements to enhance student engagement and learning outcomes. Across different cultures, gamification has been shown to break down barriers and foster inclusive learning environments. For instance, a study by Bukina *et al*. (2022) found that gamification effectively reduces intercultural barriers, such as stereotypes and language differences, promoting better communication and collaboration among international students. For medical students, virtual patient simulations, like those offered by "Body Interact," allow medical students to practice diagnosing and treating patients in realistic scenarios, enhancing clinical skills and decision-making through interactive, gamified experiences (Kononowicz *et al*.,2019). Furthermore, the work of Naderi and Moafian (2023) highlighted the success of non-digital gamification methods in vocabulary learning, particularly in culturally diverse classrooms, suggesting that both digital and non-digital games can be tailored to meet the unique needs of students from various cultural backgrounds. These findings underscore the versatility and effectiveness of gamification as an educational tool, capable of bridging cultural gaps and enhancing learning experiences across the globe.

3. International Students as Health Professionals

As international students transition into roles as health professionals (HPs), a deeper understanding emerges regarding the significance of language in their professional practice. Feeling a sense of belonging in the workplace not only fosters positive outcomes like independent work, professional growth, and effective teamwork but also contributes to a fulfilling work experience. Conversely, the absence of belonging or feelings of social exclusion can hinder learning opportunities, compromise human dignity, and evoke negative emotions such as alienation, diminished self-esteem, resignation, and apprehension towards challenges. According to Jamaan (2020); Cena *et al*., (2021), in Medicine, users are exposed to scientific and commercial medicine names. Another dimension for HP students, is that communication is across more than one domain; HP-patient and HP-HP (peer) communications are both barriers to effective communication. According to Mattila (2010), there is a need to develop clinical practice arrangements when the language of the learning environment is other than that of the student nurse. This study focuses on international students who study and live in Liverpool and experience Scouse in their day-to-day lives. Scouse, officially known as Liverpool English or Merseyside English, is an accent and dialect of English associated with the city of Liverpool and the surrounding Liverpool City Region (Honeybone, 2007).

The study focuses on international students’ sense of belonging in the university community through language communication using a web-based application, entitled ‘Schlingo’, which aims to gamify the use of day-to-day language. Examples of the different meanings of words in English compared to the Scouse and be found in Table 1. ScLINGO has a benefit for HPs who are going to be working in the NHS and a health profession, interacting with patients, who will come from different age groups. And sorts of backgrounds. How to interact with them and minimize the potential for language misunderstanding.

Table 1:Scouse terms and meaning of words

Scouse Term	Meaning	Alternative (more common) Meaning
Part 1- Day-to-day language		
Boss	excellent or satisfactory	Superior or leader
Sound	Good or okay	Physical sensation of sound or volume level
Goin’ the ozzy	Visiting hospital	
You’re a wool	Someone from the surrounding areas of Liverpool.	Wool: is the textile fibre obtained from sheep a is the textile fibre obtained from sheep a
Part 2 - Clinical Terms		

Scouse Term	Meaning	Alternative (more common) Meaning
Patient is settled	Patient is not disturbing the member of staff	Patient has become calm or stable
Bulk	In pain	Big, huge

In summary, considering the challenges that international students face from academic, social, and cultural perspectives. Additionally, for health professionals who communicate with patients and colleagues in the health sector, the risk of misunderstanding or misinterpretation of a word, adds a professional perspective to these challenges for international students.

4. Gaming for International Students

Games have been received positively by international students in terms of high engagement, experiential learning, the learning process, personal versus professional, self-efficacy and knowledge (Hamari *et al.*, 2014) For Bukina *et al.* (2022), elements of gamification for international students break down intercultural barriers such as stereotypes and prejudices, non-verbal and language barriers. For health professionals, little attention has been focused on using digital games to address international students' adjustment issues (Bissadi *et al.*, 2013). The area of health professions, particularly concerning international students, and the utilization of gaming—both digital and non-digital—to support language acquisition in their work practice, remains under-researched. While there is a growing body of literature exploring the integration of gaming technologies in education and healthcare, there is a notable gap in understanding how these tools can specifically aid international students in navigating language barriers within healthcare contexts. Given the increasing globalization of healthcare systems and the diverse linguistic backgrounds of healthcare professionals, further research in this area is crucial to develop effective interventions and support mechanisms. By leveraging the immersive and interactive nature of gaming, healthcare educators can potentially enhance language learning experiences for international students, ultimately improving their communication skills and patient care outcomes (Kukkohovi *et al.*, 2023). This avenue of inquiry holds promise for addressing the unique challenges faced by international students in the health professions, fostering cultural competence, and promoting inclusive healthcare environments. Consequently, the area of health professionals who are international students, and using gaming (digital or non-digital) to support them in using language in their work practice, is under-researched. In summary, the focus of this study is on the use of the game 'ScLINGO' for international students and health professionals to develop their sense of belonging, and improve their social communication, professional language, and communication at work and in day-to-day life practice.

5. Theoretical Framework

Activity-based theory is a multidisciplinary paradigm for comprehending the relationship between action and cognition, built upon cultural-historical activity (Vygotsky, 1978). As described by Kuutti (1996), activity theory emerged from Vygotsky's psychological research into learning, specifically from his discussion of the mediating role of tools (e.g., a game) to facilitate cognitive processes. Activity theory is suitably situated in learning, with individual actions informed by a wider cultural and historical context (diverse linguistic, cultural, and ethnic backgrounds of international students). Stemming from Vygotsky's socio-constructivism theory and the notion that learning occurs in a socially mediated environment, (Kuutti, 1996 and Squire, 2002) expanded the model of activity theory and added another layer to the system to represent the community within which the activity takes place. This forms one of the bases for developing this game, as the development of negotiations and a dialogic approach with international students is one of the main objectives of this study. The community here includes the Community of Practice (CoP), a group of people who share a craft or a profession (Wenger, 2006), students, peers, colleagues, and patients in their work placement. Activity theory includes the used tool (ScLINGO), with the subjects being international students who are health professionals. The applied rule(s) is the language (English Scouse), and the community where the learning of language mediates includes peers and colleagues. The division of labour (elements to be developed) includes teamwork, collaboration, and social communication. The expected outcomes are developed senses of community belonging, social communication, and the use of professional language. Figure zzz below illustrates the Activity theory in using the ScLINGO game.

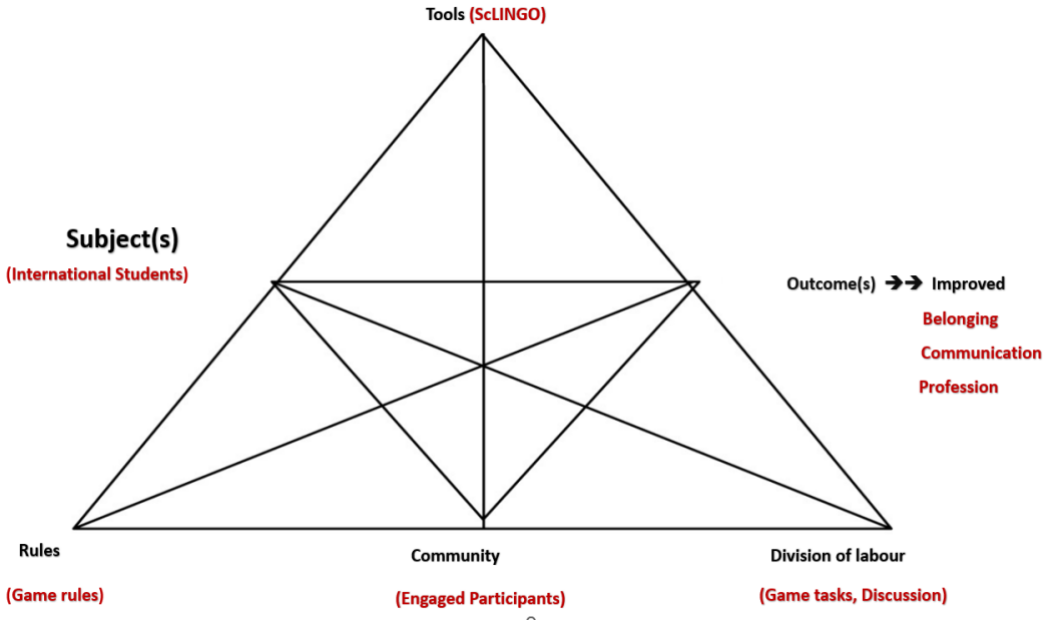


Figure 1: ScLINGO in Activity Theory

Activity-based theory posits that learning is most effective when individuals engage in hands-on experiences and active participation. By utilizing this theory, the game (ScLINGO) provides a dynamic platform for international students and health professionals to immerse themselves in practical scenarios, fostering a deeper understanding of cultural nuances and professional communication skills. Through active involvement in the game, participants can enhance their sense of belonging, refine social communication abilities, and develop proficiency in both professional and everyday language usage, thereby facilitating smoother integration into their respective environments. Besides, in building up the game, the team acknowledges that it should be rule-based which makes players understand the environment; 2) Games should be responsive which means giving players the controls; 3) Games should challenge the players; and 4) The players must build progress to achieve the game's goal (Prong *et a*l., 2018). Besides, in addition to these elements, ScLINGO has been designed to incorporate interactive group discussion and feedback by peers and the class facilitator to provide players with immediate guidance and encouragement as they navigate through the game's challenges.

6. Methodology

6.1 Conceptual Framework (Participatory Action Research (PAR))

Participatory Action Research (PAR) has been employed as a methodological approach for developing the ScLINGO game through a series of cycles, enabling active collaboration between researchers, international students, and health professionals throughout the game's design and implementation phases. It's worth mentioning that this research is still in the building-up stage of ScLINGO, aiming to simultaneously investigate, reflect, and solve issues that arise within the development and game usability, as APR suggests. Action research conducts research and takes action concurrently. According to (Baum *et al.*, 2006; Crane, 2010), this approach fosters a sense of ownership and engagement among participants (Ozaki, 2018), ensuring that the game addresses their specific needs and challenges in real-world contexts. However, a potential limitation of APR is the time and resources required for ongoing collaboration by different stakeholders and iteration, which may extend the development timeline. APR is iterative; plans are created, implemented, revised, and then implemented, lending itself to an ongoing process of reflection and revision. In action research, findings emerge as action develops and takes place; however, they are not conclusive or absolute, but ongoing (Koshy, 2010). The multiple iterations allowed us to understand domain-specific design constraints and provided insights into governing variables that drove the direction of our research. Therefore, we explain our approach as a double-loop learning process.

6.2 What is ScLINGO?

ScLINGO aims to enhance language skills and social integration among international students, addressing communication complexities in university environments. It promotes inclusivity and awareness of language diversity, fostering a sense of belonging through gameplay and discussions in classes. Future plans include tailored versions for various audiences, such as healthcare professionals in physiotherapy, expanding its utility beyond mental health nursing. ScLINGO considers two main aspects of the language (profession) and the language culture (day-to-day language). Therefore, it has two parts; C*LINGO* is based upon professional mental health terms, whereas *SLINGO* is based upon Scouse dialect. The breakdown of ScLINGO (S+C+L+INGO) is explained below.

6.2.1 S (Scouse)

Scouse, originating from Liverpool, encompasses both a dialect and the city's residents. Its name derives from a stew eaten by sailors (Hughes & Trudgill, 1979). The accent and language feature unique pronunciation, vocabulary, and intonation, influenced by Irish, Welsh, Lancashire, and maritime cultures. Notable features include terms like "boss" (meaning excellent) and "sound" (meaning okay). This distinctiveness is evident in various word meanings between English and Scouse.

6.2.2 C (Clinical)

The initial beneficiaries of this game are clinical practitioners in the Faculty of Health and Life Science at the University of Liverpool. More examples of the different words meaning between Clinical English and Scouse English can be found in Table 1 – part 2.

6.2.3 LINGO (Language + Bingo = Lingo)

Bingo is a well-known game dating back to the 16th century, where players mark off numbers on cards as they are randomly drawn by a caller. The objective is to complete a predetermined pattern on the card, such as a straight line or full card, to win a prize. Bingo is commonly played in various settings, including bingo halls, community centres, and online platforms, and it has a long history dating.

6.3 ScLINGO Team

One of the drivers of employing PAR is the engagement of different stakeholders in the development of the game (Koshy, 2010). Baum *et al.*, (2006) addressed PAR in health research and acknowledged that this approach that researchers and participants undertake, improves self-reflective inquiry, so they can understand and improve upon the practices in which they participate and the situations in which they find themselves. Hence, ScLINGO team across the iterative approach includes; pedagogical expertise (e.g. educators), professional expertise (e.g. nurses) and technological expertise (e.g. programmers).

6.4 ScLINGO Development Process

ScLINGO's phase 1 of development commenced with a cardboard prototype, facilitating hands-on testing and refinement. A ‘phase 2’ saw the transition to a digital version, incorporating online multiplayer functionality and expanded content options. Future iterations aim to integrate user feedback, explore additional features, and establish partnerships to enhance effectiveness and reach.

6.5 Phase 1: Carboard Game – CLINGO & ScLINGO

ScLINGO initially began as a non-digital game, utilizing pen and paper. Each student would require one or more printed cards before the session, resulting in extensive preparation and environmental concerns. However, due to its positive reception by both teachers and students, the decision was made to transition the game to a digital format. In the game, participants would draw cards containing language prompts or challenges and engage in interactive exercises to enhance their language skills and social integration. It is noted that at this stage, the game has two separate sub-sections (1) CLINGO (clinical words) (2) SLINGO (Scouse words). See Table 3 below.

List of Scouse words - for the facilitator

Scouse	Meaning	Example
Hiya Tya Alright What's 'appenin'	All greetings to say hello	"Hiya" "Tya" "Alright" "What's 'appenin'"
Ta-ra	Goodbye	"Ta-ra"
Ta Nice one Cheers	Thank you	"Ta" "Nice One" "Cheers"
La'	Lad	"What's 'appenin' La'"
Bird	Used when referring to someone's girlfriend	"I'll have to ask me bird first"
'Arl Fella Da'	Dad	"Am goin' the pub with me 'arl fella"
Ma	Mum	"Am goin' shoppin' wid me Ma"
Ar kid	Used affectionately when referring to a brother / cousin or friend	"Me and Ar Kid are on the way"
Bezzie	Best Friend	"This is me bezzie, Ellie"
Proper	Denoting something that is truly what is said or regarded to be	"I proper love being a scouser"

Printed card for the ScLINGO game – for the students

Clingo clichés

Challenging behaviour	Successful Leave	Therapeutic relationship
Nurses discretion	Unsettled	Optimum health
Risky Behaviour	Maintain a safe environment	Explicit Language
Increased arousal levels	Contributing Factors	Boundaries
Regular observation	Community access	Crisis

Table 2: ScLINGO on printed papers (phase 1)

It is worth mentioning that the primary resource for the Scouse words database originates from grey literature, such as "The Liverpudlian" (2023). Subsequently, the team continually updates and expands this database. Team co-creation fosters engagement and encourages ownership (Naik, 2014). Another aspect to consider is the distinction between the roles of the teacher (module content expert) and the facilitator (Scouse expert) when playing ScLINGO with students in the classroom. Finally, ScLINGO's non-digital version has been piloted with a small cohort of undergraduate students and received positive feedback from both students and teachers. However, using pen and paper does have its limitations, see a teacher quote confirms this difficulty by stating, “Pen and paper game is a hard work for you I think when you play it on a paper-based version obviously give the cards out and I have a master sheet and I would read that sheet with the master sheet laid out if I was to start at the top and work my way down where the digital package randomly generates So it was really nice to kinda have it in a new format it’s phenomenally easy to utilise in the current package click and that does the handwork for me.”

Upon agreement by the game stakeholders (lecturers, practitioners, etc.), it was decided to digitalize ScLINGO (phase 2). This shift is well-aligned and confirmed by literature (Naik, 2014; Naderi *et al.*, 2023), which demonstrates the advantages of technology in terms of accessibility and ownership (each student can access it on their mobile phone or computer screen), besides the ease of use and ability to upgrade game features. However, according to Naderi (2023), digital games should not lead to ignoring the benefits of non-digital activities and play in language education. For ScLINGO, according to this study, facilitators who experienced the non-digital version of the games have explained that the evolved discussion using printed paper was richer than students looking at their mobile screens, as Naderi *et al.* (2023), suggest that technology restrains face-to-face interaction. The preceding claim has been confirmed by the teacher’s view that states; “students may have more engagement in board games than their phones.”

6.6 Phase 2: Digital Game – CLINGO & ScLINGO

At this phase, ScLINGO (a Bingo-style game) has been digitized into a web format written with web standards JavaScript/HTML/CSS. There are two web pages: HTML controls the layout of the pages, CSS styles the look of the pages, and JavaScript adds functionality to the pages. The game is split into two web pages. The first page, called "The Caller," serves as the bingo caller itself and is used by the facilitator of the game. The second page, "The Card," is a webpage that generates bingo calls and must be opened by all players.

6.6.1 The Caller

The caller is a webpage that the facilitator of the event opens, placing it on a large screen or whiteboard where all participants can see it. When the page is loaded, a simple piece of JavaScript randomizes the order of the phrases. Subsequently, the JavaScript attaches these phrases to buttons and positions them in the centre of the screen. Because they are randomized, the order of the items on the page changes each time the page is loaded. Figure 1.1 shows the caller when first loaded.



Figure 2: The ScLINGO caller

The order of items is randomized each time the page loads, with a hidden list created simultaneously. This hidden list contains all Scouse phrases in a new randomized order, along with sound file locations. To initiate the game, the facilitator can press either "AUTO" or "NEXT." Pressing "NEXT" triggers JavaScript to read the first item on the list, causing it to flash red for 2 seconds, play a sound effect, and display in a bottom box. The top item is then removed, repeating the process with a new phrase upon subsequent "NEXT" presses. "AUTO" mode repeats these actions every 5 seconds. The game stops once all phrases are read, though usually manually before completion. This system enables facilitator-paced gameplay with randomized phrase presentation, enhancing engagement and control.



Figure 3: The Screen when the auto button has been pressed

6.6.2 The Card

During the setup phase, the facilitator loads "The Caller" on a large screen while players access the "Card" page by typing in a URL or scanning a QR code. Similar to "The Caller," the Card is an HTML webpage with CSS and JavaScript. It displays a 4x4 grid with 10 randomly selected Scouse words placed at random positions. The webpage's size adjusts based on where it's accessed. Users can access it directly or through platforms like Microsoft Teams. Each user receives a card with 10 different items. When a phrase is called out, users can cross it off their card by clicking the corresponding item on the webpage. Once all phrases are crossed out, users are prompted to call "Clingo."



Figure 4: Ticking correct word on A ScLINGO digital card

6.6.3 Piloting ScLINGO in Phase 2

The pilot involved 12 students, 1st year MSc mental health nursing students comprising a mix of local, non-local, and international students, all enrolled in mental health programs. The session was facilitated by one teacher and one facilitator. At this stage, CLINGO (https://ceds-demos.net/tools/clingo/) and SLINGO (https://ceds-demos.net/tools/sclingo/) are separate games, CLINGO started, followed by ScLINGO to prepare students before going to their placement and encourage discussion between them about used terms in their practice. Towards the end of the session, lasting 15-20 minutes, the conversation shifted towards professional language, especially as students had recently received their first timetable for clinical placements. This led to a discussion about the significance and relevance of professional language within their field.

Table 3: collected quotes from ScLINGO users (teacher, facilitator and students)

Theme	Quote
Teacher & Facilitators' quotes	
Social Discussion	"We revisited and we had a discussion, you know, both from the students' experience, you know, what did they think these phrases mean? what his professional opinion was, what they meant, and then that discussion on a word-by-word basis. While playing the game, the discussion was about the value of the word and benefits to the patient."
Learning and competitiveness	"So, I think the process of the interface of having the words and stuff like that was a real catalyst for a learning experience and getting the students thinking. Besides, The game is competitive in its essence you can see while students are playing. They are checking on each other to see who is ahead".
Accessibility and availability	"So it makes life a lot easier for the person facilitate the game. Accessible and available because it is it's an online platform, so you're not worried about haven't equipment with you. It's just it's available because it's available for anyone with a smart phone, for students, withe ScLINGO, students own the game on their phone (it is about ownership)."
Wider engagement	"just trying to raise awareness of all that it could be used as an icebreaker, but I think it's more than an icebreaker activity. I think it is saying something about not just particularly Liverpool, every geographical region of every country. So, you know, in the UK, whether you're in Liverpool, Newcastle, Birmingham, Glasgow."
Student's quote	
"As someone with a strong cultural identity, I recognize how fun and engaging it can be for friends and colleagues from outside the region to understand the many terms that local people use within daily communications, and how this can be an excellent tool to aid therapeutic engagement."	

6.6.4 Preliminary Findings

The team has collected qualitative findings based on collected feedback from interviews with students who experienced ScLINGO, these findings include Improvement and enhancement of Language Proficiency, Social Integration and Professional Communication.

Improved Language Proficiency: Interviews with participants indicated that students felt a notable improvement in their language skills after using ScLINGO. One student stated, "I feel more confident going to the shop now, especially with local phrases." This qualitative feedback suggests that gamified learning tools can significantly enhance language acquisition among international students.

Increased Social Integration: Feedback from students revealed a strong sense of social connectedness developed through the use of ScLINGO. A student shared, "Playing the game helped me make new friends and feel more at home." This highlights the potential of ScLINGO to foster a sense of belonging and community among international students.

Enhanced Professional Communication: Health professional students reported increased confidence in clinical settings. One nursing student mentioned, "Using ScLINGO made it easier to understand medical terminology and communicate with patients and colleagues." This highlights the practical benefits of ScLINGO in preparing students for real-world clinical interactions.

7. Enhancing ScLINGO: Implementing Strategies for Effective Integration and Broadened Engagement

The team at this current stage is refining ScLINGO and considering feedback from students and practitioners (lecturers and facilitators). This phase focuses on implementing four trending perspectives in the new version of ScLINGO, each designed to optimize user experience and educational outcomes. Ethical approval has been obtained to conduct a study on the impact of ScLINGO on students' sense of belonging and its social implications in both social and clinical practice (Ref, year). This study will commence after the induction day, where ScLINGO will be introduced to the wider university community.

7.1 Co-creation Process

From a methodological perspective, ScLINGO embraces a co-creation process, allowing users, including students and teachers, to actively contribute to expanding and refining its database. Research has shown that involving users in co-creating educational resources can significantly enhance their impact on learning outcomes (Ozak, 2018) and explore opportunities and limitations (Ismail & Adam, 2022). By empowering users to shape the content of ScLINGO, the game becomes more tailored to their specific needs and preferences, thereby maximizing its effectiveness as a language-learning tool. Stakeholders include Pedagogy Experts (teachers), Professionals (e.g. nurses), Technology Team (e.g. developers) and End Users (Students).

The co-creation of the game has a positive impact on students' sense of ownership over their learning. It allows them to construct their learning, leading to increased motivation and engagement (Ozak, 2018). In the study context, ScLINGO users (students and teachers) will have the opportunity to co-create the thesaurus for ScLINGO database, by adding new phases to a virtual ‘postbox’.

7.2 Facilitator Training

One of the outcomes from the pilot phase addresses the importance of the facilitator's role in using ScLINGO, as highlighted by a teacher quote: "The facilitator needs to have some knowledge of phrases to translate the terms, deconstruct them, and put them into the context of how they fit within a professionalized program. From a professional perspective, this means that you need to capture the voice of the person you serve, or you breach the regulations." Therefore, the next phase plans to provide ScLINGO facilitators with 'train-the-trainer' guidelines to support effective implementation in educational settings. These guidelines equip facilitators with the knowledge and skills necessary to utilize ScLINGO's various playing modes, including individual, group, and role-play formats. Each mode offers unique benefits, such as fostering independent learning, encouraging collaborative interaction, and promoting real-world language use. By offering diverse playing options, ScLINGO caters to different learning preferences and styles, ensuring that all users can engage with the game in a manner that suits their needs.

7.3 Wider Engagement

Although ScLINGO focuses on Scouse, the team envisions the importance of raising awareness about interprofessional learning (IPL) on a broader scale. Nationally, similar issues would arise if someone were working in Newcastle with Geordie accents or Glasgow with Glaswegian accents. Therefore, we are using a particular city and regional dialect to illustrate a broader set of verbal communication issues. I believe we should consider integrating it into the IPL components accessible to all students. Consequently, there are two planned scopes for ScLINGO's wider usability: educational integration across taught programs and inclusivity for use across all university students to promote social engagement and develop a sense of belonging.

7.3.1 Scope 1: Educational

The current ScLINGO game has primarily been utilized in modules associated with mental health topics, such as the MSc in mental health nursing program. However, considering that mental health is relevant across various disciplines, facilitators should also consider incorporating ScLINGO into other programs, such as adult nursing or physiotherapy. Therefore, ScLINGO meta-versions are planned to be developed for each module, providing specialized content tailored to the unique learning objectives and requirements of different courses.

7.3.2 Scope 2: Inclusiveness

ScLINGO prioritizes usability and wider dissemination, particularly in large-scale educational settings. For example, during an induction day welcoming 900 new students in September 2024, ScLINGO will be seamlessly integrated into the orientation program. Its user-friendly interface and intuitive design will facilitate easy access and navigation for all participants, enabling them to quickly familiarize themselves with the game and its features. The role of orientation events for international students has been addressed by Bisadi *et al.* (20213); the role of orientation programs in transferring university information should not be ignored.

7.4 Bridging Generation Language Gaps

The final outcome of piloting the ScLINGO game is the observation of a generation and language gap. It was noted that certain terms were suggested by tutors who may be three or more decades older than students, while others were proposed by students themselves. Interestingly, some terms were identified by younger individuals rather than their elders, and vice versa. This observation suggests the potential for bridging the language gap between generations. Additionally, there is a social awareness aspect regarding the use of certain words that might be offensive, stereotyping, or unacceptable within the community (e.g., "female" being equated to "Judy")

8. Conclusion and Recommendations

The development of ScLINGO is an ongoing collaborative process involving Communities of Practice (COP) (Wenger, 2006), comprising pedagogy experts, professionals, technology teams, and end users. Integrating Participatory Action Research (PAR) methodologies and activity-based theory, ScLINGO offers a dynamic platform for international students and health professionals to enhance their sense of belonging, improve social communication, and refine professional language skills in both workplace and day-to-day settings. Based on feedback from phases 1 and 2 of ScLINGO's development within its COP, it's concluded that ScLINGO incorporates diverse scenarios and cultural contexts, enriching the learning experience for international students and health professionals. Pedagogically, the next version of ScLINGO will integrate into existing language and clinical professional development curricula (e.g., physiotherapy). Socially, ScLINGO will be employed as an icebreaker on induction day for new university students in the upcoming academic year. Additionally, empirical data, collected through surveys and interviews, will evaluate ScLINGO's impact on students' sense of belonging, social communication, and professional practice. This longitudinal study will extend throughout the entire next academic year.

Additionally, empirical data collected through surveys and interviews will evaluate ScLINGO's impact on students' sense of belonging, social communication, and professional practice. This longitudinal study will extend throughout the entire next academic year.

8.1 Expected Results and Implications

The expected results from the implementation of ScLINGO include improved language proficiency, enhanced social integration, and a stronger sense of belonging among international students. These outcomes are anticipated to have significant implications for both academic and professional practices:

1. **Influence on Current Practices**: The findings could inform the development of more inclusive and effective support systems for international students in higher education institutions. By providing a gamified language-learning tool, universities can better support the linguistic and social adaptation of international students, ultimately contributing to their academic success and overall well-being.
2. **Theoretical Approaches**: The study's outcomes may influence theoretical approaches in digital gamification for language learning. By demonstrating the effectiveness of a gamified approach in enhancing language skills and social integration, the study can provide valuable insights for the development of future educational technologies and methodologies.
3. **Professional Implications**: For health professionals, the ability to effectively communicate in both everyday and clinical settings is crucial. The use of ScLINGO can help international health professional students overcome language barriers, leading to improved patient care and more effective teamwork in healthcare settings. This can contribute to the development of more culturally competent healthcare practitioners who are better equipped to serve diverse populations.
4. **Academic Relevance**: By addressing the specific needs of international students and providing a practical solution through ScLINGO, the study can highlight the importance of tailored educational interventions in fostering a supportive and inclusive learning environment.

In summary, the development and implementation of ScLINGO aim to address critical challenges faced by international students, particularly in the context of language learning, social integration and their professional practices. By enhancing their sense of belonging and communication skills, ScLINGO has the potential to make a meaningful impact on their academic journey and future professional practice.

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Games Design Frameworks: A Novel Approach for Games Design Pedagogy

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Abstract: The discipline of Games Design has surged in popularity in higher education as a route to industry for aspiring game developers. Notably, at the time of writing 138 UK Universities are now offering game design degrees, and many further education institutions. This growth is not only in volume but also in the diversity of students who enrol in these courses. Young learners, coming from various backgrounds and with differing levels of professional and academic experience, are drawn to games as a field of study. Games disciplines (such as Games Art, Design, and Programming) are often seen as more accessible than their comparative parent disciplines (such as Computer Science). This diversity presents both an opportunity and a challenge for educators: to develop teaching methodologies that not only cater to a wide range of experiences but also effectively prepare students for the creative and technical demands of the games industry. This paper introduces a pioneering design concept utilized in the pedagogy of game design, namely the use of game frameworks. A framework is a structure built in a video games engine, containing a pre-made, playable game experience, which students are taught to build upon and modify. Frameworks abstract and modularise fundamental, complex elements of the game creation process, allowing new learners to quickly become engaged with the iterative process of designing gameplay. It also allows educators to focus on a specific area of interest. For example, a student can focus just on the UI elements of the game for a whole module of study, without needing to have built the entire game first. This allows students to focus on the elements being taught, without introducing a significant amount of non-assessed content just to enable to learning. This position paper discusses our application of this approach, including the process of framework design, supportive assessment, successes and challenges.

Keywords: Games Design, Pedagogy, Video Game, Games Education, Design Framework

1. Games Engines

Game engines are software tools that serve as a means of game creation (Sobota and Pietriková, 2023). A game engine contains many of the core pre-requisite systems involved in the creation of games, such as graphics rendering, lighting, collision detection, physics, sounds and artificial intelligence. Two of the most popular game engines are Unreal Engine and Unity, which provide the fundamental systems for a multitude of popular games, such as Fortnite and Pokémon.

Historically, the game industry would use in-house solutions to provide these core systems, which would incur a significant amount of time and cost to the developer. In modern game development, game engines are used extensively, and knowledge of game engine usage is a sought-after skill in people entering the industry.

Using game engines to develop games still requires a significant amount of technical, design, scripting and artistic ability, however. Game frameworks build upon these core systems provided by the game engine to create a coherent and structured environment in which students can develop their game creation skills (Mora, Riera and González, et al, 2017)

2. Pedagogic Challenges Teaching Games Engine Development

The study of games development at University is an incredibly popular field, with 138 UK Universities offering game development courses (Hot Courses Abroad, 2024), Staffordshire University's Game Institute has approximately 1800 students studying games development-related disciplines, including games design, games programming and games art.

As interest in these courses grows, Universities are met with the target and challenge of recruiting students from a diverse range of experiences (Universities UK, 2019). Some students will study games due to their passion for the technical creation of game systems, whilst others will study for their passion for games as an entertainment medium and pastime, but with potentially less technical experience learnt at College or School.

Whilst games are inherently technical products– requiring developers to have a core set of technical skills, such as scripting/programming – they are also incredibly creative. Games should immerse a player in an experience, providing challenge, reward and narrative. We have found that a good game developer could be someone with

a strong set of technical skills with an appreciation for designing these experiences, or someone with a strong set of design skills, who has enough technical skill to implement their designs. Therefore, a one-size-fits-all approach to teaching games development is not a workable approach when teaching such a large cohort with varying technical and design skills.

With a large cohort of game development students comes the necessity for a large, multi-disciplinary staff base. At Staffordshire, the Games Institute consists of over 60 games-specific academics. To ensure a supportive and successful student-to-staff ratio, many instances of the same class will run – often in parallel with different class tutors – which creates the challenge of ensuring all students receive a consistent learning experience.

3. Industry Expectations

Games industry development companies are often comprised of large, multi-disciplinary teams, with hundreds of employees (Berg Marklund, Engström and Hellkvist, et al, 2019). Upon completing their degrees, games graduates will be expected to join these teams and seamlessly integrate themselves into the companies' development pipeline.

Significantly, it is the case that game development is a long process, with some games taking many years to come to fruition (Aleem, Capretz and Ahmed, 2016). – from initial design to commercial release. As such, graduates will invariably find themselves joining a company where the game product is very much in-development – the initial design will have been completed, alongside the core systems. Graduates will be expected to quickly familiarise themselves with the product, and begin contributing to the project by developing upon the already pre-made systems and design brief.

Additionally, the games design role is equal parts creativity and technical ability (Gross, Sumner and Thürey, 2010) – a games designer is expected to conceptualise a game idea, and then prove this concept via the creation of playable prototypes. This requires designers to have a broad range of technical skills, including the ability to script/program these prototypes, but also design and implement the environments in which the gameplay takes place.

4. Alternative Approaches

Prior to the implementation of frameworks at Staffordshire University, the requirement for graduates to have technical game development skills whilst also being able to work with a range of in-development games was addressed to a limited extent by the use of commercial game level editors.

Games would sometimes be released with additional software, such as a level editor, that would allow the user to create their own worlds to play in. Epic's Unreal Tournament (2014) was a competitive multiplayer first-person action game, and users could download the Unreal Tournament Editor – in order to create new levels of their own design.

Staffordshire University adopted the use of this level editor in its "Introduction to 3D Games Engines" module, with first year students being tasked with creating a new level of their own design. Learning how to create engaging, aesthetically-pleasing levels for this pre-existing game taught students the importance of working with the limitations of the game. Marks were also awarded for the thematical consistency of their level – did it fit well with the levels already provided with the game?

Whilst this was a valuable experience, it was the case that whilst students learned how to use the Unreal Tournament editor, they did not learn the wider skills outside of this software that were often key requirements of a games designer role – namely, the ability to script and create their own prototypes.

Additionally, since Unreal Tournament contained thousands of industry-standard assets, such as highly-detailed 3D models and sounds, students' individual projects would often have very large file sizes, sometimes over 20 gigabytes per project. This meant that students would have to spend significant time in class saving their project and transferring it external media (or cloud backup) at the end of each class. Furthermore, the submission of the project at the end of the module via the University's digital upload system was a long, protracted process – as was the process for staff of downloading the student work for marking.

5. What is a Framework?

A framework is essentially a game product that provides more functionality than would be found in a base game engine template – but is less developed than a fully complete game (Cowan and Kapralos, 2017).

The initial complex set up of required game systems – such as creating inputs/controls, animations for characters etc – is already completed. However, there will be important areas of the framework that are deliberately missing, and lesson content will involve developing these areas and making the framework fully functional.

With this approach, staff and students can focus more upon the design and implementation of gameplay experiences – such as creating and balancing abilities and enemies.

To visualise: Without frameworks, a significant portion of the module content is spent building the underlying systems of the game, with very little time allocated to creating compelling gameplay experiences with these systems (Fig 1.):

Table 1: Representation of module time spent on development without frameworks.

Developing Core Systems						Designing Gameplay		
Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9

With the implementation of a framework-approached, many of the core systems will already be implemented – requiring students to improve and expand upon these in order to create gameplay experiences within their projects (Fig. 2). This allows the module to focus on the core learning outcomes being delivered, rather than over assessing foundational skills.

Table 2: Representation of module time spent on development with frameworks.

Developing Core Systems			Designing Gameplay					
Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9

Additionally, the framework should provide visual assets that can be used to create a playable environment. By providing these assets, lecturers can ensure that the games have a consistent theme -and also ensure that the assets are well-made and efficient. The Sentinel framework used in the University's "Introduction to Games Design" module included over 50 models that could be used in the creation and decoration of levels, but with the overall project size being only 16 megabytes – 1250 times smaller than the 20 gigabyte projects created in Unreal Tournament. This reduction also has a reducing university storage requirements. Given the UK's regulations, that require assignments to be stored for a number of years, this has a significant impact.

6. Designing Frameworks

Games are inherently multidisciplinary, containing design, programming, modelling and animation content. First year students are provided these frameworks as a structured foundation, with much of the core content already developed, and each week they will learn new techniques that expand upon this core framework content.

6.1 The Three Cs: Character, Control and Camera

Frameworks are constructed using the fundamental games design principle of the "Three Cs – Character, Camera and Control", which is used to develop games of all types (Pluralsight, 2014).

6.2 Character

A Game Development framework should include a core, central character which serves as the Player's avatar within the game. This includes the character model and associated animations that support the game mechanics that students will be expected to build within the framework.

By presenting students immediately with a pre-defined character, this helps to give the framework and the associated module a unique sense of personality. The character can be used throughout the lesson content – essentially as a module mascot – that drives the week-by-week content.

This approach was used in the Staffordshire University module "Introduction to Games Design". The character "Sentinel" is introduced both in the framework and the initial lecture slides. Sentinel is described as crash-landing in its spaceship on an alien planet, and must find a means of escaping. Over the course of the module, the lesson content describes a consistent narrative, with the Sentinel encountering new mechanics and gameplay systems (which the students themselves build). Firstly, students are taught how develop the Sentinel's damage and death systems, before creating combat mechanics in later weeks (see images below). This simple – yet coherent - narrative helps to add purpose and relevance to each week's content.

6.3 Control

Alongside the base animated character in the framework is the interactive control system. Creating core inputs – such as movement and aiming – is an involved process that could potentially be a significant hurdle to a new student.

By providing students with the initial controls, this initial blocker is mitigated and allows the student to immediately begin moving the character around the (largely empty) world space – a space which they will be tasked with designing over the course of the module.

It is also important to establish the control scheme as part of the framework, as it helps to set the style and scope of the game for students: The Sentinel framework, for example, contains simple movement controls on the keyboard, the ability to look around with the mouse, and the ability to attack.

6.4 Camera

The camera is the player's viewport into game world. Different games use the camera in various ways, and a game's genre is often described via it use of camera:

First Person – the player effectively sees through the eyes of the character they control. This an immersive view into the game world. The gameplay experience is designed around the player's limited field of view, with them being required to look around to solve environmental puzzles and/or engage in combat.

Third Person – the camera is positioned behind the Player character. This adds further personality to the player's character, as the player can see their character moving and reacting to the world around them (climbing, opening doors etc). Additionally, due to the positioning of the camera behind the player character, third person games allow for a greater view of the surrounding environment.

Top-down/isometric – the camera is positioned above the world, looking down at the player character. This view gives the player greater information about the surrounding environment, allowing them to make more informed decisions. Due to the distant positioning of the camera compared to first person games, the environment can also have less fine visual detail.

In the Sentinel framework, a top-down camera is used. This encourages students to focus on the encounters and puzzles within the level, without creating the requirement for fine visual detail that would be expected with a first-person view game.

6.5 Assessment Strategy

To encourage student exploration and development of the frameworks, the module should incorporate a supportive assessment strategy. In first year modules, this should include elements that support and reward less-technical learners, whilst also offering more experienced students the ability to grow and challenge themselves.

This concept of supportive assessment is based upon ensuring students are motivated by the creation of bitesize, attainable goals that reward innovation and exploration of the framework (Blaine Lawlor and Hornyak, 2012).

In "Introduction to Games Design", the initial weeks of the module are spent introducing core concepts which are used to develop missing parts of the framework – such as a health system for the player character, enemies and hazards to avoid etc. As each of these topics are introduced, so is a small set of bite-size tasks.

These tasks ask the student to evidence that they have completed the lesson content – for example, they will be required to evidence via a short video that they have a functioning health system working with the player character. Each of these bitesize, weekly tasks carry a small mark percentage, and students are introduced to the first of these tasks from the very first class.

The purpose of these tasks is to build confidence early in first year students. Students who are less technical are able to achieve initial marks by building the functionality along with the lecturers. By tasking students with building small, missing systems within the framework – as opposed to having to build the fundamental systems that drive the whole project – the scale of the work is made more immediate and achievable.

Once the main framework systems have been developed via bitesize tasks, a more open brief can be provided that encourages research and further development. In "Introduction to Games Design", students are introduced to assessment 2 – the "project". For this assessment, students are tasked with creating a full level for the framework, which should demonstrate all of the techniques shown in the initial weeks of the module, but with clear evidence of these developed beyond the content of the weekly tasks. This permits more capable students the opportunity to demonstrate their skills and achieve high marks, whilst also ensuring that less-technical students have the required knowledge to succeed at the assessment.

7. Results

7.1 Progression Improvement

Another challenge with Games Development subjects is their inherently ab initio subjects, with most students not having studied them in the past. This often leads to challenging first year modules, especially when the module is taught in the traditional method (no framework) requiring the students to effectively master several games development skills just to build a platform to explore the core learning outcomes.

We found that the framework approach has a significant impact on improving these progression rates. For example, we have the first-year module "Introduction to Games Design" (Fig. 3):

Table 3: Student progression rates from 2019 to 2023

Academic Year	2019/20 (Pre-Frameworks)	2020/21 (Pre-Frameworks)	2021/22 (Frameworks introduced)	22/23	23/24
Progression (Pass) Rate	62%	46%	76%	83%	85%

Notably 19-20 also coincided with the global pandemic, which significantly disrupted teaching. However, this is also as far back as we have data for this specific module. Even accounting for covid disruptions, we note a significant improvement in the overall pass rates of the module.

8. Student Satisfaction

In module feedback surveys, students have expressed an overwhelmingly positive reaction to the module following the implementation of frameworks. In feedback, students have expressed that use of frameworks has been an excellent introduction to the game engine software, with them going from little experience to creating fully playable levels and gameplay of their own design within a single teaching block.

9. Conclusion

The introduction of game design frameworks has demonstrably improved student engagement, pass rates, and general satisfaction in games development modules. This approach integrates supportive assessment strategies, and allows students to focus on the core learning requirement of a module, avoiding over-assessment.

By providing a structured and flexible games foundation, frameworks help to bridge the gap between varying levels of student experience. Less technical individuals can focus on learning and developing specific game components without the overwhelming complexity of building entire systems from scratch. This method further facilitates the development of both creative and technical skills, ensuring that students are well-prepared for the demands of the games industry.

The framework approach aligns with industry practices where game development often involves expanding upon pre-existing systems rather than creating everything from the ground up.

Additionally, the use of frameworks addresses several logistical challenges faced in traditional game design education. By incorporating bite-sized, attainable goals within the assessment strategy, students are encouraged to explore and innovate at their own pace. This approach supports less experienced learners by building their confidence and competence gradually while offering advanced students opportunities to push the boundaries of their skills.

The adoption of game design frameworks represents a significant advancement in the pedagogy of game development education. It not only aligns with industry expectations but also caters to the diverse needs of the student population. The positive impact on progression rates and student feedback underscores the effectiveness of this approach. As the field of game design continues to evolve, the integration of such frameworks will likely become an essential component of educational strategies aimed at preparing the next generation of game developers.

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Comparison of two Different Game Mechanics Applied to Learning of Electromagnetism

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Abstract: The paper presents two educational escape games, Tournament of J. C. Maxwell and Chest of Lord Maxwell, which were designed with the same topic and educational goal in mind: to consolidate and deepen knowledge about magnetism and electromagnetism, and to develop communication skills, teamwork skills, problem solving skills, experimental skills and analytical thinking. Both games were used in the teaching of electromagnetism in an upper secondary school. Data were collected through observation of the game process, administration of questionnaires to students and teachers, and interviews with students. The aim of this research is to compare two different game mechanics used to address the same subject matter and educational objective. The comparison will focus on the perception of the games by the students and the teachers who have incorporated the game into their teaching.

Keywords: Game-Based Learning, Non-Digital Educational Game, Upper-Secondary Education, Electromagnetism, Skills Development

1. Introduction

Escape games are “live-action team-based games in which players encounter challenges in order to complete a mission in a limited amount of time.” (Veldkamp et al, 2020) In recent years, escape games have become a phenomenon as a non-virtual entertainment activity popular with people of all ages. Parallel to their immense popularity in the entertainment industry, escape games are gaining popularity as learning environments in primary, secondary, higher education and professional development programmes (Sanchez, Plumettaz-Sieber, 2018). In escape game literature, all activities, tasks or challenges within an escape game are called puzzles. Puzzles usually follow the simple path: problem – solution - reward (Veldkamp et al, 2020). Successful puzzle solving in educational escape games relates to learning objectives. The unique combination of puzzles, environment and overall mission aims to reach the flow state of players – state of mind characterized by intense focus and pleasure, where players are immersed in an intrinsically motivating task (Csíkszentmihályi, 1990).

While recreational escape games are mostly suitable for groups of 3 to 7 people, teachers often must prepare an escape game for whole class or some larger group of students. This can be achieved in several ways:

- By preparing the same escape game in multiple rooms, so each team plays in its own room.
- By preparing tasks at stations in a larger space, teams use the same stations but arrive at different times, so they don't clash.
- Placing all the equipment and tasks for one team in a chest. Each team has its own chest, so all teams can play simultaneously in one room. (Veldkamp et al, 2020)

In the 2021 review, Lathwesen and Belova examined a total of 93 journal articles, book chapters, and conference papers in both English and German concerning escape games in STEM education. According to the review, there is a paucity of proposals pertaining to the fields of physics and biology education, as well as interdisciplinary studies. The utilisation of experiments within the context of chemistry, physics and biology escape games was identified as a beneficial practice, as it facilitates the development of specific experimental skills. However, escape games incorporating experiments are time-consuming and less readily adaptable. The majority of escape games appear to have been designed with the specific requirements of a particular course or institution in mind. It would therefore be beneficial for the STEM educational community to adopt a more systematic approach to the coverage of standard school or higher education topics, which are taught in many different countries around the world. (Lathwesen, Belova, 2021)

2. The Games

In light of the aforementioned considerations, we decided to design 2 games with same objective and focused on the same topic – magnetism and electromagnetism. The educational objective of the games is to consolidate and deepen knowledge on the topic of magnetism and electromagnetism, and to develop communication skills,

teamwork skills, problem-solving skills, experimental skills and analytical thinking. However, the games differ in terms of their game mechanics, motivational factors, and the way they provide feedback to players. In both games, the whole class is engaged into the game, participants are divided into groups of two to five individuals, and the games are designed for one lesson (45 minutes). In following paragraphs, game mechanics of the games will be described, followed by the overview of physics content and skills that are developed through the games.

2.1 Tournament of J. C. Maxwell

Tournament of J. C. Maxwell (tournament game) is an educational escape game. The game mechanics are inspired by the game Diver (Haverlíková, 2006). The game comprises 15 stands distributed throughout the school building. Each stand is associated with a different task. By successfully completing the task, students are provided with the location of the subsequent stand. If the response is accurate, the subsequent stand is situated on the main path leading to the finish of the game. If the response is incorrect, the subsequent stand provides a hint to the preceding task, requiring the students to return and identify the correct answer. Students are divided into groups of two to five individuals, with the objective of passing the stands in the shortest possible time and with the correct answers. Figure 1 illustrates the path of the stands. All stands are marked with letters. The purple stands mark the start and finish of the game. The orange stands represent the main path (task stands), while the blue stands are the clue stands. The green arrows indicate the correct responses, while the red arrows indicate incorrect responses. If a team responds correctly to all the tasks, they will only visit the orange stands, and the word MAXWELL can be formed from the letters on their path. To prevent the accumulation of teams at the stands, communication between teams, distractions from the game, and drop in attention span, it is essential that each team's order on the main path be mixed up.

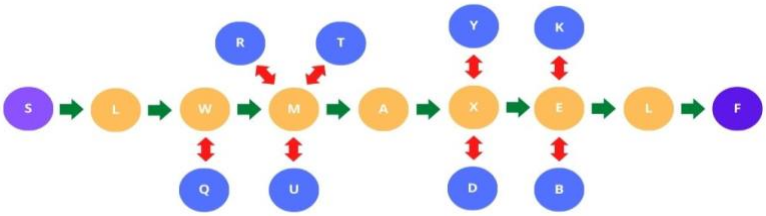


Figure 1: Path of the stands.

2.2 Chest of Lord Maxwell

Chest of Lord Maxwell (chest game) is an educational game in a real (non-digital) environment. It is an escape game, but the goal is not to escape the room; rather, it is to unlock and explore the chest. In exploring the chest, players must solve several physical puzzles. Figure 2 shows a schematic arrangement of the puzzles. The game is designed for groups of 2-5 people. Each group gets its own chest locked with a 3-digit numerical lock. All the necessary resources for the game are included in the chest. This allows multiple groups to play simultaneously in the same room without interfering with each other. The first puzzle, indicated by the blue square, is fixed to the chest and solving it will provide the players with a code to open the chest. Once opened, they will find several more puzzles, indicated by the green squares, and a smaller box locked with a 5-digit number lock. By solving the puzzles, players obtain the individual digits of the code required to open the box. The box contains a qualitative explanation of Maxwell's equations and a reward.

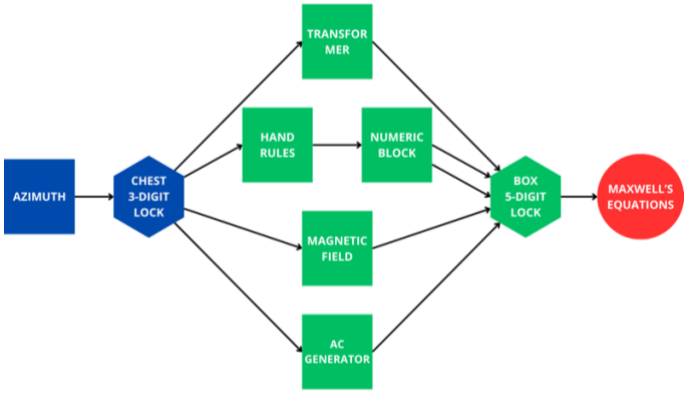


Figure 2: Schematic representation of the puzzles arrangement in the game.

2.3 Physics Content and Skills Developed Through the Games

Game tasks were based on the standards defined for teaching of physics in upper secondary schools in Slovakia for the topic of magnetism and electromagnetism. Simultaneously, the tasks aim to develop certain skills. Table 1 presents the overview of physics content and skills that are developed by the tasks of both games.

Table 1: Overview of physics content and skills developed through the games.

Physics Content	Tournament of J. C. Maxwell		Chest of Lord Maxwell	
	Skill Development	Task	Skill Development	Puzzle
magnetic field of a wire right-hand rule for a wire	picture analysis	W	problem-solving skills picture analysis	Hand rules
right-hand rule for a coil Lenz's law	problem-solving skills graph analysis analytic skills	X		
magnetic field of a coil right-hand rule for a coil	problem-solving skills equipment-manipulation skills analytic skills	E		
magnetic field of permanent magnets magnetic field lines	picture analysis	M	picture analysis	Magnetic field
Earth's magnetic field	compass usage	A	azimuth determination	Azimuth
usage of electromagnetism transformation ratio	experimental skills equipment-manipulation skills	L_1	experimental skills equipment-manipulation skills	Transformer
usage of electromagnetism	experimental skills equipment-manipulation skills – in a new situation	L_2		
Working principle of AC generator			Reading comprehension skills	AC generator
			Spatial orientation skills, analytical thinking	Numeric block

3. Research

The research was conducted in two phases. The initial phase of the study involved the testing of the tournament game. The second phase focused on the chest game. Subsequently, we analysed and compared findings from both phases with the goal to compare two different game mechanics applied in the teaching of the topic of electromagnetism in upper-secondary school. The comparison will focus on the perception of the games by students and teachers who have used the game in their teaching.

3.1 First Phase

Tournament of J. C. Maxwell game was subjected to a preliminary examination in February 2022 at the Bilingual Grammar School in Bratislava. A total of 55 students from four different classes participated in the implementation of the game as part of their regular physics lessons. The game was incorporated into the curriculum as a preparation for the summative assessment. Following the conclusion of the game, a discussion was held with the students to solicit feedback on the game. One week after implementation, an online questionnaire was sent to all participating students. The questionnaire focused on the difficulty and understandability of the game, teamwork, benefits of the game, and student attitudes towards the game. A total of 37 students completed the questionnaire voluntarily. The findings from this part of the research were presented at the GIREP Conference 2022 in Ljubljana, Slovenia (Janiga, Haverlíková, 2022). They will be published in the Springer book series Challenges in Physics Education. In addition, we posed some questions to the teachers

with the intention of evaluating the game from their perspective. The questions addressed the extent to which the objective was achieved, the level of engagement among students, the benefits and drawbacks of the game, and the teacher's attitude towards the implemented game.

3.2 Second Phase

The testing of the Chest of Lord Maxwell was conducted in December 2023 and April 2024 at three grammar schools in Bratislava. A total of 142 students participated in the implementation of the game. The course of the game was observed, and following its conclusion, an online questionnaire (the same as in the first phase) was sent to the participating students. Students completed it voluntarily, in their free time. This questionnaire focused on the difficulty and understandability of the game, teamwork, the benefits of the game, and the students' attitudes towards the game. The same questions as in the first phase were addresses to the participating teachers.

School A is the same institution where the initial phase of the research was conducted. A total of 90 students from six different classes participated in the research. The game was implemented within the context of the physics class as a form of preparation for the summative assessment. A total of 12 students from this school completed the questionnaire. The low return rate of the questionnaire may have been since the implementation of the game and the administration of the questionnaire took place just before the start of the Christmas holidays.

School B is a grammar school with Hungarian language as a primary language. Students understand Slovak, but Hungarian is their preferable language. A total of 30 students from two different classes participated in the research. The game was included in the curriculum six months after the topic was covered. A total of seven students from this school completed the questionnaire. The low return rate of the questionnaire may be attributed to the language barrier, given that the questionnaire was in Slovak, while the students attend a school where Hungarian is the language of instruction. Despite the possibility of completing the questionnaire in Hungarian, it is possible that the language barrier discouraged students from doing so.

A total of 22 super senior students at school C participated in the research. The game was introduced into the physics curriculum two years after the topic had been covered. A total of 22 students from this high school completed the questionnaire.

4. Findings

4.1 First Phase

Findings from this part of the research were presented at the GIREP Conference 2022 in Ljubljana, Slovenia (Janiga, Haverlíková, 2022). They will be published in the Springer book series Challenges in Physics Education. Therefore, we present here only a summary. The findings suggest the tournament game achieved its intended difficulty level, perceived as challenging but achievable by most students. Teamwork and physical exertion were not seen as significant difficulty factors. While most students understood the game's instructions and rules, some reported confusion due to the use of multiple communication channels (oral, written, visual). The understandability of tasks was generally high, with minimal issues reported. Although some students indicated difficulties with clues, further investigation revealed they simply hadn't visited the stands with the clues. The game was perceived as enriching by a large majority of students. The most frequently reported benefits included applying existing knowledge (71.8%), gaining new physics knowledge (61.5%), and discovering new perspectives (56.4%). Students identified teamwork, communication, and efficient work distribution as strengths of their teams, while acknowledging weaknesses like communication breakdowns and knowledge gaps. Roles primarily focused on task completion and explanation, with less emphasis on leadership, motivation, or writing. Interestingly, students in non-problem-solving roles perceived themselves as less valuable. In general, students shown positive attitudes towards the game, mainly focusing on teamwork, physical movement and the form of the game.

4.2 Second Phase

4.2.1 Observation

Observation revealed that all students were highly motivated from the outset of the game. In school C, there was a notable degree of competitiveness among the students. In schools A and B, smaller groups of three to four players were formed, while in school C, groups of four to six players were formed. In the case of smaller groups, there was a reduced need to divide puzzles and solve multiple puzzles simultaneously. If players encountered difficulties with a puzzle, they exhibited signs of frustration. In such instances, the players were queried regarding their solution procedures and provided with hints. From the observations made, it became evident that students faced the greatest difficulties with non-physics content puzzles (solving the numeric block and comprehending the method for extracting the code from the puzzles). In school A, 90% of the groups were able to solve all the puzzles and open the box within 45 minutes. The success rate at schools B and C was found to be significantly lower, with only 50% of the groups able to solve the puzzles and open the box within 45 minutes. If a group was unable to complete the game, a joint discussion was held with all groups to identify the solutions to the puzzles and to open the boxes collectively.

4.2.2 Students Questionnaire

The initial section of the questionnaire focused on how students perceived the difficulty of the game in its various aspects. The results are presented in Figure 3. The game was perceived as the most challenging in terms of the students' knowledge of physics. Conversely, they considered it the least challenging in the areas of teamwork and physical movement. This is consistent with the design intention of the game, which was to create a challenging experience in the areas of physics knowledge, skills, and logical thinking. The game requires minimal physical movement and can be mastered by an individual. A comparison of student responses from each school revealed that students at school C rated the difficulty of the game on physics knowledge as more challenging on average than students at school A and B (a bit hard) This distinction was reflected also in the ratings of overall difficulty. No significant differences were observed between the schools in other aspects of the game. It appears that the discrepancy in responses may be attributed to the fact that students at school C are superseniors, and that it has been approximately two years since they last encountered the topic in physics. In contrast, students at school A were presented with the game immediately after the topic was covered, while students at school B were presented with the game six months after the topic was covered.

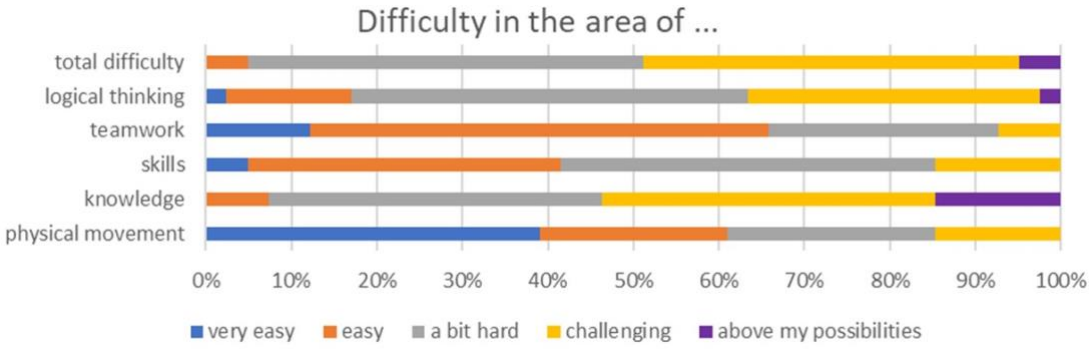


Figure 3: Relative numbers of students' evaluation of the game difficulty.

The second aspect under investigation was the understandability of the game. The students were requested to assess the degree of understandability of selected parts of the game. The results are presented in Figure 4. The students expressed high levels of satisfaction with the clarity of the rules, instructions, and clues provided during the game. A small number of students indicated that these aspects were not readily understandable. These were one student from school B and one student from school C. The problems could have been caused by a language barrier (school B) or by the fact that a few students missed the beginning of the lesson and only joined the game during the lesson (school C). In the case of the puzzles, students rated clarity as the aspect with the lowest level of understanding (acceptable or with only a few problems). Several students indicated in the questionnaire that they found the puzzles less understandable. However, they were aware that non-explicit assignments are an inherent aspect of the mechanics of escape games.

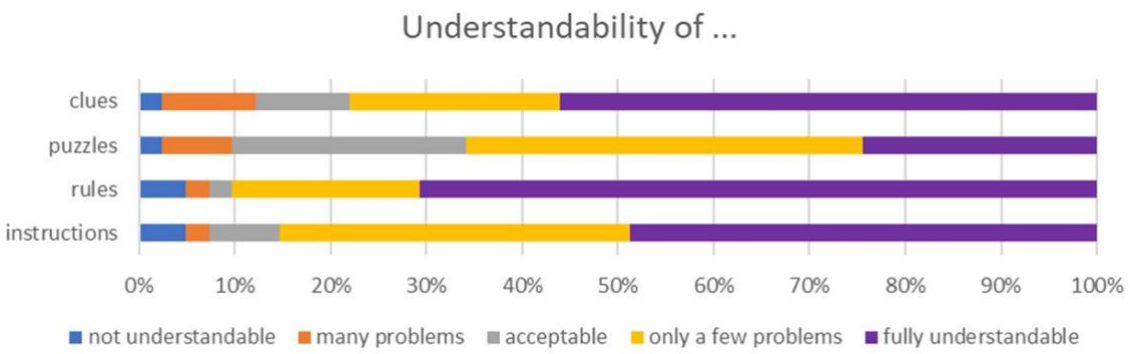


Figure 4: Relative numbers of students' evaluation of the game understandability.

In the third section of the questionnaire, students were requested to reflect on the game's potential for enrichment. Students indicated that the game facilitated the acquisition of new physics knowledge (75.6%), the acquisition of new experiences (53.7%), the development of novel perspectives on the topic (48.8%), the application of knowledge (39.0%) and the development of skills (24.4%). Only two students indicated that the game had no benefits for them. A comparison of the responses of the students from each school revealed that while in schools A and B the students' responses are evenly distributed among all aspects except skills, in school C 86.4% of the students identified acquiring physics knowledge as a benefit, while in the other aspects the frequency of responses is below 50%. We believe that this difference is caused by the significantly longer time that has passed in group C since the topic was discussed in class.

The fourth section of the questionnaire addressed the subject of teamwork, encompassing the strengths and weaknesses of the team, leadership, and the roles of each member within the team. The students identified teamwork, communication, peer-learning, work distribution, decision-making, speed, and peer motivation as the strengths of their teams. The students identified a few weaknesses in their teams, including a lack of knowledge and communication. The most frequently reported roles of team members were related to task solving, specifically solving and explaining. A small number of students reported roles as writer or motivator.

The fifth section of the questionnaire addressed the students' attitudes towards the game. Figure 5 displays the students' appreciations of selected aspects of the game. Furthermore, 54,8% of students indicated that they discussed the game with other players after the game, while 23.8% discussed it with students who did not play the game, 23.8% of respondents indicated that they did not revisit the game in their thoughts.

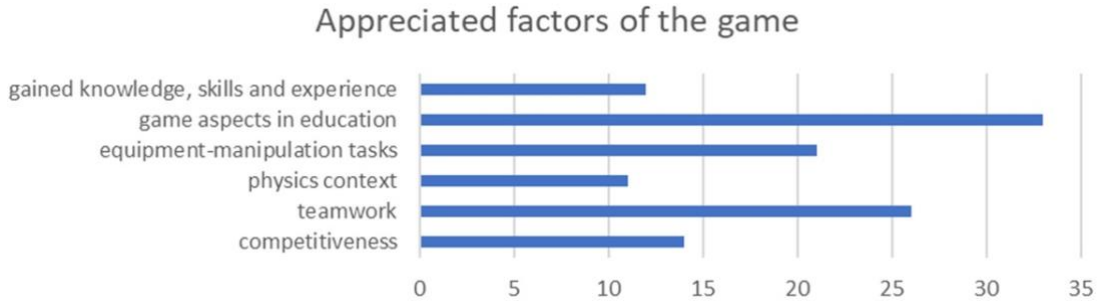


Figure 5: Absolute numbers of students appreciating selected factors fo the game.

4.2.3 Teachers Questionnaire

All three teachers involved in the research have concluded that the intended aim of the game has been fulfilled. The students demonstrated their ability to solve problems and consolidate their knowledge of the topic of electromagnetism. The format of the game necessitated collaborative effort and communication between the students. To solve the problems, students were required to engage in analytical thinking, including the identification of the task, the solution of the problem, and the acquisition of the code. Teachers from schools B and C posted that including the game in the sequence immediately following the teaching of the topic of electromagnetism would have been more beneficial.

Furthermore, the teachers were impressed by the level of student engagement. The teachers asserted that the small group work and game format facilitated the involvement of students who were previously quiet or inactive

in the teaching process. However, they emphasised the significance of the way students were allocated to groups to prevent the combination of students with inadequate physics knowledge. Failure in the game could result in frustration and a further decline in interest in physics.

The game's primary benefit, according to the teachers, is its capacity to engage students. The format of the game introduced a novel element to the usual structure of physics teaching. "Another significant advantage is that it encourages students to develop critical thinking, rather than merely memorise the content they have learned in class." Furthermore, one teacher emphasised the historical aspect of the game, stating, "I also appreciate the historical background of the game and the overall story provided for the chest, as this can also engage pupils who do not have a very positive relationship with physics."

All teachers expressed a desire to incorporate the game into their future teaching practices.

4.3 Comparison of the Perception and Evaluation of the Games

The data collected in phases one and two of the research, comprising observations, questionnaires completed by students and teachers, and interviews with students, was used to make an initial comparison of the perceptions of the two games. A comparison was made between the two games from the perspectives of the students and the teachers.

4.3.1 Students' Perspective

In terms of difficulty, students rated both games similarly in all aspects. Of particular interest is the aspect of physical movement, as the chest game requires almost no physical effort, whereas the tournament game involves rapid movement within the school building. An important strategy to win is not just to solve the problems correctly, but to solve them as quickly as possible. Two-thirds of the students who played the tournament game identified movement as an appreciated factor. Several of them reported that incorporating movement into this activity helped them to focus, think, and engage better in the game. They referred to it as a nice change in the routine of the lessons.

In the case of understandability, again, the students' ratings are very approving except for the clarity of the task assignment. In this aspect, the understandability of the tournament game assignments was rated at a higher level (only a few problems) than the understandability of the chest game puzzles (acceptable). As also noted by some students in the questionnaires, the puzzles of the chest game were not given explicitly, as it is an escape game, which may have caused that some students rate them as less understandable. A second factor that may have caused this difference is the specificity of the research sample. Most of the data collected from the second phase of the research came from school C, where the research was conducted with superseniors. Hence, with students who played the game approximately 2 years after having studied the topic. This point will need to be explored in the future with emphasis on selecting the same research sample for both games.

A significant aspect that was commended by both students and educators was the method of motivation. Tournament of J. C. Maxwell is designed as a team competition. Consequently, the motivating factor was competitiveness. In the case of the game Chest of Lord Maxwell, the motivating factor is the desire to explore the unknown and to open the locked chest. Both forms of motivation were identified by the students as being effective. In the case of the chest game, the motivating factor of competitiveness was also evident. Groups competed to explore the chest in the shortest possible time. However, the game was not designed with this in mind, and this factor is not encouraged in any way during the game. In the case of the tournament game, there have been instances where some teams have prematurely concluded the competition because they lacked the confidence to prevail against the other team. The anticipated motivational effect of competitiveness was, in fact, the opposite of what was intended. It is therefore of great importance that the composition of the teams is carefully considered in these games.

Each of the game provides feedback to students in different ways. In the case of the tournament game, students receive immediate feedback on their solution. If students choose the correct answer the game navigates them to the next task. If they answered incorrectly, the game navigates them to a stand where they get a hint and return to the previous stand to solve the task again. In the case of the chest game, students get 5 numbers from the five puzzles that make up the numerical code for the lock. If they solve the puzzles correctly, they open the chest. If the chest does not open, the students know that they do not have the correct code, but they do not know which of the numbers is incorrect and therefore which puzzle they did not solve correctly. Thus, the

feedback in this game is neither immediate nor sufficiently addressable. As a result, this requires students to be more resilient to frustration and more assisted by the teacher.

The importance of teamwork was identified as an appreciated factor in both games. The application of teamwork in the context of a game can result in a reduction in the perceived difficulty of the game, the maintenance of motivation, and the prevention of frustration. It facilitates peer-to-peer discussion and learning among students.

4.3.2 Teachers' Perspective

From the teacher's point of view, one of the most important aspects in deciding, whether to include a game in teaching, is the difficulty of the game in terms of preparation. In the case of the tournament game, the preparation process is more challenging due to the necessity of planning the location of the stands within the building, preparing the tasks within the envelopes, and then placing the envelopes and all the materials into the school. In contrast, the preparation for the chest game is relatively straightforward. The teacher is required to prepare the chests only once, after which they simply need to be checked before the lesson and brought into the classroom. Conversely, he must purchase the chests and numerical locks.

The format of Chest of Lord Maxwell allows for the entire class to participate in the game simultaneously and in the same location. This enables the teacher to monitor their students' activities, observe them at work, and address any issues that may arise. In the case of the tournament game, students are dispersed throughout the school building, and the teacher is unable to monitor their progress, identify any difficulties they may be experiencing, or help as needed.

5. Conclusion

The objective of this research was to examine how students and educators perceive the integration of two games with different game mechanics in physics education. The comparison enabled the identification of several key factors that should considered during the development and implementation of the game.

It is essential to establish an appropriate level of difficulty for the game, ensuring that it is neither too straightforward nor too challenging for players. The incorporation of non-explicit tasks serves to augment the complexity and duration of the game. It is recommended that in-game feedback be provided in a prompt and accessible manner. The incorporation of teamwork is a highly valued element, as it serves to mitigate the perception of difficulty, bolster motivation, and facilitate peer-to-peer learning. Nevertheless, the composition of the team is a crucial aspect that demands careful consideration. The efficacy of the teaching process is contingent upon the alignment of the learning and game goals, as well as the time required for preparation and implementation of the game. The format of the game has an impact on the role of the teacher during the game, which may be that of an observer, moderator or helper.

Given the limited sample size and the notable discrepancies between the samples, it is not feasible to generalise the conclusions drawn from this study. It is our intention to reinstate these two games in the classroom, with a particular focus on the selection of appropriate research samples.

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Breaking Math Anxiety: A Success Story From an Indian Government School

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Abstract: Mathematics anxiety and fear among children pose significant educational challenges worldwide. This study examines the efficacy of a hybrid learning approach that combines digital game-based learning with hands-on activities to enhance mathematics engagement, reduce anxiety, and improve numeracy skills while fostering algebraic and mathematical thinking. The research was conducted at Government School, Ramagondanahalli, Bengaluru (RGHL), involving over 400 children aged 6-10 years from grades 1-5. Participants were primarily first-generation learners from economically disadvantaged backgrounds with limited access to educational resources. The intervention comprised weekly 70-minute sessions over six months, featuring the digital game "Magic Math Spell Caster" alongside modified traditional board games such as Snakes & Ladders, Bingo with Place Value Cards, and a custom Memory Card Game. The curriculum also incorporated activity worksheets with math manipulatives and practice sheets. The didactical approach underpinning the intervention was based on six key principles: Treating mathematics as a language to be spoken, promoting algebraic thinking; Structuring games into levels with well-defined learning objectives to scaffold mathematical thinking; Connecting concrete and abstract concepts to deepen understanding; Employing a hands-on approach to reinforce learning; Providing resources to every child to ensure equal access; Integrating assessments as digital interactive worksheets within gameplay. This approach allowed children to explore, make connections, and construct knowledge independently, fostering both algebraic and broader mathematical thinking skills. The program encouraged peer-to-peer learning by grouping children with different math proficiencies. Students progressed through game levels at their own pace, often exceeding curriculum expectations. This study contributes to the growing body of evidence supporting hybrid learning approaches in mathematics education for all children, emphasizing the development of robust mathematical and algebraic thinking skills.

Keywords: Hybrid Mathematics Pedagogy, Game-Based Algebraic Thinking, Mathematical Anxiety Reduction, Numeracy Skills Enhancement, Scalable Math Education Model

1. Introduction

In Bangalore, India, an innovative approach to mathematics education is unfolding at the Government School Ramagondanahalli, Bengaluru (RGHL). Operating under a Public-Private Partnership (PPP) model, The Government of Karnataka collaborates with Inventure Academy (an International School) and Whitefield Ready (an NGO) to offer English-medium instruction to some of the city's most underprivileged children (Kumar & Naik, 2020).

Many RGHL students are children of migrant laborers, enter the school without prior formal education, lacking foundational literacy and numeracy skills. This diversity in the student body presents a significant challenge: effectively teaching mathematics to a class with widely varying proficiency levels and interest (Banerjee & Duflo, 2011).

While RGHL's dedicated teachers work tirelessly to bridge learning gaps, they've identified a critical barrier: math anxiety. This phenomenon, characterized by feelings of tension and anxiety that interfere with the manipulation of numbers and solving mathematical problems, is not unique to RGHL but is a global issue impacting students' performance and long-term relationship with mathematics (Ashcraft & Moore, 2009).

The COVID-19 pandemic has exacerbated existing educational disparities, particularly affecting disadvantaged students (UNESCO, 2021). In India, even before the pandemic, only 28% of fifth-graders could perform simple division (ASER Centre, 2019). The prolonged school closures have likely worsened this situation (Azim Premji Foundation, 2021).

To address these challenges, Inteligen Games & Robotic Private Limited (Inteligen) designed an intervention for RGHL that combines digital games, physical activities and hands-on learning. This approach is grounded in research supporting the efficacy of game-based learning in mathematics education (Ke, 2008; Habgood & Ainsworth, 2011).

This study explores the impact of this hybrid learning approach on math anxiety and numeracy skills among RGHL's primary school children. The insights gained could inform strategies to improve mathematics education

and promote educational equity in India and beyond, particularly in the post-pandemic context (Bose et al., 2022).

2. Understanding the Challenge

2.1 Math Anxiety: A Complex Problem

To appreciate the impact of RGHL's new approach, we first need to understand math anxiety and why it has affected so many children (Ashcraft & Moore, 2009).

2.1.1 Why Math Anxiety Happens?

For many RGHL students, math feels like learning a foreign language. They're already struggling with reading and comprehension in English (their second or third language), and now they're expected to grasp mathematical vocabulary, syntax and complex concepts. It's no wonder stress levels rise (Beilock & Maloney, 2015)! Teachers at RGHL have found it challenging to build even basic numeracy skills, let alone guide students towards solving word problems, tackling application questions or developing higher-order thinking skills in math. The confidence of children in the math class was worrying and all the stakeholders were keen on implementing an alternate approach to make children open to learning math (Ramirez et al., 2018).

2.1.2 The Cascading Effect of Math Anxiety

When students feel anxious about math, it creates a vicious cycle. Their worry takes up mental energy, making it harder to concentrate and solve problems. This leads to poor performance, which in turn increases anxiety about future math tasks (Foley et al., 2017). Over time, students might start avoiding math altogether, limiting their academic and career options. For RGHL's students, many of whom are already facing significant life challenges, math anxiety could become yet another obstacle to overcome in their pursuit of a better future (Maloney & Beilock, 2012).

2.2 The Power of Play in Learning

While the challenges were clear, the solution came from the world of games. Research has shown that game-based learning can be a powerful tool in education, especially in subjects like math. Games can make learning fun and reduce anxiety (Ke, 2008). Games provide immediate feedback, helping students learn from mistakes (Habgood & Ainsworth, 2011) and adapt to different skill levels, ensuring each student is appropriately challenged (Plass et al., 2015). Game based learning encourages problem-solving and strategic thinking (Kim & Chang, 2010) which fosters collaboration and peer learning (Castellar et al., 2015). With these benefits in mind, Inteligen worked with RGHL to bring game-based learning into their math classrooms.

3. Methodology

3.1 Digital Game: Magic Math Spell Caster

At the heart of the intervention is an innovative digital game called "Magic Math Spell Caster". This game transforms math learning into an exciting magical adventure for kids from kindergarten to third grade. Here's what makes it special:

The Magical World:

- Students become young magicians in a fantastical world with 600 levels across four difficulty tiers
- Math skills are used to cast spells, defend magical towers, and defeat boss creatures
- The game aligns with standard elementary math curricula, complementing classroom instruction

Learning Objectives:

- Develop strong number sense and mental math fluency
- Master basic arithmetic operations
- Introduce algebraic thinking concepts
- Enhance understanding of place value
- Reduce math anxiety and increase engagement with mathematics

The Digital Abacus: A Revolutionary Learning Tool

- At the core of the game is a unique digital abacus that makes math visible and tangible:
- Color-coded, numbered beads that students move on screen
- Clear layout showing place values (ones, tens, hundreds, thousands)
- Students perform math operations by physically manipulating beads
- Provides immediate feedback and adapts in complexity as students' progress
- Bridges concrete and abstract mathematical thinking

How It Promotes Learning:

- Hands-on interaction engages multiple senses, enhancing understanding and retention
- Visual representation makes abstract concepts more accessible
- Supports various learning styles through its multi-modal approach
- Scaffolds the development of mental math skills
- Allows for easy identification and correction of errors

Adaptive Learning:

- Difficulty levels adjust based on each student's performance
- Ensures students are consistently challenged at an appropriate level
- Supports differentiated instruction in diverse classrooms

Progress Tracking:

- Comprehensive summary of the students' performance in the game.
- Allows monitoring of progress and identification of areas needing improvement

By combining engaging gameplay with innovative learning tools like the digital abacus, Magic Math Spell Caster doesn't just teach math—it transforms students' relationship with the subject. It builds confidence, fosters a love for learning, and makes math an exciting adventure rather than a dreaded chore.

Teachers at RGHL have observed remarkable changes. As one educator noted, "Students who once feared math now eagerly ask for more problems. They're not just learning math; they're enjoying it. The game has made the abstract world of numbers real and exciting for them."

3.2 Hands-On Fun: Physical Games and Activities

While the digital game is a key component, the approach also emphasizes hands-on, physical activities to reinforce learning and provide a multi-sensory experience. These activities include:

Math-Focused Snakes & Ladders:

- Traditional dice replaced with specially designed cards
- Cards pose math questions with answers always 6 or less
- Questions build number sense and mathematical vocabulary
- Players read questions aloud and give oral answers
- Creates an immersive environment for hearing, speaking, and learning math language
- Helps children associate math with fun and social interaction

Bingo with Place Value Cards:

- Combines the excitement of Bingo with place value learning
- Cards show numbers in different forms (e.g., "43" and "4 tens and 3 ones")
- Children match numeric representations with place value descriptions
- Reinforces understanding of tens and ones visually and kinesthetically
- Example: For "43", child sees both the number and a place value card showing 4 tens and 3 ones

Memory Card Games:

- Designed to build mental math skills
- Includes pairs of cards with equivalent mathematical expressions
- Enhances recall and promotes quick mental calculations

Manipulative-Based Worksheets:

- Special worksheets accompanied by math manipulatives
- Objects children can touch and move to understand math concepts
- Bridges concrete and abstract thinking
- Allows for hands-on exploration of mathematical ideas

These physical games and activities serve multiple purposes:

- Reinforce Concepts: They provide additional practice of skills learned in the digital game
- Multi-Sensory Learning: Engage multiple senses, catering to different learning styles
- Social Interaction: Encourage peer learning and communication about math
- Vocabulary Building: Create opportunities to use mathematical language in context
- Confidence Building: Offer a low-pressure environment to practice math skills

Teachers at RGHL have noted the complementary nature of these activities. One teacher shared, "The combination of digital and physical games keeps the students engaged. They're learning the same concepts in different ways, which really helps the ideas stick. Plus, it's wonderful to hear them using math vocabulary naturally as they play."

By integrating these hands-on activities with the digital game, the approach ensures a well-rounded, engaging math learning experience. Students not only learn math concepts but also develop communication skills, social skills, and a positive attitude towards mathematics.

3.3 Putting It All Together: The Hybrid Approach in Action

RGHL implemented this new approach over an 8-month period. Students played the digital game for about 70 minutes each week. The physical games and activities were woven into regular math lessons throughout the week.

This hybrid approach—combining digital and physical learning—offered several advantages:

- It catered to different learning styles. Some kids learn better on computers, others through physical activities.
- It kept things interesting. The variety prevented boredom and maintained engagement.
- It reinforced concepts in multiple ways, helping ideas "stick" better.
- It made math feel less like a dreaded subject and more like a fun challenge.

4. Results

The intervention at RGHL demonstrated significant positive outcomes. Let's break down the results:

4.1 Dramatic Change in School Exam Results

The school's internal exams revealed a striking transformation. Prior to the intervention, 20% (24 out of 120) of students across grades 1-5 scored above 60% in mathematics examinations. Following the implementation of the game-based approach, this percentage increased to 83.3% (100 out of 120 students), representing a 63.3% point improvement. This remarkable improvement shows the program's effectiveness on students of all ages.

4.2 Beyond Grade-Level Performance

One of the most exciting outcomes was seeing students, even those in lower grades, mastering concepts beyond their current grade level. Many grade 1 students were solving problems typically seen in Grade 2. Older students were exploring advanced topics out of sheer curiosity and enjoyment. This self-driven learning was unprecedented in the school's history.

4.3 Qualitative Changes in the Classroom and Long-term Impact

Teachers reported significant changes in student behavior and attitudes. Students who once dreaded math class were now eagerly participating. There was a noticeable decrease in math anxiety across all grade levels. Students appeared more confident, more willing to tackle challenging problems, and less stressed during math lessons.

The confidence gained in math began to positively influence performance in other subjects. Teachers believe this new approach to learning could lead to higher retention rates and better academic outcomes in the years to come.

The results at RGHL indicate the efficacy of innovative and engaging teaching methodologies in mathematics education. The implementation of enjoyable and accessible mathematics instruction has not only improved test scores but may have altered the educational trajectory of the students.

4.4 Beyond the Numbers: Transformative Impacts

The success of the intervention at RGHL goes far beyond improved test scores. The most striking outcomes were in how students approached learning itself.

4.4.1 Fostering Self-Directed Learning

The most remarkable outcome was the way the students took charge of their own learning. The engaging nature of the games encouraged children to practice math voluntarily, even outside of class time. This self-motivation is a crucial life skill that extends beyond mathematics. One teacher noted, "I'm amazed to see students asking for more math problems or wanting to play the game during free periods. They're driving their own learning now."

4.4.2 Building True Proficiency, Not Just Memorization

Unlike traditional rote learning methods, this approach helped students understand mathematical concepts deeply. They weren't just memorizing procedures, but grasping why those procedures work. "Before, students could recite multiplication tables but struggled with word problems. Now, they understand what multiplication really means and can apply it in various situations," explained a Grade 4 teacher. This growth in handling tough math concepts is setting students up for success in higher grades and beyond. They're not just learning math—they're learning how to learn, a skill that will help them throughout their lives.

5. Discussions

The success of the RGHL intervention offers valuable insights for other schools facing similar challenges.

5.1 What Made it Work

5.1.1 Personalized Learning

The adaptive nature of the digital game allowed each student to progress at their own pace. This personalized approach meant that both struggling students and high achievers were appropriately challenged.

5.1.2 Low-Stakes Practice

The game environment provided a safe space for students to make mistakes and learn from them without fear of embarrassment or negative consequences.

5.1.3 Immediate Feedback and Peer Learning

The approach fostered an environment rich in immediate feedback and peer-to-peer learning:

- Digital Instant Feedback: The game provided immediate responses to students' actions, allowing for quick identification and correction of mistakes.
- Physical Game Interactions: Board games and activities encouraged students to help and learn from each other.
- Collaborative Learning: Students naturally took on teaching roles, explaining concepts to their peers.
- Multifaceted Feedback: Students received instant feedback from both the digital game and their classmates.

Teachers at RGHL provided a powerful observation that encapsulates the impact of this approach: "Teachers observed students explaining concepts to each other during the board games. The students were not just

learning math; they're learning how to communicate and support one another. The immediate feedback, whether from the game or a classmate, keeps them motivated and helps concepts stick."

5.2 The Future of Math Education

The success of the RGHL intervention opens up exciting possibilities for the future of mathematics education, particularly in challenging and resource-constrained environments. This section explores potential avenues for expansion and further research.

5.2.1 Scaling Up

The positive outcomes at RGHL suggest that this hybrid learning approach could be beneficial if implemented on a larger scale. Considerations for scaling include:

- Investigating how the program can be tailored to different cultural and educational settings across India and globally (Banerjee & Duflo, 2011).
- Cost-effectiveness analysis: Evaluating the economic feasibility of widespread implementation, particularly in low-resource areas (Kumar & Naik, 2020).
- Partnership models: Exploring collaborations between educational institutions, NGOs, and technology providers to facilitate broader implementation (Bose et al., 2022).

5.2.2 Teacher Resources and Professional Development

The RGHL experience underscores the crucial role of teachers in the successful implementation of innovative educational approaches. Future initiatives should focus on:

- Comprehensive teacher training programs: Developing modules that equip teachers with the skills to effectively use game-based and hybrid learning approaches (Boaler, 2016).
- Ongoing support systems: Creating networks for continuous professional development and peer learning among teachers.
- Teacher-led innovation: Encouraging and supporting teachers to adapt and create their own educational games and activities (Blikstein, 2013).

5.2.3 Technology Integration

As access to technology improves, even in underprivileged areas, there's potential for more sophisticated and personalized learning experiences:

- Adaptive learning systems: Developing more advanced algorithms that can provide highly personalized learning paths for each student (Verkijika & De Wet, 2015).
- Data-driven insights: Leveraging learning analytics to provide teachers with real-time insights into student performance and areas needing attention (OECD, 2018).

6. Conclusion

The case study of RGHL demonstrates the transformative potential of innovative pedagogical approaches in addressing complex educational challenges, particularly in resource-constrained environments. By reimagining mathematics education through game-based learning, Inteligen and RGHL have not only improved academic outcomes but also fundamentally altered students' relationships with mathematics.

This approach aligns with research by Boaler (2016), who emphasizes the importance of fostering a positive mindset towards mathematics. The success of the game-based learning program in reducing math anxiety and increasing engagement correlates with findings from Verkijika and De Wet (2015), who observed similar positive outcomes using game-based interventions to address math anxiety.

The significance of mathematical literacy in the 21st century cannot be overstated (OECD, 2018). The RGHL intervention offers a promising model for enhancing mathematical competencies across diverse student populations, resonating with UNESCO's (2019) call for more inclusive and equitable quality education. The power of this approach lies not just in its engaging design, but in its ability to transform students' emotional responses to mathematics – from fear to confidence, confusion to understanding, and dread to excitement. This emotional

shift is crucial for long-term mathematical engagement and success, as highlighted by Ashcraft and Moore (2009) in their work on affective factors in mathematics education.

Looking ahead, the RGHL study provides valuable insights for educational interventions in underserved communities globally. It underscores the potential of creative, technology-enhanced, joy-centric learning approaches in mathematics education. As argued by Blikstein (2013), such innovative methods can democratize access to quality education and help every child discover their potential in mathematics.

In conclusion, this case study contributes to the growing body of evidence supporting the efficacy of game-based and hybrid learning approaches in mathematics education. It offers a promising roadmap for educators and researchers seeking to address educational inequities and improve mathematical literacy in challenging contexts.

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Repositioning Vulnerable Youth Through Educational Esports Programmes

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Abstract: A growing number of young Danes experience a drop in well-being as well as there is an increase in diagnoses such as ADHD and autism. These challenges are often linked with school refusal and an increasing need for special education programmes. Since 2007, selected vulnerable youth (age 16-25) have been offered an alternative to regular youth education called Specially Planned Youth Education (Særligt Tilrettelagt Ungdomsuddannelse or STU). More than 30% of students attending STUs are diagnosed with autism or ADHD. The purpose of this paper is to explore the learning potentials of esports educational programmes with this specific target group. The study presents data from an ongoing research project entitled "Esports as learning space and gateway for vulnerable youth at STU", which is supported by the Velux Foundation and currently in its second year while looking to finalise in 2026. More specifically, we analyse data from ten interviews conducted with vulnerable youth at three STUs, who participate in educational esports activities with commercial multiplayer games, primarily *League of Legends*, *Counter-Strike* or *Valorant*. The interviews concern the students' gaming interests, their experiences with attending the esports programmes, and their perceived learning outcomes. All interview data have been coded and analysed using thematic analysis. Patterns and recurring themes in the data have been sought after based on questions of how students perceive themselves, what activities they engage in during esports education, and what the potential learning outcomes of the education are. Drawing on Dialogical Self Theory, we analyse and discuss the students' different I-positions and identify possible transformations made possible through the STU activities, which aim to support students in obtaining an autonomous and meaningful adult life. Our preliminary findings show that students generally have more positive experiences at the STU's than at their previous education. This includes adopting different I-positions that are more committed to a community than what they experience in their leisure gaming.

Keywords: Special Education; Vulnerable Youth; Social Gaming; Esports; Communication; Dialogic Self Theory

1. Introduction

A growing number of young Danes experience a drop in well-being as well as there is an increase in diagnoses such as ADHD and autism (Dumstrei, 2023). These challenges are often linked with school refusal and an increasing call for special education programmes. At the same time, a recent survey shows that most Danish children and youth (ages 1-15) are active gamers with 46% of them playing daily or almost daily, with boys playing for longer periods than girls (Medierådet for Børn og Unge et al., 2023). The survey also shows that more than half of the children aged 9-15 play games in order to meet with their friends.

In this study, we will take a closer look at social gaming in the context of special education. We are interested in studying how vulnerable youth (aged 16-25) participate in esports programmes at Specially Planned Youth Education (Særligt Tilrettelagt Ungdomsuddannelse or STU), which is offered to vulnerable youth unable to attend regular forms of youth education. More than 30% of the STU students are diagnosed with disorders such as ADHD and autism (Ministry of Children and Education, 2019). Moreover, several of the STU students have experienced school refusal and suffer from low well-being and/or stress, isolation and anxiety. Our exploration is part of an on-going research project entitled "Esports as learning space and gateway for vulnerable youth" (2023-2026) funded by the Velux Foundation. In this study, we wish to focus more specifically on how the vulnerable youth experience their participation in the esports programmes, where they play competitive multiplayer games, primarily *Counter-Strike* and *League of Legends.* This brings us to our research question: How do vulnerable youth position themselves as participants in esports programmes at Specially Planned Youth Education?

2. Multiplayer Gaming as a Gateway to Well-being and 21st Century Skills

Extensive research has mapped how playing multiplayer online games may contribute to the development of 21st century skills, especially communication and collaboration, which are key to succeeding in online games (Zhong et al., 2022; Qian & Clark, 2016). Research has also shown how multiplayer gaming may be used in the classroom to include at-risk school children, who rarely participate in everyday teaching (Hanghøj et al., 2018).

Moreover, several studies analyse links between well-being and playing online games, showing that the value or harm of gaming on well-being cannot be determined solely from whether and how much people play, but rather depends on contingent factors related to the player, the game, and the gaming context (Hartanto et al., 2021). An important factor is young people's social capital, which both involve bonding (e.g. trust) as well as bridging interests. A quantitative study finds that young people with high social capital are able to increase their sense of well-being and self-esteem through frequent gaming; whereas young people with low social capital tend to experience a decrease in their sense of self-esteem as well as increase in depression symptoms in relation to frequent gameplay (Kim et al., 2022). All these studies demonstrate how gamers' development of social relations (online and offline, school, and non-school) are key to young people's well-being. At the same time, we need more knowledge on how social gaming in educational contexts is experienced from the perspective of vulnerable youth.

3. Esports Education Programmes at STU

Our study explores the participation of vulnerable youth in esports programmes at three different STUs in Denmark. There are several similarities across the three esports programmes. First, they are all coordinated and taught by teachers with solid gaming experience, who invite the students to play competitive online multiplayer games such as *Valorant*, *League of Legends, The Finals* and *Counter-Strike* over the course of a 3 year period in order to develop personal, subject-specific, and social skills, which is the overall aim of STU. Secondly, each esports programme works with individual learning goals for each youth. Examples of goals may involve being able to complete an internship, being able to show up for teaching on a regular basis, or being able to ask for help when feeling lonely. Thirdly, the STUs have a dedicated gaming room with gamer PCs and high-speed wifi, allowing smooth gaming experiences - cf. Figure 1. The rooms are organised so that students can play together in groups and correspond with the esport games, designed to be played in teams of 5. There are between 6-12 students assigned to each esports programme.



Figure 1: A gaming room at an STU.

There are also important differences between the three STUs. One concerns the number of lessons devoted to the esports programmes. Esport activities involve one day per week at STU 2 and 3, but three days per week at STU 1. Another difference concerns the integration of esports gaming activities with other subjects. STU 3 combines esports with physical exercise and media design, whereas STU 1 offers esport as a standalone activity. Moreover, there is substantial variation among the students in terms of their personal and social challenges.

4. Methodology

The following are our methodological considerations, focusing on data collection and coding strategies. Our data consists of ten semi-structured interviews (Kvale, 1996) conducted with students enrolled in the three esports programmes. The selection of the ten students was based on our aim to represent a wide range of experiences and positions, and, to a lesser extent, on accessibility. Not all students felt comfortable or prepared to be interviewed at the time of our data collection. Consequently, the findings presented in this paper are influenced by the specific voices available to us.

During the process of obtaining informed consent from the students, we addressed the five issues identified by Gallagher et al. (2009): ensuring that participants had sufficient information to make an informed decision, verifying their understanding of the information, managing parental or guardian authority, assessing their capacity to consent, and ensuring that consent was given voluntarily, without coercion or undue influence. These issues were addressed in the initial twelve months of the project, which were dedicated to acquiring domain knowledge through fieldwork.

All interviews were audio-recorded. Given the relatively small dataset, we chose a strategy that emphasised preserving authenticity (Hammersley, 2010) and staying connected to the interviewees' lived experiences (Forsey, 2012). This involved listening to the recorded interviews in various ways while taking notes. Although individual listening sessions occurred, we were also inspired by the Framework Method (Gale et al., 2013) and the methodology of story-sharing (Onwuegbuzie, Leech, & Collins, 2010). Therefore, we conducted shared listening and debriefing sessions with all research group members present.

The table below (Figure 2) provides an overview of the ten interviews, including data on age, STU experience, and game preferences - both at home and at the STU.

Table 1: Overview of interview data.

Name	Age	Experience at STU	Games played at home	Games played at STU
Mike (STU 1)	17	1st year	GTA5, Farming simulator, Ready or Not	Counter-Strike
Noah (STU 1)	22	3rd year	Counter-Strike, FIFA, Fortnite	Counter-Strike
Teis (STU 1)	17	1st year	GTA5, Fortnite, Roblox	Counter-Strike
Magnus (STU 2)	20	3rd year	League of Legends	League of Legends
Morten (STU 2)	19	1st year	League of Legends, Ghost of Tsushima, Lethal Company	League of Legends
Kim (STU 2)	22	2nd year	League of Legends	League of Legends
Mark (STU 2)	22	3rd year	Persona, learning games, League of Legends	League of Legends
Simon (STU 3)	19	2nd year	League of Legends, Elden Ring, Marvel Snap	League of Legends
Alfred (STU 3)	19	1st year	World of Warcraft, Fortnite, Hearthstone, Overwatch	League of Legends, Roblox, Fortnite
Oscar (STU 3)	18	2nd year	Counter-Strike, League of Legends, Dead By Daylight	League of Legends, Counter-Strike

We used thematic analysis (Braun & Clarke, 2006) to familiarise ourselves with the data, incorporating both inductive and deductive strategies for coding data and developing categories (Braun & Clarke, 2019).

5. Theoretical Perspectives

We use Dialogic Self Theory (DST) to conceptualise how the students position themselves as participants in the esports programmes, and to understand their construction of meaning when reflecting on their participation. The dialogic self is understood as a multiplicity of I-positions within a 'society of mind' meaning that it is both multi-voiced and dialogical (Hermans, 2013). The I-positions can both be internal and external. They combine and reflect how the self relates to the environment (Hermans, 2013). An internal I-position could be 'I as a mother', where external I-positions refer to an 'extended domain of the self', e.g. 'my children' (Hermans, 2013, p. 83). In DST the 'other' have two qualities, both the actual others independent from the self, but also as constructed and reconstructed through the imagination of the self. In this way 'my children' exist in tension between the voice of the actual others and how this voice is constructed within the self (Hermans, 2013). Beyond the I-positions there are also meta-positions of the self, which is a position distanced from one or several I-positions that observe these positions and consider them from a 'helicopter view' (Hermans, 2013). We draw on DST in order to understand how vulnerable youth media use is a form of expression that generates ongoing dialogue in the self, as Fecho (2013) illustrates. He argues that reading, writing, and artistic expression can be seen as a valuable media used by youth to "seek understanding of the chaos around them" (Fecho, 2013, p. 128) and that youth need different means to construct such meaning. In this sense we understand each student's participation in the esports programmes as an engagement in media where different I-positions are expressed in dialogue.

6. Analysis

The analysis presents how vulnerable youth positioned themselves as participants in the esports programmes as STU Students in contrast to prior school experience (section 6.1), as alignment between leisure and STU gaming (section 6.2), and as participants in communities (section 6.3).

6.1 Being a STU Student in Contrast to Prior School Experiences

The first theme concerns I-positions where students in one context primarily feel isolated and stressed while in another more at ease and sensing a high degree of autonomy. These experiences and narratives reflected how the students had shifted external I-positions from being school pupils to being STU students. Our coding showed how the internal I-positions among the students of being isolated, struggling mentally or not feeling cared for dominate their recollection of experiences of public school. One student recalls his school experience like this:

> *"It was awful. The school didn't care if we were there or not. The pupils were all mentally switched off, so you couldn't have a conversation with anyone. I felt very alone"* (Oscar).

Another student describes his pre-STU school experience in a similar vein:

> *"Public school is torture. School is the worst invention ever. During my last six years in school we constantly changed teachers. I really struggled"* (Morten).

In contrast to this, the students portray themselves as more at ease as students in the esports programmes:

> *"At the STU everything is more relaxed, you don't have to worry about grades, you are taught different stuff, social stuff, you learn to live on your own, whereas in school it is much more academic. At the STU it is much more about your mental state and how you feel. They make an effort so when the day is done you leave with a smile on your face"* (Mike).

For some the position they describe themselves with is more akin to friends than students and teachers.

> *"We have a great atmosphere here, where we get to have fun with each other, including the teachers. You could never do that at my former school. If you made a joke with a teacher, they would send you straight home! it is like hanging out with a bunch of friends and not teachers"* (Kim).

The internal I-position of feeling at ease or relaxed among teachers and peers at the STU is related to having a sense of freedom, to be able to choose.

> *"I love the freedom here. There is a lot of freedom. Freedom to say, I don't feel like doing this. For instance, if there is a game I don't want to play, I don't need to play it. They get that I don't want to. That makes me feel more comfortable… about the entire school actually"* (Kim).

Among the ten students, only one (Mike) expressed predominantly negative feelings about the esports programmes. Whereas his peers experienced fewer constraints and more agency, this student continued to struggle to find a position where he could pursue his interests. Here is what Mike said about the teaching and the teachers at the programme:

> *"They start to piss me off sometimes. I don't like playing Counter Strike. Everyone should have the right to choose what they want to play"* (Mike).

Mike explains that he did not himself choose to enter the esports programme, nor did his prior gaming interest align with the games they play at the programme. The latter being a subject we will discuss in the following theme.

Overall, the students describe how their prior school experiences are predominantly negative, whereas their participation in the esports activities at the STUs is generally positive. The students position themselves internally as more at ease at the esports programmes, they view the learning environment as less demanding, and they experience to various degrees being part of a group with positive social relations. Considering that these are young people, who throughout their educational life have struggled with school academically and/or socially, the overall impression from our analyses is that the students thrive as participants in the esports programmes.

6.2 Aligning Positions Between Leisure Gaming and Gaming at the STU

The second analytical theme concerns the students' adopted I-positions as *gamers* - both in relation to playing at home (leisure gaming) and playing at the STU (educational esports). All of the students played games frequently at home (cf. Figure 2), which often involved different types of games, ranging from multiplayer to more casual games. Some students described specialised game experiences, such as Oscar, who had played on a semi-professional *Counter-Strike* team, or Mike, who had a deep knowledge of enacting the role as fireman on a dedicated *FiveM* server, which is an online mod for *Grand Theft Auto*. This variation of game genres (First Person Shooter versus Online RPG) suggested that the students had different game preferences. Generally, the students all experienced positive outcomes of playing at home, e.g. in terms of relaxation or maintaining online friendships.

In comparison to playing at home, the students' alignment with the aims of the esports programmes varied. We identified four different I-positions, which reflect how the students aligned themselves differently toward the esports activities at their local STU. The first I-position concerns students, who did not align themselves with the gaming activities on their esports programmes. They mainly preferred to participate in the classroom as *individual gamers*, similar to playing alone at home. Mike is an example of a student taking this I-position as he clearly stated how he would prefer to "be left on his own" to play something relaxing and that he did not like playing *Counter-Strike* at the STU. Interestingly, Mike did play other First Person Shooters at home, which suggests that he was more misaligned with the STU context than with the game type. Another student adopting the individual gamer position was Alfred, who sometimes agreed to play *League of Legends* with the other students in the classroom, but often struggled with using toxic language and "tilting". Consequently, he was sometimes allowed to play his preferred games individually such as *Baldur's Gate III*. The students who adopted the individual gamer I-position were all new to the STUs and only partially identified with the overall aims and concept of the esports programmes.

The second I-position is the *social esports gamer*, which we saw among students, who mainly participated in the esports programmes for social reasons. These students explained how they primarily showed up to hang out and "have a good time" (Alfred) with their friends. In the words of Teis: "It doesn't matter what we play as long as we are having a good time [hygge]". The students identifying with this position would often play different games at home and at the STU, indicating a weak alignment between their personal gaming preferences and the games that their teachers had chosen for them to play at the STUs.

The third position, the *curious esports gamer*, was expressed by students, who were new to the games chosen by their teachers, but had developed an interest in the games. As an example, Oscar had several years of experience playing *Counter-Strike (CS)*, but had limited prior experience with playing *League of Legends (LoL)*, which was played at his STU. This meant that Oscar had to learn *LoL* from scratch, a massively complex game, in order to take part in the class. However, Oscar did not mind learning a new game, as he was interested in playing the game together with other team members at the STU, especially those with a competitive mindset like himself. In this way, some students aligned themselves with their teachers' choice of esports games at their STU,

even though they had not played these games before entering the STU. In some cases students had also begun playing the games at home after being introduced to them at the STU.

The fourth and final I-position we identified is the *serious esports gamer.* This I-position concerns students, who had strategic aims and considerable experience with playing the games in their esports programmes. These students were clearly aligned with the aims of their teachers as they continually tried to improve their game skills, strategies and team performances, often with a focus on team communication. An example is Simon, who had become so experienced with *League of Legends* that he had also tried to fill out the demanding role as team leader during game sessions.

As the breadth of I-positions show, there was substantial variation as to how the students experienced alignment between their identities as leisure gamers and as esports gamers at the STU. Some of the students were clearly aligned, other students willingly accepted the game preferences of their teachers, and others again expressed negative opinions of the games they had to play. This points to an important dilemma of choosing games for teaching esports to vulnerable youth with different gaming preferences.

6.3 Participation Across Committed and Non-committed Communities

The third analytical theme concerns the students' adopted I-positions as members of different communities. We identified three positions. The first was in relation to playing at home (leisure gaming), which we describe as a *non-committal* I-position. Secondly, we identified two forms of *committed positions*: one concerning being a part of the STU and the other being a team member.

The students' experiences with gaming communities from their leisure time involved friends from previous relations, people they had met online and regularly interacted with, or more or less random people they encountered online. One student (Noah) explained that he had gained several friends through discord communities in his leisure time, but that they only met online. Noah preferred to game online and explained that the good thing about gaming online is that you can always just leave and take a nap on the couch. In this way, Noah's I-position of being a leisure player was *non-committal* as it involved informality and low obligations towards the gaming community. Several of the students' I-positions related to leisure gaming are non-committed with low obligations with the option to "tap in and out of relations" when they prefer.

The I-positions that the students assumed as part of the esports programmes at the STU's were different. At the STU, they experience being part of a community, which involves presence in-game, in the class, and at other locations at the STU. This allows for different I-positions and possibilities for participation which all are variations of being *committed* to the community. Some students had experienced getting 'real friends' where they can talk about problems or dilemmas. Kim explains that he has gained "camaraderie" in the esports programme, which he has not experienced elsewhere, even though he had played *LoL* (the game played at STU 2) since he was 7 years old:

> "*Many expect that gamers have friends online when they sit and play online. But at the STU you also get physical friends, people you can physically hang out with. And … I don't know, go out in town, and have a pizza with, … Virtual or physical face-to-face is different. You get completely different camaraderie than you would get if you just sat and played and met them online.*" (Kim)

Kim's experiences of having friends physically and at the STU are different then online friends, among other things because there are different opportunities or potentials connected to physical friendships and activities. In this way, the students' participation in esports class permeates the boundaries of their leisure time, making it easier for them to socialise. Magnus explained that in the esports programme they get to know each other on the pitch (football analogy) but also personally. Mark experienced that he is better at communicating with people outside of the esports class where the game becomes a good topic to initiate talks with peers. Mark explained that he and Magnus do not have a lot in common besides *LoL*, but it is easier for them to communicate about *LoL* because it is a shared interest they are both passionate about. Further Mark experienced that talking about a specific game can lead to another conversation later on.

> "*It's really an icebreaker if you need to start a conversation with someone else. Like, have you seen the new patch notes and everything? And then move into a conversation from there*." (Mark)

It is not easy for Mark to initiate a conversation. But talking about the game as a topic, a new I-position emerges, where it is easier to initiate a conversation with his peers because of their common passion for the game. In this

way, the external position of *being a participant in the physical STU community* permeates the in-game and in class experiences and allows new I-positions for the students such as *I as an initiator of conversation*. For some students, the community they experienced at the STU led them to experience new friendships and positive relations, for others they became aware of other programmes at the STU and began to see opportunities in other subjects. We also identified an I-position as 'communicating team member', which highlights the difference between committed gameplay at the STU and non-committed gaming at home. When Mark played *LoL* at home, he did not trust or cooperate with players he met online and explained that it is *"almost like two different games when you play at home versus here,"*. In the esports programme he experienced being part of a team:

> *But when you're in Esports, where you actually have to do things with others, you are kind of forced into it…. is just where you sit in an enclosed/confined room and are forced to cooperate with others. You can't just go completely autistic and do your own thing. You have to communicate with others.* (Mark)

For Mark you have to do things with others in esports and you are actually forced into doing it. He also used his diagnosis of autism to explain that you cannot "just go completely autistic", in the sense that, here is a task that you cannot do alone but you must communicate with your teammates. Several students experienced that being a team member was closely tied to how they experienced collaboration and communication in the game. Moreover, Mark also described how he was not used to collaborating in the other classes at the STU, where they mainly work individually on their own assignments.

The esports programmes at the STU offer different I-positions as being part of a committed community than they encounter in their leisure gaming activities. To a degree that students say that the same game played at the STU compared to at home are almost two different games. The possible i-positions of being part of a committed community are both in relations to in-game and being team members, but also in relations to getting to know the other students before and after playing, and even broader at the STU.

7. Discussion

This study has aimed to provide more knowledge on how vulnerable youth perceive their participation in esports programmes. In this way, we have both tried to highlight the beneficial and inclusive aspects of esports activities, but also tried to shed light on how students' gaming interests imply many different I-positions. In other words: gaming is not just gaming, but always involves contextual and normative practices, which require negotiation among the social participants to make sense.

The analysis shows how the esports programmes offer unique social spaces for vulnerable youth, which allow them to adopt new I-positions - i.e. as students in the STU classroom, as esport gamers, as team members and as members of learning communities, which involve new forms of relations, commitment and communication. Overall, the students expressed positive experiences attending the esports programmes, which were in stark contrast to their negative experiences with prior forms of education. At the same time, the interviews also revealed that the students' participation involved tensions, which may create dilemmas for making the esports programmes succeed. A key finding here was the varying alignment between the students' game preferences at home and the esport games, which they had to play at the STU. Some students clearly experienced a strong or at least acceptable match between the two gaming contexts, whereas other students were less optimistic and even negative about the teachers' preferred games.

Another key finding is that the esports programmes at the STUs allows for the construction of I-positions that are committed to communities, which can help the students to communicate, form friendships, being part of a team/group, and talk with other people. The experience of participating in a committed community was rather unique for the STU-students as they seldom experience this in their leisure gaming activities or their prior schools. One aspect that requires further investigation is if the online participation in the esports programmes (offered at STU 1 to help students integrate slowly into the esports programme) offer the same or similar possibilities for adoption of it-positions as being physically present.

A limitation to our study is, as mentioned, a potential selection bias. Because of the vulnerable position of the youth attending the STU, the teachers suggested which students to be interviewed, which might have prioritised students with more positive experiences. Furthermore, some of the suggested students did not want to talk to us. In this way, there may be other I-positions present among the students, which we did not have access to. It is important to emphasise that several of the I-positions described in the analysis are somewhat overlapping.

The I-positions suggested here rely heavily on the researchers interpretation and could be conceptualised differently. Through our continued studies, we hope to refine and deepen the categories.

8. Conclusion

In this study we have used Dialogic self-theory to interpret how vulnerable youth position themselves as participants in esports programmes at three STU's in Denmark. We conclude that students have more positive experiences at the STU compared to prior school experiences and that participation in the esports programme allows for students to construct somewhat unique I-positions as members of committed communities being team members or students at the STU's. This potentially has a positive impact on students' construction of their self and identity. Further research is needed to identify and detail the different I-positions adopted by the students but also to understand how the esports programmes facilitate the construction of the students I-positions. For example, how alignment between students' I-positions as leisure gamers and the games played at the STU can impact the I-positions students develop.

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"Open World" Texts: A Framework for Analyzing Recombinatory Writing Games (RWGs)

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Abstract: This paper uses a literary studies and game-based design approach to propose a theoretical framework for understanding, assessing, and designing recombinatory writing games (RWGs) as well as for establishing the relationship between RWGs and the larger category of creative writing games for reading (CWGR). Central to understanding this framework is the way RWGs integrate and develop Surrealist and Oulipo writing techniques (play, collaboration, juxtaposition, and constraint) to democratize traditional notions of Literature in order to create the inclusive, non-judgmental arena necessary to establish open world exploration and creativity as motivators in writing games for reading. This paper develops a theoretical approach and then uses it to analyze example games and prototypes to clarify *divergence*, *juxtaposition*, *textuality*, *open world*, and *play* as the key aspects of the framework. No framework has yet been established for examining CWGR or RWGs, thus this paper represents a necessary foundation for future research and design as well as an essential part of the larger project aimed at developing creativity and inclusivity as motivators for game-based reading and writing.

Keywords: Creative Writing, Reading, Games, Literature, Open World, Surrealism

1. Introduction

The West assumes Shakespeare wrote the greatest works of all time. This notion has kept a very good writer's work alive, however, the hierarchy of genius reduces the inclusivity of Literature, and undermines creative, exploratory approaches to reading and writing, particularly for the majority of students, who do not identify as geniuses or even writers (Waitman, 2009; Runco, 2014). This along with the fact that writing in school is primarily associated with assessment (Boscolo and Hidi, 2007), creativity is increasingly perceived as childish as students progress academically (Jones, 2023; James and Nerantzi 2019), and the majority of educational reading games are not aimed at advanced reading, sets up a difficult task for those wishing to inspire upper-secondary students.

This paper proposes a framework for examining how game-based approaches to rearranging classic texts—recombinatory writing games (RWGs)—can motivate players by establishing a playful, building, exploratory experience comparable to open world games like *Minecraft*. This experience opens an inclusive creative space by democratizing the hierarchies associated with writing and Literature, and its recombinatory aspect facilitates creative and interpretive interactions with a primary text by combining Surrealist game-based techniques, the algorithmic recombination of the Oulipo, and the practice of "critical deformation": the idea that textual reorganization can serve as an effective method for critical analysis (McGann, 2001). To analyze this game-based process, *divergence, juxtaposition, texutality, open world,* and *play* are proposed as an analytical framework.

2. Surrealist, Game-based, Combinatory Writing

Surrealist writing games democratize traditional notions of Literature by turning the artistic process into a collaborative exploration focused on the concepts of "chance" and "the marvelous" (Durozoi, 2004, p. 65). "Chance" and "the marvelous" are technical terms referring to the way two objects combined at random (chance) can function to inspire new ideas (the marvelous). Surrealist methods modify French parlor games to develop a suite of collaborative, chance-based, combinatory games focusing on the production of surprising juxtapositions. The most famous textual example, *Exquisite Corpse*, asks players to write part of a single sentence while blind to what other players have written. The chance-based intersection of sentence parts is given overall coherence by syntax: article + adjective + noun + etc. The game transforms the notion of artistic production from the product of singular genius to a collaborative, playful, combinatory process.

This process revolves around the moment of unfolding, an action that reveals and connects the individually produced texts. Unfolding actively combines writer and reader, as each writer becomes a reader of a final text that they have co-authored but have never seen in full. This collaborative reading also pertains to future readers: the crease left by the fold acts as a material acknowledgment of the collaborative and chance-based process for any future reader (Laxton, 2009). This awareness of the text's collaborative creation transforms "reading" from the traditional notion of *convergent* sense making or comprehension (Bos et al., 2015), into a search for surprising and *divergent* juxtapositions, an experience comparable to that of the original writers/readers.

Collaborative, combinatory writing also challenges the notion of the text as fixed information in a one-way knowledge transfer from writer to reader. This is replaced with text as trace of playful process where connections can work at varying levels of cohesion. This may even go so far as to include "failure"; however, the measure of a "failed" juxtapositions is established by the reader rather than the writer, representing a further level of both textual openness and reader inclusion. This is in direct contrast to the way we typically read Shakespeare: as a set of ingenious connections established centuries ago and delivered to us under the threat of assessment.

The central mechanic of Surrealist writing games—juxtaposition—went on to influence the field of 20th century art (Lusty, 2021), to be used pedagogically in the field of Creative Writing, particularly songwriting (Pattison, 2010; Gooderson and Henley, 2017), and has recently been shown to improve solution-based processes (Mastria et al., 2022). In almost all fields, however, the emphasis on product has re-established a product- and assessment-focused process that undermines inclusion and creativity. Key to understanding the potential of Surrealist process is to understand this forgotten democratic aspect: how combinatory game design sets up a participatory community that transforms the writing and reading experience into in a creative and inclusive search for surprising textual juxtapositions.

3. Recombinatory Writing and "Critical Deformation"

While the Surrealists used these methods to produce original works of art, the experimental group Oulipo used combinatory methods as filters on source texts. Their methods quantify the "marvelous" juxtaposition in Surrealist game design, shifting from chance as a mechanic for sourcing texts (players write whatever they want) to data mining (a source text is mined by one of their algorithms) in what amounts to a mechanization of the combinatory process (Motte, 1986). For example, the ten sonnets of Raymond Queneau's *One Hundred Thousand Billion Poems* can be recombined to produce 10^{14} poems. Rather than a singular combination driven by individual players, this method runs basic algorithms to explore a nearly infinite number of combinations on a source text. While Surrealist method decenters the artistic product, the Oulipo jettisons it completely; the point is not the poems but the mathematical rules ("constraint") driving the composition (Motte, 1986). In essence, the process replaces traditional creative writing with algorithmic textual design.

While *One Hundred Thousand Billion Poems* still acknowledges individual genius, running its constraint on Queneau's poetry, S + 7 represents a combinatory equation, involving no original work except what is produced by running the constraint (it replaces every noun in a text with the dictionary entry seven places from the original). This procedural filtering treats the original text as *material* from which to systematically "fold" a "new" text (Queneau, 1986). Writer becomes coder, designing algorithms to create a productive recombination of the original text. The approach jettisons the notion of a single product to such a degree that even the process produced, S + 7, represents only one of numerous potential algorithmic processes of this type.

The Oulipo did some work on turning this combinatory approach into a method for literary interpretation, but this was not taken seriously until Jerome McGann coined the term "critical deformation" and made an in-depth argument that isolating parts of a literary text can reveal connections and thus serve as a critical reading tool (McGann, 2001; Ramsay, 2011). As McGann's deformations are too complex to present briefly, Yedda Morrison's conceptual artwork can clarify this approach. In her critical deformation "*Darkness, All that/the Remains:* a biocentric reading of Joseph Conrad's *Heart of Darkness,* 1902", Morrison (2012, p.177) erases "all things human" from the novel so that *Heart of Darkness* opens with enormous gaps:

flood

wind

river.

Rather than raising her original environmental questions, however, the process introduced ethical questions about race: "erase whites only? Thereby erasing colonialism? So blacks are "part of nature"? Erase blacks? As in erasing black history? Again?" (p. 177). This highlights the divergent and emergent nature of critical deformation. Rather than selecting quotes to support a predefined argument, ideas and critical questions emerge in the deformation process, which is essentially a Surrealist folding of the text driven by an Oulipian algorithm.

The presence of the fold as a mechanic in critical deformation reveals the surprisingly coherent and useful nature of this wildly divergent, collaborative, playful and sometimes nonsensical mechanic. In essence, critical deformation aims for the Surrealist product (surprising juxtaposition) with an Oulipean approach (systematic

exploration). The only characteristic absent is the rule-based framework: Oulipo has "constraints", Surrealism has parlor games, but critical deformation lacks a clearly defined set of rules to direct the process.

4. Creative Writing and Expressive Deformation

The lack of defined process in critical deformation makes it useful for experts but reduces the collaborative element and gears the method away from inclusion and towards experts. An example of this is the critical deformance "*Imagining Nonlinear Reading*", a word-cloud concordance of Dylan Thomas (see figure 1) built in digital, immersive 3D (Jones, 2012). Late one night at the lab, a student saw the word clouds and exclaimed, "Wow, that's beautiful!" This, however, was quickly followed by, "So…how do you play it?"

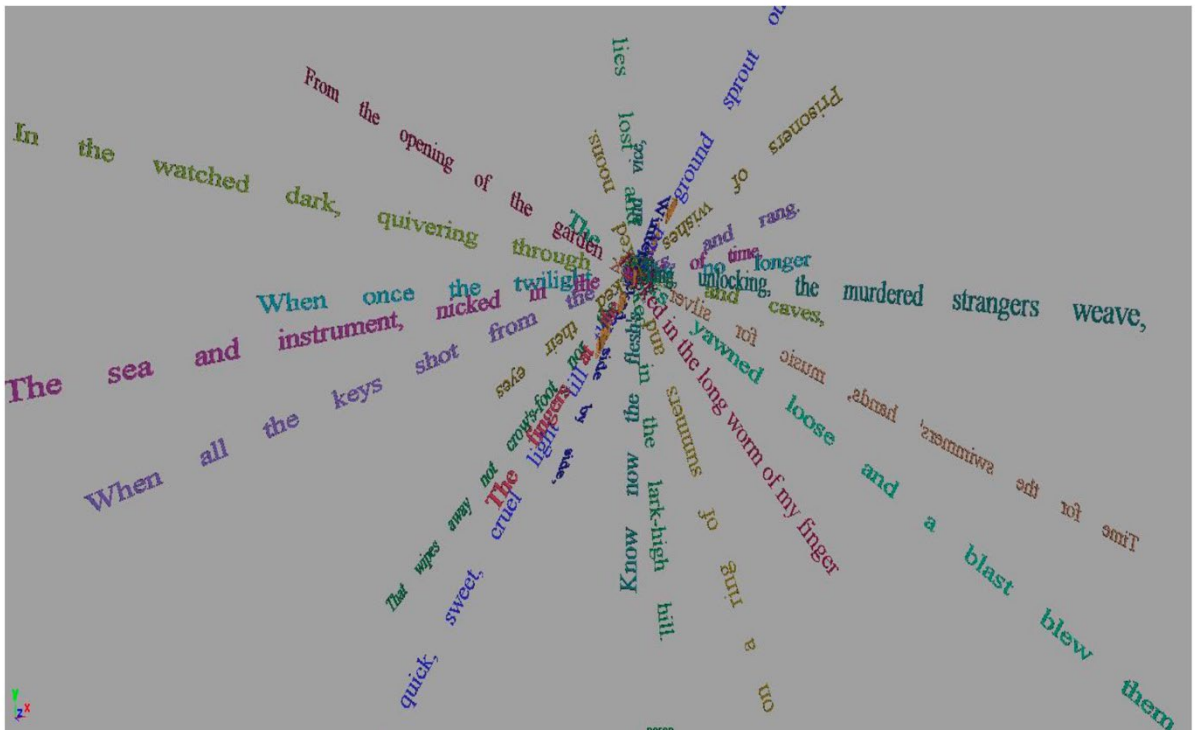


Figure 1: *Imagining Non-linear Reading*: word cluster surrounding "lock"

The lack of clearly defined methods in critical deformation has been overcome to some extent in the field of Creative Writing (CW) by emphasizing the artistic and expressive nature of the output. A common example of this kind of expressive deformation is the "replacement poem", an exercise where a poem missing key words is completed by students (Gropp and Jorgenson, 2020). As a critical deformance, this process reveals the incredible density and complex linguistic structures of good poetry; however, the motivator in CW is often the creation of a new expressive piece. In other words, the answer CW gives is that the product is beautiful, regardless of its usefulness. This removes the "critical" element from the process, but it reveals the incredible power of presenting reading from a design perspective, where the reader identifies themselves as a builder, modifying and building one text from another, developing their goals and processes as they go.

In CW, framing the writer as builder/designer moves reading from an information search to a process of mining the master texts for building blocks (ideas, structures, language, syntax) to use in a new artistic product. This designer/builder frame also creates an inclusive relationship to Literature. It doesn't matter if Shakespeare hands over the brick or if it is lying in the street. For students who see themselves as creative, this represents a goldmine in terms of producing engagement with literary texts. The problem with this, however, is twofold: first, creative self-expression does little to engage students who do not see themselves as creatives (Boscolo and Hidi, 2007); second, the central goal of critical deformation is not to produce art but to engage in interpretation. So, how do you adapt deformations as critical tools while motivating "non-creative" users?

This paper proposes five categories of analysis for writing games that attempt to do just that: *divergence*, *juxtaposition*, *textuality*, *open world*, and *play.* This framework can be used to analyze the extent to which the broader category of creative writing games for reading (CWGR) develop an open-world, exploratory, building

experience and establish divergent creativity as a motivator for rule-based recombination. In other words, the framework assesses CWGR as game-based critical deformations, i.e. as recombinatory writing games (RWGs).

5. Creative Writing Games for Reading (CWGR)

Replacement poems qualify as CWGR, however, they allow the writer to use any words they like in the replacement, which means the level of recombination is lower than if the writer were allowed only text from the original. Party games like *Apples to Apples* are also CWGR, however, they have no relationship whatsoever to a primary text. Thus, they are combinatory as opposed to recombinatory. And both these approaches use Surrealist and Oulipo methods like chance and the fold to varying degrees to drive their processes. In view of this radical variety in CWGR, the present paper proposes a framework to specifically examine the extent to which these processes use rules/constraints ("games"), collaborative or chance juxtaposition, and a "playful" (Stenros, 2015) or divergent approach to create inclusive, "open worlds" for design/builder-based textual exploration. This framework will be developed by looking at the way RWGs combine game-based design with the motivation of CW combinatory practice (traditional notions of writing a poem), allowing creativity and self-expression to function even for users with low self-efficacy in creative writing. The analysis will find that RWGs develop an open world, sandbox/building relationship between the reader (who functions as a co-writer) and the literary text: words become material, like the blocks of *Minecraft*, and writing becomes exploration (skimming), building/designing (text mining), and solving (reading). The games imply that one need not be an artistic genius; one need only stack blocks in interesting ways.

In many ways, *Minecraft* set up this game-based approach by redefining the notion of what makes a video game. One of the most played games in the world, it is not really a game at all: there is little sense of competition, scoring, or goals beyond exploration and building (Duncan, 2011). It is almost solely based upon the motivation provide by design/building. The first version plopped the player down by a beach with no goal beyond placing blocks and smashing them: "left click to place or mine blocks" (Person, 2009). *Minecraft* remains hugely popular (nearly one million online now according to activeplayer.io/minecraft) despite its rudimentary graphics, and while it has added some first-person shooter and survival elements, it remains fundamentally an exploration and building platform (Duncan, 2011).

In *Minecraft,* "playing" consists of wandering an infinite world and building freely. Like *Roblox*, the central "game" mechanic is design. Likewise, recombinatory writing games (RWGs) are only games in the sense that they present reading and writing as a design-based experience. Rather than a beach, a RWG plops the player down in a work of literature with the essential motivator being to smash things up and reassemble them in new ways. The master literary text becomes the blocks in *Minecraft,* each word equivalent to a different material. The rules built into language (grammar, sense, and narrative), make a very simple rule (line them up) quite complex. In *Minecraft*, players learn that different combinations create different effects; in RWGs, the player arrives with long training in their language's grammatical, syntactical, and narrative combinations. While *Minecraft* began with thirty blocks (grown to over 800), blocks in a RWG are equivalent to the user's vocabulary.

The measure of the open world aspect of an RWG can be understood in contrast to the closed, solution-based aspects these games also employ. For example, storytelling games are collaborative creative writing games whose goal is to reach a particular set ending (Perez & Bidarra, 2022), so the parts are creative, but the ending is solution-based. *Apples to Apples* is probably the most a popular purely recombinatory game: the texts are fixed, players select what text to play, and the combinatory result is judged by a single player. This makes it solution-based, though a solution based predominantly on the interpersonal dynamics of public judging. Both storytelling games and games like *Apples to Apples* are RWGs, however, they do not focus recombination on an original text. Thus, one might argue that they are creative writing games that use recombination, but their goal is essentially creative or communal as opposed to critical, as the deformation aspect is absent.

Even in CWGR that succeed in recombining an original text, there is the consideration of how and to what level. The highest level of "textuality" would be a game like *Dylan Thomas Dominoes* (Jones, 2021) that *only* uses the text of the original literary text under consideration in its deformation. Remove the game element from this approach, and you have something comparable to a text-analysis tool like Voyant, the product of the game comparable to an information visualization or "direct visualization" (Manovich, 2011). A direct visualization uses "distant reading" (Morretti, 2005)—a computational and quantitative approach that visualizes large quantities of text—to move "distant" enough from a text that it becomes a map of its own internal relationships. A simple example of this would be an author's complete works laid out in chronological order with all positive words highlighted in red. From a distance this becomes a density plot of the writer's positive word use over time.

CWGR with low textuality do not necessarily lose their function as deformations. While dismissing it as "subjective", McGann does include "adding" in his definition of critical deformation mechanics: "reordering", "isolating", "altering", and "adding" (2001). An example of a RWG that uses recombination of the original text but also allows subjective addition is "One into another". This Surrealist game, redesigned as an RWG ("analogy riddle") in a recent study (Jones, 2023), asks students to make riddles out of two terms in a literary text. While the goal is to compare terms, the riddle clues are user-based and thus represent an addition to the text under analysis. This moves the product away from the original text and into the student's contemporary experience. As such, it represents a lower "textuality" or use of the original text; however, it can allow for a higher level of divergent thinking, as the analogy can go anywhere, and grounding a comparison in student experience can also increase the open world aspect, as it opens the text outward to connect with the student's world.

One of the central design challenges of a fully open-world game is the high cognitive load of exploration-based, building/design mechanics: too much openness in a game can leave the player/writer lost. This is why zombie attacks were added to the early version of Minecraft (Duncan, 2011). This gave players a sense of something specific to do: build for protection. Misuguided notions of creativity as a completely open and free activity produce this problem of cognitive load: a lack of guidance can make creative play "grueling", as Margaret Robertson points out in her *Minecraft* game analysis (2010). On the other hand, a more solution-based system that leads to a pre-determined answer, while reducing cognitive load, limits the ability for an RWG to foster open exploration. Play is replaced with the race for a single solution.

This paper's exploration of Surrealist game design, Oulipo algorithmic composition, and critical deformation serves as the foundation for understanding RWGs as *interfaces that use open world game design to aim the creativity of combinatory writing at critical deformation*. The rest of this paper explores specific mechanics and games with the goal of clarifying the relationship between CWGR and RWGs. While this paper focuses on the framework, a future paper will present data from an ongoing research project designing and testing RWGs in Norwegian upper-secondary schools (Jones, 2023).

6. Freewriting as Experiential Frame and Mechanic

In CWGR, the open space of freewriting can function to develop both a divergent (Baer, 1993) and playful (Stenros, 2015) mindset as well as to train users in creativity as skill, motivator, and game objective. This, in turn, gives the player the skills and mindset necessary to experience recombinatory textual play as an open world.

The primary rule in freewriting is not to stop. This dismissal of judgment opens the low-stakes space essential for divergent performance (Amabile, 1982). In the 1980's, Peter Elbow famously developed narrative freewriting as a critical tool in American university writing courses (1973/1998); however, freewriting is fundamentally at odds with RWGs, as recombination reduces the words a writer can choose. In view of this, each of the following CWGR freewriting modifications train the user to navigate from the open space of divergent creativity toward the convergent (logical or solution-based) space of critical thinking and writing:

Open freewriting has no constraints, the only rule to keep writing. It functions to 1. Establish an experience of freewriting from which the other forms diverge, acting as a baseline for navigating between divergent and convergent thinking; 2. Develop the skill of divergent thinking/writing to reduce the cognitive load of recombination so it can be experienced as an open world activity. 3. Refocus writing from coherence and self-expression to a game-like, playful, combinatory mechanic facilitated by constraints.

Blind freewriting asks writer to close their eyes. This disrupts the hand-to-eye connection of traditional writing, a disruption that encourages divergence and begins the embodying process that is part and parcel of making textual interaction an immersive, material process of exploratory block stacking.

"Word bomb" drops random words into the freewrite that the player must immediately incorporate. This produces a radically divergent moment that must be turned convergent (incorporated into the freewrite). Note that while open freewriting cannot be easily gamified, word bomb introduces the possibility of altering game speed and thus can be used for scoring and competition. These kinds of game elements are key to establish "flow" (Csikszentmihalyi and Le Fevre, 1989) and demonstrate how the relationship between aspects in the framework—in this case divergence vs. convergence—can become game elements.

Catchphrase drops logical phrases into a freewrite. The player must then continue writing from that phrase. While convergent in the sense that the phrase must make sense, these result in divergent moments when the phrase succeeds in turning the writing in a new direction. In CW, the term "I remember", however, this typically

produces fluency over divergence. In the study associated with this paper, the catchphrase "Evil clowns should rule the world because" was used to combine convergent argument structures with divergent, playful content.

Non-sense asks players to put words together that *don't* make sense. This works to reveal other linguistic capabilities associated with stacking word-blocks like rhyming, random, sight-based, alphabet-based, or algorithmic ordering. Non-sense also serves to physicalize the process by moving players toward sound (rhyming) and sight (writing whatever they see), which disrupts logical, convergent, narrative-based writing.

The five variations of freewriting can function as game mechanics. For example, the first stage of the RWG prototype *Poetry Planet* (Jones, 2024) sets the player up as a space explorer whose goal is to conquer the most territory on a planet surfaced in the words of a classical literary text. The first screen—"Blast Off"—is split, a rocket ship on the left and a writing area on the right. To "fuel" the rocket, the player goes through a series of freewriting variations. The only prompt given is "Words are rocket fuel—start writing!" Typing fuels the rocket, the goal to reach the top of the screen. "Blast off" trains the player in basic divergent writing skills, develops their sense of writing as an unjudged, open world experience (write whatever you want), and introduces them to word stacking (juxtaposing) as a mechanic for progressing in the game.

7. Game Analysis: Poetry Planet

After completing the "Blast Off" level, the player flies to a *Poetry Planet,* a planet wrapped in the text of a classic piece of literature or a text of the player's/teacher's choice. The text is strung from south to north as a single line of words, the reversal effected by the organization pre-deforming the text to a certain degree. The goal of the game is simple: conquer the most territory. To do this, players move from word to word, the only rule to make sentences. When the path a player leaves circles a chunk of text, they have "captured" it (see figure 2).

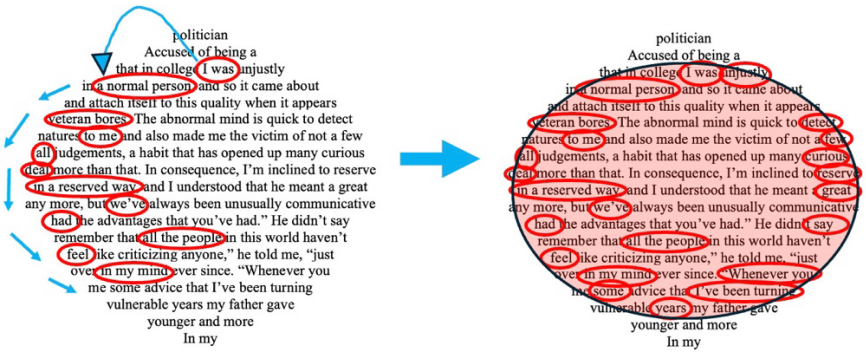


Figure 2: "Capture" in *Poetry Planet*

After capturing, a player can "mine" an area by playing "Mine the River" (see figure 3), a Tetris-like game where words drop from the top of the screen and must be dragged to the incline and ordered into sentences. The words dragged to the incline slowly slide down toward the pile. Once a sentence is completed on the incline, the trap door open and it is stored as "cargo". The goal is to keep the screen from filling during the allotted time. Mining gives players necessary elements to repair their ship and text for use in battles with other players.

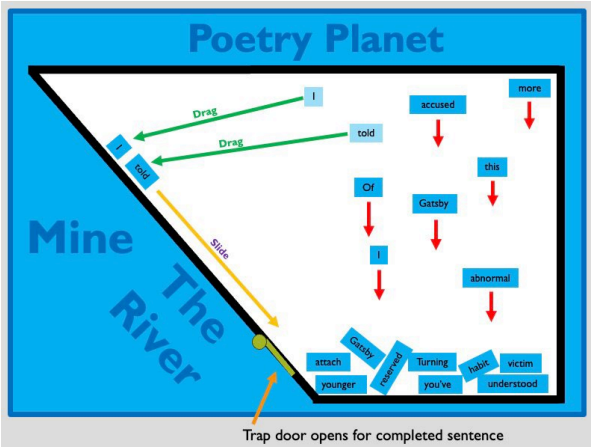


Figure 3: "Mining" with "Mine the River"

To win the game, players/teams can use any words in their "cargo" (all the sentences from "capture", "mine", and "battle") to make a "riddle sentence". Each team/player submits their riddle sentence for judging, and one is selected by majority player vote. Teams/players race to "solve" this riddle sentence by finding the location of each word on the textual planet (see figure 4). This mechanic is the one that most clearly moves from divergent word-block stacking toward convergent, solution-based thinking, as there are a limited number of correct answers. This mechanic also moves the player back to the original text (skimming to find pieces of the "riddle sentence") and makes a knowledge of that text strategically advantageous for more quickly completing the riddle sentence. This is promising in terms of arguing that this RWG functions as a CWGR in terms of using recombination not simply as a game mechanic but to motivate interaction with the original text.

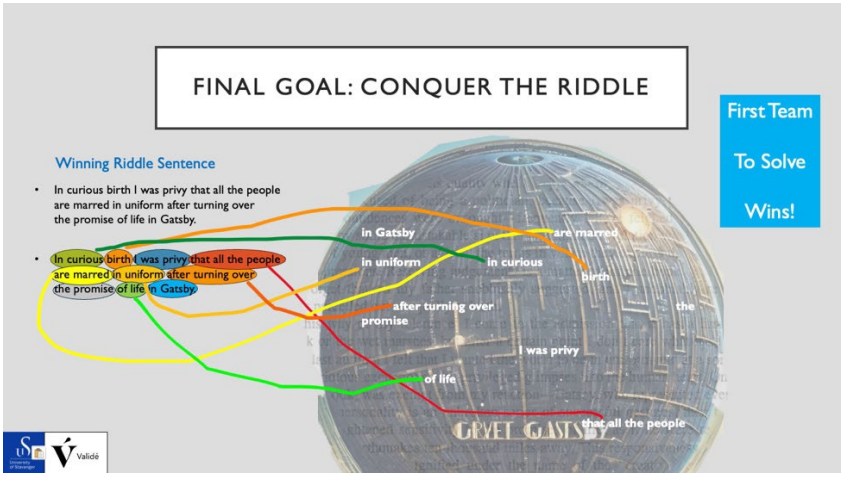


Figure 4: Screenshot of final stage of *Poetry Planet* prototype

The example of *Poetry Planet* shows us how game design can be used to direct highly divergent and subjective/additional writing (users freewrite with words not related to *Gatsby*) toward a second level that involves 100% textual recombinatory interactions (only Gatsby text is used in capture/conquer) through a third level of second-level recombination (designing a riddle sentence from recombinations built during gameplay) that sets up a potential foundation for critical analytical work (more complex riddle sentences build more complex conceptual juxtapositions/interpretations) toward a final riddle-solution stage, which is fundamentally convergent in terms of being solution-based (very few possible answers), and uses spatial immersion (fluency in the map of the planet/text) to set up an information visualization (knowledge about the spatial relationships between specific terms in relation to the overall planet).

Typically, RWGs only become clearly effective as reading tools when the games are followed by discussion and analysis that compares the game experience to a traditional reading of the text. While the game element in *Poetry Planet* has made deformation an accessible process, it has yet to do likewise with complex interpretation.

8. Using the Framework on *Poetry Planet*

This paper proposes the following framework for analyzing CWGR as RWGs:

- **Divergence**: the relationship of divergence to convergence in mechanics or game experience.
- **Juxtaposition:** the ways in which the game produces surprising juxtapositions from the original text.
- **Textuality**: the level to which a game uses the original literary text.
- **Open world**: mechanics and game experiences focused on free exploration and building.
- **Play**: the level to which the game uses a playful mindset as game experience or objective.

This framework reveals the following about *Poetry Planet*: 1. *Divergence: Poetry Planet's* "Blast Off" stage is extremely divergent, the critical or even sense-making aspect of reading sidelined to speed and competition. The "word bomb" variation begins some movement toward convergence in the sense of forcing players to integrate the *Gatsby* text. The game grows progressively more convergent in terms of strategy- (team building) and solution-based (riddle solving). Overall, the prototype moves from an open world, divergent structure to a solution-based one, as there are a limited number of answers to the riddle sentence. The final search is the least divergent action, however, as it involves repeatedly looking for meaning in context, it develops textual familiarity which can scaffold divergent thinking in post-game interpretation; 2. *Juxtaposition and Textuality*: the central

mechanic of *Poetry Planet* is textual juxtaposition, however, in the open freewriting phase of "Blast Off", there is no textuality (connection to the primary text), and as the player can write anything, surprising juxtapositions are less common than the later phases of constrained freewriting like "Word Bomb". The "planet" in *Poetry Planet* is completely *textual* (100% from Gatsby) and is, in fact, already a *juxtaposition*/deformation as the text is organized such that new juxtapositions have already been laid out across the planet's surface; 3.*Open world:* the immersive sense of approaching a planet makes the *open world* aspect both spatial and textual. It is spatial in the sense that a player can fly freely across a 3D text-planet and textual in terms of this paper's central argument: the free, exploratory, building experience of creative recombination makes an "open world" of the original text; 4. *Play:* much of the play in *Poetry Planet* is sacrificed to game mechanics. For example, the speed of "Blast Off" make it less playful; however, the high level of recombination in a strategic master riddle sentence (designed to be hard to find) and the presence of an interested audience (the other team) increases the playfulness of the product. Note that there is almost no collaborative recombination in *Poetry Planet*.

9. Conclusion

This paper has used Surrealist and Oulipo theoretical approaches to set up a framework for understanding and exploring recombinatory writing games (RWGs) as a subset of creative writing games for reading (CWGR). RWGs use recombinatory rules that function like Oulipean "constraints" as a method for critical deformations driven by Surrealist game-based juxtapositions. This framework is important as it represent a step forward in the analysis and design of RWGs as useful tools in directing the motivation of creativity toward reading and writing. It also can be useful in examining the extent to which creative writing helpers like AILit (Bakken, 2024) or other literary games (specifically role-playing games like *Losswords*) could potentially integrate recombination as a method for creative engagement and textual analysis.

For reasons of space, a forthcoming paper will have to connect this framework to the data collected in "Gamifying Reading", an ongoing study where RWG prototypes are being play-tested with 100 upper-secondary students in Norway accompanied by surveys examining how the games are experienced by different personality types (OCEAN model), by self-identified creatives versus non-creatives, and as a way to examine the difference between divergent versus solution-based aspects of the games on user experience and engagement. Specifically, this proposed framework will be useful to examine the data in the study. The final term that needs to be added in a future reworking of this framework is "criticality": the level to which a game encourages, scaffolds, or produces critical reading of the original text.

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Embedding Psychology Themes in University Induction Using a Digital Escape Game

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Abstract: An "escape room" style game was developed as an induction activity for first year psychology students, encouraged by the need for icebreakers that meet specific, relevant and transparent learning outcomes. The game concept was designed using the escapeED framework for game-based-learning (Clarke et al., 2017), including consideration of narrative, participants, theme, objectives and evaluation. Groups of up to six students worked on an iPad "board" that had clickable objects on a representation of a lecturer's desk. Students had 20 minutes to solve four puzzles that identified objects to click on and reveal digits for a padlocked bag. However, clicking the wrong objects would cause loud music that would "disrupt the staff office". The four puzzles symbolised learning outcomes that students will develop throughout their course, such as seeking and evaluating evidence, using maths, and referencing. The puzzles also used staff profiles to promote discussion about psychology research, prompt the development of supportive networks and relationships with staff. A realistic calendar puzzle highlighted the social and academic opportunities that students should engage in as part of the psychology community, which they could also identify as by wearing the pin badge they unlocked on completion of the game. Psychology staff facilitated reflection on icebreaker activities, including themes of teamwork and leadership roles, asking for help, and learning and adapting from mistakes. A thematic analysis of three focus groups later highlighted that students resist looking at assignment feedback and are concerned about wasting staff time in office hours. This led to recruitment of senior students to facilitate the escape room, and changes in our reflective practice tutoring to address issues raised during the game. Overall, students reported a sense of fun and competition from the activities and felt better prepared for learning after the introduction to psychology skills during induction.

Keywords: Realistic, Psychology, Reflection, Icebreaker, Community

1. Introduction

Icebreaker activities typically encourage groups of individuals to introduce themselves and begin to develop a spirit of teamwork, community or belonging. This can be applied to university courses during induction, as students meet their peers and start to develop friendships and supportive academic networks. Icebreaker activities tend to be game-based or playful, and Chlup and Collins (2010) argue that this helps to foster a safe environment for adult learners, supporting students to share knowledge and learn from each other, and communicate concerns or solutions for shared problems. Indeed, introductory activities are arguably important in the context of social and emotional learning, as learners must be aware of their own behaviours and develop skills to understand and relate to others (Dressel, 2020), particularly since the transition to university might introduce greater diversity in the social sphere. Chlup and Collins give examples of icebreaker activities such as sharing unique personal interests or characteristics, engaging in reflection on how an individual relates to other members of a class, and swapping creative ideas to answer a prompt. These activities could foster qualities such as social engagement and interdependence, and celebrate diversity. The current research project began as an evaluation of the icebreaker activities for psychology induction at a UK university, where the original activities included a teambuilding challenge to construct a spaghetti tower, "find a person who…(matches various criteria)", and a problem solving discussion on moral dilemmas, though the learning outcomes for these was unclear.

Several studies have demonstrated effectiveness of icebreakers for increasing class engagement and sense of connection. For instance, Abbas et al. (2022) used chat bots in an online discussion forum to stimulate icebreakers between university students and found that over half of participants reported engagement with users on the platform had increased their sense of belonging at university. Similarly, Sasan et al. (2023) found that students who participated in icebreakers were more engaged in class discussion and reported greater sense of community. Students also reported that icebreakers helped generate a friendly atmosphere and positive mood for learning, and it helped to make facilitators more approachable. Chopik and Oh (2024) reported that students taking part in a self-disclosure icebreaker experienced a significant increase in perceived closeness with classmates and sense of belonging. Similarly, Jarusriboonchai et al. (2016) developed a mobile game where players answer personal questions about themselves and are challenged to learn information about the rest of the group. The playfulness of the game allowed participants to avoid perfectionism and enjoy being creative with their answers. The looseness of the game rules allowed different groups of participants to approach the

tasks in different ways, which parallels individual differences in learning. They also describe participants laughing at others making mistakes, indicating a non-threatening learning environment.

One element missing from some educational and icebreaker games is a formal reflection on the learning outcomes of the activity (Veldkamp et al., 2022; Cloude et al., 2021). Brooks et al. (2014) noted that students do value learning about their learning outcomes, and this could be embedded early in the curriculum to help students gain self-awareness, evaluate their learning needs, and acknowledge their values and transferable skills (Higher Education Academy, 2015; Pretorius & Ford, 2016). Delaney et al. (2021) used a group reflection following an engineering icebreaker, where students were challenged to build effective towers and discuss their performance; players indicated problems that could be addressed as they developed through the module. Similarly, Braad et al. (2023) asked learners about their metacognition (thinking about thinking) following game-based learning, which was perceived as useful for novices. An escape room was chosen for the current project as it can provide a breadth of collaborative learning tasks to reflect upon, and adapts well to target challenges to sense of belonging during university induction, including communicating expectations, building relationships with teaching staff and socialisation within course groups (Thomas, 2012).

Fotaris and Mastoras' (2019) systematic review highlights how escape rooms can have several benefits, including leadership, problem solving, critical thinking and communication. The use of narrative in Escape Room design makes them well suited to a constructivist approach to learning, as diverse learners collaborate to find the best method of addressing problems, perhaps based on their prior knowledge, experience and education. Morrell, Eukel and Santurri's (2020) nursing escape room highlighted perceived benefits, including confidence, engagement and active listening, and real-life implications. Escape games can be set in the context of induction, such as in Nybo et al. (2020), who introduced staff, academic calendars, polices and learning objectives. It also lends itself well to providing scaffolding, such as using pre-determined hints, evidenced in von Kotzebue et al.'s (2022) digital escape room on sex education. The escape room can also provide immediate feedback and action, which are effective in aiding game-based learning (Wouters & Oostendorp, 2013). A psychology-themed escape game was run with three first-year psychology cohorts and evaluated within the context of university induction and sense of belongingness.

2. Game Concept

The game was designed using the escapeED framework for game-based-learning (Clarke et al., 2017), including consideration of narrative, participants, theme, objectives, and evaluation. Importantly, the puzzles were varied and accessible to those who are new to psychology, and have varied skillsets. The first version of the game was piloted by game designers and enthusiasts, who completed it successfully with no psychology background. The game takes place in a seminar room on university campus, during the first week of induction. Four classes of 15-20 students organise themselves into groups of up to six and are given a name badge to write on. Students are verbally briefed that they have 20 minutes to solve four puzzles and unlock a padlocked bag on their desk. Groups are given an A4 booklet containing the instructions and puzzles and participants are encouraged to separate the puzzles so they can work on several at once, but encouraged to help each other and seek support from the three tutors (psychology lecturers) facilitating the session. Each group has an iPad that displays the "board" for the game (created in PowerPoint) and requires players to click on objects to find digits for the padlock. The board represents a lecturer's desk and depicts 19 objects including a computer, calendar, lunchbox, and pin board with "staff of the week" profiles. The instructions explain that the lecturer has a gift for players but has hidden the padlock combination; players are given permission to "move" objects but if they click on the wrong ones it will "unplug the earphones" and cause loud music to play and disrupt the office. The music included 10 second clips from popular rock, metal, ska, drum n' bass and 80's pop, and aimed to foster a sense of individuality and approachability of tutors. Selecting the correct objects reveals a padlock digit and plays applause audio.

The rationale for the four puzzles is explained in terms of psychology learning themes, community and belonging. The choice of puzzle focus was guided by feedback from first-year tutors, and identified skills that students start developing early in their degree, including statistics, referencing, critical thinking, and finding information from reliable academic sources. This aimed to set the context and expectations for ongoing studies. One of the most important elements of the game was to encourage students to learn to make mistakes and ask for help; earlier student feedback had indicated that some avoided booking office hours with tutors because they did not want to "*waste staff time*" or ask stupid questions, thus might miss opportunities for support. From the second version of the game, senior students were recruited to facilitate the game and take part in reflective discussion, where they emphasised the importance of engaging with tutors consistently.

2.1 Puzzle 1: Definition Search

Participants are given nine general psychology definitions and must fill in a grid with a one-word name for each definition (e.g. brain, stress, memory). These align vertically down the centre to spell out "bold four". A cognitive psychology journal abstract is included at the bottom of the page, aptly focused on visual search and memory when there are distractor objects. Five words in the abstract are in bold and name objects from the desk, which makes no sense within the context of the abstract. One letter of each of these objects is replaced by a number, e.g. "**Spe4kers**", and the bold 4 indicates the correct object. Players are not immediately told that they can search online for answers to the definitions, as the aim was to encourage them to ask questions about the rules. The puzzle aims to remind students that they have the skill to expand their knowledge by continually searching for answers.

2.2 Puzzle 2: Academic Timetable

Students are presented with a timetable grid that shows real modules, as well as activities including study groups, Campus Jobs, sports and societies, CV workshop and participating in research. This highlights how university is 9-5, and encourages students to consider the different opportunities available to them. Beginning at "start", players must follow a series of arrows to navigate through the grid and should end on one of the desk objects. Arrow directions are obtained by answering seven multiple choice questions on topics including biological, cognitive and clinical psychology. The task also encourages students to keep track of their working, so they can evaluate where they have made mistakes.

An underlying theme of this task was to encourage students to take part in a rich array of extra-curricular activities, particularly having observed low attendance for Psychology Society and career events. Such activities can help to develop soft skills, boost social engagement and self-confidence (Buckley & Lee, 2021), as well as increase wellbeing and belonging (Winstone et al., 2020), so are a valuable part of the university experience. Reflecting on experiences, skills, and employability is also embedded in the curriculum since students might not appreciate or communicate these on their CV (Dibben & Morley, 2019).

2.3 Puzzle 3: Maths

This puzzle highlights the active research of psychology stuff, showcasing a poster on perceptions on eating meat. Attention is drawn to a pie chart and bar graph about eating insects and other animals. Players must calculate a sum and select one of four answers, each of which is paired with one object from the desk. This task encourages mistakes if players are not attending to detail, since the pie chart gives raw data, so the sum will be incorrect if they do not calculate percentage first.

This puzzle encourages students to learn to accept and spot mistakes in a safe environment, which is an important part of learning (Brookfield, 2017). As much as 80% of learners can feel anxiety when working with numbers (Onwuegbuzie & Wilson, 2003), and this can lead to avoidance and fear of failure. Group reflection on this activity provides a platform to voice apprehension, where tutors can reassure new starters that they will be supported throughout their learning of statistics. Research also finds that students are reluctant to communicate statistically (Malik, 2015) so the puzzle provides an early opportunity to practice this. Tutors can model their approach to solving problems and position learners in the zone of proximal development, helping them to attain a higher level than what they can manage independently (Vygotsky & Cole, 1978). Engaging in this type of task could be used to help develop metacognitive skills (thinking about thinking) and self-efficacy (Franklin & Garfield, 2006), and is expanded in another research project that the students take part in during their modules.

2.4 Puzzle 4: Referencing

In this task, players complete a referencing puzzle to identify which of four colleagues was "staff of the week". Provided staff profiles include a photograph, current research keywords and other interests (e.g. boardgames and playing double bass). Solving the puzzle spells out "therapy" which matches one staff profile, which can then be clicked on the iPad board. The puzzle tasks include finding the first letter of a journal or article title, or the first initial of an author, and a visual guide is provided to identify different parts of a reference. This puzzle introduces an abstract from a child psychology journal (published by a colleague) to demonstrate the types of literature students should be reading. The reference list is formatted in APA style (American Psychological Association) and gives a head start to understanding the benefits of following guideline standards.

This task aimed to emphasise the approachability of staff, with unique and perhaps relatable interests. Psychology students have a personal academic tutor for their entire degree, but attendance at timetabled sessions can be low, so encouraging elements of less formal interaction might help foster open communication, staff-student community, and potentially support higher retention.

2.5 Reflection

On unlocking the bag students were rewarded with an "Achievement Unlocked" pin badge to identify themselves as part of the university psychology community. The bags also contained paper feedback forms to evaluate the game. Game facilitators helped to ensure 100% completion for students who engaged in the task. Tutors facilitated a group reflection on challenges, learning and evaluation of the task, with topics including growth mindset (Dweck, 2015), making mistakes, encouraging use of personal tutors, and discussing how reflective practice has a prominent place in psychology education (Van Beveren et al., 2018; Halpern et al., 2010). Group reflection typically lasted up to five minutes.

3. Evaluation

The game was evaluated by reflecting on the gameplay, debriefing with game facilitators, collecting feedback slips, and then more formally by conducting focus groups and collecting survey data.

3.1 Gameplay

In the first play-through of the game around 70% of groups completed, which meant some were not rewarded with a badge or sense of achievement. Facilitators were further instructed to give extra hints to groups struggling to finish in time, increasing completion to 90%; one or two groups failed to engage in the task, or with facilitators. Some tutors were observed supporting one group for the entire session, rather than working the room, which took some element of independence from learners, so future games incorporated a more formal briefing, and outline of expected aims and learning outcomes. Likert scales were used to collect feedback from 54 participants: 25.92% said it was too hard while 66.67% said it was about right; 88.89% said it was fun, with the remainder being undecided, 87.04% agreed it helped them interact with peers and 70.3% agreed it helped them interact with tutors (20.37% undecided). The game was then simplified and reordered to make it clearer which elements were puzzles and which purely for context.

3.2 Qualitative Data

Three focus groups were conducted by an undergraduate research assistant, each with four participants. Focus groups lasted around 45 minutes and the game materials were distributed to refresh memory. The focus group included questions about induction and expectations, walking through experience of doing the game, challenges and enjoyment, perceived learning and social life several weeks on. Data was analysed using thematic analysis (Braun & Clarke, 2006) and three themes will be discussed: appropriateness of induction activities, evaluating performance and social connection.

3.2.1 Appropriate of Induction Activities

When evaluating their first weeks at university, students reflected on their experiences. Mature students commented on some activities being childish, such as signing up for a doctor "*it was a bit tedious to me*", "*I was literally clawing at my eyes wanting to do something that was psychology or just work or something…I felt my motivation dropping a bit*". Thus, it is important that the game is mature as well as playful. Other students did not attend some induction activities, so it is important to emphasise the value of psychology-themed induction in advance. The escape game was evaluated as "*best activity so far*", "*it's a bit of a taster…this is what we're going to cover in a fun and interesting way*", and students valued the "*doable chunks*". Experiences on the game parallel the academic reality, including the need to read instructions carefully and ask for help if unclear "*before you start tackling the problem...first, you need to know what you're about to do*". It also mirrors the breadth and depth of study: "an *expectation of the amount of work that you have to do to get a four-digit number".* Students discussed feeling lost, both physically and psychologically "*I felt nervous…I had no idea where to go*", which parallels feelings when participating in an escape room. However, students valued our separate Treasure Hunt Walking Tour, which helped decipher the abbreviations for buildings and give a sense of space.

3.2.2 Evaluating Performance

Students reflected on their performance during the game, general academic skill, and being evaluated by peers and staff. The musical element of the game introduced a social comparison: "*I felt dumb at first, but since everyone was making mistakes I felt more comfortable and it was funny*"; it is useful to reflect on learning to improve, as students also commented that they resist looking at assignment feedback, and thus may miss opportunities to develop. One development from the game was that we changed the personal tutoring system, so all year groups meet together, and can share reflection on their challenges and achievements, to encourage others: "*Yeah, I think it might have helped me if my teammates were just as clueless as I was, in the sense that would have given me like, a comforting feeling that I'm not stranded on my own*". Although the game was evaluated as being quite hard, many commented on enjoying the sense of competition with others, feeling pride upon achievement "*oh my God I feel so great*", and not feeling "*inadequate*". However, some did comment on anxieties about learning, and seeking support from tutors "*I don't like asking for help either cuz I feel like they're gonna think I'm like stupid or something. So I just sat there like, 'uh-oh, what am I gonna do', and luckily, the lecturers are so nice and they sat with me*", for this reason we recruit senior students to join induction and talk about the value of engaging with tutors.

3.2.3 Social Connection

Groups discussed intentions to socialise at university, challenges and successes when making friends, and interacting with tutors. Several commented on focussing purely on learning: "*I don't want to make friends*" and "*I don't really have to fit in*", though also reflected that they now value the social connections they have developed. Students may not immediately appreciate the support that peers can provide, but social media platforms are a way of helping one another "*we have a little group chat where we just cry about things we don't understand*". Some students who did not connect well at the start also discussed feeling lonely and considering dropping out, describing some interactions as "*superficial*" because they only attend university for a few hours a week. This is why students are encouraged to form regular study groups (as highlighted in one of the puzzles). Another sub-theme was on personal interests, with some being disappointed with the university societies, and others feeling like induction was not aimed at them, due to their religion. A student suggested distributing flyers with halal food options around the city, and the university now hands out maps showing local LGBTQ venues. Our staff-organised socials are now more inclusive from this discussion, with one participant commenting "*I was SO happy when I saw the staff had added a trip to Sprinkles [ice cream venue]".* Conducting induction activities in person (rather than online) is beneficial as students will gravitate towards people who look similar or approachable, with one commenting to a mature student "*I knew if I sat next to you I'd feel safe*", and they reflected on how we connect with people who are going through the same experience. There was some contrast in how students connected with staff. Some were "*excited*" to talk to researchers "*in the sort of area I want to go into*" and valued informal research chats with staff in the corridor, others noted the importance of the personal tutor system when transitioning to university "*you kinda feel like, lost. So... you have like lots of doubts…if you have a specific person to ask questions, then that's gonna be easy*". One student who considered dropping out said they did not "*know if I was succeeding*", so would have valued reaching out to staff.

3.3 Discussion

The game successfully provided a fun, different and relevant introduction to psychology study, breaking the ice socially and academically. It models provision of a comprehensive taster of learning objectives and could be adapted to different courses. The escape game style allowed tutors to provide scaffolding for all groups and mirror the expected engagement in seminars. The process of planning the game encouraged collaboration with colleagues, to highlight and target development needs and better coordinate this across year groups. Similarly, focus group discussions allowed students to voice their experiences, leading to a change in personal tutor sessions, which now combine year groups and end with a social that splits across three venues, to cater for diversity needs (instead of just going to the pub). The element of music in the game was useful to provide instant feedback to players, and indicate need for support from tutors. This helped to provide a light-hearted atmosphere for learning and making mistakes, similar to Jarusriboonchai et al. (2016) and Sasan (2023). The inclusion of a reflective debrief allows tutors to draw attention to developing skills and achievements in the game and academic study, such as social engagement, leadership, compromise, and providing critical feedback. There was also indication that the informal interaction with staff across induction helped make them more approachable during seminars.

One limitation of the project was that the many elements made it difficult to evaluate their effectiveness, whether that be sense of belonging, or skill development and awareness. A university belonging scale was included to question sense of connection, respect and welcoming (Imperial College, 2020, adapted from Yorke, 2015) but responding was low (indicating another issue that first year students do not engage with research participation). Indeed, the focus groups provided useful insight, but might have recruited more outgoing and confident students and not those who were disengaged with the game, who might need more support. The game itself did not enforce prolonged social engagement, or interaction with all the tasks, as participants could choose to complete one puzzle independently. The group reflection could address this, but should be expanded to 30 minutes, explicitly discuss all learning outcomes and make it relatable to the domains assessed: cognitive, knowledge, practical and professional skill and transferrable skills. These activities could be revisited a month after induction, as Thomas (2012) stressed the need for induction to extend beyond the welcome week.

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Enhancing Team Cohesion Through a Custom MOBA Game: Development, Implementation & Impact

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Abstract: The quality of a team in organizations has an impact on the success of the team in achieving their goals. Team building activities are one of the elements which can improve relationships in different kinds of teams. One of those can be playing competitive digital games, whether for teams working remotely or on site. This paper presents a case study that explores the design and development process of an innovative online game that combines elements of third-person action and multiplayer online battle arena (MOBA) games to provide an experience that strengthens team cohesion. The game design and mechanics support distribution of team roles based on Belbin's theory, highlighting the importance of diverse roles for balanced team functionality. By integrating unique character functions, the game encourages players to understand and appreciate the different roles individuals play in a team, enhancing empathy and mutual respect among team members. The game is uniquely designed to be simpler and more accessible than typical MOBAs, making it an ideal tool for educational and organizational settings to boost team cohesion and communication skills among people from various backgrounds. The leveling of the playing field allows individuals with minimal gaming experience to participate fully and effectively. The design principles ensure that the core mechanics of the game encourage teamwork and effective communication over individual skill, emphasizing collective success. The case study delves into the development process, the challenges faced, the solutions implemented, and the outcomes observed as part of a research project conducted between 2022-2023. The findings suggest that game-based learning can significantly transform traditional team-building methods, introducing a new paradigm for fostering high-performance teams in an increasingly digital world.

Keywords: Competitive Games, Game Development, Multiplayer Online Battle Arenas, Soft Skills, Team Cohesion, Team-Building

1. Introduction

In the rapidly evolving landscape of organizational management, the strength and cohesion of teams have become pivotal to achieving strategic objectives. Team cohesion, which embodies the unity of purpose and mutual commitment among team members, is not only vital for enhancing productivity but also critical for fostering an environment conducive to innovation and growth (Casey-Campbell, Martens, 2009; Chiocchio and Essiembre, 2009; Grossman et al, 2022). Recent developments in educational technology, particularly the integration of game-based learning, have introduced novel methods for cultivating essential teamwork skills (Ellis et al, 2008). Both commercial, open-source and serious digital games have been examined for their potential to foster teamwork and other important social skills (Di Pietrantonio and Mendonca, 2022; Kovalčík, Švecová and Kabát, 2023; Qian and Clark, 2016; Zheng et al, 2021; Zhong et al, 2022). Earlier studies have identified digital games as effective tools for collaborative learning (Hämäläinen, 2011; Karakas, Manisaligil and Sarigollu, 2015), imparting teamwork skills (García et al, 2016; Hewett, 2022; Wang and Chen, 2012) and enhancing team cohesion (Anderson and Hilton, 2015; Garcia et al, 2022; Greitemeyer and Cox, 2013; Keith et al, 2016; Keith et al, 2021). Riivari, Kivijärvi and Lämsä (2021) explored how collaborative learning and the use of games can improve the acquisition of teamwork skills within higher education settings. Wang and Huang (2021) examined serious collaborative games and identified game mechanics supporting collaborative play, with the most common being the player team and chatting channel.

Group processes in existing digital environments have primarily been studied through multiplayer online role-playing games such as *World of Warcraft*. However, teamwork in *WoW* is almost never enforced and it is possible to achieve high levels of the game without any social interactions. On the other hand, multiplayer online battle arenas (MOBAs) must be played together in a group, requiring coordinated team play and strategic decision-making. These games provide a dynamic and engaging platform for enhancing team dynamics (Tang, 2018) and their players get a sense of satisfaction from teamwork (Johnson, Nacke and Wyeth, 2015). They simulate challenges that require collaborative problem-solving, effective communication, and adaptive leadership—skills crucial for any high-functioning team. In MOBAs "individual players act collectively; teams coordinate to meet shared goals" (Tyack, Wyeth and Johnson, 2016). As Buchan and Taylor (2016) suggest, researching group processes in MOBAs can help develop understanding of group processes in work contexts.

Incorporating digital tools and gamification into employee training and development processes is increasingly seen as a vital strategy to enhance team cohesion and adaptability within modern organizations. Research by Stacho et al (2022) explores the utilization of digital tools and gamification in the adaptation process of Generation Z employees. Their findings highlight a significant gap in the adoption of these innovative practices, with only 30% of employers in Slovakia implementing comprehensive adaptation systems that include gamification elements, despite recognizing the potential benefits. This gap suggests a critical opportunity for organizations to enhance their adaptation strategies, particularly in engaging the incoming tech-savvy workforce effectively.

To enhance team performance within organizations, our project merges the dynamic mechanics of MOBAs with Meredith Belbin's theory of team roles. This integration is designed to cultivate an environment where team cohesion, communication, and role functionality are paramount. The union of these frameworks not only enriches the player experience but also stands as an effective developmental tool for assessing team dynamics in scenarios that mirror both competitive and collaborative professional settings. Meredith Belbin's research, which culminated in the identification of nine distinct team roles, provides a structured methodology for understanding and optimizing team dynamics. These roles are segmented into three categories: Action-Oriented (Shaper, Implementer, Completer Finisher), People-Oriented (Resource Investigator, Teamworker, Co-ordinator), and Thought-Oriented roles (Plant, Monitor Evaluator, Specialist), each offering unique contributions to team success. For instance, Shapers are dynamic and driven, often challenging the team to improve. Implementers, however, are more practical, turning ideas into actionable tasks, while Teamworkers support and maintain team cohesion through their cooperative nature. As Belbin explains, "[t]eams roles are functions of the different demands made on team members if the team is to become effective. Individuals respond to these demands in different ways" (Belbin, 2010). Belbin does not prescribe an exclusive role for each team member. One person can prefer two or more team roles. He also emphasizes that team members can consciously choose to play a distinctive team role (further aligning professional teamwork with playing).

Our research aims to build upon these findings by developing and implementing a MOBA game with complex gameplay mechanics and an emphasis on role specificity to improve team cohesion. Its working title is *Untitled Belbin MOBA Game* (*UBMG*), and it has not yet been released publicly. The structured environment of MOBAs forms temporary teams of complete strangers who must collaborate intensely and strategize in real-time to fulfill complex tasks within a short time (Mora-Cantallops and Sicilia, 2018), mirroring the dynamics of professional team settings. In Buchan and Taylor's (2016) findings, optimal functioning teams should consist of friends communicating through a voice chat, at similar play level and willing to perform different team roles. In professional settings individuals with different skill levels and work experience can be grouped to perform a task without prior acquaintance. We simulate this condition by testing the developed game on groups of strangers with varying levels of experience with digital games. Communication mechanics are implemented together with specialization of team roles that in Belbin's management theory should support effective teamwork (Belbin and Brown, 2022). The intention is to enhance the game's effectiveness in promoting a balanced team dynamic, where members appreciate and leverage their diverse roles for collective success. By aligning the game design with established theoretical frameworks, we aim to create an innovative tool that not only enhances team cohesion but also serves as a model for future developments in educational game design. The current paper presents a detailed case study of this game's development process, from conception through testing, with an emphasis on the challenges faced and the solutions implemented. We discuss the specific game mechanics and features designed to foster team cohesion and examine their effectiveness based on participant feedback collected during the study period between 2022 and 2023. Our empirical insights and practical frameworks can be applied across various environments to enhance team dynamics, making a significant contribution to the dialogue on innovative educational tools and lifelong learning. This paper aims to demonstrate how MOBA digital games can transform traditional team-building methods and set new standards for developing high-performance teams in a digital-first world.

2. Game Design and Gameplay Implementation

MOBA games such as *League of Legends* and *Dota 2* are characterized by their strategic depth, requiring players to select from a diverse roster of characters to form a balanced team capable of both offensive assaults and defensive stands. These games emphasize real-time collaboration, strategic role fulfillment, and adaptive tactics, all within a high-pressure environment where teams must destroy the opponent's base to win (Mora-Cantallops and Sicilia, 2018). Our original MOBA game *UBMG* is designed with simplicity and team collaboration at its core. The game mechanics are streamlined to ensure that players of all skill levels can participate effectively. The

primary game mechanics include character roles, communication, and interactive elements such as chests. To further enrich the character designs in *UBMG*, each character's unique abilities and their strategic importance in the game are closely aligned with their corresponding Belbin roles. These abilities enhance the gameplay experience by enabling players to engage in complex strategies and interactions that mirror real-world team dynamics. Each team consists of five fixed characters: Marksman, Flyer, Healer, Jungler, and Bruiser. Number of five team members has been proposed to be optimal for MOBAs (Thavamuni, Khalid and Iida, 2023). The roles are designed to promote interdependence, team cohesion, communication and strategic collaboration. Below is a detailed mapping of the game roles to the corresponding Belbin roles (Table 1). There may be more than one team role each member can perform, so it is possible to map nine Belbin roles onto five game characters.

Table 1: Game characters and their corresponding Belbin team roles

Healer	- maintains team health and stability during battles, using abilities such as healing, protection spells, and status enhancement, provides support during critical moments - can use directed spell to heal one character for 30% of hit points at a time or place a field that heals anyone standing in it for 5 seconds	The Healer is a character suitable for Teamworkers. Teamworkers are cooperative, perceptive, and diplomatic, supporting and encouraging teammates (Belbin and Brown, 2022). Complementary Belbin roles: Implementer, Specialist.
Flyer	- focuses on reconnaissance and coordination, providing strategic information from a high vantage point and coordinating team efforts - their abilities include flying to high points, vision enhancement, and strategic coordination	The Flyer combines best the roles of Resource Investigator and Coordinator. Resource Investigators are outgoing and enthusiastic, exploring opportunities and developing contacts, while Coordinators clarify goals and delegate effectively (Belbin and Brown, 2022).
Marksman	- offensive and strategic role, utilizing long-range attacks to disrupt enemies and provide strategic guidance to the team - abilities include long-range attacks making use of strategic positioning skills	The Marksman is suitable for the role of a Plant. Plants are creative, imaginative, and unorthodox, solving difficult problems by coming up with original ideas and strategies (Belbin and Brown, 2022). Complementary roles: Completer Finisher, Monitor Evaluator.
Bruiser	- leads the team in frontline engagements, ensuring strategic plans are executed effectively - they have high durability, strong melee attacks, and crowd control ability	The Bruiser integrates the roles of Shaper and Implementer. Shapers are dynamic and thrive on pressure, driving the team forward, while Implementers are practical and efficient, turning ideas into actions (Belbin and Brown, 2022).
Jungler	- manages resources and provides critical analysis, unlocking chests by answering questions and offering strategic advice - they can open chests to add boosts for the team by answering questions	The Jungler can perform the role of a Monitor Evaluator. Monitor Evaluators are serious-minded, prudent, and capable of providing logical, impartial, and critical views (Belbin and Brown, 2022). Complementary roles: Plant, Completer Finisher.

Voice communication is integral to the game's mechanics. Players must continuously share updates, make strategic decisions, and call for support, ensuring the team functions cohesively and can respond quickly to changing situations. For instance, the Flyer relays critical information from high vantage points, the Jungler reads out questions to unlock chests, and other roles communicate their needs and status. Interactive elements such as chests add a layer of strategy and teamwork. The Jungler can unlock these chests by answering questions, providing boosts and resources essential for the team's progress. This requires collaboration, as players must work together to solve the puzzles and gain the benefits, such as increased health, damage, or strategic advantages. The game progresses through a series of objectives that require strategic planning and execution. Teams must capture key points, defend their base, and engage in battles with the enemy team. The constant need for communication and collaboration ensures that every player is actively involved in the team's success. For example, in a scenario where the team plans an attack on an enemy tower, the Flyer would ascend to a high vantage point to observe enemy movements, relaying real-time updates and coordinating the attack to ensure

that team members are positioned effectively. This scenario showcases the Flyer as a Resource Investigator, identifying opportunities, and a Coordinator, organizing the team.

UBMG stands out from typical MOBA games in several significant ways:

- Fixed character roles: Unlike other MOBA games that offer a vast array of characters and emphasize team composition and meta-strategies, *UBMG* features only five fixed characters. Each team consists of the same roles, reducing the complexity of character selection and promoting balanced team dynamics and equal participation.
- Accessibility for all skill levels: The game is designed to be accessible to players with varying levels of gaming proficiency. The controls and abilities of the characters are straightforward, ensuring that people with different gaming experiences can play together. Experienced gamers do not gain a significant advantage from complex mechanics, as the game has a short learning curve and focuses more on strategy and teamwork rather than individual skill mastery.
- Emphasis on voice communication: The core mechanics of *UBMG* rely heavily on communication via voice chat, enhancing team coordination and strategic planning. Players must continuously share updates, make strategic decisions, and call for support, fostering a high level of interaction and cooperation. While this is also true for other MOBA games, it is vital for people to develop their communication level by sharing all kinds of information that players of different games would obtain from tutorial or introductory rounds playing against bots.
- Interactive elements: The game includes interactive elements such as chests that the Jungler can unlock by answering questions. These elements add a layer of strategy and teamwork, as players must collaborate to provide the correct answers and gain the benefits.
- Low poly graphics: The game features simple, low poly graphics designed to run on most types of non-gaming specific computers. This ensures that the game is easily readable and understandable, even by people with specific needs, and does not distract players from the objectives.

By integrating fixed character roles, ensuring accessibility for all skill levels, and emphasizing continuous voice communication, *UBMG* offers a unique approach to team-based gameplay. These design decisions, combined with the incorporation of Belbin team roles, create a cohesive and collaborative gaming experience that differs significantly from typical MOBAs. The emphasis on real-time communication and strategic planning over individual skill mastery ensures that team cohesion and effective collaboration are at the forefront of the gaming experience. These abilities not only define the gameplay mechanics but also deepen players' understanding of how each role contributes to the team's overall strategy and success. By engaging with these characters and their unique abilities, players experience firsthand the dynamics and challenges of working within a diverse team, enhancing both their strategic thinking and team collaboration skills.

The game takes place in a classic MOBA setting with three lanes connecting two opposing bases (Figure 1). Each lane is guarded by defensive towers, and the primary goal is to destroy the enemy's central structure. The journey towards this goal requires careful strategic planning and execution, beginning with the character selection phase. During this phase, five players on each side choose characters whose abilities complement each other, and they engage in real-time voice communication to strategize. This early interaction sets a collaborative tone, emphasizing the importance of choosing appropriate roles and planning a coherent strategy.

AI-controlled minions spawn at each base and move along the lanes toward the enemy. Players must work alongside these minions, using them as both shields and support to progress towards enemy towers. This aspect of the game necessitates players to communicate their movements and intentions, deciding collectively when to advance or retreat, thereby reinforcing team dynamics. Each character in the game is designed with unique abilities that necessitate reliance on other team members. For example, the Bruiser can absorb a great deal of damage and is effective at breaking through enemy lines, but this character relies on the Healer for sustainability and the Flyer for setting strategic traps that can disrupt enemy formations. This interdependence ensures that no single player can dominate the game alone, emphasizing the importance of each team member's role and fostering a sense of mutual reliance.

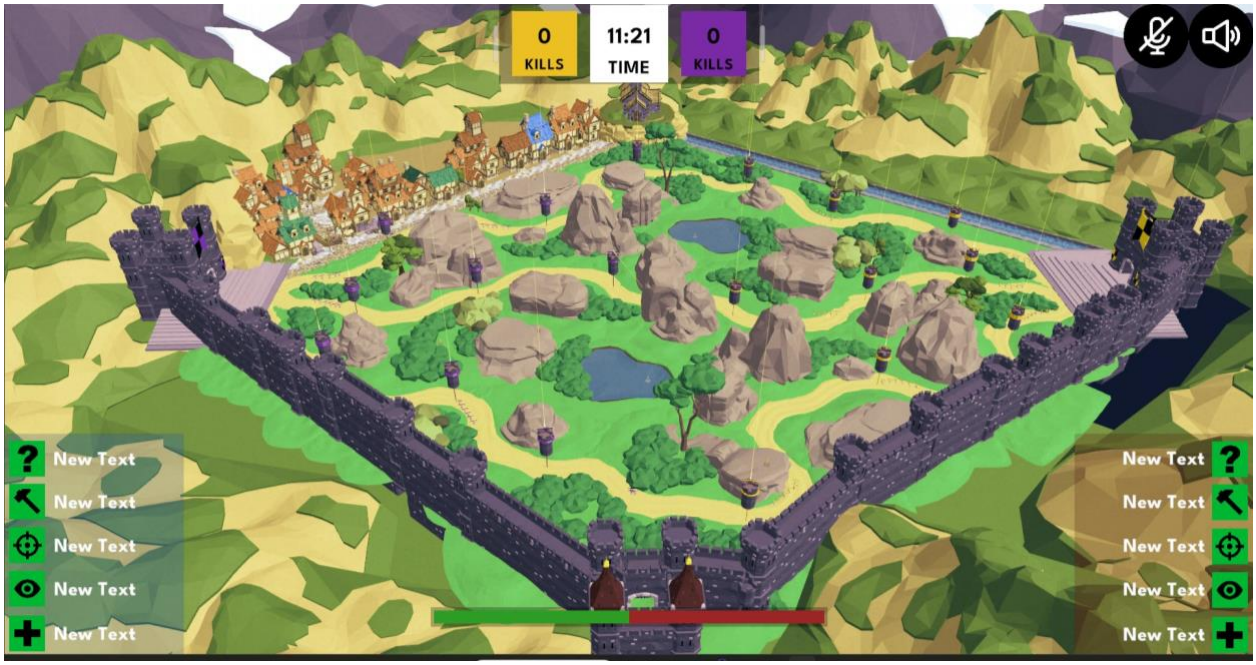


Figure 1: Overview of the map with the typical three lanes layout known from MOBA games

Players must continuously share updates about their status, enemy locations, and potential strategic moves. The third-person perspective of the game means that players do not have a complete view of the battlefield, further emphasizing the need for sharing information and coordinating actions. This setup encourages players to rely on each other for a comprehensive understanding of the game state, enhancing team collaboration.

Strategic decision-making is a constant necessity in the game. Teams must make collective decisions on when to push for objectives, defend against enemy advances, or regroup and strategize. These decisions require a high level of team consensus and adaptability, fostering a deeper engagement with the team's strategic processes. The immediate feedback from these decisions, whether in the form of successful engagements or objectives or learning from failures, helps teams adapt their strategies in real-time. This continuous loop of action, feedback, and adaptation is instrumental in developing team cohesion and dynamic problem-solving skills. By engaging with this MOBA game, players not only enjoy a strategically rich competitive experience but also develop essential soft skills applicable to any collaborative environment. The game's design, which integrates complex team roles and dynamic gameplay, acts as a powerful tool for team building. The deliberate alignment of game mechanics with real-world team dynamics ensures that players learn valuable lessons about teamwork, communication, and strategic planning, which are critical for success in both the virtual and real world.

In the development process, there were periodical tests of gameplay that revealed bugs and glitches that were fixed, but also some shortcomings in original design that proved to be gamebreaking. For example, the Marksman character was able to shoot on towers that were not yet reached by minions or even attack the enemy's core under the right angle. This was solved by nerfing his ability by shortening the arrow trajectory. Similarly, the Flyer (who was originally intended to observe) was used to not only surprisingly attack enemy players from behind, but also was able to drop directly on top of the enemýs castle and attack the core outside the reach of minions. First issue was fixed by adding a sound when the character touches ground and can shoot, the second issue was addressed by adding a roof to the castle.

3. Research Overview and Methodology

Following the detailed account of the game's design, this chapter outlines the methodological framework used to assess the efficacy of the custom-designed MOBA game in enhancing team cohesion. The target population in the conducted quantitative research was selected through purposive sampling, i.e. according to the determined characteristics and on the basis of inclusive criteria. We selected students from three different faculties of UCM in Trnava, Slovakia. To ensure that the subjects did not form teams prior to the study, the sample was selected only from first-year students. The total sample consisted of 144 respondents, with 124 valid responses (74 female and 50 male). In terms of age, the sample consisted of 91 respondents aged 18-21 years, 27 respondents aged 22-25 years, and 6 respondents aged 31 years and older. Respondents varied not only in

their current educational orientation, but also in their background (gymnasiums, business and hotel academies, vocational schools and others). Eighty-eight respondents regularly play computer games, while 36 respondents indicated that they do not play computer games. Out of 121 respondents, 69 meet new people in online spaces, while 52 do not. To measure team cohesion, we used the Youth Sport Environment Questionnaire (YSEQ; Eys et al, 2009). The YSEQ assesses the perception of cohesion in youth teams and was developed from the Group Environment Questionnaire (Carron, Widmeyer and Brawley, 1985). These questionnaires are commonly used in research focused on group cohesion in sports psychology. The complete questionnaire consists of 18 items, with responses available on a 9-point scale ranging from "strongly disagree" (1) to "strongly agree" (9). Higher scores reflect a stronger perception of cohesion. Cohesion is evaluated in two aspects (dimensions): task cohesion (TC), represented by 8 items (e.g., "We are united as a team"), and social cohesion (SC), represented by 8 items (e.g., "Some of my best friends are members of this team").

The second method comprises two separate questionnaires targeting the following aspects of inclusion:

- Need for Social Inclusion (NSI) – this questionnaire evaluates the extent and strength of the need for inclusion and its characteristics. It allows for diagnosing the motivational component of affiliation. The content focus and question formulation follow the experiences and attitudes influenced by this need.
- Social Inclusion (SI) – this questionnaire evaluates the degree and extent of social inclusion, allowing for diagnosing the behavioral component of affiliation (Kollárik, 2008).

The third method, the Achievement Motivation Inventory (AMI; Schuler and Prochaska, 2011)), is designed to diagnose achievement motivation in a professional context and consists of 170 items assigned to 17 scales (dimensions): compensatory effort (CE), competitiveness (CO), confidence in success (CS), dominance (DO), eagerness to learn (EL), engagement (EN), fearlessness (FE), flexibility (FX), flow (FL), goal setting (GS), independence (ID), internality (IN), persistence (PE), preference for difficult tasks (PD), pride in productivity (PP), self-control (SC), status orientation (SO).

The experiment proceeded in three stages:

1. Initial assessment (pretest) of cohesion level, social inclusion, and AMI in experimental and control groups.
2. Implementation of the designed game in the experimental groups. All participants underwent a comprehensive training session designed to familiarize them with the game mechanics and the specific roles they would be playing. This standardization was critical to ensure that all participants had a similar level of understanding and capability with the game. Following the orientation, teams participated in multiple gameplay sessions where they could apply and refine their teamwork and strategic skills in a dynamic and competitive environment. The game sessions were designed not only to stimulate participants' strategic thinking and role execution but also to foster intense collaboration and communication within the teams. All gameplay sessions were standardized. This involved controlling game variables such as session duration (60 minutes), game settings, and specific challenges presented during the game. The sessions were closely monitored to ensure adherence to the experimental protocol and to facilitate accurate data collection
3. Post-test assessment and two follow-up tests of cohesion level, social inclusion, and AMI in experimental and control groups after completing the game implementation in the experimental groups.

In addition to the post-test, interviews and feedback sessions were conducted after game sessions to collect qualitative insights from participants. This data helped to enrich the understanding of the quantitative findings and provided nuanced perspectives on the participants' experiences and the perceived impact of the game on their teamwork skills and cohesion.

4. Results and Discussion

The experimental results reported in Table 2, where the asymptotic significance values of the chi-square test are displayed (significant differences with $p < 0.05$ are bolded), reveal several notable findings.

Table 2: Experimental results

	Social inclusion								Team cohesion		Achievement motivation inventory															
	NSI	SI	a	b	c	d	e	f	SC	TC	PE	DO	EN	CS	FX	FL	FE	IN	CE	PP	EL	PD	ID	SC	sO	CO	GS
Kruskal-Wallis H	5.396	13,926	18,418	23,776	11,315	7.876	18,473	38,757	3.225	19,195	5.491	1.797	1.661	10,645	12,856	6.777	2.120	14,833	2.909	7.334	5.715	.771	2.965	2.626	.494	12,555	1.122
df	8	8	8	8	8	8	8	8	8	8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	,714	,084	**,018**	**,002**	,184	,446	**,018**	<,001	,919	**,014**	,139	,616	,646	**,014**	**,005**	,083	,548	**,002**	,406	,062	,126	,856	,397	,527	,920	**,006**	,772

- Social Inclusion: The experimental groups demonstrated significant improvements in three out of eight dimensions of social inclusion between the pre-test and post-test groups. This indicates that the interventions applied had a meaningful impact on specific aspects of social inclusion, enhancing participants' feelings of being socially accepted and integrated.
- Team Cohesion: There was a significant increase in the task cohesion aspect of team cohesion within the experimental groups. Task cohesion refers to the degree to which group members work together to achieve common goals. The improvement in this area suggests that the experimental interventions fostered a stronger sense of teamwork and collaboration focused on task achievement.
- Achievement Motivation Inventory: The experimental groups reported significantly higher levels in four dimensions of the achievement motivation inventory:

- Confidence in Success: Participants in the experimental groups showed an increased belief in their ability to succeed. This boost in confidence can positively influence their motivation and performance.
- Flexibility: The increased flexibility suggests that participants became more adaptable and open to change, which is critical for effective problem-solving and performance in dynamic environments.
- Internality: Higher internality scores indicate that participants felt a greater sense of control over their outcomes, attributing success to their efforts and abilities rather than external factors.
- Competitiveness: The rise in competitiveness reflects a heightened drive to excel and outperform others, which can be a strong motivator in both individual and team contexts.

The significant differences observed in these dimensions suggest that the interventions applied in the experimental groups were effective in enhancing specific aspects of social inclusion, team cohesion, and achievement motivation. These findings support the hypothesis that playing MOBAs can positively influence group dynamics and could be used for team building in various organizations. The qualitative data from post-game interviews and open-ended survey responses enriched these findings by providing context to the numbers. Participants described their experiences of adapting to the dynamic demands of the game, mirroring the flexibility often required in professional environments. Many highlighted a greater appreciation for the strategic importance of different team roles and reported a more profound respect for the diverse skills each team member brought to the table. This feedback underscores the value of a gamified learning environment in fostering a deeper understanding of team dynamics and enhancing strategic execution and planning. Additionally, the dynamic nature of the game—requiring continuous adaptation and strategic communication—was frequently praised. Participants noted that these aspects of the game improved their agility and responsiveness, skills that are invaluable in the workplace. This aspect of the game not only made the learning process more engaging but also more closely aligned with the real-world challenges that professionals face. The synthesis of this quantitative and qualitative data paints a clear picture: integrating structured game-based learning environments with theoretical models like Belbin's team roles can significantly enhance crucial workplace skills. The marked improvements across various dimensions of team dynamics suggest that digital game-based interventions are potent tools for developing not only individual skills but also a collaborative team

culture. This approach provides a compelling alternative to traditional training methods, offering a more engaging, effective, and adaptable way to enhance team performance in professional settings.

5. Conclusions and Recommendations

The study underscores the importance of structured activities promoting social inclusion and team cohesion. Digital game-based activities, especially MOBAs respecting Belbin's team roles theory, show potential to enhance team dynamics and communication. Both quantitative and qualitative analyses indicate improvements in team cohesion, social inclusion, and motivation, confirming gamified learning environments' effectiveness in developing teamwork skills. These skills are essential in high-functioning teams, crucial in today's interconnected work environments. Integrating Belbin's team roles into game design helped participants appreciate diverse team roles, leveraging their strengths and enhancing overall team performance. The positive outcomes highlight the value of sophisticated gamification strategies in team development programs, beneficial in educational and organizational settings.

Future research should explore these interventions' long-term effects to determine sustained improvements. Given the study's reliance on self-reported results, future investigations should record gameplay performance metrics. Replicating the study with a diverse sample could provide insights into the findings' generalizability. Investigating specific mechanisms through which interventions exert their effects could refine strategies for different contexts. Exploring other psychological and management theories within the gamification framework could add dimensions to team training, including leadership development and conflict resolution. Further research could examine customized game elements tailored to individual team needs and preferences, enhancing engagement and effectiveness. The significant improvements in social inclusion, team cohesion, and motivation highlight the potential of digital game-based interventions to enhance group dynamics and individual motivation, contributing valuable knowledge to educational psychology, organizational behavior, and game-based learning.

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Digital Educational Escape Rooms as E-courses Using D-EER4SmL: Investigation of Motivational Affordances

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Abstract: Research has shown that educational escape rooms (EERs) motivate and engage learners in the learning process, mainly due to the incorporation of game elements into their educational context. As a result, various frameworks have been proposed to design and develop EERs over the past few years. However, these frameworks fail to highlight the important "D"-digital factor of technology which transforms EERs into Digital Educational Escape Rooms (DEERs), as well as the smart pedagogy (SmP), which in turn goes beyond game-based approaches and is currently essential for the design and the development of well-orchestrated and reusable smart learning solutions. Due to the fact that technology increases motivation, this study introduces the work-in-progress framework D-EER4SmL, primarily based on John Keller's theory of ARCS and the 10-step systematic design process for the development of motivational e-courses, tailored to learners' preferences. The framework was aligned with various EER design principles, along with Smart Pedagogical (SmP) approaches, which could be facilitated by web technologies in order to design and develop DEERs as e-courses. To confirm the motivational aspect of smart learning and the assumption that digital technology provides additional motivation, a DEER e-course was developed, based on this framework. The DEER e-course was delivered to ICT students - future ICT teachers/e-learning educators - who would be trained in instructional/e-learning design utilizing web technologies. A total of 108 higher education students of digital systems voluntarily participated in the workflows of the DEER e-course, played the game, and evaluated motivational affordances (MAs), after completing it. Quantitative data analysis was conducted, based on an improvised questionnaire for DEERs, aligned with Keller's Instructional Materials Motivation Survey (IMMS). As far as motivation is concerned, the framework was proven effective in the initial research findings; however, further research is needed to confirm its effectiveness within the wider context of smart learning.

Keywords: Digital Educational Escape Rooms, Motivational Design Process, ARCS, Project-Based Learning, Smart Learning

1. Introduction

Escape Rooms (ERs) were first introduced in Japan in 2007 as recreational games. Yet, since 2012, they have spread around the world and are used in various fields, including education, as innovative tools (Makri, Vlachopoulos, and Martina, 2021). In Educational Escape Rooms (EERs) learners engage in cooperatively playful, problem-based activities within a constrained timeframe, developing their knowledge and soft skills in accordance with learning objectives (Fotaris and Mastoras, 2022) and pedagogical guidelines (Makri, Vlachopoulos, and Martina, 2021). In light of the rapid integration of ICT and particularly Smart Technology (SmT) in education, EERs have become more engaging, authentic, and learner-centered learning environments. In EERs, ICT mainly serves the following purposes to: a) structure a Digital Educational Escape Room (DEER) game, such as revealing the narrative, supplying codes, solving puzzles, and/or providing additional information; b) foster immersion by facilitating learners' discovery and interpretation of new knowledge; c) keep track of learners' safety; d) help learners acquire ICT skills related to their subject matter; e) facilitate educators' work; f) handle large groups well. Despite technological advances facilitating EER installation, DEERs still lack clarity regarding the "D"-igital factor as a result of their definitions. In Fotaris and Mastoras's definition of DEERs (2022), players unlock digital locks through technology, usually by completing online forms or password-protected documents (e.g., smart phones, apps, VR/AR, QR codes, etc.). Is this, however, sufficient to describe the role of ICT in a DEER? If DEERs are considered virtual learning spaces, namely Technology-enhanced Learning Environments (TELEs), what learning aspects do they actually enhance by integrating technology? What about the case of DEERs as e-courses? Using technology to enhance learning can be beneficial in five different ways, according to Daniela (2021), provided we consider the perspectives of each dimension separately. As one of the five dimensions, motivation can be enhanced by technology. A number of studies have concluded that DEERs motivate learners even when used in on-line and remote learning settings (i.e., Grāvelsiņa and Daniela, 2021; López-Pernas et al., 2021 etc.). In addition, they argue that DEERs are more effective when game-based learning or gamification is incorporated, but in order to assess the levels of efficacy based on motivation, game practices should be combined with motivational theories. The international literature describes several EERs design frameworks (i.e., Clarke et al., 2017; Fotaris and Mastoras, 2022 etc.) without all of them being validated or emphasizing how ICT can enhance learning (Karampa and Paraskeva, 2022). Because of this, little data is

available on how DEERs should be designed, especially in the form of e-courses, to provide optimal learning, currently referred to as Smart Learning (SmL). The proposed D-EER4SmL framework aspires to offer a solution to all the above-mentioned questions, although it has not yet been validated. In this study, it is employed in an effort to explore how technology facilitates pedagogy to enhance learners' motivation, evaluating the Motivational Affordances (MAs) of SmL that learners perceive. In the following paragraphs, the research method and the findings of this study are described, with recommendations for future improvements.

2. Research Method

2.1 Research Objective and Research Questions

The concept of SmL can be defined as optimal learning that takes place in a learning environment, operating as service or product of the teaching and learning process when SmP and SmT interoperate effectively to provide learners with a range of learning affordances. The purpose of this study is to investigate the motivational affordances (MAs) that learners perceive from participating in a DEER e-course based on the above-mentioned consideration of SmL using the D-EER4SmL framework. Following are more specific research questions that address this broad research objective of this study:

- RQ1. Does the DEER e-course developed based on the D-EER4SmL framework *stimulate learners' curiosity, arouse, and sustain their interest (MA1)*?
- RQ2. Does the DEER e-course developed based on the D-EER4SmL framework *guide learners to effective goals (MA2)*?
- RQ3. Does the DEER e-course developed based on the D-EER4SmL framework *involve learners in authentic tasks (MA3)*?
- RQ4. Does the DEER e-course that is developed based on the D-EER4SmL framework *involve learners in inquiry and problem-based processes (MA4)*?
- RQ5. Does the DEER e-course that is developed based on the D-EER4SmL framework *help learners control and regulate their learning (MA5)*?
- RQ6. Does the DEER e-course that is developed based on the D-EER4SmL framework *enhance collaborative learning among learners (MA6)*?
- RQ7. Does the DEER e-course developed based on the D-EER4SmL framework *promote learners' assessment and reflection on their learning, so that their achievements can be recognized (MA7)*?

2.2 Creating a DEER E-course Using the "D-EER4SmL" Framework

The D-EER4SmL framework (

Figure 1) is a work-in-progress framework for creating DEERs in the form of e-courses, aiming to provide SmL. This consideration is based on the following four guidelines (Karampa and Paraskeva, 2022): a) select innovative pedagogies, namely SmP, beyond game-centered approaches to well-orchestrate learning designs; b) outline the role of technology and its integration in DEER structure, content, and functionality in alignment with selected pedagogies to provide Smart Learning Affordances (SLAs); c) identify frameworks or even strategies and recommendations proposed internationally in the literature on designing (D)EERs and combine them with proposals related to SLAs; d) evaluate the framework through the development and implementation of DEERs in the form of e-courses by investigating the related SLAs. As a result of these guidelines and considering the fact that technology: a) is the essential but unclear "D" factor in creating Digital EERs; b) facilitates SmP, the driving wheel behind SmL (Daniela, 2021); c) might affect the learning process by creating additional motivation (Keller, 2000), which in turn has impact on learners' performance, including competences, and future achievements (Ryan and Deci, 2009); the D-EER4SmL framework attempts to provide a holistic solution. It is primarily based on Keller's (1987) ARCS motivational theory (Attention, Relevance, Confidence, Satisfaction), which uses a systematic 10-step design process to develop motivational courses and e-courses (Keller and Suzuki, 2004), tailored to learner preferences. These steps are divided into four distinct phases, these of Analysis (MD1), Design (MD2), Development (MD3) and Pilot – Evaluation (MD4).

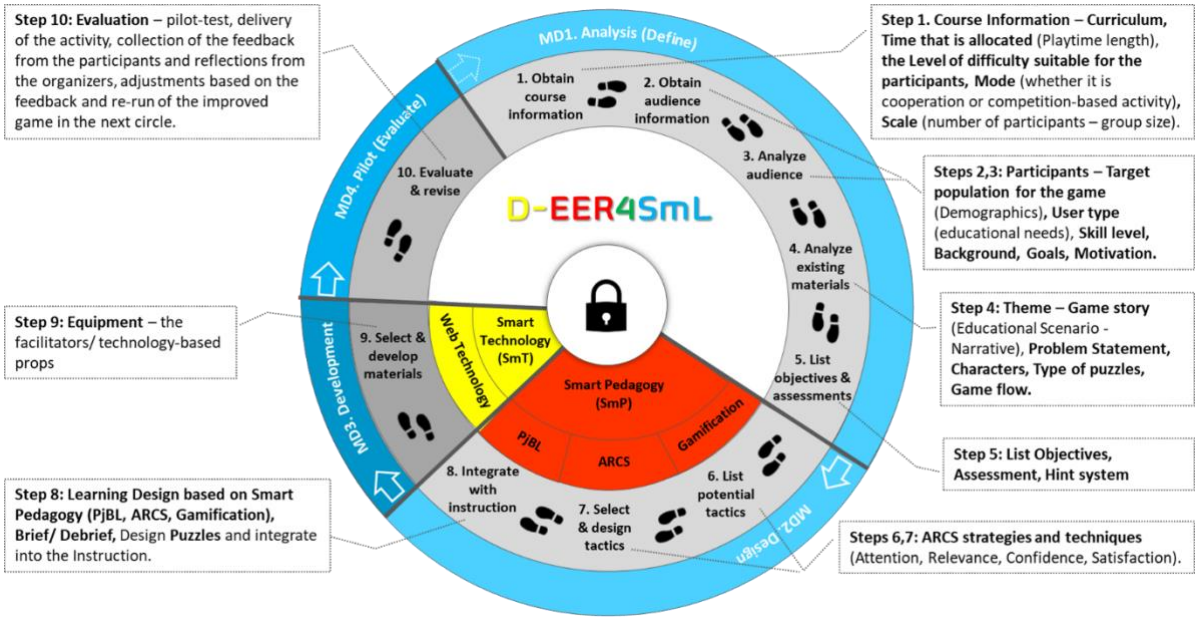


Figure 1: The D-EER4SmL framework

Analysis (MD1): Analysis is necessary to create any learning context. In D-EER4SmL, analysis covers steps 1 to 5. Step 1 identifies the DEER e-course information (title, description, curriculum, and educator details) as well as potential constraints (time for playing and briefing/debriefing), scale (the number of participants), mode (cooperative or competitive), difficulty (educational level), and budget (Fotaris and Mastoras, 2022). Thus, the development of a DEER e-course titled "Workshop on innovative teaching and learning methods and the pedagogical use of ICT in educational practice" was considered essential to prepare 108 postgraduate students at a Greek university department of digital systems for their future careers as e-educators. The DEER e-course namely offered practical application of the theoretical background behind the academic course of e-trainers' training. Therefore, after completing the DEER e-course, learners would be able to apply pedagogical concepts to design, develop, implement, and evaluate the educational process in Technology-Enhanced Learning Environments (TELEs). Moreover, they would be capable of adapting and orchestrating pedagogical methodologies to digital tools and environments. It meant that it would result in a collaborative and open e-course, in which learners would be able to enroll voluntarily. The DEER e-course was planned to last approximately three months (during the spring semester), including two weeks for briefing and debriefing. In the briefing period, participants were profiled based on demographic data, including their starting skill level, background, and goals, along with their motivation. Thus, a questionnaire was given in the form of an interview and the recorded answers were analyzed (steps 2, 3). Individuals in the sample ranged in age from 23 to 58, reflecting a diverse range of ages among postgraduate students. A total of 18,5% (n = 20) of participants were males and 81,5% (n = 88) were females. They came from a wide range of academic disciplines related with STEAM fields (i.e., humanitarian, social, and medical studies, technology/engineering, mathematics etc.). Furthermore, it is worth mentioning that, only 14,8% (n = 16) were unemployed, 52,8% (n = 57) had not any ICT knowledge certification, and 28,7% (n = 31) had no previous experience participating in on-line courses. Nevertheless, a total of 78,7% (n = 85) felt that usability, functionality, and accessibility were the most important factors to consider when developing an e-course, while 14,8% (n = 16) prioritized clear learning design (goals, modules, interaction, duration, resources/tools, forms, and assessment criteria). In terms of competencies, learners mainly highlighted the enhancement of 21st century skills and ICT skills, derived from their participation in the DEER e-course. They emphasized the importance of 4Cs (n = 47), as they expected to boost critical thinking and problem-solving, creativity, and innovation to resolve conflicts, make right decisions, construct digital artifacts and products, through the formulation of interdisciplinary STEAM teams for strengthening communication and collaboration. However, most participants put weight on the enhancement of their pedagogical background as a means to link theoretical concepts (i.e., teaching and learning methodologies, strategies and so on, ER and gamification concepts etc.) with digital (and/or web) technologies and apply this knowledge to educational practice effectively, resulting in well-designed e-learning solutions. They also discussed their short-term and long-term goals. As part of their short-term goals, they acknowledged the successful completion of the DEER e-course, new knowledge, and skills for personal and professional development. On the other hand, their long-term goals included the design and the development of e-courses,

employment as e-educators, namely future career in the e-learning industry. Following the analysis of existing material (Step 4), the DEER theme was identified as an "Escape from School". The educational scenario was based on a case study of an ER, which concerns the escape of teachers from their school (place) where they were trapped. Featuring a humorous narrative, it describes the end of a typical school day (time), when the principal meets with the teachers (participants) to discuss and design school action plans for the current school year about "Evaluation of School Units - Collective Planning - Internal and External Evaluation of the Work of the School Unit" (problem). Since the Institute of Educational Policy (IEP) in Greece has established this policy for the last two years, the problem referred to an authentic situation. This included creating and coordinating working groups, proposing action plans, and recording and evaluating these plans. As the discussion comes to an end, the teachers find themselves "virtually" stranded in the teachers' office amid confusion. They realize that the door is locked, the ground floor windows are all barred for safety, no one has any keys, while the exit key is in the principal's office (puzzles and challenges). Learners were required to act as teachers in groups of four or five and specialize in one of five scientific fields of STEAM. As well, new roles concerning Instructional Designers, Learning Designers, Educational Technologists, and Multimedia Designers (roles) would result in the creation of action plans that integrate innovative teaching practices in a multidisciplinary approach to e-course design and development. To achieve this, they had to follow the game-flow, which means unlocking several spaces (i.e. classes, laboratories, offices etc.) into the school to reach the exit in a specific order. Step 5 specifies a list of objectives (**Figure 2**). Learning objectives must be aligned with the game objectives, as well as with the puzzles and the learning outcomes. Thus, this step requires clarification of the types and forms of assessment which are related to hints and can affect learners' performance (Fotaris and Mastoras, 2022).

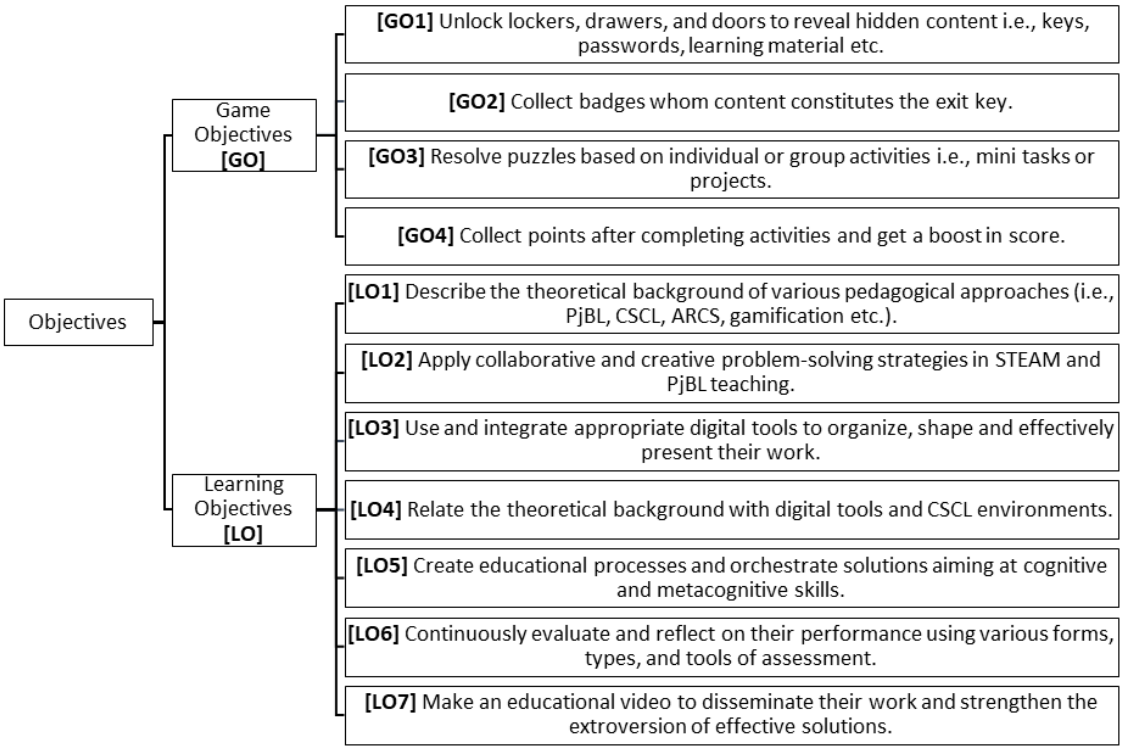


Figure 2: DEER e-course game objectives (GO) and learning objectives (LO)

Design (MD2): D-EER4SmL describes the design process in steps 6-8, where puzzles are incorporated into an SmP-based learning design. As defined by Uskov, Bakken and Aluri (2019), SmP describes the required pedagogy (methods, strategies, techniques, activities, and judgments), enhanced by technology, capable of providing optimal learning processes and environments with corresponding levels of smartness, that is sensing, inferring, adaptation, anticipation, self-learning, and self-organization. To begin with, SmP is equipped with sensing methods, which means that learning data is collected and utilized as part of teaching and learning. This data is then used by SmP to infer information and evidence, which is communicated to students mainly as feedback. Thus, SmP emphasizes self-learning and self-organization in groups and communities through social interaction, so students can learn individually or collectively. Moreover, it helps students predict their future outcomes as well as adapt to the learning process quickly. By tailoring the learning experience to learners' characteristics and preferences such as motivation, skills etc., SmP enables learners to access information more efficiently and

eventually achieve their goals (Lorenzo and Gallon, 2019; Daniela, 2021). Based on previous analyses of DEER e-course specifications, a set of ARCS strategies was selected (Karampa and Paraskeva, 2023) from a variety of tactics (Keller, 2000; Keller, 2010; Keller and Suzuki, 2004; Hodges, 2004) which are strictly related to the factors of Attention (A1-Perception Arousal, A2-Inquiry Arousal, A3-Variability), Relevance (R1-Goal Orientation, R2-Motive Matching, R3-Familiarity), Confidence (C1-Learning Requirements, C2-Success Opportunities, C3-Personal Control) and Satisfaction (S1-Self Reinforcement, S2-Extrinsic Rewards and S3-Equity), as well. Since the e-course is a non-game context that could be transformed into an escape game, the ARCS strategies were aligned with ERs' concepts, gamification elements and game-design techniques (Werbach, Hunter and Dixon, 2012). On the other hand, constructivist approaches reflect SmP concepts, thus Project-Based Learning (PjBL) is considered a suitable methodology for teaching and learning. Besides, PjBL is governed by seven core principles, these of learner-centered environment, collaboration, analytical content, authentic tasks, multiple presentation modes using various ICT tools, time management and innovative assessment (Han and Bhattacharya, 2001), which were found common in (D)EERs (Makri, Vlachopoulos, and Martina, 2021; Markula and Aksela, 2022) and are deeply linked with ARCS. According to Han and Bhattacharya (2001) using PjBL in instruction involves three phases. Two subphases make up the first phase of "Planning", where a collaborative learning environment should be the first subphase in developing the "Overall Climate". The second subphase of "Inquiry" involves selecting themes and topics as well as sharing resources, conducting the study and the investigation.

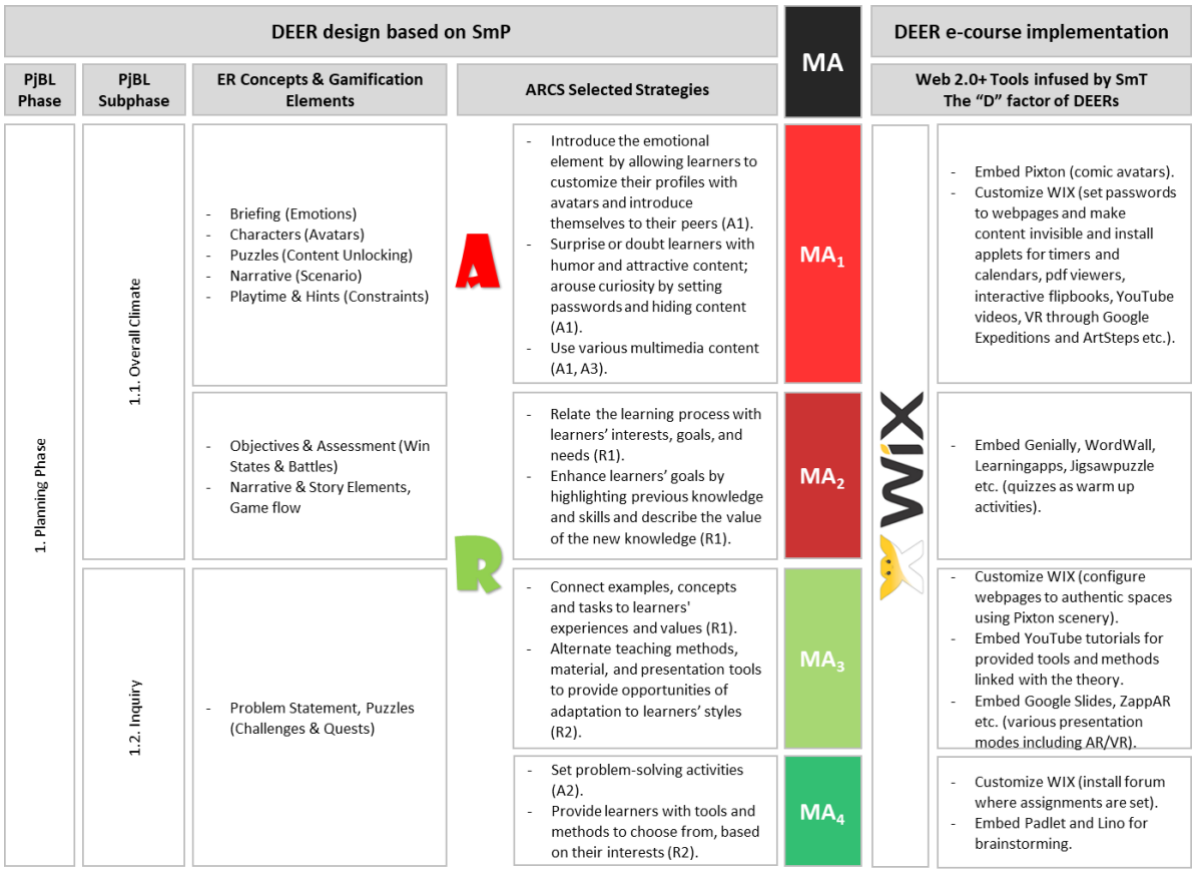


Figure 3: DEER design & e-course implementation – Planning Phase

There are three subphases in the second phase of "Creating". The first subphase is "Analyzing Data", where students make decisions about their projects. The second subphase is "Collaboration" which involves all necessary communications and collaborations to come up with a solution. Furthermore, the third subphase of "Developing Thoughts" involves constructing the artifacts, assembling, and building the final product.

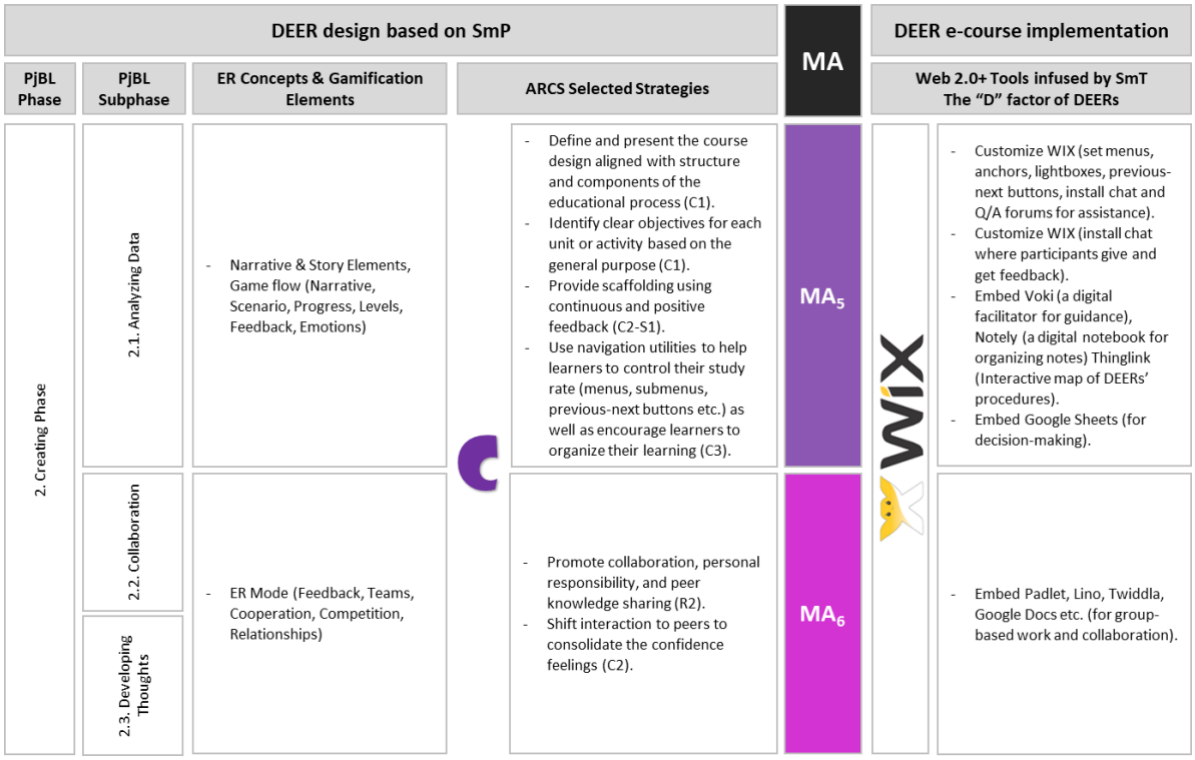


Figure 4: DEER design & e-course implementation – Creating Phase

Two subphases are included in the third and final phase of "Processing". During the first subphase "Presenting Knowledge", the project is presented to the learning community and further disseminated to the society. Reflection and follow-up constitute the second subphase of "Reflection" where students reflect on their and other groups' work, recommending improvements. The described procedures and workflows of PjBL, as well as incorporated strategies and techniques, were further aligned with the educational scenario.

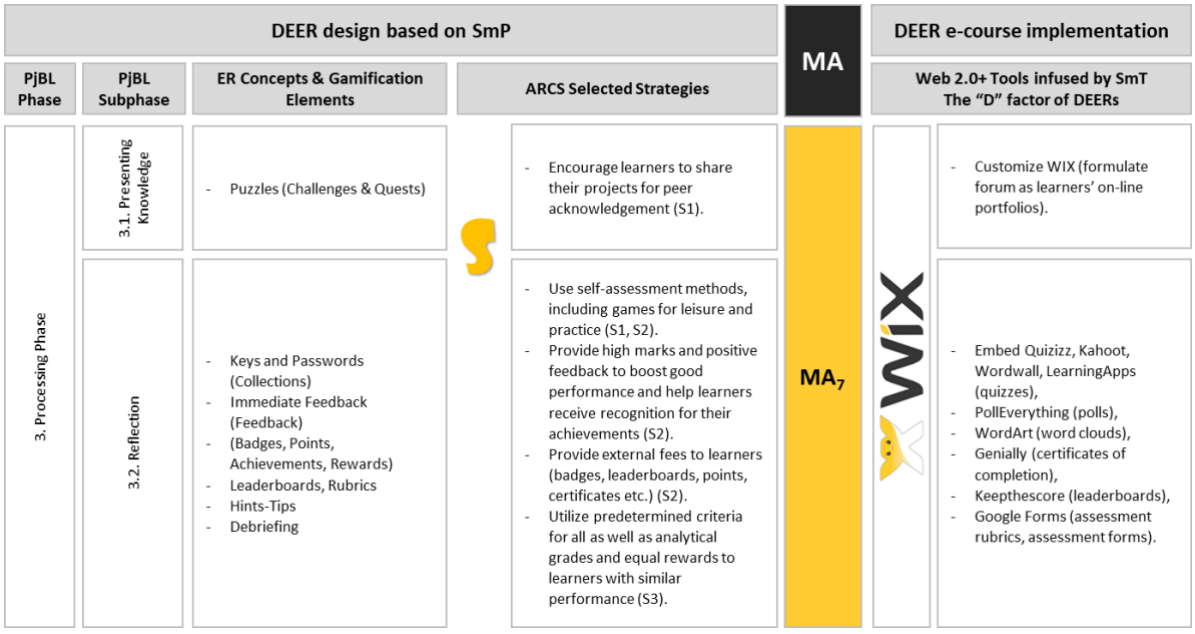


Figure 5: DEER design & e-course implementation – Processing Phase

Therefore, every PjBL subphase was matched to a different space in the school scenery, such as an office, a classroom, or a lab. In terms of puzzles, they were designed as individual or group-based activities. The completion of mini tasks by the students, for example the interaction with web 2.0+ tools that facilitate SmP, could resolve puzzles in a specific order, unlock doors and reach the exit. The design is presented in **Figure 3**,

Figure 4, **Figure 5**. MAs have been aligned with design elements (procedures and workflows, strategies, etc.) from which they emerge to the maximum extent possible.

Development (MD3): Step 9 involves putting the learning design into practice and creating the DEER e-course through the selection and development of materials. Because the WIX platform provides easy drag-and-drop functionality, no budget constraints, and a variety of customization tools, the DEER e-course was developed using this platform. ER equipment was provided via web 2.0+ tools (infused by SmT) in order to facilitate teaching and learning with corresponding features/levels of smartness (Uskov, Bakken and Aluri, 2019). Since digital equipment is less tangible, multimedia content with a high level of interactivity was chosen as props and facilitators in the digital spaces (e.g., AR/VR). A number of pages were tailored to the different locked virtual rooms within the school, while others contained hidden learning material and extra information (e.g., structure, goals, duration, etc.) (**Figure *6***). The "D" factor is described through web 2.0+ technologies in **Figure 3**, **Figure 4**, **Figure 5**, as well.

Pilot – Evaluation (MD4): The final step (step 10) refers to pilot, where learners' reactions as well as their level of satisfaction are determined in order to make revisions (Keller, 2000). Design and development tactics are evaluated for effectiveness, thus, DEERs should undergo several playtests. As mentioned, 108 postgraduate students took part in the DEER e-course and after completing the “playtest”, they conducted assessments at this final step. According to the learning design, they evaluated their projects through self and peer-assessments. In addition, they reflected on the DEER e-course by filling in an improvised questionnaire based on Kellers’ Instructional Materials Motivation Survey – IMMS (Keller, 2010). The questionnaire was provided to learners during the debrief period, where they mainly evaluated the “D” factor of DEERs that facilitates the learning design of the DEER e-course, based on SmP and the MAs that emerge from this combination.

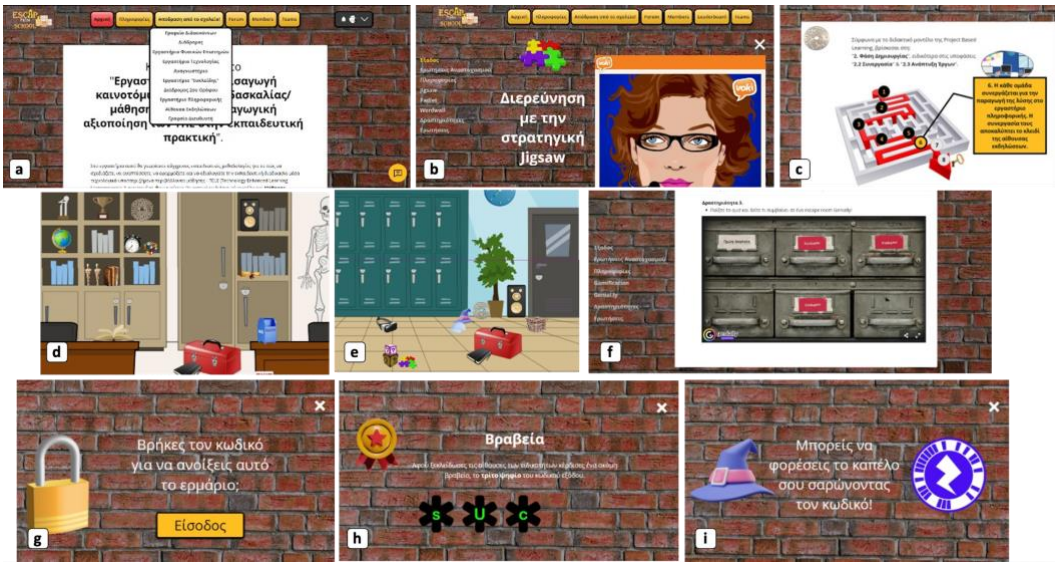


Figure 6: a. DEER e-course homepage – WIX. b. Digital facilitator – Voki. c. Interactive map of the gameflow – Thinglink. d. e. Customized webpages of school spaces – WIX, Pixton. f. Puzzle – Genially. g. Locked locker – WIX lightbox. h. Badges/password element collection – WIX lightbox. i. AR content – ZappAR.

2.3 Research Model

The research model employed in this study investigates the provision of MAs of a DEER e-course when it is designed and developed based on the D-EER4SmL framework. Within this model, the variables are differentiated based on their representation before and after the implementation of the DEER e-course, at the phases of briefing and debriefing, respectively. A baseline assessment of the DEER e-course's MAs was based on learners’ previous experience with e-courses, including DEER e-courses. Through D-EER4SmL processes, these pre-intervention variables serve as benchmarks for comparing post-intervention assessments. Following the D-EER4SmL processes, post-intervention variables are measured to capture the participants' perceived MAs. Pre-post survey models are used to discern potential statistically significant differences between constructs of the model before and after the DEER e-course implementation based on D-EER4SmL. This analytical approach helps to investigate how D-EER4SmL could achieve SmL through the lens of MAs.

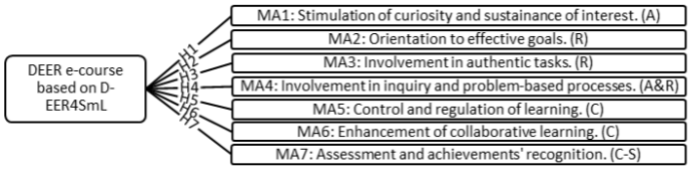


Figure 7: The proposed research model

2.4 Data Analysis and Results

The survey procedure utilized a 5-point Likert scale (from 1 – Strongly Disagree to 5 – Strongly Agree) to ask 35 questions about motivational content adapted to the context of the DEER e-course (**Figure 3**, **Figure 4**, **Figure 5**). Data analysis and statistical tests were conducted using IBM SPSS version 29. Seven factors (MA1 – MA7) were formulated for pre, and post data and for these factors reliability check was conducted. Using Cronbach's alpha (indices for MAPRE= 0,747 and MAPOST= 0,774), it was determined that the reliability of factors before and after the DEER e-course implementation ranged from acceptable to good (Mallery and George, 2000). Furthermore, paired sample statistics were computed to reveal the average response across participants (mean) and to gauge dispersion or variation in responses (Std. D) before and after the DEER e-course implementation (**Table 1**).

Table 1: Paired samples statistics

Paired Samples			PRE		POST	
		N	Mean	Std. D	Mean	Std. D
Pair1	MA1PRE – MA1POST	108	3,5119	,39117	4,1733	,56134
Pair2	MA2PRE – MA2POST	108	3,7185	,44008	4,2074	,56630
Pair3	MA3PRE – MA3POST	108	3,4877	,54196	3,9228	,57030
Pair4	MA4PRE – MA4POST	108	3,2245	,71282	3,9444	,51534
Pair5	MA5PRE – MA5POST	108	3,3161	,43500	3,6402	,50799
Pair6	MA6PRE – MA6POST	108	2,8642	,57290	3,7870	,51852
Pair7	MA7PRE – MA7POST	108	3,6543	,43753	4,1327	,52495

According to paired samples statistics, the mean values for the seven factors (MA1 – MA7) improved before and after the implementation of the DEER e-course. A paired samples t test was also conducted (**Table 2**). Since all mean values of MA1 – MA7 factors after the DEER e-course implementation were significantly higher than before, and the level of significance corresponding to all differences was 0,000 < 0,001, there was a statistically significant improvement.

Table 2: Paired samples t test

Paired samples t test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. D	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MA1PRE - MA1POST	-,66138	,55607	,05351	-,76745	-,55530	-12,360	107	,000
Pair 2	MA2PRE - MA2POST	-,48889	,57247	,05509	-,59809	-,37969	-8,875	107	,000
Pair 3	MA3PRE - MA3POST	-,43519	,68731	,06614	-,56629	-,30408	-6,580	107	,000
Pair 4	MA4PRE - MA4POST	-,71991	,45565	,04384	-,80682	-,63299	-16,420	107	,000
Pair 5	MA5PRE - MA5POST	-,32407	,54638	,05258	-,42830	-,21985	-6,164	107	,000
Pair 6	MA6PRE - MA6POST	-,92284	,55367	,05328	-1,02846	-,81722	-17,321	107	,000
Pair 7	MA7PRE - MA7POST	-,47840	,57919	,05573	-,58888	-,36791	-8,584	107	,000

3. Discussion and Conclusion

Initial research on MAs proved the D-EER4SmL framework effective. The DEER e-course appears to increase collaborative learning more than any of the other MAs among learners (MA6). As part of the playtest, learners demonstrated personal responsibility, shared knowledge, and assisted peers by using communication and collaboration tools. A higher MA4 was observed as well, which refers to learners' involvement in inquiry and problem-based processes. In conjunction with their own pre-existing knowledge, learners constructed their digital artifacts by studying material using various methods (pedagogical approaches) and tools (digital technologies). During this study, they even investigated external resources, made critical decisions regarding the actual problems of the hypothetical teachers they represented, and ultimately solved a multitude of puzzles to progress. Learners were also intrigued during the playtest, owing to the attractive comic school scenery, humorous narratives of authentic situations, avatars, varied means, and high interactivity of multimedia content (MA1). Through ARCS goal orientation strategies, MA2 aimed to guide learners to effective goals, whereas MA7 aimed to assess and reflect on learners' experiences throughout the DEER e-course using self-assessment (quizzes), peer-assessment (forums, leaderboards, badges, word clouds, etc.). Increased MA3 issued learners' involvement in authentic tasks, such as using ICT to implement well-designed e-learning solutions. Additionally, increased MA5 indicated that learners managed their learning through clear course design, organized content, study management information, and easy navigation, usability, and accessibility. Reflecting on D-EER4SmL framework processes, several factors may explain the positive results. First, the DEER e-course was tailored to learners' profiles, an essential part of SmP. A theme that was authentic, relevant to their backgrounds, skills, motivations, and personal goals was chosen, along with a game story that featured hypothetical teachers from STEAM fields mixed and matched in groups to work in a common hypothetical workplace. Emphasis was placed on the skills they wished to enhance (4Cs and pedagogical use of ICT in their learning environments). A comprehensive educational solution was orchestrated based on a suitable and documented methodology of PjBL, aligned with SmP principles. Goals and motivations for the e-course as well as their future careers were also considered. In no way did they want to give up the effort; so, emphasis had to be placed on the selected ARCS tactics during the design process, not only to complete the e-course achieving high grades, but also to highlight the value of knowledge by potentially facing problems in their future careers as potential educators in e-learning environments. Learning objectives and assessments were set in this direction. Furthermore, gamification elements and ER concepts were incorporated to develop the DEER e-course in a game format and align the game objectives to the learning objectives. Reflecting on the development processes it is necessary to illustrate the "D" factor of the DEER e-course. Assuming that the framework integrates SmP effectively based on the previous thoughts on the design processes, the web technologies enhanced learners' motivation. The customization of the WIX platform and the integration of various Web 2.0+ tools were not only used to structure and implement the DEER e-course, but also to integrate digital props according to the learning design. In comparison to other advancements in education like AI, robotics, big data analytics, etc., web technologies appear outdated and less intelligent. However, education technology is already on this pathway, and web technologies now leverage many of these smart features; what is lacking is the orchestration of frameworks (including DEERs), in which SmP and SmT interoperate effectively towards SmL, providing learners with a wide range of learning affordances. The present study investigates this perspective only through the lens of MAs. The interfunctionality of SmT within the learning environment will certainly need to be improved to achieve higher levels of smartness, so as to increase even more the provided MAs, i.e., MA3, MA5, MA7, by developing DEERs that are more immersive, reflective, and self-regulating. As SmL encompasses a wider set of smart learning affordances than MAs, further research is necessary to confirm the effectiveness of the D-EER4SmL framework in this broader context.

Acknowledgement

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Design and Evaluation of the Digital Algebra Game for Children

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Abstract: Children may find learning algebra challenging as the algebraic concepts are abstract for them. To address this challenge, contextualizing algebraic concepts through storytelling and gamification can foster a more enjoyable and comprehensive learning experience. In this study, we introduced the Digital Algebra Game (DAG), a low-fidelity prototype designed to leverage digital game-based learning and storytelling frameworks. Our evaluation involved 96 children aged 9 to 11, along with four teachers, in a primary school setting. Thematic analysis of interview data revealed a positive reception of DAG among both children and teachers. The most unique feature of this game lies in students' ability to transform equations into stories. This approach is believed to not only enhance students' creative thinking but also contribute to their success in mathematics Furthermore, the narratives constructed by students around equations within their daily lives with familiar objects are particularly noteworthy. These insights underscore the potential of incorporating personal experiences into educational game design to enhance engagement and understanding. By bridging the gap between abstract concepts and tangible experiences, educational games like DAG have the potential to enhance learning processes and make mathematics more accessible and enjoyable for children.

Keywords: Digital Game-based Learning, Algebra, Digital Storytelling, Participatory Design

1. Introduction

With the advancement of technology in today's world, the use of digital games in the educational landscape has become widespread. Prensky (2001) proposed the theory of **digital game-based learning (DGBL),** combining education design with digital games. After 20 years, DGBL continues to receive significant attention as a popular research topic in the field of education implying that there are still a number of open research questions to address (Brooks & Sjöberg, 2020).

Mathematics is commonly acknowledged as one of the most challenging subjects taught in schools. It holds significant importance in education systems worldwide and is believed to have an impact on students' future paths (Kayan et.al., 2022). Researchers assert that the process of learning mathematics may come with challenges that can lead to repeated experiences of failure and a lack of motivation (Doabler et.al.,2022). It is found that the use of digital games is beneficial not only for teaching mathematical concepts like numbers, algebra, and measurement but also for enhancing mathematical skills such as reasoning and inquiry (Hendriana et.al.,2018). Recent studies suggest that digital educational games (DEGs), when designed with real-world contexts and authentic tasks, can enable students to connect new information with their previous experiences (Yang & Chen, 2020). Determining which elements in a DEG make learning more enjoyable, engaging, and effective for learning is a crucial aspect of well-designed DEGs (Yang & Chen, 2020). Noteworthy is that perceptions of such qualities can be different from the student and teacher perspective, but empirical studies in this regard are limited (Mekler et.al., 2017). The potential of DGBL can be augmented by **digital storytelling (DST)** method, which has been used in education in recent years. Storytelling helps students understand the importance of mathematics in their daily lives (Bulut et.al.,2022).

The primary goal of our work is to identify which elements in our **Digital Algebra Game (DAG)** have effects on perceived usability, usefulness, attractiveness, and acceptance from the perspective of students and teachers. Following the Human-centered Design approach, the prototypes will be iteratively evaluated with representative end-users (i.e., students aged 9-11) to enhance the game's design. This paper presents our empirical study with 96 students and 4 teachers, who were involved in evaluating the initial DAG prototype. Results thereof address two research questions (RQs):

> **RQ1**: Which elements of DAG based in digital game-based learning and digital storytelling are perceived as usable, useful and attractive for students and teachers?
>
> **RQ2**: (a) What are the quality of stories created by 9-11-year-old students based on algebraic equations?

Overall, the contributions of this paper are twofold: First, identifying the DGBL and storytelling elements conducive to the acceptance of DAG from the student and teacher perspective. Second, gaining insights into

student ability to understand and contextualize abstract algebraic equations by creating stories around them. Both aspects can enrich the body of knowledge in the realm of DEGs.

2. Background

Our DAG has been created by integrating DGBL into DST (Section 2.1) to enable learners to delve deeper into the understanding of algebra. This integration is linked to two established learning theories (Section 2.2); each theory is briefly described due to the space limit.

2.1 DGBL and DST

According to research conducted in mathematics education (Majid & Ridwan, 2019), DGBL has been found to enhance students' problem-solving and critical-thinking skills, and DEGs can enhance understanding, particularly in challenging abstract topics, subjects requiring a longer comprehension process, and strategic planning in mathematics education (Majid & Ridwan, 2019). Games where students take on a designer role positively impact their academic performance, creativity, and motivation (Bulut et.al.,2022). Therefore, game design has become increasingly important for a student's development. In this regard, young people are interested in being game creators and designers. Hence, it is crucial to identify a mechanism that can support students to take on a designer role. This is where DST contributes to.

Digital storytelling presents interactive digital narratives based on sound, visuals, videos, music, and text in a digital environment (Albano et.al.,2020). Most importantly, students can establish a strong connection between real life and mathematics subjects. Through storytelling, meaningful contexts can be established for students regarding mathematical problems, making mathematics more accessible and facilitating easier learning of mathematics for students (Casey et.al., 2008). DST relates to daily life, providing a means to concretize abstract mathematical concepts (Albano et.al.,2020). According to Niemi (2018) using DST could engage students actively and increase their participation. Students using DST in class changed their attitudes toward negative numbers and improved their algebraic thinking (Casey et.al., 2008). Nonetheless, there are only limited studies exploring the integration of DGBL and DST on children's algebra learning.

2.2 Learning Theories

One of the well-recognised learning theories for DGBL is the Experiential Learning Theory developed by Kolb (1984). Accordingly, the learning process is divided into four stages for learning to be effective: concrete experience, reflective observation, abstract conceptualization, and active experiment. Many students see mathematics as an unrelated subject that have no real relevance to what they encounter in their lives (Clark, et.al.,2013). The Experiential Learning Theory as a teaching method is especially useful for building the relationship between mathematics and daily life. This method gives students the opportunity to reach abstract symbols based on a concrete experience (Morris, 2020).

Another prominent theory is the Constructivist Learning Theory. Accordingly, individuals do not passively receive knowledge; instead, they actively reconstruct it in their minds by comparing new information with existing knowledge (Bodner, 1986). According to Pelech (2021) new principles have been proposed to create a constructivist learning environment during lessons. Firstly, students should learn from various sources, not just their teachers, to build their own knowledge. The advancement of technology has increased the possibilities for students to acquire knowledge from different sources. Secondly, the importance of "authentic products and society" is emphasised. In learning environments, real-world conditions and unique topics closely related to students' lives create effective learning outcomes (Pelech, 2021).

3. Methodology

The aim of the user-based evaluation study presented in the following was to collect feedback from students and their teachers on our initial DAG prototype (Section 3.1). The data gathered were to inform the game's further development as well as address our RQs (Section 1).

3.1 Development of DAG Prototype

The 'Digital Algebra Game' (DAG) is an interactive journey where students design real-life stories, incorporating elements from their daily lives using given mathematical equations.

We have applied the learning theories (Section 2.2) as a design framework to inform the development of the game. The game offers three levels. In the first level, students are asked to select the correct story that aligns with the chosen character and place, enabling them to connect the abstract equation to a concrete scenario. This is consistent with the principle of exploration upheld by the Experiential Learning Theory. Moving on to the second level, the goal is to fill in the blank spaces within the story related to the chosen equation, character, and place. In the third level, the most challenging, encourages players to unleash their creativity. Here, the objective is for the player to create an entirely original story, incorporating the chosen equation, character, and place. At this level, the student encounters real-world conditions, aiming for active learning that aligns with the principle of authenticity advocated by the Constructivist Learning Theory. In these three levels, students experience an interactive learning process through active experience. Additionally, their ability to concretize abstract concepts promotes conceptual learning. This approach is consistent with the learning theories (Section 2.2). This multi-level structure not only helps students relate mathematical concepts to their daily lives but also ensures that the first two levels efficiently prepare players for the challenges of the third level. The experience concludes upon the completion of all three levels. In a collaborative twist, players can invite their friends to join the game after the third level, allowing them to view and interact with the stories created by other participants (Figure 1).



Figure 1: An example page from the prototype.

The most unique feature of this game lies in students' ability to transform equations into stories. It is grounded in a unique mindset that connects mathematical equations with stories. We provide students with an equation and encourage them to weave it into a compelling story. This approach is believed to not only enhance students' creative thinking but also contribute to their success in mathematics. An illustrative example is presented in the prototype (Fig. 1). The aim is to help students grasp the connection between equations and daily life, demonstrating how abstract elements like 'x' can be concretized through the use of DAG. In the initial stages of the game idea, the plan was to develop it for a mathematics class, given that the first author was a mathematics teacher. It was observed that students struggled with the subject of algebra as they found unknown expressions (such as x, y, z) particularly abstract. Hence, the aim was to ground the game in the tangible aspects of algebra and its real-world applications. Building upon the storytelling theme, paper-based storyboards, visuals, and scenarios were developed (Figure 1), realising the idea of integrating DGBL and DST (Section 2.1).

3.2 Participants

The study was granted an ethics approval by ANONYMOUS; participant information sheets were provided and consents from students, teachers and parents were obtained. The target group of DAG was students aged 9-11 years old. The first author visited primary school to collect data. Participation in the study was voluntary without involving any kind of compensation. A total of 96 students and 4 teachers from 4 different classes, spanning three age groups (9, 10, and 11 years old), took part in the study conducted at the school (Table 1).

Table 1: Participants detail

Role	Class Code	Age	Year Group	Girls	Boys	n
Students	A	9-10 years old	5	11	11	22
Students	B	9-10 years old	5	15	10	25
Students	C	11 years old	6	13	11	24
Students	D	11 years old	6	12	13	25
Teachers	-	-	-	-	-	4
Total						96 students and 4 teachers

Unique codes were generated for each participant. For students, the code is structured as [Class Code: A/B/C/D]-[Participant number: two-digit] (e.g. D-15). For teachers, the code is simply designated as T1, T2, T3 and T4.

3.3 Data Collection

The evaluation process included both individual and group-based settings. Students were asked to evaluate the game after watching the prototype presentation. These evaluations aimed to provide the researcher with insights into the game's understandability and playability from the user perspective. Additionally, the study aimed to examine students' perceptions of the idea of creating stories inspired by equations and to analyse the stories they create within a mathematical context.

Semi-structured interviews and focus groups using the same set of questions on perceptions of the game's quality) were conducted. These qualitative data methods were used to enable comprehensive data to be obtained. The game was introduced in four different classes using the whiteboard to present the DAG prototype. Each session lasted approximately 40 minutes, with the duration varying with the number of questions students asked about the game. After concluding the DAG presentation, to allow all students to provide feedback on the prototype, blank sheets of paper were distributed. Recognizing that not all students might feel comfortable expressing their opinions orally, this method enabled students to give feedback with written text and drawing. After distributing the blank papers, individual and group interviews were conducted. Some students volunteered to be interviewed individually (n=38) whereas other students preferred to be interviewed in a group format (n=45); there were altogether 9-10 groups with the group size varying from 4 to 5. All interviews were audio-recorded. Semi-structured interviews were also conducted with four teachers individually at school.

4. Results

Data from teachers and students were collected and analysed separately using an inductive approach.

4.1 Analyses of Student Data

We performed a thematic analysis, identifying three main themes and associated sub-themes (Table 2). The inter-rater reliability (IRR) between the two DGBL researchers on the sub-themes was high with Cohen's kappa of 0.85. Consensus on different codes was reached after discussion.

Table 2: Themes and sub-themes for student data

Theme	Sub-theme	Description
DGBL Design	Content (equation)	Presentations of different equations, including symbols used
	Challenge (levels)	Game mechanics for moving up to next level with more challenging equations
	Reward (points)	Collecting points as reward for solving an equation
Storytelling	Characters	Options of non-player characters for stories
	Places	Options of places as contexts of stories
Perception	Positive	Game features positively perceived and commented
	Negative	Game features negatively perceived and commented

4.1.1 DGBL Design and Storytelling

The highest proportion of students' comments (52%) were related to characters. Many of them suggested adding additional character options and making them more personalized (Table 3).

Table 3: Student themes with subthemes, examples, and frequencies (descending order)

Theme	Sub-theme	Examples of sub-themes	f	%
Storytelling	Characters	More characters are needed like animals, superhero. Add names the characters. More personalize needed and some more features.	48	52%
	Places	Add more places such as airport, shop, campsite, or village.	41	45%
DGBL Design	Content	Equation can be change. The equations are easy but ideal for creating stories.	37	40%
	Structure	Add more levels (ex. tutorial level). I would add bonus level and power-ups.	40	43%
	Reward	Add collect point section.	6	7%
Total			96 Students	

Some student comments are intriguing, for instance, D14 remarked, *"… more family members, like cousins, aunt, neighbor, and older brother or sister because... mmm I guess I want it to be more familiar*." This indicates their preference for characters that closely resemble their own lives. Many students also mentioned the absence of animal figures. Some students favoured the option to design their own characters, expressing their preference for a more personalized and customized gaming experience. By allowing students to physically manifest themselves in the game through the characters they create or choose, a sense of empathy and emotional connection is established between the player and the game (Stenros, 2017). Such emotional connections can significantly enhance student motivation and a sense of ownership towards the game. Gee (2008) points out that effective game design improves the learning process which is achieved through players' attachment to characters they care about.

Students have expressed their interest in naming characters after their family members, and those with pets, such as dogs and cats, have expressed a desire for the option to select animals as characters. This situation can be linked to students' preference for game environments that mirror their real-life circumstances. Emphasizing game environments that replicate real-world situations is seen as a means of directing students toward solving real-life problems, which is the concept of well-designed games (Stenros, 2017). Consequently, game environments that reflect real-world situations capture their attention effectively. Students express a strong desire to design their own characters. Gee (2008) emphasizes that deep learning includes not only a strong sense of ownership but also the ability to create.

Regarding the sub-theme *"Content*", a group of students commented that the equations were simple but ideal for creating stories. Other students suggested that the equations should be different at each level and that the difficulty of equations should increase with level. D4 commented that *"Equations should be a little harder for level 3. I think this is a bit more challenging for beginners but in a fun way, this is very understandable*".

Regarding the sub-theme *"Challenge"*, a group of students expressed that the levels were understandable and clear, suggesting that more levels could be added. D1 proposed the addition of a tutorial level to enhance understanding, especially as the game progresses. D5 mentioned, *"I would add a bonus level and power-ups."* Another group of students highlighted that level 3 was the most creative and enjoyable part. D7 shared, *"I like level 3 because I can create my own story, it offers more flexibility. I feel freedom and more creativity."*

Regarding the sub-theme *"Reward",* some students expressed that incorporating a point-collecting feature during the game could enhance creativity and competitiveness. A16 suggested a creative idea by drawing a picture and proposing that students could receive certificates based on the points they collect upon completing the game.

4.1.2 Perceptions of Game Features

In general, students perceived the game as fun, expressing a desire to play it during class. While the game serves an educational purpose, it is crucial for it to be enjoyable and truly playable for students (Kafai &Burke, 2015). Another positively perceived feature is "sharing with your friends", It can promote social interaction, collaboration, communication, and competition among peers (Gee,2008).

Some students (~13%) pointed out that making a story with simple equations could be challenging. B11 remarked, *"This game is so easy, but I'm not sure I can create a story."* According to the literature, in schools

many students excel in traditional exams but face challenges when it comes to applying and interpreting their knowledge in real-life scenarios, an important and prevalent issue in education today (Gardner, 2011; Slater, 2022). This highlights the importance of students developing interpretative skills, which go beyond merely solving problems on paper. Some students found the game's gradual difficulty progression logical. Facing these difficulties prompts them to revisit previously learned tactics and develop more effective approaches. This situation may encourage the enhancement of players' skills and thoughts. Such incentives contribute to enriching players' learning experiences (Gee,2008).

4.1.3 Sample Stories of Students

Students were provided with opportunities to create their own stories after being introduced to the prototype. Additionally, to gain a deeper understanding of the DAG (turning equations to story), we aimed to incorporate the stories created by students following their examination of the prototype.

Table 4: Sample stories

Student	Equation	Story
C15	x-4=12	"A boy went to a shop to buy some food with his mother. A boy has some money. A boy bought a bag of apples for 4 pounds. And he has 12 pounds later. How much money is there first time?"
D17	a+4=5	"Mike is in the park. Mike plays football. If he is gonna gain 4 points, he is gonna total 5 points. What are the first-time points?"
A12	x-4=12	"A girl has lots of pencils. We can say x for these pencils. Minus 4 pounds equals 12 pounds. Can you find x?"
B9	a+4=5	"Daisy and her cat went to park to play ball. She has a ball, and if she gains 4 ball. Now she has 5 balls.
D14	b-5=14	"Lily likes school. Lily like painting. Lily goes to school and has 14 colorful pencils. Lily gave 5 pencils to friends, what's happens?"

Five stories were selected from the students' narratives to serve as examples, as shown in the table above. Various criteria have been used in the literature to evaluate the constructed stories (word problems). As noted by Silver and Cai (2005), the most used criteria for problem construction are "quantity," "originality," and "complexity." Quantity refers to the number of correctly constructed problems considering the given problem construction tasks, originality emphasizes the personalization of the constructed problems, and complexity indicates the extent of mathematical relationships embedded within the problem situation. In the study, difficulties encountered in story construction include failure to provide sufficient information to achieve the goal (B9), inclusion of unnecessary information (D14), and failure to use question sentences (B9). Upon examination from a quantitative perspective, it was observed that some stories were solvable (C15), while others lacked mathematical knowledge. Furthermore, students were observed to construct original stories, adhere to the DAG prototype, and create narratives based on their immediate surroundings. When examined for complexity, it was noticed that some students' stories (C15, D17) were more closely related to mathematical content, while others exhibited livelier narratives and better depicted real-life contexts where algebraic equations could be applied (C15, D17). Additionally, students showed enthusiasm for creating stories from their daily lives using mathematical equations, as evidenced by the numerous illustrations they produced, including their pets in many instances.

4.2 Analyses of Teacher Data

A coding scheme was derived by applying thematic analysis to teacher data. The IRR between the two researchers was reasonable with Cohen's kappa of 0.602. Consensus on divergent coding was reached after discussion.

Table 5: Themes and sub-themes for teacher data

Theme	Sub-theme	Description	f
Storytelling	Places	Add familiar places like Wingate village.	2
DGBL Design	Content	Equations can be change.	3

Theme	Sub-theme	Description	f
		There be a single equation for each level.	
	Structure	Add more levels (ex. tutorial level). It can be free play mode.	3
	Reward	Students can collect points	2
Perception	Positive	This game helps students by allowing them to solve and create, fostering their creativity.	3
	Negative	The game is not quite suitable for 9-year-olds	2

4.2.1 Comments on DGBL Design and Storytelling

Two of the four teachers commented that Characters and Places needed to be improved in a way similar to the remarks made by their students, incorporating familiar individuals and places from students' surroundings to enhance acceptance. Regarding the sub-theme "Content", three teachers remarked that generating diverse stories from the same equation at every level could enhance student creativity. T2 stated, "*Let there be a single equation for each level and let's see students' various stories based on that single equation. This approach would make more sense and be more interesting for students*." Concerning the sub-theme "Structure", T3 commented: "*Free play mode? It can be a mode where students can play comfortably without the purpose of competition*." As discussed in (Gee,2008; Stacey & Macgregor,1999). if players do not feel comfortable during the game, they may struggle to move and explore within the game, which may negatively impact their learning experiences. For "Reward", T2 mentioned that "*Students can gather points, which would make the competition more intense and could be engaging for students*."

4.2.2 Perceptions of Game Features and Impacts

T3 evaluated the game positively, commenting that the idea is logical and interesting, and noted that in general students struggle with independently creating stories or problems based on given equations, a skill covered in their lessons. The DAG provides a step-by-step approach, guiding students in the process of creating stories or problems and encouraging creativity. Furthermore, two teachers appreciated the sharing feature. T4 stated that *"… share with other classes and year groups. We can see variations."* Nonetheless, two teachers expressed concerns regarding the game's appropriateness for 9-year-old students, suggesting that it is more suitable for 10-11-year-olds. They proposed using symbols, such as squares or triangles, instead of x, y, and z for younger students. This approach aligns with the idea that using different variable concepts and symbols can aid in comprehending unknown and algebra (Edwards, 2000).

5. Discussion

In our study, we collected and analysed data from both students and teachers on our DAG prototype in terms of its perceived usability, usefulness, and attractiveness (RQs, Section 1). The participants assessed the usability of the DAG positively in general. Both students and teachers generally agreed that the incorporation of the DAG in learning algebra education would be beneficial for learning algebra in an engaging and constructive way.

In the third level of DAG, digital storytelling has been integrated to enhance students' creativity and relate mathematical concepts to daily life (Section 2.1). This part of the game has received positive reactions from both students and teachers. Additionally, some students argue that the progressively challenging levels are the most captivating game element. The gradual increase in difficulty of these levels has facilitated students' step-by-step progress in the game. In accordance with the Constructivist Learning Theory (Section 2.2), it realised that, based on the students' perspectives on the game, the students have the potential to progress step by step by discovering and experimenting rather than receiving direct information. Participants, both teachers and students, expressed dissatisfaction with the character and setting choices in the game, suggesting a preference for selecting familiar locations and individuals from their immediate environment, such as relatives, friends, and pets. They showed a desire to represent everyday activities and people from their communities rather than fantastical settings.

The inclusion of characters and places in the game allows students to establish a connection between mathematics and daily life. It is crucial for students to experience mathematics in the classroom rather than just listening to their teachers and then trying to apply it later. This method enables students to understand abstract

symbols based on concrete experiences. According to Kolb (1984) (Section 2.1), the Concrete Experience Learning cycle increases students' confidence and develops a more positive attitude towards learning content. When examining the stories created by students (Section 1-RQ2), the constructed problems were analyzed in terms of clearly expressing the problem situation, the structure and nature of the problems, solvability, and originality criteria, as defined by Silver and Cai (2005) in the context of "measuring problem construction." Considering these criteria, it was observed that students are eager to create stories but face several challenges. Literature suggests that students often attempt to create ordinary, trivial, unsolvable problems due to their inability to acquire problem-solving skills (Silver & Cai, 2005; Van Harpen & Sriraman, 2013). One could argue that creating the story in this way encourages students to reflect more deeply and understand the equations they are working with. This approach has the potential to help students link equations to real-life contexts, fostering effective learning and creativity. In the next stage of the research, it is aimed to address this deficiency through the teaching process, and it is expected that students will gradually improve their problem-solving skills in terms of language and expression and mathematical appropriateness throughout the instruction.

The tests and evaluation studies conducted primarily focused on usability. But two learning theories (Experiential Learning Theory, Constructivist Learning Theory) have been instrumental in constructing the game, including designing levels 1, 2, and 3. These theories helped in designing the content of the game, not the interaction. The learning theory explanations and constructivist approaches are primarily used for the pedagogical design of the game. However, it can be argued that these theories are more relevant to the design and content of the game's design rather than its usability aspects. It has been observed that the students enjoy the game, which suggests that the theory is effective. This observation is further substantiated by empirical data, indicating that the students' enjoyment supports the validity of the theory.

Like many empirical studies, ours has some limitations. First, the study is limited to the DAG; the generalizability to other mathematical concepts may be limited. Second, the study is limited to a sample from one school; the demographic variables of students could influence how they perceived the game.

6. Conclusion

This study involves the development of DAG, which facilitates the real-life contextualization of abstract subjects like algebra for students. The findings obtained from our user-based evaluation may be of practical interest to educators seeking suitable tools to enhance similar learning experiences for students.

In our future research, we aim to improve the reliability of our findings by expanding the participant pool. Given that DAG is designed to benefit a broad spectrum of students, our strategy involves increasing the diversity of sample by recruiting individuals from diverse backgrounds with different socio-economic backgrounds to ensure a more comprehensive and representative analysis. The interactive high-fidelity DAG will be implemented with the state-of-the-art game development technologies such as Py-game. The learning impact of the interactive DAG game can be measured through systematic control with pre- and post-tests when implemented in the classroom to determine if it creates a genuine effect. Our future studies will aim to iteratively improve DAG through systematic user-based evaluations, focusing on both the cognitive and experiential aspects of the learning and teaching process that the current game aims to support.

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The Ideological Dilemma in Using Games in Global Citizenship and Development Education

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Abstract: The objective of this paper is to contribute to discourse informing the use of computer games in Global Citizenship and Development Education. In doing so, it addresses the incompatibility and conflict between the values imbedded in games and those informing development education practice. It is aimed at both formal and informal educators who see the potential in using games in their practice and want to reconcile this dilemma. It is also aimed at policy makers and influencers who want to shape the structures governing such digital spaces in the public interest. The research involved an interdisciplinary literature review across the fields of Education, Game Design, colonialism and social activism. The analysis takes a postcolonial perspective and is informed by the theory and practice of critical pedagogy in youth work and development education. The study was conducted as part of Doctoral research and project work with NGOs over a seven-year period to 2024. In this context it is important to note that this is a rapidly changing and evolving sector. The development of computer games and immersive technologies over the past 20 years has been transformational, in their interactive capabilities and global proliferation, particularly with the emergence of "The Metaverse". Such expansion has been critiqued as a process of Colonialism, where young people's time, creativity, identities and attention is being commodified, monetised, packaged and sold to the highest bidder. The structure of the games industry, their content and the ecosystem surrounding gaming are all ideologically driven. Such ideology aligns with one of three systems: the neoliberal hegemony emanating from transnational corporations and market economies; the state control being exerted by China and others; or a blind commitment to opensource being advocated by many industry innovators, developers and users. When using games in an educational context, and particularly when addressing Social Justice and Global Citizenship, the values and cultures underpinning all three of these ideologies are problematic. It is the contention in this paper that such spaces can also be developed as informal educational spaces informed by values aligned with critical global citizenship and development education. Now is the time for development educational practitioners, conscientious games designers and policymakers to collaborate, to act, to legislate, to experiment and carve out a safe, progressive, dynamic, decolonised digital space for engagement with issues of global citizenship and development education.

Keywords: Development Education, Global Citizenship, Decolonisation, Metaverse, Games Based Learning, Critical Games.

1. Introduction

The Research for this paper was undertake as part of a literature review looking at the use of computer games in global citizenship and development education it also sought to inform a project to develop such a game with Trocaire, an international NGO based in Ireland. Its objective therefore is to inform Games Designers and Development Educators about the ideological drivers informing and shaping both games selves and the games industry. While there are many critical perspectives which could be taken in analysing games, colonialism and decolonisation are a key part of current discourse on development education.

The subject of this paper is computer games and their application in global citizenship and development education. It will open by defining both terms and looking at the use of games global citizenship and development education and their evolution more broadly as a social economic and cultural phenomenon. This will be viewed through a Colonial critical lens highlighting the challenges in using this medium to understand and address oppression when indeed, it has become an instrument of such oppression. The paper will conclude with a presentation of decolonising initiatives within games and will highlight principles which should be applied is reconstructing gaming as a medium for global citizenship and development education.

2. Global Citizenship and Development Education

The term "Development Education" is used in Ireland to describe initiatives which engage people with issues of Global Justice and Sustainable Development, "*…aiming to bring about positive change, informed by values of equality, diversity, sustainability, human rights and responsibilities.*" (IDEA, 2017). The Irish Development Education Association suggests this should start by encouraging people to understand and challenge the cultural, environmental, economic, political and social causes of poverty and oppression. The international NGO, Trocaire adds that "Development Education" should be an active and creative process which encourages optimism, participation and action for a just world, "*engaging children, young people and educators through a process of interaction, reflection and action.*" (Trocaire, 2017).

While "Development Education" is often used in its own rite it is also used as an umbrella term to describe a range of initiatives with similar aims but often using different descriptive titles and definitions. Such terms include "Global Citizenship Education", "Global Education" and "Education for Sustainable Development". In this paper I have chosen to use the generalised phrase "*Global Citizenship and Development Education*" which emphasises both a development and political imperative. Games are widely used in this sector to raise awareness, build understanding and encourage critical analysis (Keating, 2022). The next section will explore the background to how games have been used in this context and more broadly how mainstream games have evolved, highlighting some of the challenges inherent in their approach to development.

3. Social Simulation in Educational Games

Salen and Zimmerman (2006) (2005: 80) define a game as "*… a system in which players engage in an artificial conflict defined by rules which result in quantifiable outcomes*". Jesper Juul adds to this definition by focusing on the agency of the player, who, in applying understanding, effort and skill can positively affect their progress in the game. The player therefore feels attached to the outcome of the game and they relate emotionally to what happens (Juul, 2011).

During the 1950s and 1960s extensive work was done on designing and using games within higher education and the NGO sector to raise awareness, build understanding and encourage a critical analysis of development issues. Academics such as Harold Guetzkow (1996) and William Gamson (2013) developed games which exposed students, over prolonged periods, to simulations of complex international relations (Inter-Nation Simulation, INS, 1966); the mechanics of domestic conflict and social movements in the USA (Simulated Society, SimSoc, 1966); as well as global justice, sustainable development and macro-economic systems. Local planning authorities and NGOs in the UK developed a series of very elaborate simulation games to encourage collaboration between civil society groups and state agencies around issues of environmental conservation and urban planning. Taylor and Watson (1978), Gamson maintained that such games "*open up the world to vicarious experiential learning,*" (2013; 616). While his games are physical role play games, he acknowledged that the future of such simulations lie in computer games within virtual environments.

An early example of the use of computer games in development education is identified by Bogost (2010). "Save the Whale", a game designed for Atari in the mid-1980s, involved the player in the role of Greenpeace, attempting to prevent whale poaching. The 1980s saw the growth in single and dual player games such as the classic Space Invaders and Pacman however, Mayra (2009) highlights the technical leap forward made in the early 1990s with the advances in processing power of home PCs and the integration of graphics cards and programming techniques which enabled the simulation of 3-Dimensional movement in gameplay and the exponential growth in the popularity of the medium.

4. Colonialism in Games

Many of the simulation games which emerged using this technology have similar themes to the physical ones developed as educational games. The "world building" genre of simulation games such as Sim City (1989) and Civilisation (1991), are commonly referred to as "God Games" (Poole, 2001). They were developed as entertainment products and have been very commercially successful. They place a strong emphasis on strategy and negotiating the complexity of interconnected social, economic and environmental systems, giving the player power to shape and grow their "worlds" (Mayra 2010:100). While acknowledged as a potentially powerful learning tool, commercial games inevitably compromise on realism in favour of entertainment value. Such games are often informed by questionable political values (from a global citizenship and development education perspective), rewarding hedonism, colonialism and economic exploitation, Penix-Tadsen, P. (2019). Herz (2001) posits that such games often allow players construct the physical layout of such worlds without considering underlying social tensions and the oppression inherent in colonialisation. For example, the domains in such games are often characterised as 'new worlds' and 'frontiers', limitless territory that can be determined and shaped by each individual player (Gunkel, 2018).

Other authors have been more forthright in their criticism of computer games, claiming that many are blatantly colonial in nature (Bastian et al 2015. Carpenter 2021, Skotnes-Brown 2019, Mukherjee, 2017 Mayar, M. and Schubert, S. 2021). Games series such as *Civilisation*, *Age of Empires* (1997), *The SIMS* (2000), *Oregon Trail* (1971), *World Of Warcraft* (2004) and others have, to varying extents, incorporated: a militarised prerogative to subdue; a cultural prerogative to civilise; and an economic prerogative toward domination. Carpenter (2021) refers to these as 4XGames - "Explore, Expand, Exploit, Exterminate". Games researchers have also highlighted

how many games embed narratives, imagery and gameplay which are, racist (Daniels, 2012, Nakamura 2009), sexist (Harvey, 2022, Flanagan 2009), exploitative (Wark 2007, Crocco 2011), aggressive and the encourage the erosion of empathy (Anderson C. A, et al, 2010, Fraser A 2012).

5. Proliferation of Computer Games

The most significant change since 2020 however, has seen a shift in public attitudes towards computer gaming. As a result of the pandemic, video games have gained legitimacy as a socially orientated media. This is despite sustained concern in the proceeding decades about deviant behaviour in games and unbridled extractive consumerism which pervade the narratives, the gameplay, the culture and the business model driving the computer games industry (Purchese, 2014). The World Health Organisation categorised video game addiction as a mental health disorder in May 2019, but less than a year later, they launched an initiative encouraging people to connect with friends and community through online gaming, #PlayApartTogether, (Lufkin, B. (2020). Research by Barr and Copeland-Steward, (2022) shows how online gaming became a social lifeline during lockdown, with a significant shift in patterns of play from single player to multiplayer socially interactive games. There is an ongoing debate that would frame computer games as both the addiction and the therapy, the poison and the antidote, the trivial distraction and the essential medium for social interaction (Keating, 2021).

In October 2021 Facebook formally rebranded to Meta. Mark Zuckerburg took that opportunity to formally adopt the concept of "The Metaverse", committing to spend $10 billion per year on technologies to enable it to happen (Isaac, 2022, Barr, 2021). The idea of the Metaverse, or The Metaverses, has been driven by the proliferation of computer games and related technology. It's definition is however, nebulous; utopian or dystopian depending on your point of view; real or imagined; here already, or another 20 years down the road. Some see the Metaverse as the future for human-technology interaction, others as a giant marketing ploy perpetrated by mega corporations to consolidate their power and their profit. Whatever one's perspective, there is momentum behind the expansion of the gaming "ecosystem" to create an integrated experience where people can work, play, socialise and learn in virtual world. A world envisaged in Neal Stephenson's 1992 novel "Snow Crash", when the phrase, "the Metaverse" was first coined, (Stephenson, 2022).

Such an ambition might have seemed fanciful even 5 years ago. However, recent developments in gaming, artificial intelligence and virtual reality technology, corporate restructuring in the sector, Covid and massive financial backing has made the prospect of an integrated, interactive digital environment plausible. Covid has accelerated this mass migration and has further defined it as a social rather than a solitary space (Barr, M., & Copeland-Stewart, A. 2022), a space which Mark Zuckerberg and Meta seem primed to develop, (McWilliams, 2022).

6. Who Controls This Space?

While the vision for a metaverse anticipates a unified digital experience, the reality is that there is limited interconnection between different applications. The discourse on the development of the games industry and the Metaverse is one of corporate control, mergers and acquisitions, territorial expansion, speculation with rising and falling share price, (Piccha, 2022). In 2014, the 100 million registered users of Minecraft found that ownership of their online identities, many of the assets they had created and the community they had built, transferred over night from Mojang, the Swedish start-up who created the game, to Microsoft (Makuch, 2014). With this success under their belt, Microsoft are now looking to do the same with the games company, Blizzard/Activision and their 400 million monthly users, (Warren, 2023). Also in 2014, Facebook began purchase negotiations with Oculus. During these negotiations they committed to ensuring that users of Oculus would not be required to have a Facebook account and they would not be subject to advertising. Since then, they have rowed back on both of these commitments and the BBC has reported on the anger of Oculus users who believe the company sold out to Facebook (BBC, 2021).

These examples illustrate that mergers and acquisitions in this sector have an impact beyond the purchase of technology, licences, databases, or even brands and customer loyalty. Gamers and VR users are often heavily invested personally in the Metaverse, they project their identities, socialise, learn, earn, create, and live, to a certain extent, *in this space*. This construct of games and the Metaverse as a space or even a "territory" is key to understanding the mentality of the community of users and the extent to which current developments can been seen as colonial in nature, (Smethurst.et al. 2023).

While the exploitation of the Global South by the Global North is being enacted in through games, Amrute (2019) points out that when we think about colonial relationships in this context, we need to treat the South as being dispersed across the globe. While most of the companies are based in the USA, so too are many of these being usurped, excluded, exploited and oppressed within, or because, of this technology. Hao (2022) cautions that the industries contributing to the development of the Metaverse may not actively proport slavery and the racist beliefs that dehumanized entire populations, they have, however, developed new ways of exploiting cheap and precarious labour. Exploitation within and through games extends beyond the financial as articulated in a 2021 report for the European Commission. This report highlighted the use of computer games and related platforms to recruit, indoctrinate and direct young people into violent extremism and terrorism (Lakhani 2021). This is not unexpected as such extremists have been very active in adapting digital media to their purpose, as can be seen

7. Governance and Regulation

in their use of the internet and social media (Duncombe, 2019). Games are particularly powerful as a site for radicalisation (Schlegel, 2021, Robinson and Whittaker, 2021).

Given the scale of social, economic and political activity involved in this ecosystem, concerns have been raised about control and regulation. The EU has highlighted challenges relating to the governance and geopolitical control of the metaverse. They present three possible models for control including:

1. Regulation and legislation overseen by the state;
2. Free, decentralised and open access for all;
3. For profit business control overseen by the tech companies, (Council of the European Union 2022:13).

In their assessment they see the USA favouring corporate control; China favouring tight state control, both vying for ideological dominance (Council of Europe, 2024). Alternatively, tech activists and innovators have traditionally been vociferous supporters of open access (Erickson, 2022). The EU report concludes that those who now take control of the building blocks of the Metaverse, whether state or corporate actors, are set to become its gate keepers in the future. The report closes with the unanswered question. "*Will there be a system of governance which will be subject to some form of democratic legitimacy?* (Council of the European Union 2022:13). A recent Forbes Magazine report entitled "*Will it be owned by corporations, or will the metaverse be a space in which people hold the keys to their own identity?*" (McCauley 2022) also draws attention to the current battle for control of our digital future. The term "Metaverse Manifesto" is being used by a range of opensource campaigners looking to keep an open, inclusive metaverse that empowers its inhabitants. (Dolata, M. and Schwabe, G. 2023; Buckley, C., Holley, D. and Fallin, L. 2023)

8. Decolonising Gaming

The term "Civic Gaming" has been used to describe simulation and role play which address social issues. Research undertaken by Oberle et al (2020), and Lenhart et al. (2008) indicate that young people who play such games demonstrate a more significant interest in politics and contribute more to charities than those who don't. Keating (2016) and Bastian et al (2012) highlight the value of such games in fostering empathy with those who are marginalised and in actively engaging young people who show limited prior interest in social justice issues. Flanagan (2020) expresses a higher level of ambition for computer games as a contemporary art form which can, and should, be used as a political tool to intervene, subvert or disrupt the dominant narrative within games themselves, the industry controlling them, and more broadly within society.

With roots in both a feminist reaction to the misogyny within computer games and returning to the critical analysis inherited from Guetzkow and Gamson, Flanagan (2010) reinforces the potential of the "Activist Game" or "Critical Game" and documents the emergence of games that address social issues in such a way as to explore notions of agency on the part of those who are marginalised and of the gamer in addressing injustice in the real world. Such Critical Games promote positive social change. Flanagan and Nissenbaum (2007) observe that progressive game design and its underlying technology, should emerge from progressive social values. They propose a framework, "Values at Play" (VAP) which encourages designers to consider issues such as diversity, justice, creativity and expression, inclusion, cooperation, equality and gender equity when conceptualising and developing games.

This commitment to the integration of critical social values is further developed by Schrier (2021) in her reflection on the games' development process. She highlights the importance of congruence between the objectives of critical gaming and the process by which such games are designed, developed and distributed.

Flanagan and Jakobsson (2023) highlight the emergence of decolonising games designed within communities to reflect on the experience of Native Americans. Ellwood Barnes (2021) sees the potential of computer games as a means of "*..reimagining traditional ways of knowing and being, and (their) transposition into the medium of videogames is survivance, a continuation of Native stories and Native life*",(Ellwood Barnes 2021). Mukherjee (2018) joins with Frasca (2001) and others in calling for the initiative in games design and development to be taken by the Global South and the power of the medium repurposed to the benefit of the majority of the world's population.

Penix-Tadson (2019) point to the shifting profile of those who play and make computer games towards the people of the Global South. He posits that Computer Games can be decolonial and refers to Mukherjee's ground-breaking 2017 study "Videogames and Postcolonialism: The Empire Plays Back" as highlighting how games can provide a medium of protest. Penix-Tadsen (2019) highlights how many designers have taken up this challenge, actively contributing to game cultures and designing games which acknowledge and engage with the challenges faced by people of the Global South in their diversity of geographical, socioeconomic, political and cultural contexts.

9. Framing Games as an Activist Space

The real challenge presented by Flanagan and Schrier (2021) is not only to design a game, or digitise a particular campaign, but rather to open up a space within digital gaming where new approaches and methods informed by Global Citizenship and Development Education can emerge. Rather than this space modifying existing games or adapting game platforms to serve Critical Gaming, the suggestion is that new collaborative platforms need to be built from scratch based on values of inclusion, equality, respect, dialogue, creativity, and critical reflection. Flanagan sees such an initiative being led by games designers with a personal and political commitment to values of social justice, she refers to these as "*Conscientious Game Designers*". In line with Penix Tadson's (2019) commentary on the games industry more generally "*... the time has come to redefine video games and game culture from the perspective of the global south*" Penix Tadson (2019:26).

In advising activists how to challenge corporate colonialism within the technology sector Amrute (2022) suggests a number of things which need to be bedded into any anti-oppressive initiative. Rather than be resigned to corporate or repressive state control over technological spaces she encourages activists to undermine tech colonialisms, and "*reframe the stories of tech inevitability and fixedness in our patterns of engagement with the world*" (Amrute 2022:2). What we intend to do needs to be reflected in how we go about doing it. Amrute (2022) proposes the adoption of principles to be applied in the decolonisation of technology. The following draws from this and other work cited in this paper to apply such principles when considering the use of games in global citizenship and development education.

1. *Values based design:* Global citizenship and development education principles must be central to the technology and methods being used. The approaches need to be constantly critiqued, reimagined, practiced and repeated. There should be a seamless congruence to the level whereby the digital spaces feel like a development education spaces and people become attuned to this as a way of being.
2. *Join with existing movements:* As outlined movements do exist that are actively trying to break the bind between tech, data and exploitation by using technology to address community generated questions and create digital platforms based on cooperative, democratic principles. Partnering with such groups and building interdisciplinary alliances would be important in developing practice and resources as well as ensuring the initiative remains true to Freirean principles.
3. *Solidarity across the Margins:* Amrute (2022) also recommends that one should refuse to engage with technology and organisations which compromise your values and to actively share your knowledge and technology with others, particularly those on the margins. It is important that any such movement grows from the margins, particularly from the Global South and people who are excluded from political discourse in the Global North.
4. *Facilitating Global Citizenship and Development Education Methods:* Any such space would need to be based on Global Citizenship and Development Education values, theory and practice. This process should include activists and technologists who are prepared to embark on a collaborative journey of discovery and action in order to shape a space for social change.
5. *Transference to the Real World:* One of the challenges in operating within a virtual environment is that peoples understanding and activism may be restricted to that space. This brings us to the concept of transference which relates to how we bring experiences, understanding, skills, analysis and a commitment to act, from the virtual into our real lives and visa versa. (Khasawneh et al. 2024) It is

necessary to acknowledge that players live in the real world, they access the metaverse from real rooms, on real streets, within real communities under the protection of real governments, or not, as the case may be. As it is for refugees, the stateless, the homeless, the disenfranchised, the poor and the oppressed. Frasca, (2019) reminds us that "*The space inside the screen negotiates its meaning with the space that surrounds it*". If games are to be a medium for social change they need to negotiate the relationship between the liminal and the real, ensuring that dialogue, reflection and action within the game initiates dialogue, reflection and action within physical communities and societies.

10. In Conclusion

This paper has presented the challenges inherent in using computer games in global citizenship and development education. It also highlights the power and proliferation of the medium and as such one which cannot be overlooked and indeed one which could have a profound and constructive impact in this discourse. It is also apparent through this review that it is not only the content of computer games which needs to be addressed but the structure of how they are designed, developed and distributed. The recommendations presented require a mobilisation of Development Educators, Conscientious Games Designers and Activists on the margins in the global south and north with the shared vision of building an alternative games ecosystem which challenges the Colonial hegemony which has defined discourse in games and development to this point.

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Engagement Strategies in a Peer-quizzing Game: Investigating Student Interactions and Powergaming

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Abstract: Educational games are a popular means of engaging students in learning activities. However, students in game-based learning environments often engage in powergaming to reap undeserved rewards and spoil the experience of their peers. This may happen when the students pretend to engage in game activities or collude with other students, exploiting the game settings and rules to maximize their points. In this explorative study, we investigate powergaming in three settings of an asynchronous online multiplayer peer-quizzing game in a blended learning setting – a first-year programming class in a Canadian university. We designed three experimental settings with three versions of an education game which allowed different levels of powergaming. The between-subject study involved three experimental groups: Group 1 used a game version where they received weekly performance feedback and tips on how to improve their performance, Group 2 used a game version with access to an existing resource bank, allowing them to maximize the number if their activities in the game, and Group 3 served as a control group with no additional interventions. The research aimed to investigate 1) the association between the power gamers' activity, their grades and their preference to work alone or in a group, 2) the types of activities (type of quiz questions) most used by power gamers, and 3) which game setting was the most conducive to power gaming. The results show that better grades are not associated with higher activity levels in the game. Students who engaged in more diverse types of game activities had better learning outcomes The control Group 3 had the highest average grades. As we expected, Group 2 engaged in the highest number of activities, esp. in creating questions, a form of powergaming. The qualitative results showed that contrary to our assumption the powergamers in Group 2 was not harmful, because it created a rich set of resources in the game and fostered student engagement in the game.

Keywords: Serious Games, Game-based Learning, Peer-quizzing, Engagement

1. Introduction

Game-based learning (GBL) has emerged as a promising pedagogical approach that harnesses the engaging and motivating power of games to facilitate learning (Marques and Pombo, 2021; Riet, 2019). By incorporating game elements, mechanics, and principles into educational contexts, GBL aims to create immersive, interactive, and enjoyable learning experiences that promote active participation, problem-solving, and knowledge acquisition (Bösche and Kattner, 2011). The growing interest in GBL in blended learning is driven by the recognition that traditional, passive lecture-based learning practices often fail to capture and maintain learners' attention, resulting in poor retention rates (Calle et al., 2019; Soo and Lee, 2022).

In contrast, well-designed educational games have the potential to tap into learners' intrinsic motivations, reduce lapses in attention, and maximize knowledge retention and prevent learners from blanking out during exams (Calle et al., 2019; Iverson, 2019). The success of GBL depends on various factors, including the visual and audio impact of the game, the appropriate blend of challenges, rewards, learning content, and assessment units, and the overall narrative structure that binds these elements together (Stefan et al., 2022; Wang et al., 2016).

In this paper, we study the gameplay behaviour of students playing three versions of an online asynchronous peer-quizzing game in a blended learning environment during one academic term. The game developed in our lab is called ToQ (Towers of Questions) (Kiron et al., 2019; Kiron and Vassileva, 2018). The game offers three types of quiz questions: multiple-choice questions (MCQs), true/false questions, and short answer questions. Students can create quiz questions, answer questions created by their peers, and review the questions they have already solved. The game rewards are points that can be earned by creating quiz questions and answering them correctly.

We wanted to explore if variations of the game setup that could make it easier to power-game would lead to increase in powergaming. We also wanted to explore if there is any relationship between the preferred studying mode (alone or group) of students and their activities in the game, including their preferred question types. The rationale for exploring this relationship is constructing the three types of question (MCQ, T/F, and Short answer) demands distinct thinking processes. For instance, in a multiple-choice question, the student needs to create

effective distractors. Students need to create T/F questions that are not easily apparent to their classmates. Short answer questions require more effort to evaluate the possible answers.

The participants were 1st year students in an Introduction to Programming course, who were randomly assigned to three groups each using a different version of the game. The first two groups, Groups 1 and 2, played versions of the game that included additional support: the version played by Group 1 included instructions and tips on creating good quiz questions and the version used by Group 2 provided a question bank from where students could choose and posting questions as their own. Group 3 played the game without additional supports.

The study has three primary objectives. The first objective is to explore which experimental group shows signs of hyperactivity or powergaming. The second objective is to analyse the relationship between the students' preference for learning (alone or in group), their in-game actions, and academic performance, with particular attention to the most active students who could be powergamers. The in-game actions include asking or answering questions and browsing the solved questions and the question bank (for Group 2). The third objective is to identify the most frequent categories of quiz questions (Multiple Choice Questions, True/False, and Short Answers) used by power gamers. Understanding the preferred question types will shed light on power gamers' learning strategies and preferences. By addressing these three objectives, this paper aims to contribute to the understanding of powergamers' behaviour, how effectively they learn and if they harm or benefit their peers in the context of a peer-quizzing game. The findings could inform the design of educational games.

2. Background

Game-based learning (GBL) has gained significant attention in recent years as an innovative pedagogical approach in higher education. By incorporating game elements and principles into educational contexts, GBL aims to create engaging, interactive, and motivating learning experiences for students (Guerrero-Quiñonez et al., 2023; Islam, 2017). The use of gamification techniques, such as challenges, rewards, competitions, and immediate feedback, can enhance learning effectiveness and promote active participation, collaboration, and problem-solving skills (Ceccarini and Prandi, 2022; Islam, 2017).

One of the key components of GBL is the use of rewards to motivate and reinforce desired behaviours and learning outcomes (Nipo et al., 2023; Perbawa and Rapiyanta, 2024). Rewards in educational games can take various forms, such as points, badges, leaderboards, virtual currencies, or unlockable content (Dong, 2023; Featherstone, 2022). However, the use of rewards in GBL is not without its potential drawbacks and negative consequences. An overemphasis on extrinsic rewards can undermine learners' intrinsic motivation, shifting their focus from the natural value of learning to the pursuit of external incentives (Kaldarova et al., 2023; Klit et al., 2020). This can lead to a superficial engagement with the educational content, where learners prioritize the acquisition of rewards over deep understanding and meaningful learning (Yu and Tsuei, 2022).

Another concern in GBL is the potential for students to exploit the game mechanics and reward systems in ways that subvert the intended learning objectives (Dong, 2023). Some learners may find ways to "game the system" by discovering loopholes, cheats, or strategies that allow them to earn rewards without genuinely engaging with the educational content. The exploitation of GBL by some students can have negative ripple effects on the learning experiences of their peers (Klit et al., 2020). When a significant portion of the learner population engages in exploitative behaviours, it can disrupt the collaborative and supportive learning environment that GBL aims to foster (Kaldarova et al., 2023). Other students may feel pressured to adopt similar strategies to keep up with their classmates, leading to a breakdown in the social dynamics and a loss of trust and cooperation within the learning community.

To mitigate these issues, educators must carefully design and implement GBL activities, striking a balance between intrinsic and extrinsic motivation (Fu and Yu, 2006). This can involve using a variety of reward types, such as social recognition and meaningful feedback, alongside tangible rewards (Caeiro-Rodriguez et al., 2021). Additionally, educators should establish clear guidelines and expectations for student behaviour, emphasizing the importance of academic integrity and genuine engagement with the learning material.

Game-based learning has the potential to revolutionize higher education by creating engaging and interactive learning experiences. The use of rewards can be a powerful motivational tool. Still, it is essential to consider the potential negative consequences of an overreliance on extrinsic rewards and the exploitation of the system by some students. By carefully designing GBL activities and fostering a culture of intrinsic motivation and academic integrity, educators can harness the benefits of game-based learning while minimizing its drawbacks, such as powergaming.

3. Experiment Design

This section provides an overview of our research methodology, including details on how we recruited the participants, designed the experiment, and collected the data. This study was granted approval by the behavioural ethics board of our university, identified as BEH ID-101. Students were recruited from a first-year programming language course. Participation in the study was voluntary, and as an incentive, students who actively participated in the game had the opportunity to earn up to five percent of their final grade as participation marks in the class. Students who decided not to be a part of the study had the five percent grade added to their final exam's weight.

After giving their informed consent, the students were directed to a pre-survey, which collected their information about their study preference. After removing those who opted out of the study or dropped the class, n=128 students participated in the study. The students were divided into three groups at random, with each group playing a different game version. The first group, Group1 (n=41), received feedback and suggestions from moderators. The second group (n=47) had access to a pre-existing question bank, and the third group, Group 3 (n=40), served as the control group, playing the game without support. The uneven number of students in the groups is a result of some students dropping out of the game or the course during the study.

The students were given pseudonyms to participate anonymously in a peer-quizzing game themed as a tower defence game. The game's theme revolves around students creating quiz questions (towers) based on the course material they are studying, answering the questions (attacking the towers) created by their peers and browsing the already answered questions (conquered towers). The game rewards are points that can be earned by creating quiz questions and by answering questions correctly. The students played the game alone and asynchronously using their computer's web browser. They logged in to the game using the credentials provided to them after signing up the consent form. There was no chat, or another communication channel provided for them in the game environment. The game interface featured segments tailored for the experimental groups. When students logged in to the game, they saw their version of the dashboard. For Group 1, weekly feedback was shown to the students including tips for creating good questions. A link to an existing question bank was shown only to Group 2. Group 3 was shown the game's interface without any extra support.

To gather comprehensive data for the study, we collected information from various sources. In addition to the pre- and post-study survey responses, we obtained gameplay data for each student. This data included the number of questions each student created and answered throughout the game. Furthermore, we collected a detailed log of all the events that occurred within the game. This log contained the specific questions students created, answered, and viewed, along with precise timestamps indicating when they signed in and out of the game.

4. Data Analysis and Results

The students' game performance, preferences for working alone or in a group, and class performance are presented in Tables 1 - 3. The activities performed by each experimental group in the game are summarized in Table 1. Group 2, with 47 students, had the highest levels of activity across all three metrics - questions created (45.31%), questions answered (33.38%), and questions browsed (39.35%). Group 1, with 41 students, had the lowest activity in answering (24.64%), and browsing (27.77%). Group 3, with 40 students, created fewer questions (26.42%) than the other two groups, but answered the highest number of questions (41.98%). This may suggest that group size alone does not determine activity levels, and there may be other factors influencing student engagement with the game, such as the different game supports provided to each group and the dynamics created within each group. Group 2 with the access to a question bank was the most active in creating new questions (which was easier, having access to a question bank) and engaged in browsing solved questions.

To determine if there are significant variations between groups, we need a breakdown of solo vs. group work preferences. Table 2 displays each group's preference for working individually or in a group. Interestingly, most students in Groups 2 and 3 preferred working alone (55.32% and 62.50%, respectively), while the students in Group 1 were evenly split between group and solo work preferences.

The average percentage grades for each group on assignments, lab tasks, and their final grade are presented in Table 3. Group 3 had the highest average scores across all three measures, with an 88% on assignments, 90% on labs, and an 81.46% final grade. The scores of Group 1 and Group 2 were similar, though Group 2 slightly outperformed Group 1 in the average final grade (75.38% vs 74.82%).

Table 1: Summary of game activities by experimental groups.

Group 1 (n=41)	Created	229	28.27%
	Answered	189	24.64%
	Browsed	1394	27.77%
Group 2 (n=47)	Created	367	45.31%
	Answered	256	33.38%
	Browsed	1976	39.35%
Group 3 (n=40)	Created	214	26.42%
	Answered	322	41.98%
	Browsed	1651	32.88%

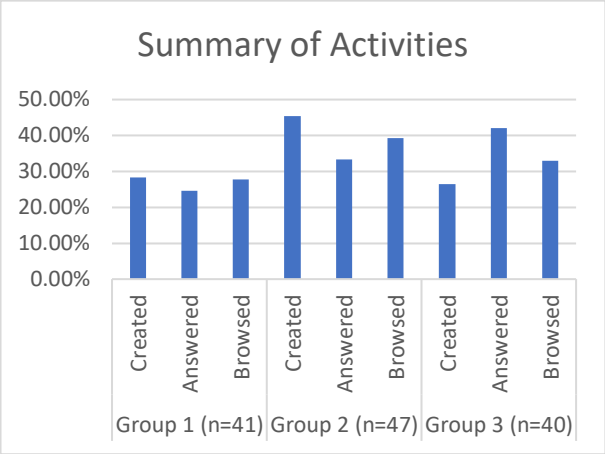
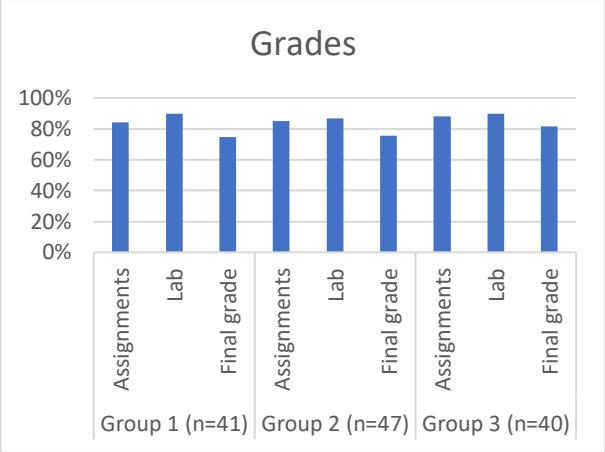


Table 2: Students' preference for working alone or in a group by experimental groups.

Group 1 (n=41)	Group	20	48.78%
	Alone	21	51.22%
Group 2 (n=47)	Group	21	44.68%
	Alone	26	55.32%
Group 3 (n=40)	Group	15	37.50%
	Alone	25	62.50%

Table 3: Average percentage of grades of students in experimental groups on assignments, lab tasks, and final grade.

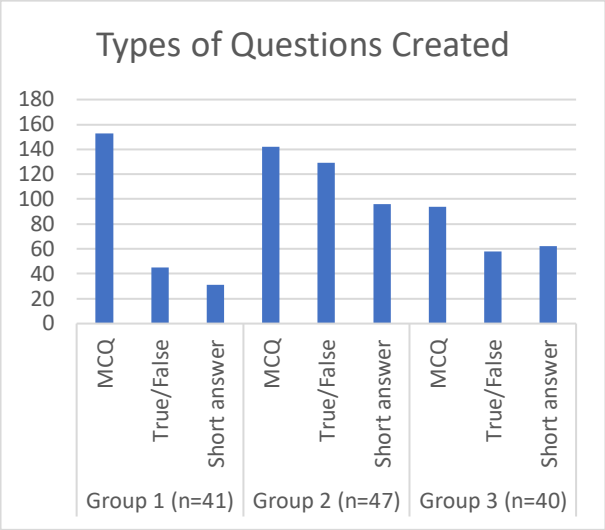
Group 1 (n=41)	Assignments	84%
	Lab	90%
	Final grade	74.82%
Group 2 (n=47)	Assignments	85%
	Lab	87%
	Final grade	75.38%
Group 3 (n=40)	Assignments	88%
	Lab	90%
	Final grade	81.46%



The type of questions asked by the students could impact game dynamics and engagement levels. Table 4 shows the breakdown of the types of questions - multiple choice, true/false, and short answer - used by each group in the game. Group 1 created the most multiple-choice questions (153), and much fewer true/false (45) and short answer (31) questions. Group 2 had a more even split between multiple choice (142), true/false (129) and short answer (96). Group 3 created multiple-choice the least (94) with a fairly even number of true/false (58) and short answer (62) questions. This provides insight into the question style preferences of each group. Group 1 favoured multiple choice, while Group 3 used it the least. Group 2 utilized all three question types more evenly.

Table 4: The types of questions created by each experimental group.

Group 1 (n=41)	MCQ	153
	True/False	45
	Short answer	31
Group 2 (n=47)	MCQ	142
	True/False	129
	Short answer	96
Group 3 (n=40)	MCQ	94
	True/False	58
	Short answer	62



The correlation coefficients for the different factors in each experimental group can be found in Table 5. We calculated the correlation coefficient using various factors including students' preferences for working alone or in a group, the number of questions asked, answered, and browsed, and the grades obtained (assignment grades, coding lab grades, and their final grade).

Table 5: The correlation coefficients for each of the experimental groups.

		Preference Group/Alone	Asked	Answered	Browsed	#Assignments	#Codelab	#Final Grade
Group 1	Group/Alone	1.000						
	Asked	0.070	1.000					
	Answered	0.261	0.298	1.000				
	Browsed	0.228	0.443	0.747	1.000			
	#Assignments	-0.052	0.243	0.240	0.310	1.000		
	#Codelab	0.051	0.143	0.154	0.179	0.555	1.000	
	#Final Grade	-0.138	0.020	0.110	0.220	0.786	0.579	1.000
		Preference Group/Alone	**Asked**	**Answered**	**Browsed**	**#Assignments**	**#Codelab**	**#Final Grade**
Group 2	*Group/Alone*	1.000						
	Asked	-0.103	1.000					
	Answered	-0.179	0.577	1.000				
	Browsed	-0.249	0.733	0.897	1.000			
	#Assignments	-0.110	0.246	0.205	0.291	1.000		
	#Codelab	-0.085	0.273	0.189	0.281	0.776	1.000	
	#Final Grade	-0.227	0.096	0.234	0.265	0.855	0.701	1.000

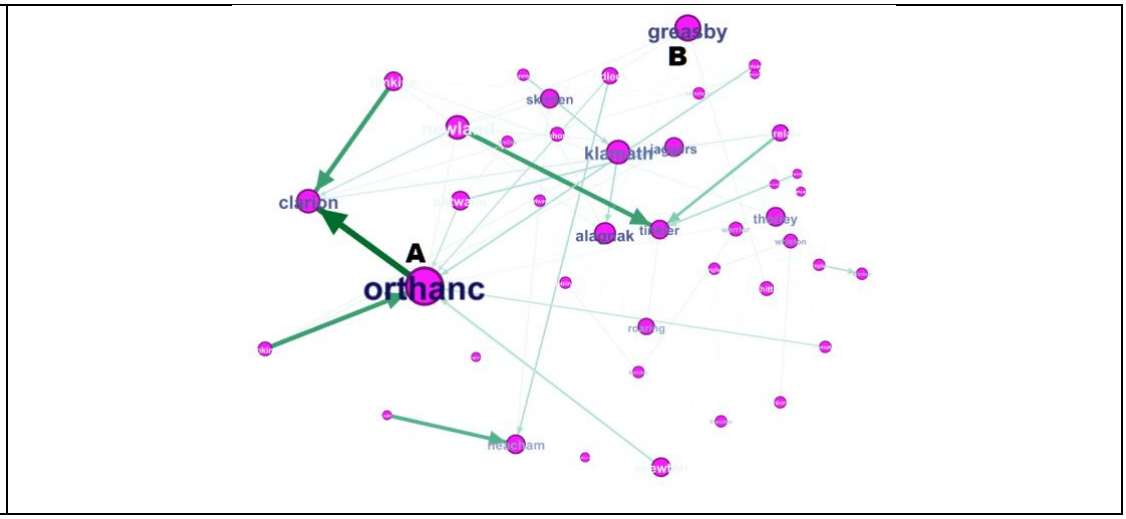
		Preference Group/Alone	Asked	Answered	Browsed	#Assignments	#Codelab	#Final Grade
Group 3	*Group/Alone*	1.000						
	Asked	0.044	1.000					
	Answered	-0.011	0.757	1.000				
	Browsed	0.039	0.826	0.900	1.000			
	#Assignments	-0.219	0.280	0.182	0.254	1.000		
	#Codelab	-0.212	0.242	0.189	0.240	0.808	1.000	
	#Final Grade	-0.368	0.178	0.160	0.237	0.852	0.820	1.000

Across all three groups, strong positive correlations can be seen between the game activity metrics, especially questions browsed and answered. The likelihood of questions being answered increases with higher levels of browsing questions. Assignment grades, lab scores, and final grades also tend to be strongly correlated, which is logical as assignments and labs are components of the final grade. Interestingly, game activities have only weak to moderate positive correlations (varying between and 0.020 to 0.291) with assignment, lab and final grades performance. The highest correlations can be found in Group 2, with correlations of 0.291, 0.281 and 0.265 between questions browsed and assignments, labs, and final grades, respectively. It is interesting to note that unlike in Group 1 and 2, in Group 3 the correlations between the grades and the number of questions asked are higher than those for questions browsed. This could suggest that creating new questions without any support has a stronger effect on learning performance. Yet, the differences are small. Overall, it seems that in-game activities do not readily translate to higher academic performance in assignments and exams.

In Group 1, there is a negative correlation (-0.138) between students' preference for working alone or in a group and their final grade, indicating that those who prefer group work tend to have slightly lower grades. The preference for working alone or in a group in Group 2 and Group 3 is negatively correlated with variables such as answered, browsed, and final grade. This indicates that students who prefer group work tend to have lower engagement in these activities and possibly lower final grades.

Figure 1 shows the social network of interactions between students in each experimental group. The directed edges represent interactions (solving a question created by the other student). The size of each node represents it centrality (i.e. the number of interactions with different peers).

Group 1



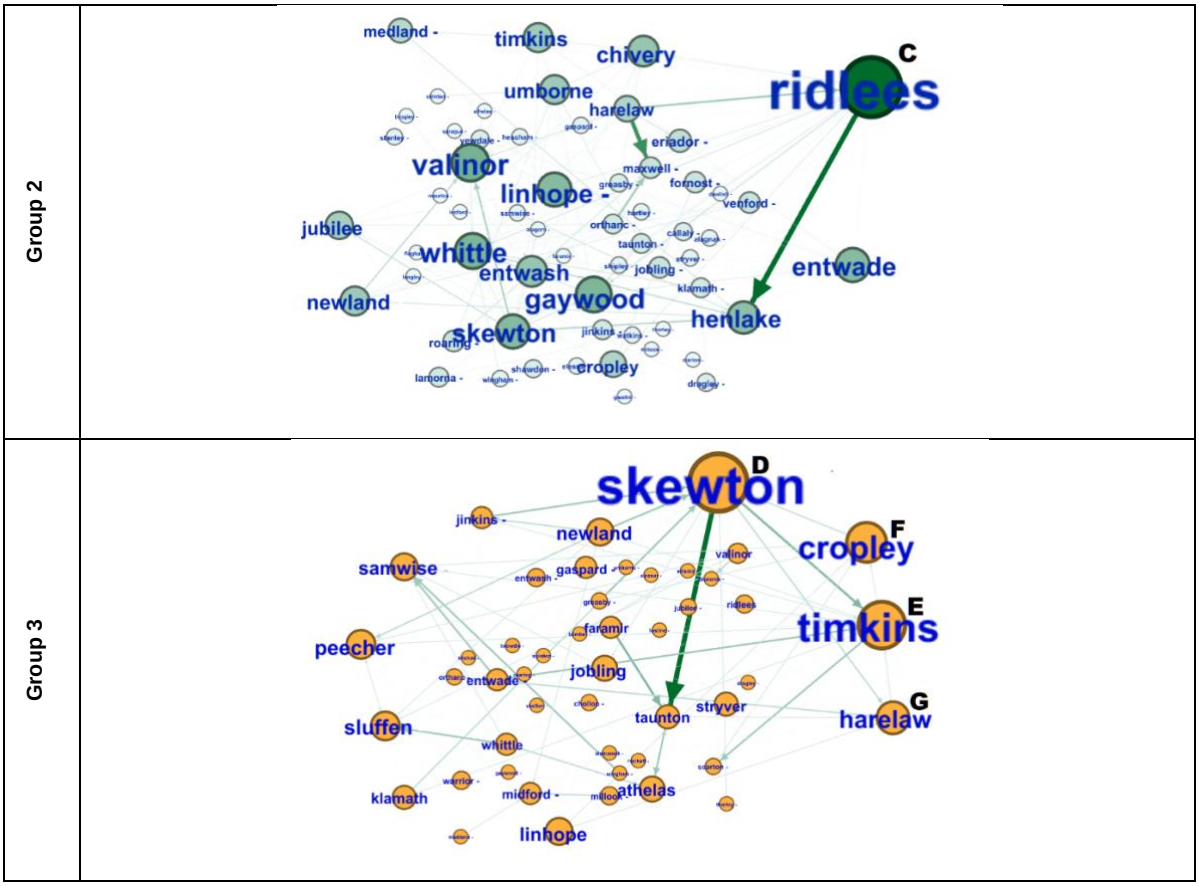


Figure 1: Network graph of the experimental groups. The nodes are the students, and the edges show their interactions with other students. The size of the node corresponds to the number of questions created.

When comparing the activity of students in terms of question creation, which could be a sign of powergaming, Group 1 (Density: 0.043) has two visibly large nodes (A and B), Group 2 (Density: 0.045) has one large Node (C), and Group 3 (Density: 0.048) has three large nodes (D, E, and F). The thickness of an edge represents repeated interactions between two nodes that may potentially signify a collusion (another forum of gaming). We observe that in Group 1 there are 5 to 6 pairs of students who engage in repeated interactions, while in Group 2 and 3 there are only 2-3 such pairs.

5. Discussion and Limitations of the Study

The findings from this exploratory study offer several points for discussion regarding student behaviour and performance in educational games or online learning platforms. One key area of interest is the relationship between activity levels and grades. Although one might assume that increased engagement leads to higher scores, these findings indicate a more complex relationship. The activity levels of Group 2 were the highest across two out of the three metrics in Table 1, and they also had the second densest network of student interactions in Figure 1. However, this group had average grades that were neither high nor low compared to the other two groups.

In contrast, Group 3 had the lowest activity in two out of the three metrices according to Table 1, and highest activity levels and the most connected network, and they obtained the highest average grades. This brings up uncertainties regarding the form and level of engagement that promotes optimal learning. It is possible that Group 3's approach of selective, focused interactions and a preference for solo work allowed for deeper processing of the material, leading to better outcomes. The results of our study are consistent with Tejada-Simon's research (Tejada-Simon, 2024). They reported there was no statistically significant connection between student engagement with the games and their course grades.

Another notable point is the varying use of question types across groups. Group 1's heavy dependence on multiple-choice questions and their avoidance of short answer questions, coupled with their lower average grade, indicates that the choice of question format could affect the learning process. Short-answer questions

might encourage deeper understanding compared to multiple-choice questions. Utilizing a variety of question types may have helped Group 3 perform better. Another factor is whether someone likes to work alone or in a group. Group 3, which had significantly more students who preferred working alone than students who preferred working groups, performed better than the other two groups where the student preferences were more balanced. However, the correlations in Table 5 don't show a clear, consistent relationship between group work preference and performance metrics.

Finally, we noticed some evidence of powergaming by a few students in all groups. However, we did not observe any negative effects of powergaming on the other students. On the contrary, it seems that the contributions by the powergamers were beneficial to other gamers. First, these students created a positive example through their gameplay behaviour. Even in Group 2, where they had a source of questions they could use, they did not copy directly questions from the database, but tried to improve them. By creating many questions, they made sure that there were always questions available to other students that they could answer. Second, powergamers can generate imperfect questions that may stimulate other players to adapt and improve them. This involvement can result in deeper exploration of subjects, exposure to diverse viewpoints, and a more enriching learning experience for all. Third, powergamers may introduce topics not taught in the class, adding unique questions to the question bank of the game. The question bank can become a supplementary learning resource. Finally, the presence of powergamers raises the overall game interaction and energy in the class, fostering a more dynamic and stimulating learning environment that benefits everyone.

It's important to consider the limitations of the study. The sample sizes of each group are relatively small, with 40-47 students each. Larger samples would provide greater confidence in the patterns observed. The specific design of the educational game or platform could also skew behaviours and outcomes. Despite these limitations, this experiment offers valuable insights into how different interaction patterns and preferences among students relate to learning outcomes. It challenges assumptions that more activity and interaction are always better and highlights the need to consider the type and quality of engagement. Future research will explore these dynamics in more depth, with larger samples and a wider range of academic contexts.

6. Conclusion

The study explores the complex connections among student behaviours, preferences, and performance in an educational game. A comparison of the engagement and performance of three groups of students under different game conditions, considering activity levels, question type usage, solo/group work preferences, and interaction patterns, uncovers several important findings. Higher activity levels do not necessarily translate to better grades. Although Group 2 had the highest levels of creating, answering, and browsing quiz questions, their average grades were only moderate. Meanwhile, Group 3 had lower activity but the highest grades. This suggests that the quality and type of engagement may be more important than sheer quantity.

The type of questions created by students may influence learning outcomes. The lowest average grades were observed in Group 1, which heavily utilized MCQs and avoided true/false and short answer questions. In contrast, Group 3's more balanced use of all question types aligned with their higher performance. This indicates that a mix of question types, including those that require articulating understanding, may be beneficial. The highest preference for solo work was observed in Group 3, which had the highest average grades. Correlations between group work preference and performance metrics were inconsistent across groups. This suggests that while these preferences shape interaction patterns, they don't necessarily dictate outcomes.

Student interaction patterns, as visualized in the network graphs, show some alignment with activity levels and grades. Group 2 performed well in activity levels and network density but had average grades. Despite having the lowest activity compared to Group 2, Group 3 achieved the most connected network, and higher average grades. Within groups, browsing and answering more questions correlated with better assignment and lab scores, which in turn correlated with higher final grades. Active engagement with course content, such as exploring and attempting questions, could enhance individual learning. Furthermore, the bigger nodes belong to the most active students who asked the most questions. Despite their tendency to be overactive, which could be considered as powergaming, they may have played a beneficial role in the game.

Future research could build on these findings by exploring similar questions with larger, more diverse samples and across different academic subjects and platforms. Qualitative data, such as quality analysis of the questions created (using experts or trained large language models), student interviews and content analysis of the interactions (attempted answers to questions, time to first correct answer, etc.), could provide deeper insight into the factors driving these patterns. This study emphasizes the importance of carefully designing and

evaluating these platforms, considering activity levels, question types, interaction patterns, and individual preferences. Furthermore, while powergamers are usually seen as troublemakers in game-environments, our findings suggest that may be beneficial depending on the type of games. While their overactivity might be a concern for us, the overactive users were the ones responsible for providing questions for the other students to answer.

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New Age Mages: An Interactive Way to Explore and Subvert Gender Biases

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Abstract: From a young age, children are exposed to societal standards of gender and gender roles and, by extension, inherent sex-based biases, which can become inculcated into their worldview. These biases affect their daily lives negatively in ways that can seem almost natural unless specifically pointed out. Table Top Role Playing Games (TTRPGs) are pen-and-paper games that revolve around collaborative storytelling in a shared, collectively imagined and built world, usually involving 2 to 5 players. TTRPGs provide a safe, controlled environment to mimic social interactions in a way that video games and other forms of media cannot. This paper introduces a new TTRPG, *New Age Mages*, aimed at a younger audience, with the goal of introducing the concept of biases and helping them to see things from a different perspective. In *New Age Mages*, players interact with a world where magic is commonplace as students that have recently unlocked their magic, while a Game Master (GM) narrates the world as determined by the players' choices. The game's magic system allows it to mimic the influence and/or impact of modern-day gender roles and biases without referring to them directly while remaining simple and easy to learn for a new player. The game also aims to subtly incentivise the Players to make decisions that would be different from what they might usually make, and promote trying to understand the others' points of view. We believe this game will be useful for those seeking to help children gain a better understanding of gender roles and their subversion. We use a questionnaire based on the Gender Role Attitudes Scale (GRAS) to measure the impact gameplay has on players' ideas of gender roles. We also test the game with some initial gameplay experiments among a smaller audience that is more familiar with TTRPGs and present the results. Our work explores not only the ability of TTRPGs to influence perspectives and opinions, but also doing so specifically in the space of understanding gender roles among a younger audience.

Keywords: TTRPG, Gender Bias, Games-Based Learning

1. Introduction

1.1 Table Top Role-Playing Games

Table Top Role-Playing Games (TTRPGs) are collaborative storytelling games that add elements of randomness and gamification to what would otherwise be a linear discourse. Usually, in a TTRPG, the group consists of a Game Master (GM) and multi-players who create and play Player Characters (PCs). The GM acts as the facilitator, guiding gameplay, building the world and narrative, while ensuring the rule adherence. TTRPGs provide an immersive experience for players as they explore a sandbox world (presented by the GM) through their PCs. This allows them to explore concepts and ideas they may not be able to in real life. Alongside presenting the world and Non-Player Characters (NPCs), the GM creates a custom story built around the PCs to explore and play through.

1.2 Gender Roles and Biases

Gender roles (and, by extension, gender biases (implicit and otherwise)) are so heavily ingrained into the world around us it affects us in smaller, almost imperceptible ways. While there have been and are movements attempting to shift worldviews to be more open-minded, this may take many lifetimes. Gender biases affect everyone (no matter how much we may believe otherwise) and, therefore, we feel we should attempt to foster change. With this intent, we have created a TTRPG to attempt such. In this paper, we detail the specificities of the gameplay that lend themselves to this effort and the preliminary experiment we conducted to measure if it has the intended effect of shifting implicit gender biases towards a more open-minded point of view.

1.3 Motivation

TTRPGs are a highly social activity and have long been established in the therapeutic and psychological industries to be very powerful tools (Hawkes-Robinson, 2011). Additionally, they are currently gaining traction in fields such as education to enhance the learning experience (Hawkes-Robinson, 2011). While there are comparatively

few studies on RPGs (of which TTRPGs are a subset), we believe there is enough supporting evidence to pursue this direction of intervention.

2. Background

Games-based learning has gained much traction due to the variety of skills it can impart to learners. Studies have found that, while there is empirical evidence to support the effectiveness of this, games must be built for learning-based outcomes to truly be effective (Hainley et al, 2016). However, there are insufficient studies comparing traditional teaching to games-based learning (Hainley et al, 2016). The study of serious games as educational tools has found them effective, with games imparting higher skills requiring a longer playtime to master (De Jans et al, 2017). One study by Mortara et al (2014) used pre- and post- questionnaires to evaluate the effectiveness of a serious game on cultural awareness (Icura) and found that designing with the outcome in mind allows for the mechanics to be designed correspondingly and also a better understanding of the data collected and analyses to conduct when evaluating the game.

Garcia-Cueto et al (2014) measure sexism against women but not men, and do not consider it from the perspective of gender equality. They introduce a scale that considers two factors: Transcendent and Sexist attitudes, which represent the equality-based and sexist attitudes respectively, in order to address this gap.

TTRPGs have traditionally been considered social interactions or collaborative (rather than competitive), and let players progress skills such as creativity (Coe, 2017; Dyson et al, 2016) and social skills (Henning et al, 2024). It has also been found that people who play TTRPGs are more empathetic than their counterparts (Rivers et al, 2015; Merilainen, 2013). Additionally, TTRPGs can facilitate exploration of gender identity, as shown in George et al (2023). A work by Gutierrez (2017) takes a look at TTRPGs as an effective therapeutic tool for adolescents in many aspects. Additionally, it has been found that engagement is important in therapy as patients that are more involved more easily reach recovery (Abdel-Salam and Gunter, 2013). TTRPGs allow for higher engagement as players can easily identify with their PC and use them as a buffer to explore ideas in a safe space, allowing players freedom to experiment with things such as gender identity (many modern TTRPGs are non-discriminatory) and the like. However, players tend to, after a variable period of experimentation, prefer to play characters closer to themselves (as shown in Woodley (2024)). This allows practitioners to tailor narratives as necessary.

Additionally, a study on the communication aspect of TTRPGs (Adams, 2013) found that players' real world needs could be satisfied through in-game interaction i.e. the application of TTRPGs has use for multiple aspects of a person's life (Gutierrez, 2017). The findings and analyses from prior studies using games for knowledge transfer, social interactions, and awareness creation form the basis of the design of the TTRPG we developed and tested. To the best of our knowledge, our application is unique and priorly untested.

3. Methodology

The methodology for this experiment is two-part. One part is the game design, as the components of the game have been built specifically for our stated purpose, with a few significant shifts from TTRPG standard practice. The other is the questionnaire used to measure implicit gender bias and the effect of brief exposure to gameplay on participants' views.

3.1 Methodology: Game Design

New Age Mages (NAM) is a TTRPG for 3-5 players (including a GM) set in a world where all people gain magic at the age of 16. The magic is elemental and expresses itself in two ways: waxing (create and destroy the element) and waning (manipulate and weave the element), which students are taught to harness. Players play students who have recently unlocked their magic and are beginning to utilise it.

The mechanics for this game drew inspiration from Apocalypse World (Baker, 2013) (the playbook configuration) and the Belonging Outside Belonging system (Alder, 2020) (tokens and their usage) via Apocalypse Keys (Nedjadi, 2022) (the existence of Conditions). The binary magic system and the way Conditions are handled (amongst other things), are unique to the game (although the magic system does use a set of basic elements as

its foundation). However, as this game was specifically formulated for this project, the various aspects of the game design form a cohesive system that helps nudge players (and PCs) towards certain behaviour.

The game is set in a modern fantasy setting, which is explained in detail in NAM. NAM, as with most TTRPGs, is an open-world setting so players are encouraged to advocate for their beliefs. To this end, players can push back using moves such as *Interact with Someone* or any other move that fits the fiction.

During the experiment, for the sake of consistency, all groups followed the same overall sequence of events, both in terms of gameplay and the experiment itself.

3.1.1 Gender Roles and Portrayal

NAM uses thinly veiled gender role equivalents - its magic system. The magic system is elemental in nature (using 8 elements as Playbooks) and there are two main ways in which magic is expressed, waxing and waning magic. Each PC is randomly assigned their expression of magic, to reflect that biological sex is not a choice.

The abilities of magicians with waxing and waning magic and how they are treated in-game are a direct reflection of real-life gender roles. Waxing magicians are considered to be stronger, more competent, and better suited for positions of power. Waning magicians are considered to be weaker and less powerful, and it is believed that they should only occupy positions supporting waxing magicians. In gameplay, the GM portrays the world and its residents as favourable towards waxing magicians and dismissive of waning magicians.

While the two kinds of magic users with different social standings and an inherent social preference for one of these two types could be used as a depiction of any kind of bias, (e.g. race, sexual orientation, etc.) we focus on gender identity, since biological sex (which is incorrectly correlated directly to gender), is often perceived to be a clear binary between male and female, despite this being untrue. Gender identity and presentation are not always related to assigned sex (and each other), and transgender individuals (both binary and non-binary) are individuals who do not identify with the gender assigned at birth. Further, gender bias is extremely common and both the GM and the players are likely to have come across this.

While other games such as Monsterhearts (Alder, 2017), Thirsty Sword Lesbians (Walsh, 2021), and Bluebeard's Bride (Whitney, Kelly, Richardson, 2018) all explore queerness, femininity and a lack of agency, NAM is directed in its approach and expects a younger and less familiar playerbase. The goal of making the waxing and waning magic systems separate from the gender of the player characters is to emphasise how arbitrary the binary division can feel when it is not something one is exposed to and internalised. Additionally, the biases portrayed in the setting and shown in the game design (past just waxing and waning magic) are reflective of these gender biases.

3.1.2 Moves

In NAM, there are 3 types of moves: Basic Moves, Mage Moves, and Roleplay Moves. The Basic Moves are moves that every player has access to at all times (so long as triggering conditions are met). They add an element of randomness to what would otherwise be a linear writing process. There are 5 Basic Moves - together they cover the range of general probabilistic actions a PC might take.

Mage Moves and Roleplay Moves are unique to each expression of magic (waxing and waning magicians have access to different moves). The Mage Moves allow the PCs to access their magic. The Roleplay Moves influence player behaviour - providing benefits for having their PCs act in a certain way (something we hope carries over to the players themselves in the real world). There are 3 options each for Roleplay Moves, and players choose 1 when creating their character. This cannot be changed.

3.1.3 Roleplay Beats and Conditions

Roleplay beats give players Tokens. Each Roleplay Beat encourages positive behaviour in the PCs, and meeting these Roleplay Beats allows the player to gain 2-4 Tokens each time. There is no maximum limit to the number of Tokens players can hold at a given time.

While many TTRPGs have systems for combat, NAM does not as physical conflict is not something we wish to encourage. Instead of a physical harm mechanic, NAM features Conditions, which are emotional effects that

befall a character. Examples include Scared, Uncertain, etc. The GM asks a player to mark a specific Condition (as appropriate) if the fiction requires it.

The details of each playbook's Roleplay Beats and Conditions are found in NAM.

3.1.4 Rolls and Tokens

NAM uses 2 six-sided dice to induce randomness (2d6). When a player rolls, they decide to spend up to 2 Tokens and roll the dice. After rolling, they can choose whether to add or subtract the Tokens spent. The Tokens must be spent in one direction i.e. spending 2 tokens means a player cannot add and subtract 1, leaving them with the same result.

Under specific circumstances, the GM may ask the player to roll with Benefit or Consequence, in which case the player rolls 3d6 with Tokens and removes one die of their or the GM's choice (if rolling with Benefit or Consequence respectively). The aim of these rolls is to give/take power from the player, depending on whether they are rolling with Benefit or Consequence.

There are 3 success tiers to NAM moves. Success tiers are how the results of the rolls are interpreted.

[0, 5] is an undersuccess. A PC's actions fail because their efforts were somehow insufficient.

[6, 8] is a success. A PC's actions succeed in the way they intended.

[9, 14] is an oversuccess. A PC's actions fail because their efforts were over-exuberant.

3.1.5 Changes to Drawn-Upon Systems

In Apocalypse World (Baker, 2013) and, most Powered by the Apocalypse (PbtA) games, playbooks provide archetypes for players when creating and playing their characters. In contrast, NAM uses playbooks to allow players to choose the elemental type of magic they use. While each playbook has a unique combination of Conditions, all other inter-playbook differences are cosmetic in nature. This was done in the interest of simplicity for both younger audiences and newer players.

While Apocalypse Keys (Nedjadi, 2022) has a unique combination of Conditions that we drew upon, the Conditions in NAM are far less hard-hitting. The game mechanics of Apocalypse Keys have consequences if all 4 Conditions are marked and they may only be cleared via specific moves. In contrast, in NAM there are no special consequences to marking all 4 Conditions and players may clear a Condition at any time by spending 3 Tokens.

3.1.6 Improvements to Initial Game Design

Due to player feedback, a few mechanical changes to roll and Token systems were made to NAM to increase playability.

Initially, we used 3d6 with the following tiers:

[3, 6] as an undersuccess

[7, 10] as a success

[11, 15] as an oversuccess

We found that reducing the dice rolled to 2d6 made the tokens more consequential.

Additionally, previously players could choose how many Tokens to spend before the roll, up to 3 Tokens and these could only be added. The change in the amount of Tokens players could choose to spend up to (from 3 to 2) was a direct consequence of the change in dice. Allowing players to choose to add or subtract their spent Tokens after having rolled added versatility, and made Tokens feel more effective.

During initial playtesting, we found that players felt that rolling with Benefit and Consequence (at the time, rolling and removing the die closest to/furthest from (in the case of Consequence/Benefit respectively) made no difference as had similar statistical effects (driving the result closer to a success). Therefore, this was changed to make Benefit and Consequence more effective.

After these changes were made, we found that players found gameplay more enjoyable.

3.1.7 Module

For this experiment, players were presented with the same module and series of events each time - they unlocked their magic, went through a day of classes with a minor interruption, went to the local mall, had a friend go missing, and then rescued them.

While in standard TTRPGs there are usually multiple modules for the sake of variance, we used a standard module and series of events to reduce variables.

3.1.8 Example Gameplay

As mentioned, TTRPG gameplay takes place almost conversationally, with the GM and players taking turns describing the environment and NPCs (the GM) and PCs (players). The following is an example of what gameplay may look like (please note that this is inspired by but not directly taken from a real playthrough):

Player 1 has a waxing pyromancer, Mirai and Player 2 has a waning hydromancer, Rafael. They meet their fellow student, Andrea, at school after they receive their powers.

Andrea: Hi Mirai! Congratulations on your powers. How does it feel?

P1(Mirai): It's great. Do you want to see?

Andrea: Absolutely.

P1(aside): I want to try to create a puff of flame in my hands

GM: That is a mage move, you can roll for Create.

P1: I am spending one token. Oh I rolled a 12, so I can't really save it, but the token brings it to 11.

GM: With an oversucccess, you create a large flame that licks the ends of your hair for many seconds before going out. Take the condition Reckless.

Andrea: Well, that was pretty impressive, especially for your first day. Do you want to volunteer for the school festival?

P1(Mirai): We'd love to. You can put both our names down, right Rafael?

Andrea: Oh…actually, we'd rather only have waxing mages for this. Wouldn't want to overwhelm anyone with the work, you know.

P2(Rafael): I'm sure I wouldn't be overwhelmed, but I'm not interested anymore.

Andrea: Well...Mirai we'd still love to have you! Think about it and let me know. Rafael…err…good luck, I'll see you around.

P2(aside): I'd like to use the water in my bottle to splash Andrea in the face.

GM: That's a mage move, you can roll for Manipulate.

P2: I'd like to spend one token. I rolled an 8 so I will add the token to make it a 9 and keep it a success.

GM: Good work. You pull the water from your bottle and it snakes through the air before splashing Andrea in the face and dripping onto the floor. They seem shocked.

P2(Rafael): I'm *so* sorry. I hope I didn't…overwhelm you.

3.2 Methodology: Questionnaire

The questionnaire used for this experiment was based on the Gender Role Attitudes Scale (Garcia-Cueto et al, 2015). The Gender Role Attitudes Scale (GRAS) measures implicit gender bias in two parts, with each question measuring one or the other:

Sexist Attitude: This measured attitudes that were sexist, i.e. gender-role conformative. There were 7 questions measuring this in each split segment of the questionnaire.

Transcendent Attitude: This measured attitudes that were assessed as defenders of equality from an egalitarian perspective. There were 3 questions measuring this in each split segment of the questionnaire.

Each question provided a simple statement and asked participants to rate them on a scale of 1 to 5, with 1 being 'heavily disagree' and 5 being 'heavily agree'. For a measure of open-mindedness, Transcendent Attitude answers should tend towards 5, while Sexist Attitude answers should tend towards 1.

While most of the questionnaire remained the same, there was a change in the way it was administered and one minor change: the questionnaire was split into two halves, with one being administered before gameplay and one post. Additionally, some questions were slightly reworded to have more precise intent (Table 1), as the original questionnaire referred to sex as the social marker for the gender binary rather than gender identity. For example, 'People can be aggressive and understanding, regardless of their sex' was reworded to 'People can be aggressive and understanding, regardless of their gender'.

Table 1: Changes made to the GRAS Questionnaire

GRAS Statement	Questionnaire Statement
People can be aggressive and understanding, regardless of their sex (T)	People can be aggressive and understanding, regardless of their gender (T)
People should be treated equally, regardless of their sex (T)	People should be treated equally, regardless of their gender (T)
GRAS Statement	**Questionnaire Statement**
Children should be given freedom depending on their age and how mature they are, not depending on their sex (T)	Children should be given freedom depending on their age and how mature they are, not depending on their gender (T)
Boys have the same obligations to help with household chores as girls (T)	Everyone has the same obligations to help with household chores, regardless of gender (T)
Household chores should not be allocated by sex (T)	Household chores should not be allocated by gender (T)
We should stop thinking about whether people are men or women and focus on other characteristics (T)	We should focus on characteristics other than gender (T)
My partner thinking that I am responsible for doing the household chores would cause me stress (S)	My partner thinking that I am responsible for doing the household chores would cause me stress (S)
The husband is responsible for the family so the wife must obey him (S)	The husband is responsible for the family so the wife must obey him (S)
A woman must not contradict her partner (S)	A woman must not contradict her partner (S)
I think it is worse to see a man cry than a woman (S)	I think it is worse to see a man cry than a woman (S)
Girls should be more clean and tidy than boys (S)	Girls should be more clean and tidy than boys (S)
Men should occupy posts of responsibility (S)	Men should occupy posts of responsibility (S)
I think boys should be brought up differently than girls (S)	I think people of different genders should be brought up differently (S)
I think it is right that in my circles of friends, my future domestic activity is considered more important than my professional activity (S)	I think it is right that in my circles of friends, my future domestic activity is considered more important than my professional activity (S)
A father's main responsibility is to help his children financially (S)	A father's main responsibility is to help his children financially (S)
Some jobs are not appropriate for women (S)	Some jobs are not appropriate for women (S)
I accept that in my circle of friends, my partner's future job is considered more important than mine (S)	I accept that in my circle of friends, my partner's future job is considered more important than mine (T)
Mothers should make most of the decisions on how to bring up their children (S)	Mothers should make most of the decisions on how to bring up their children (S)
Only some kinds of job are equally appropriate for men and women (S)	Only some kinds of job are equally appropriate for people of all genders (S)
In many important jobs it is better to contract men than women (S)	In many important jobs it is better to contract men than women (S)

4. Experimental Setup

This experiment was conducted for 14 participants in groups of 2. Each session was 3 hours, split into half an hour for pre- and post- questionnaires, half an hour for explanations of the setting and mechanics, and 2 hours of gameplay. Each session followed the same series of events: a setting description, the pre-questionnaire, an explanation of mechanics, gameplay, and the post-questionnaire. At no point in time was identifying data such as names collected from the participants.

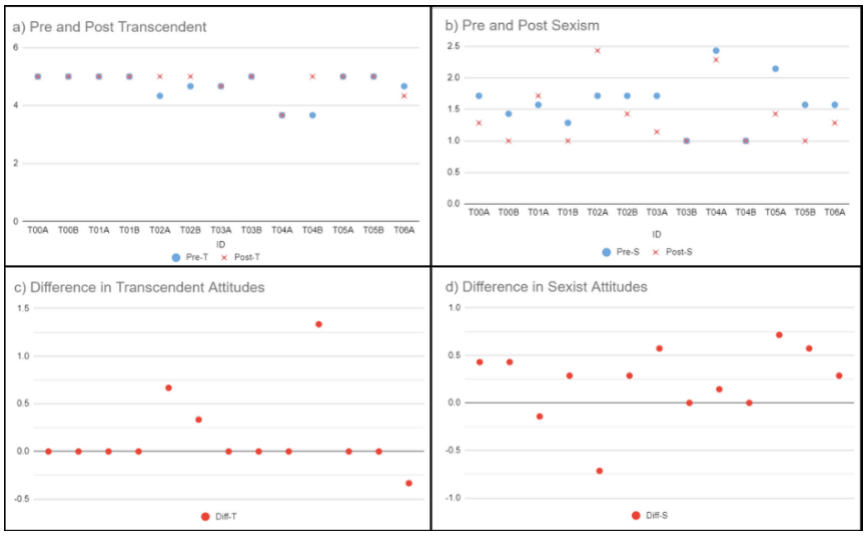
While there were 14 participants total, one was repeated across sessions and their results for their second session were not considered. The 13 participants ranged from ages 22 to 42 and all had some prior experience with TTRPGs (not this game). There were 2 female, 7 male, and 4 nonbinary participants.

The participants were all experienced players of TTRPGs, with all players having played both more rule-intensive, heroic fantasy games, such as Dungeons and Dragons, and other rules-light PbtA games. The players were also all already aware of gender roles and biases, and many were nonbinary. This is not the intended audience, however, this was to ensure that they had experience with how PbtAs mechanics are intertwined with the premise of the game, as well as the discrimination and bias faced due to gender, and could provide informed feedback.

5. Results and Discussion

5.1 Results

The scores for the pre- and post- questionnaires were calculated separately for Sexist and Transcendent Attitudes by taking the participants' answers and averaging each section to receive their overall score. These scores were then compared pre-and post- for each category. We noticed that for Transcendent Attitudes the scores mostly did not change post game (3 increased, 1 decreased; figure 1a). The trend we saw with Sexist Attitudes was interesting: 9 decreased post-game play, 2 showed an increase, and 2 no change (figure 2b).



Figures 1: a) Pre and post transcendent attitude scores of participants, b) pre and post sexism attitude scores of participants c) Difference in transcendent attitude scores of participants, and d) difference in sexist attitude scores of participants

While recording the total tokens earned by participants throughout the game, we found no correlation between Tokens earned and gender bias scores (both Transcendent and Sexist). This may be due to the highly subjective method of earning Tokens.

5.2 Discussion

The purpose of this research was to allow questioning of biases through the use of a unique TTRPG. We considered the difference between participants' scores between their pre- and post-game questionnaires an indicator to evaluate the effect of brief exposure to gameplay. As the two sections of the questionnaires measure different things, they are evaluated and discussed separately.

5.2.1 Transcendent Attitude Scores

Generally, we see that Transcendent Attitudes either increase or stay the same, with one outlier. This *is* the effect we hoped to induce, however if we look at a plot of the differences between pre- and post- scores (measured by subtracting pre- scores from post-scores), we see that the observed difference is negligible (figure

1c). Cronbach's Alpha was low (0.58) and the p-value for the Wilcoxon Signed-Rank Test (0.86) (while not statistically significant) was high, indicating that the Transcendent Attitude section of the questionnaire can be an unreliable measure of Transcendent Attitude.

The sample size was small, the scores for pre- and post- were similar, and the participant ser was primed to lean away from gender roles and biases. Additionally, compared to the questions for the Sexist Attitude section of the questionnaire, the Transcendent Attitude questions are vague and open-ended. With a few changes in verbiage, we believe this can be improved upon.

5.2.2 Sexist Attitude Scores

The Sexist Attitude scores of participants had higher variance with a measurable effect of brief exposure to gameplay on Sexist Attitude scores. Upon calculating the difference between participants' post- and pre-questionnaire scores (calculated by subtracting post- from pre- to maintain readability, i.e. a positive difference indicates fulfilment of the intended effect) we see significant improvements in implicit gender biases (figure 1d). Upon calculating Cronbach's Alpha (0.75) and the p-value for the Wilcoxon Signed-Rank Test (0.03), we find that not only is the Sexist Attitude questionnaire an acceptable measure of Sexist Attitudes in participants, the difference induced by brief exposure to gameplay is statistically significant.

The findings, even from the small set of participants, validate the game design and mechanics in nudging a positive change in sexist attitude.

Throughout gameplay, we received feedback (and perceived via player reactions) that players were becoming increasingly aware of the implications of the bias introduced. Most players reacted by pointing it out, out of character, and pushing back against the discrimination in-character, even when the discrimination was not directed at their PCs.

5.3 Limitations

The experiment was run on very aware participants. The reason for this was two-part. First, we wished to run the experiment with a TTRPG-experienced audience so that feedback would allow us to make changes to make gameplay better, if necessary. Second, we wished to run it with a smaller, more accessible sample size before expanding to the intended audience. All of the participants were familiar with gender bias and viewed it negatively. We were unable to draw conclusions about any differences between genders due to the smaller sample size and many participants identifying differently within the trans and non-binary umbrellas.

A second relevant is the initial questionnaire was split across the pre- and post- questionnaire, meaning that each questionnaire had only 10 questions, leading to comparatively slightly less reliable data. While this was done to prevent recall of questions and repetition of answers, we have come to understand that this is negligible due to the nature of the experiment, as after 2 hours of intermediate gameplay, it is unlikely participants would have enough recall to affect results. Additionally, by using the full questionnaire before and after gameplay, we can track changes across individual questions alongside our initial type-dependent calculations.

The third factor is the only two trackable aspects of NAM are Tokens and Conditions. During gameplay, however, we only tracked Tokens earned by players as Conditions are more heavily dependent on luck and gameplay than player biases. While, due to the nature of TTRPGs, we cannot track every interaction, some changes in mechanics would let us add some aspects that could be tracked like Tokens, letting us measure the players' implicit bias and see any changes over the course of brief/extended gameplay.

6. Conclusion

In this work we introduce a rules-light TTRPG aimed at recognising and reducing implicit gender bias among players, creating immersive and freeform gameplay that subtly reflects real-world issues. This game, *New Age Mages*, is designed to be easy to pick up and play. We explain our methodology and why it is easy to introduce this game to a new audience and encourage GMs to make this game their own as necessary (a detailed section for GMs is included in NAM). We also conduct initial playtesting for our game, showing that this game can be adapted to multiple kinds of playgroups. Furthermore, we show how to use an existing gender bias scale to measure the changes in the participants' attitudes. This work and the designed TTRPG may be helpful in understanding the effects of exposure to biases in a controlled environment, potentially over a longer period of

time (i.e. over multiple sessions of this game). Further, it may be utilised by educators trying to explain gender bias in a veiled way to a younger audience while immersing them in a situation where they face bias.

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Cybersecurity on the Move: Investigating the Efficacy of a Movable Escape Room as an Educational Tool for Healthcare Employees

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Abstract: *Introduction*: This research investigates the effectiveness of a cybersecurity escape room as an educational intervention to increase awareness of cybersecurity risks towards a safer work environment. The escape room aims to educate participants and cybersecurity and to make them more resilient against various cyberthreats. *Method*: To validate the effectiveness, a pre-test-post-test design with 96 participants was conducted, 42 also completing a delayed post-test and 29 participants served as a control group. All participants were healthcare professionals. Using the HAIS-Q, six themes were investigated (namely email usage, passwords, ransomware, social engineering, incident reporting, and software updates) using the three constructs from the Knowledge, Attitude and Behaviour model. *Results*: The escape room had an overall immediate positive effect on participants ($t(95) = -6.259$, $p < 0.001$), and this effect persisted after 1 month ($t(25) = -2.946$, $p = .006$). Zooming in on individual themes, the immediate scores improved for email usage, passwords, social engineering and software updates, whereas the delayed scores improved specifically for email usage and passwords. *Conclusion*: The results show that the cybersecurity escape room may be a promising way to enable employees to resist cybersecurity threats. Nonetheless, the results need to be interpreted with caution. The research design experienced some dropout, meaning that results could differ with increased participation. Furthermore, it is not entirely evident which aspects of the escape room caused the observed effect; this is subject to future research.

Keywords: Cybersecurity, Educational Intervention, Escape Room, HAIS-Q, Healthcare.

1. Introduction

The implementation of Electronic Health Records (EHR), widespread use of wireless devices and the uptake of the Internet of Things (IoT) has changed patient care and hospitals in a rapid pace. The use of interconnected devices is now a standard practice of almost every patient (Cartwright, 2023). This, however, also results in an increased and diverse attack surface, threatening the operational continuity of both patient data and hospital processes.

To illustrate, EHRs are crucial in patient care. Its operational unavailability disrupts hospital functions and endangers patient safety (Larsen, 2019). When confronted with EHR failures, some hospitals shut down departments (Guardian, 2017). Between 2018 and mid-2022, 14 Dutch hospitals experienced IT failures leading to the unavailability of EHRs, closure of Emergency Rooms, delays for outbound patients, and postponed surgeries (IGJ 2022). The most common causes for the unavailability of EHRs arise from cyberthreats, both in the digital (e.g., hacking or data exfiltration) and in the social domain (e.g., password sharing or shadow IT). A recurring theme for cybercrime is human error, which manifests in sending information to the wrong recipient, reusing passwords, connecting to unsafe public hotspots, or being manipulated via social engineering tactics.

1.1 Countermeasures

To counter cyberattacks, both technical and non-technical countermeasures can be implemented (Khonji et al., 2013). Technical countermeasures, such as automated email classification using content, meta data or destination URL inspection are increasingly effective to counter email phishing (Khonji et al., 2013). However, despite major advancements, technological approaches may not be able to detect all threats as they are based on historic data and attackers constantly innovate (Hoheisel et al., 2023).

Mitigating these cybersecurity risks extends beyond technological solutions; the human element, which is often overlooked, plays a pivotal role in securing the organization (Safa, Von Solms & Futcher, 2016). This requires employees to learn behaviour and skills which contribute to a cybersecure organization. Unfortunately, learning new skills and behaviour is challenging (Lewis et al., 2013). Through deliberate practice one can improve their skills (Issenberg et al., 2005). There are four principles involved in successful practice: i) repetition of the skill, ii) continuous assessment of the performance and improvements, iii) with detailed feedback, this will result in iv) improving skills in a controlled setting. Deliberate practice is commonly implemented in medical practice for skill development (Lehtinen, 2023). In the context of cybersecurity training, with a focus on social engineering (i.e. a

cyberthreat that aims to manipulate the end user), a meta-analysis containing 19 studies, 37 effect sizes and 23 146 research subjects, found a medium effect size of educational interventions (Bullee & Junger, 2020). Moreover, the effect size differs for different interventions. Some are highly effective, whereas others have a negative or no effect (approximately 1 in 3). Interventions where participation is highly intensive (e.g., playing a game) were associated with a higher effect size compared to those with a low intensity (e.g., reading a static text) (Bullee & Junger, 2020). Finally, the researchers found a slight but significant decay in the effects of interventions over time.

An alternative to improve cybersecurity awareness could be an escape room. An escape room offers an interactive adventure, engaging groups of usually 2-8 individuals in collaborative puzzle-solving to exit the room (Cohen et al., 2020). These themed environments create immersive challenges, demanding effective teamwork for success. The cognitive and social abilities of each team member and their collective synergy significantly influence the team's performance. To thrive in an escape room, participants must synergize, emphasizing interdependence among teammates striving for a common objective.

The potential success of the educational escape rooms lies in the interplay between the story line which provides the scenario, problem-based puzzles that require teamwork to get solved, and a post-game reflection (Fotaris & Theodoros, 2022). Benefits of escape rooms include improvements of various of skill types in interpersonal, intrapersonal, and academic skill development. Thereby, escape rooms have been shown to be effective in improving both knowledge and skills in different subject areas (Morrell & Eukel, 2020, von Kotzebue, Zumbach & Brandlmayr, 2022).

The potential success of learning in an escape room may be explained as the product of multiple learning theories coming together (Fotaris & Theodoros, 2022). Relevant are the following theories of learning:

- Social Constructivism, a learning theory that emphasizes active participation and collaboration, finds practical application in escape rooms. In an escape room, participants engage in real-time experiences, collaborating with peers to overcome challenges, fostering critical thinking skills (McKinley, 2015).
- Bloom's Taxonomy, a framework for designing learning objectives and assessing understanding, plays a crucial role in the design of escape room puzzles. These puzzles cater to different levels of thinking, such as classifying information for understanding, thereby promoting higher-order thinking skills and deeper understanding (Bloom, 1956).
- Kolb's Experiential Learning Cycle, which outlines a four-stage process: concrete experience, reflective observation, abstract conceptualization, and active experimentation, emphasizing hands-on learning and reflection for a deeper understanding and application of knowledge (Kolb, 1984). According to this theory, learning occurs through experiencing, reflecting, thinking, and doing. In an escape room, participants actively engage with puzzles (Concrete Experience), reflect on their experiences and challenges (Reflective Observation), form concepts and theories (Abstract Conceptualization), and apply their knowledge in new situations (Active Experimentation). This holistic approach to learning allows participants to integrate their experiences into a cohesive whole.

Summarized, puzzles within an educational escape room (EER) are problem-based and require communication and team-working skills, which are considered intrinsic parts of the way in which adults learn, while a robust storyline helps to set the stage, and post-game reflection helps to solidify the learning goals. This creates a dynamic educational environment which may improve the retention rates compared to traditional learning (Abdulmajed, 2015).

Despite potential benefits, little work has been done on using escape rooms for organizational cybersecurity. Some initiatives are available, such as the briefcase-based escape room for high school juniors and seniors (Mello-Stark et al., 2020). In teams of three, the participants need to complete seven puzzles to solve the mystery. All games relate to codes and encryption, including Caesar cypher, Steganography, strong passwords and soft skills. The latter is to prevent a single person from completing the entire game alone (Mello-Stark et al., 2020). The games allow for discussion on security practices. For example, the game starts by figuring out how to open the case. The code is the birthday that can be found on the card; this is an opportunity to discuss whether using your birthday is a good password. Regarding evaluations, these are suggestions by the authors for future research.

DeCusatis et al. present a security awareness virtual escape room based, which is themed as a science fiction environment where the participants play a robot that learns about cybersecurity (2022). The game is diverse and handles nine topics: USB devices, passwords, cryptography, multi-factor authentication, phishing, social

engineering, defence in depth, firewalls and malware. Focus on (pre-) college students. In total, 120 participants tested the game, resulting in 5 out of 8 Octalysis metrics scoring at least 7.9 out of 10. The before-and-after security awareness assessment showed improvements, but the exact extent was not detailed in the manuscript (DeCusatis et al., 2022).

A third initiative from Löffler et al. used the principles of an escape room to build a virtual equivalent for teaching staff about cybersecurity awareness (2021). In teams, the participants go through 8 different topics, including physical security, passwords, phishing, social engineering, and online banking. The learning goals in that study relate to raising cybersecurity awareness and knowledge sharing, peer learning, and problem-solving. The overall mystery in the escape room is to reveal the rogue employees who are committing financial fraud, thereby aiming to teach employees about cybersecurity awareness (Löffler et al., 2021). The outcome of the player evaluation was that 65 out of 81 rated the game as positive, 4 were negative and 12 did not answer.

Although there is limited work on cybersecurity escape rooms, it is good to see initiatives for different audiences emerging. However, a general shortcoming is the limited systematic evaluation of the achievement of the intended learning outcome.

1.2 Research Question

In this study we aim to determine if an escape room can be used to improve cybersecurity knowledge, attitudes, and behaviour of healthcare employees. Therefore, the research question of this study is: "*How does participation in a cybersecurity-themed escape room affect participants' cybersecurity knowledge, attitudes, and behaviour over time?*"

Two hypotheses were formulated:

> **H1**) The null hypothesis is that there is no significant difference in participants' overall scores on the HAIS-Q survey immediately after completing the cybersecurity-themed escape room, as compared to their pre-test scores.
>
> **H2**) The null hypothesis is that there is no significant difference in participants' overall scores on the HAIS-Q survey approximately one month after completing the cybersecurity-themed escape room, as compared to their pre-test scores.

2. Methodology

2.1 Subjects

Employees from 26 healthcare organisations in the eastern part of the Netherlands were invited via email to participate in a cyber themed escape room. This was part of a larger cybersecurity effort for all healthcare personnel in the eastern part of the Netherlands.

2.2 Power Analysis

An a priori power analysis was performed using G*Power (Faul et al., 2007) to establish the minimum sample size needed to test this study's hypotheses. Results indicated the required sample size to achieve 90% power for detecting a medium effect (i.e., $d = 0.5$), at a significance criterion of $\alpha = .05$, was $N = 44$ for a two-tailed paired t-test. Therefore, the obtained sample size of $N = 96$ is considered adequate for testing the study's primary hypothesis.

2.3 Materials

Two types of materials were used in this study: 1) a survey for measuring information security awareness and 2) the cybersecurity truck escape room. The survey consisted of the Human Aspects in Information Security Questionnaire (HAIS-Q) (Parsons et al. 2014). This instrument is built on top of KAB (Knowledge, Attitude, and Behaviour) model that assumes that if knowledge increases, attitudes can be improved which could lead to an improvement in behaviour. The scale consists of 7 areas, each divided into 3 sub-areas, with each 1 question for each of the KAB constructs, resulting in a total of 63 items. To measure the items, a 5-point Likert scale was used, whereby each statement is answered using answer options ranging between 'Strongly disagree' and 'Strongly agree'. For example, the focus area 'Password Management' has the sub-areas: 1) 'Using the same password', 2) 'Sharing passwords' and 3) 'Using a strong password'. Examples of questions from the password focus area

are: “It is a bad idea to share my work passwords, even if a colleague asks for it” (Attitude), “I use a different password for my social media and work accounts” (Behaviour) and “A mixture of letters, numbers and symbols is necessary for work passwords” (Knowledge). The reliability of the HAIS-Q was originally calculated based on the responses of 500 employees and showed a Cronbach's alpha of .88 (Knowledge), .88 (Attitude) and .91 (Behaviour) (Parsons et al. 2014). In our study, only the 12 relevant sub-areas to the cybersecurity truck were included.

The employed cybersecurity truck escape room is a mobile escape room fitted inside a 40 ft container[1] and can be considered a ‘pop-up escape room’ (Fotaris & Theodoros, 2022). The experience was split into 3 parts: a) pre-briefing, b) game, and c) de-briefing. During the pre-briefing, participants are explained the safety procedures and the scenario of the escape room. In the main part, the game, participants had to solve cybersecurity related puzzles and handle correctly given the scenarios they encountered. As such, the escape room followed the Three Act Structure in narrative creation (Davison, 2006). Summarized, the procedure for the escape room was as follows:

- The pre-briefing consisted of 3 elements: *i*) the participants received a safety briefing (since they will be in a 40 ft cargo container standing on a trailer); *ii*) directly after, the participants are confronted with the first cyberthreat, the social engineer, where they are persuaded to share Personally Identifiable Information (PII) as if this was required to start the game (i.e. name, date of birth and phone number); *iii*) introduction to the game scenario, where the goal is to obtain a code to disarm arm a bomb before the timer runs out. Then, the participants climb into the truck and the escape can begin.
- During the game, participants solved puzzles to get codes for locks and safes; secure behaviour earned additional time, while insecure actions lost time. Solving all puzzles in time disarmed the bomb and completed the game. Games and situations in the escape room included:
    - Social engineering: At the beginning of the game, directly after the briefing, the game leader tries to make the participants share Personally Identifiable Information (PII). Although none of the retrieved data was stored during the debriefing, it is explained that by sharing PII, the offender can tailor the attack to you.
    - Data classification: In this puzzle, the participants had to place the given data items (e.g., information flyer, invoice, health record) in the correct category (public, confidential, restricted). A code appeared once all items were in the correct position (and turned around).
    - Maze + Periscope: In this two-person game, player 1 controls an arrow on a screen, where the left and right are swapped, as well as forwards and backwards. Player 2 looks through a periscope and looks out for a code that could open a lock.
    - Items: In the escape room, various items found in an office environment are lying around. Some items contained PII, so returning them to the 'security box' could earn additional time. One of these items is a USB storage device that fits in the USB port of the PC. Returning this item would also earn additional time; however, plugging it into the PC triggers a ransomware attack and reduces the time left on the timer.
    - Phishing: One of the codes can be unlocked by correctly identifying the suspicious elements of a potential phishing email in the PC's inbox.
- In the third and final stage, the participants were debriefed by doing a walkthrough of the threats they encountered during the experience. The debriefing was led by a policy officer of the healthcare organization, who discussed a series of question with the escape room participants. These questions focused on what the participants observed during the escape room, what actions they took and why, how they reflect on their cooperation during the escape room, and on how the themes presented in the escape room relate to organizational policy and how participants would act if a real cyberthreat occurred in the organization.

2.4 Procedure

A pre-test post-test control group design was used as an experimental design. The target population for this study were employees employed in the healthcare sector and can included: Information Security Officers, Data and Privacy Officers, Department Managers, Nurses or Physicians. These employees were invited through a mailing via a network partner who facilitates cooperation in both the area of daily routine care and the field of

[1] https://escaperoommobiel.nl/cybersecurity-truck/

medical assistance in the case of a disaster or crisis. One of their activities is organizing training sessions for their network in the region. The healthcare employees, who stem from different organisations, had to register a timeslot in teams of 3-8 persons in advance (the majority registered a team of 8). In the dataset, teams of 2-9 (median = 5) were observed. There were 3 days of data collection during which participants took part in the escape room. One month after the data collection, participants were invited via e-mail to complete the delayed post measure. Additionally, after the 3 days of data collection, employees who were invited but did not participate in the escape room study were invited via email to complete the survey so that they could function as a control group. For an overview of the data collection timeline, please refer to Table 1.

Table 1: Time schedule of the data collection

	Pre-test	Cybersecurity truck	Post-test	Delayed post-test
Experimental	3/4/5 October 2023			2 November 2023
Control	6-30 October 2023	-	-	-

2.5 Study codes

To anonymously track an individual participant through multiple surveys, Self-Generated Identification Codes (SGICs) were used (Audette 2019). Such a code is created by combining the answers to a set of 5 personally salient questions in a pre-determined order. Examples of such questions are: “First initial of your first middle name?”, “First initial of your mother’s first name?”, or “Number of older siblings”. Answers could be “Katherine”, “Mary” and "2"; these answers would translate into the code: ‘KM2'.

2.6 Variables

The variables in the analysis were: pre, post, delayed.

‘Pre’ measured the score on the HAIS-Q scale before participating in the cybersecurity truck. ‘*Post’* measured the HAIS-Q score directly after, whereas ‘*delayed*’ measured the score after one month. All HAIS-Q answers were coded to range from –2 up to +2. For all variables, the score was calculated by the sum of all 36 items and therefore ranged from –72 up to +72.

2.7 Analysis

A t-tests were used to test the hypotheses. For the analysis, we adopted an "intervalist" perspective, aligning with the concept of Likert scale construction and usage. This meant that we treat the averaged scale as an approximation of continuous data (Harpe, 2015, Schrum et al, 2020). The following three data assumptions must be met for the paired t-test: 1) independence, 2) paired and 3) normality (Pallant, 2020). **Independence** of observations refers to research subjects being independent. This criterium is met since each research participant completed their own form. **Paired** means that the pre and post measure occur from the same individual; this is the case, since we were able to track each respondent anonymously using study codes. **Normality** is the requirement of the difference between the pre, and post measure are normally distributed; a visual inspection of the Q-Q plots was performed, and this did not indicate problematic non-normality.

Comparing the control group (M = 27.2, SD = 5.9) and the pre-test (M = 26.3, SD =7.1), no significant difference was observed (t(47.56) = -0.714, p = 0.479) for the overall scores. Zooming in on the thematic scores, no significant differences appeared, refer to Table 2. Thus, participants in the escape room did not appear to significantly differ from non-participants.

Table 2: Overview of scores for the different conditions, with their p-values per theme and for the total HAIS-Q score.

	Pre-test vs control group (N = 133 vs 29)		
Theme	Pre	Control	p value
Email	6.9 (3.0)	7.7 (3.0)	0.193
Passwords	8.5 (2.0)	8.7 (1.5)	0.497
Ransomware	1.1 (1.4)	0.8 (1.3)	0.359
Social engineering	-0.5 (2.4)	-1.2 (3.0)	0.196
Incident reporting	6.8 (2.4)	7.6 (1.7)	0.075
Software updates	3.5 (2.4)	3.7 (1.7)	0.648
Total	**26.3 (7.1)**	**27.2 (5.9)**	**0.479**

* p<0.05; ** p<0.01; *** p<0.001;

3. Results

3.1 Hypothesis 1

The results from the pre-test (M = 16.3, SD = 7.3) and post-test (M = 30.8, SD = 6.1) indicate that the cyber truck escape room made an improvement in the HAIS-Q scores, t(95) = -6.259, p = .001 (two-sided). This translates to a Cohen's d of 2.16 and can be classified as a large effect (Cohen, 2013). Hypothesis 1 is therefore rejected in favour of its alternative H1a: participants will achieve significantly higher overall scores on the HAIS-Q survey immediately after completing the cybersecurity-themed escape room compared to their pre-test scores. Zooming in on the scores for the individual themes, an improvement in the scores for email, password, social engineering, and software updates was observed, whereas no improvement was found for the remaining themes: ransomware and incident reporting. Please refer to Table 3 for an overview of scores for both the pre-test and post-test by theme.

3.2 Hypothesis 2

There was a significant increase in the HAIS-Q score measured one month after the cyber truck (M = 31.0, SD = 4.4) compared to the score directly before the cyber truck (M = 26.5, SD = 7.4), t(25) = -2.946, p = -.006. This translates to a Cohen's d of 0.74 and can be classified as a medium effect (Cohen, 2013). Hypothesis 2 is therefore rejected in favour of its alternative H2a: participants will maintain significantly higher overall scores on the HAIS-Q survey one month after completing the cybersecurity-themed escape room compared to their immediate post-test scores. An improvement was observed for the themes social engineering and software updates. No difference was observed for the remaining themes: email, passwords, ransomware, and incident reporting. Please refer to Table 3 for an overview of scores for both the pre-test and post-test by theme.

Table 3: Overview of scores for the different conditions, with their significance levels per theme and for the total HAIS-Q score.

	Pre-test vs post-test (N = 96)		Pre-test vs delayed post-test (N = 26)†	
Theme	Pre	Post	Pre	Delayed post
Email	**6.8 (3.1)**	**7.9 (2.9)** ***	6.9 (3.5)	7.1 (2.6)
Passwords	**8.3 (2.0)**	**8.8 (2.0)** *	8.3 (1.9)	9.1 (1.8)
Ransomware	1.1 (1.4)	1.3 (1.1)	1.2 (1.4)	1.4 (1.2)
Social engineering	**-0.4 (2.4)**	**1.6 (1.4)** ***	**-1.0 (2.7)**	**1.4 (1.7)** ***
Incident reporting	7.0 (2.5)	7.3 (1.9)	7.3 (2.6)	7.7 (1.3)
Software updates	**3.5 (2.4)**	**4.0 (2.1)** ***	**3.8 (2.1)**	**4.4 (1.8)** *
Total	**16.3 (7.3)**	**30.8 (6.1)** ***	**26.5 (7.4)**	**31.0 (4.4)** ***

* p<0.05; ** p<0.01; *** p<0.001; pre-test was conducted directly before, post-test was conducted directly after, and delayed post-test was conducted approximately one month after the escape room.
† 42 respondents completed the delayed post-test, only 26 could be matched with their pre-test results.

4. Discussion and Conclusion

The present study took a novel approach to cybersecurity training in the form of an educational escape room. Results showed a positive effect on the knowledge, attitude, and behavioural intention of participants on a mixture of cybersecurity themes; positive effects were observed directly after the participation and persisted for at least one month.

These results are particularly promising because traditional cybersecurity suffers from problems. Even though traditional training often has a positive effect (Bullee & Junger, 2020), motivation for and participation in traditional training tends to be lower (Aldawood & Skinner, 2019), potentially even problematically so (Tally et al., 2023). An educational escape room may not suffer from the same problems. Furthermore, an educational escape room, being a more intensive training form, due to the active participation and collaboration with peers (in line with the Social Constructivism learning theory) and application of knowledge in new situations together with the reflection on outcomes and experiences (Experiential Learning theory), has the potential to achieve stronger, longer-lasting effects in participants. Our study indeed found that the cybersecurity educational escape room had large effects; on the total HAIS-Q score, comparing the pre-test to the direct post-test and the delayed post-test scores, the achieved effect sizes were respectively 2.16 and 0.74 (Cohen's d). In comparison, traditional training methods achieve a lower average effect size of 0.54 (Bullee & Junger, 2020). Bullee and Junger (2020),

also found that interventions with a high intensity (e.g. a game) had a significantly higher effect compared to those that were less intense. From experience the second author can say that this intervention was intense, even for those with a background in cybersecurity. Moreover, it was also found that interventions that focus on a specific topic were more effective compared to those with a broader focus. Although the entire escape room focuses on many topics, it had a large effect size. Alternatively, one could explain the escape room experience as a *collection o*f small specific interventions, bundled together in a shell. Looking at the individual themes, 4 out of 6 had a significant improvement when comparing the pre and post-test measures.

In line with Bullee & Junger (2020) and the decay effect in general (Ebbinghaus, 1913), the effect of the escape room reduced over time. For some themes, the effect completely decayed over time, whereas others did not decay that much, refer to Table 3. The improvement for the theme of social engineering remained significant over time. To reduce the effect of social engineering via the telephone, previous research reported a significant reduction of victimisation after the distribution of an information flyer and a card holder. This effect was observed 1 week after the distribution of materials. However, the second week after distribution, the effect disappeared (Bullee et al., 2016). Although there was a difference in modality (Face-to-Face vs Telephone), the intervention part in the escape room experience that tackled social engineering made a lasting impression. A suggestion for future research would be to test of this finding remains stable if the sample size improved, given that this was based on only 26 observations.

5. Limitations

However, some caution is warranted when interpreting the results of our study. The research design suffered from several dropouts; partially due to errors in the study code system and partially due to some participants simply not completing all surveys. This could have affected the results. Furthermore, due to the voluntary characteristic of the intervention, resulting in a range of different team sizes from 2 to 9 participants (rather than 8), with a median of 5 participants. Since the escape room experience can differ depending on the number of participants, this could have influenced the results of our study.

Furthermore, even though the HAIS-Q measurement instrument has been validated (Parsons et al. 2014), it should be noted that intention does not always translate into actual behaviour (Fishbein et al., 2023). Additionally, our latest measurement was approximately one month after the intervention. Future research needs to investigate for how long the effect would last exactly and when a new intervention is required. In the case of repeating this intervention, is it also not yet known if this would have similar effects. Finally, the applied cybersecurity escape room intervention consisted of many elements: the escape room task with various parts, as well as a final debriefing reflecting on the experience and its themes. It is not yet clear which elements exactly caused the effect that we found.

Nonetheless, this study showed promising results about an escape room as a novel cybersecurity training intervention in the healthcare sector.

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A Platform of Serious Video Games Co-built for the General Interest

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Abstract: In a context where training takes place both in initial courses and in lifelong continuing education, the use of games offers a way of promoting effective and sustainable learning: by its very nature, this medium is an open work in which players can become involved and give meaning to their learning. Ikigai - Games for Citizens offers a unique ecosystem for creating serious, expert video games and offering them free of charge to people who want to learn while having fun, as well as producing a set of learning-related data that can be used for research and customizing training courses. By bringing together universities, Grandes Ecoles, research laboratories, associations, and institutions, Ikigai is a collaborative consortium of general interest, implementing the co-construction of videogame services between scientific experts, video game professionals and educational engineers. Together, they are producing a centralized platform of serious games and associated services that can be used by teachers at a moderate cost by pooling resources: the building blocks of each game can be reused in other games developed. The consortium is committed to general interest and popular education by making the games available free of charge to members and the general public. The decentralized infrastructure set up by Ikigai, which respects privacy by design, means that game usage data can now be collected on a national scale, but conceptually it could extend much further. The data collected in compliance with the RGPD will eventually be used to draw up enriched user profiles to offer personalized courses, teaching recommendations and progress monitoring as close as possible to the learner, using AI in particular. Ikigai is also heavily involved in the construction of new digital standards in education, which are needed to ensure the interoperability of data for lifelong monitoring of learners. But also, for the digital education ecosystem, to guarantee a sovereign, efficient, coherent, and sustainable cloud on a European scale .

Keywords: Video Games, Serious Games, Training, Learning Analytics, Artificial Intelligence

1. Introduction

Gaming attracts a wide and varied audience, with a diversity of activities ranging from card games to video games, board games and role-playing games. The video game itself is quite polymorphous in its use, with a variety of media ranging from smartphones to computers and home or mobile games consoles. One of the great strengths of this medium lies in the commitment it allows its audiences to make (Brown, 2004), like an open work (Eco, 1962) that allows players to give a personal and/or shared playful meaning (Genvo, 2008).

Furthermore, although scientific evidence has long been accumulating to show that games are a useful medium for diversifying learning methods and engaging learners (Sanchez, 2020; Sauvé *et al.*, 2007), producing and distributing them is rarely an easy task for educational establishments wishing to develop learning games (a term we prefer to serious games, as the game activity is always serious for the player who invests in it, but it is the consequences of the game that are not, and they enable learning that values trial and error and the correction of mistakes), whether in terms of the resources and skills to be deployed in creating them or in distributing them to the target audience.

Another obstacle identified is the difficulty experienced by teachers in implementing turnkey video games whose content they cannot modify to suit their teaching needs.

This article presents the rational elements that led to the establishment of a shared national eco-system to meet the needs and obstacles identified in the production of games for learning in the context of initial or continuing training, as well as feedback on the practical implementation of the ikigai.games platform built since 2018 across France.

This unprecedented structure incorporates a powerful system for the distributed collection of game usage data, with the aim of fueling research that will enable the development of new edutainment approaches and more detailed analyses of the impact of games on learning. Using artificial intelligence in particular, this research could also lead to the development of new tools aimed at offering end-users play-based solutions and personalised training courses in line with their profile.

2. Challenges of a Video Games Platform Based on Learning Analytics for Education

While the vast majority of French citizens are in favour of video games as a medium, they are relatively rare in initial and continuing education. However, it has demonstrated real potential for engaging people in learning and discovering new knowledge. Even more, when it does exist, it rarely provides personalised activities that meet the specific needs of each student.

2.1 Video Game Audiences in France

Video games are a particularly well-established medium in people's media landscape, as revealed each year by the survey "Les Français et le Jeu Vidéo" (SELL, 2023). Video games are even considered to be one of the main cultural activities of the French, and even their favourite digital leisure activity.

Nearly 72% of French people declare that they play video games at least occasionally, and this proportion spans a wide range of generations (SELL, 2023), clearly demonstrating that video gaming is by no means an activity confined to children and young adults. Nearly half of all gamers say they play video games at least once a week - over 21 million people in France (SELL, 2023). Video games, in all their diversity, are an interesting medium to use to reach a wide range of audiences.

At the same time, this passion for the medium becomes a constraint that needs to be taken into account when producing video games for education: gamers have expectations linked to their own video game culture, shaped mainly by the video game market. The production of video games with a learning or training objective will therefore have to conform to these expectations in order to engage its audiences, at the risk of breaking the magic circle of the game (Huizinga, 1938).

2.2 Practical Benefits of Video Game in Education

As far as its audiences are concerned, video games are a new medium that has yet to be fully exploited in the context of training, compared with media that are considered to be older: the written word (books, magazines, articles, etc.), audio and video. While the latter bring sound and moving images to written texts and images, video games offer a range of additional tools that can be used for learning: interactivity, immersion, modelling, multiplayer, personalisation, artificial intelligence, reticularity and even virtual, augmented or even diminished reality. Video games sometimes allow for a "reflexive, distanced and 'second-degree' playful attitude" (Barnabé et al, 2018) enabling meta-reflexivity on the playful practice in progress.

Taking Gee's (2003) Learning Principles as a starting point, three particular points that we felt had not yet been worked on drew our particular attention in the design of the games built as part of the development of the ikigai platform. These are: the game's ability to manipulate simulations of complex systems on scales of time and space that are not accessible in the real world, the ability of the video game environment to immerse the learner in a representation linked to the mental schemas that we want students to learn, and finally, the ability of a game mechanic to directly support the intended learning (procedural rhetoric according to Bogost (2008)).

All these elements can be complex to put in place, but they contribute to the popularity of video games. They are also particularly useful in a learning and training context.

2.3 Research Into the use of Video Game in Education

The use of games in education is a subject of research in its own right (Sanchez, 2020), providing an increasingly rich analysis of the contributions of gamification to pedagogy and enabling new, more effective learning strategies to be envisaged (Bayeck, 2020). Although gamification is a marginal medium, particularly when compared with the entertainment games market, it has long been used in learning contexts (Sauvé *et al*, 2007) because, by its very nature, gamification enables a number of processes to be put in place that have to do with the objectives of the educator (Gee, 2003): transferring and analysing information, learning by making mistakes, manipulating things that cannot be manipulated, visualising systems on scales that are invisible in reality, or constructing mental representations based on concrete representations linked to the theoretical concepts being taught. Accompanied by a reflective debriefing with the teacher (Sanchez, 2023), the game proves to be particularly effective for anchoring knowledge and know-how and for the cognitive remediation sometimes necessary to correct misconceptions.

As regards video games specifically, scientific studies have also demonstrated their impact on three main sources of motivation as defined by Sauvé and Viau (2002), namely "[...] the effort or energy that the person is prepared to put into accomplishing a given learning task":

- the feeling of competence as defined by Bandura (2009): "The individual's perception of his or her ability to organise and carry out the course of action required to produce the desired results",
- the feeling of controllability defined by Wigfield and Wentzel (2007) as "Perception of autonomy over certain aspects of learning",
- and the perception of value defined by Viau (1999).

The importance of narrative in video games is also revealed in the learners' involvement in the game and in learning (Maldonado, 2023).

By virtue of its medium, the video game is also a medium that makes it easy to collect usage data, the analysis of which, possibly coupled with other approaches such as experimental cognitive psychology or group sociology, should make it possible to go much further than the state of the art in terms of personalising content and supporting students, well beyond facilitating evaluation of its use and its impact on learning (see part 5).

3. Obstacles to the Development of Games in Education

However, there are many obstacles to the production of games, particularly video games, dedicated to learning. One of the first, if not the most frequently cited by education actors, is the high cost inherent in this type of project. Far from the hundreds of millions of euros required to produce blockbuster video games, the sums typically in the region of €50,000 to €200,000 needed to develop a modest educational video game that meets video game quality standards in terms of game mechanics, graphics and affordance are a major difficulty in developing this type of project and, above all, in producing enough of them to cover the needs of the various disciplines and levels. As a result, such projects are often out of the reach of a single school, which cannot invest so much money in a project of this type without any guarantee of its usability over time, its educational relevance, and the assurance that it will be able to evolve in the future to keep pace with changes in content.

Although some experiments are being carried out on an exploratory basis, the economic equation is that the widespread use of this teaching tool is only possible by acting collectively on the scale of all those involved in education by agreeing to share the tools developed. At present, the conditions under which such a tool is produced by a school are a source of problems.

Often produced as a service, the games produced are then delivered as is by the developer, who is often too weak economically to ensure their maintainability over time or even their possible evolution when it comes, for example, to adding educational customisation algorithms. It is therefore up to the client to maintain and subsequently develop the game, which is rarely done in practice and leads to the obsolescence of previously available games. However, in addition to maintaining use, the school is often interested in upgrading the game, which can be of several kinds, from adding content to new functions. Maintaining a game in relation to the different operating systems that support it already requires a continuous updating of the product, which schools are struggling to guarantee.

Another difficulty is the relative confidentiality of the games produced once they are ready to be distributed to the public. It's not uncommon for a game developed by a university to appear on a dedicated page of the institution's website and then gradually fall into oblivion, with no response several months after its release. What's more, it is quite rare for this type of project to be used outside the institution that produced it, despite the fact that there are common audiences elsewhere, and sometimes even in circles of distribution completely related to that of initial or continuing education: mediation, communication, entertainment, etc. In short, the substantial investment made often struggles to pay off due to a lack of users.

Finally, the last point highlighted in this review is that the games produced are of very uneven quality, often failing to match the digital literacy of the target audiences. As we saw in part 2, there are many different audiences for video games, but they are also used to the quality of commercial video game productions. To win over these audiences, it is therefore important to offer productions of a quality that matches their expectations, of a quality that corresponds to the video game market. A serious video game that does not meet these standards will never be perceived by its target audience as a truly entertaining tool.

4. Ikigai, a Collaborative Ecosystem to Bring Video Games Into Education and Move Beyond the Demo Effect

In 2017, the Ikigai project was born within Sorbonne University. Its aim? To create a high-quality range of video games with specific educational objectives. But it was in 2020, following the identification of the many obstacles to the production of games in many universities, that the Ikigai project changed scale and became a national consortium structured as a non-profit association. The consortium's aim is to make gamification available to teaching, popular education, research and cultural and scientific mediation by removing all the obstacles identified.

4.1 Description of the Consortium

In May 2024, the Ikigai - Games for Citizens consortium brought together 17 universities, 6 Grandes Ecoles, the three major French national players in digital higher education, research laboratories, associations and institutions (Games for Citizens, 2024). The consortium is involved in a number of research and content production projects for various higher education and continuing education institutions.

With the support of three French ministries (Ministère de l'Education nationale, et de la jeunesse; Ministère de la Culture; Ministère de l'enseignement supérieur et de la recherche), the more than 40 members are working in partnership to use video games for learning and mediation in the general interest, on a variety of themes and for different audiences.

4.2 Pooling of Resources Between Partners

The central element around which the pooling of resources is built lies in the recruitment of a team known as the "Frame": this brings together a group of video game professionals as well as a range of professions relating to the technical structuring of the web, AI and data sciences, communication, training and the administration of a national consortium. By pooling human resources, each of the association's partners not only participates in the emergence of new joint projects, but also benefits from a significant amount of work time on its own projects that the core team can dedicate to it, at an optimised cost.

In support of this approach, and to bring pooling to its optimum, all the resources produced for the games, all their building blocks, can be reused for other games developed for all the members of the consortium. This pooling allows development costs to be optimised and investment to be sustained over time, authorises the re-use of common elements, but also guarantees the possibility of improvements and continuous innovation through control of the sources and the permanent availability of a team of specialists. Over the years, the studio has built up a wealth of expertise, as well as a digital capital consisting of a catalog of learning and educational video games that is constantly being expanded.

4.3 Co-design by Teaching Teams and Video Game Specialists

The team of video game professionals at Ikigai - Games for Citizens has developed a methodology that involves co-developing each project with the teaching and educational teams of the partner organisations. By systematising procedural rhetoric (Bogost, 2008), its game design principles include reflection on the situations that lead players to engage in meaningful activities from a learning perspective.

This dual approach to games and teaching means that the products are designed to meet the expectations of identified audiences as closely as possible: players, as well as teachers and trainers. To satisfy these two targets, the fun approach is chosen in consultation with the educational objectives and the context of use of the game for the defined audience.

Finally, the game must be produced in line with the standards of the videogame market and meet the expectations of a demanding audience with a videogame culture that needs to be taken into account.

4.4 Co-Distribution

Among the obstacles identified, the visibility of the final production was a key factor. If the game created is perfectly produced, it is a shame that it is not widely distributed and promoted in line with the human, technical and financial investment made. On the basis of these considerations, the members of the consortium decided to create a common distribution platform: a reference portal where all the members' creations would be

distributed, but which could also host the members' past productions or games created elsewhere that are of educational and entertaining interest to the public.

This reference portal (Ikigai, 2024) is now online and is constantly being enriched with new content, distributed free of charge and without advertising, for the widest possible audience, beyond the first circle of initial and continuing education institutions.

For the members of the consortium, the implementation of this type of platform on a national scale also enables the deployment of services associated with the games on an unprecedented scale: a set of data linked to the use of the games is constantly extracted, in compliance with the GDPR, enabling teachers to monitor training and the creation and distribution of customised content, as well as creating an unprecedented volume of data for research into teaching through video games.

4.5 Open to Research

The collection of data on the use of games, made possible by the medium of video games, is also a valuable resource for measuring the impact of a game-based educational tool. A large volume of data can be identified, such as the time spent on a game, per game session, learning effectiveness, user audiences, etc.

The diversity and quantity of this data will enable a whole range of research into digital education, game-based education and Artificial Intelligence for education (see part 5).

Ikigai's Scientific Advisory Board, made up of around thirty researchers from among its members, is piloting research into gamification. The areas studied cover a wide range of issues relating to game-based education, from practical implementation to indicators for evaluation. The Scientific Advisory Board also acts as an ethics committee within the consortium, guaranteeing compliance with GRPD and promoting ethics in research in this field and in the use of its findings.

Respect for private data has led the Ikigai - Games for Citizens consortium to deploy an Edge computing network structure (Sulema et al, 2023). Players' personal data (if they are connected to their account) is only hosted within their training establishment. Outside their institution, this data remains inaccessible in its current state: only statistical results and analyses carried out on this data can be transmitted to the outside world.

Data is stored in Learning Record Stores (LRS) using the xAPI format. Each training establishment has a Data Processing Unit (DPU), possibly a cluster of machines, which is capable of analysing local data as well as liaising with DPUs on other sites to request data processing.

A software layer (API) enables the data to be processed locally, without any transmission to the outside world, thereby ensuring the confidentiality of the data by only allowing the transmission of aggregated results between the DPUs, the results of processing a set of individual items of information. This type of architecture, considered as an edge computing scheme, can be extended on a large scale over time and makes it possible to optimise research work in terms of the volume of processed/treatable data, confidentiality and network traffic.

As the xAPI ecosystem is very flexible, a hierarchy of xAPI declarations had to be designed in order to define a set of metadata declarations related to the use of a game ranging from global concerns (meta-analysis) to concerns specific to certain user activities in a given game (Sulema et al, 2023): thus, for example, data such as the number of games started can be counted (global data) regardless of the type of game, but also the number of puzzles completed for games linked to challenges (data specific to a category of game). These declarations enable analyses and research with different meta-analysis granularities for the widest possible diversity of games at each level of scale chosen for an analysis.

Finally, to ensure that it is possible to work with data collected as widely as possible, the consortium is involved in the European Promotheus-X project (Promotheus-X, 2024), which aims to define interoperable data formats between the services that produce them and those that use them in the field of education.

5. Video Games, a Gateway to Lifelong Learning of Tomorrow

By its nature, video games make it possible to create data on learning and the use of games in education. By the way it is structured, the Ikigai - Games for Citizens consortium network makes it possible to collect this data on a national scale and beyond. The combination of these elements means that there are benefits for all users: the scientific community obtains a set of data unequalled in number and quality for conducting research. This research will make it possible to establish a new, fairer and more effective model for user training (De Clercq,

2023): personalised pathways, centered on the user him/herself, with pedagogical recommendations enabling continuous training throughout the learner's life.

5.1 Use of AI Made Possible by Structuring

Ikigai's national network infrastructure can collect a sufficient volume of data to train a Machine Learning algorithm in a federative learning mode. Several models will be trained to improve the user experience and enable the creation of enriched personalised profiles to provide better support for learners.

For example, these AIs will be able to detect a student's shortcomings in real time and offer them a set of personalised recommendations to help them achieve the objectives defined by the course. This same information, transmitted to a teaching team, will enable precise monitoring of learning and better support for learners.

On the research side, trained AIs will be capable of analysing personal and collective dynamics during educational activities, enabling the subsequent improvement and creation of new algorithms specialising in education.

5.2 Serving the Training Needs of all

Using the data collected and the power of the algorithms and AIs integrated into Ikigai's national network, a range of services will eventually be available to training establishments and their learners, whatever their initial or continuing training course, ensuring the possibility of personalised courses throughout life.

Learners will be presented with a video game that can be used to develop an educational course for personalised skills enhancement. Learners' difficulties and errors will be identified. A possible drop-out or lack of commitment will be detected, as will the repetition of errors that at first seem innocuous, but which may point to cognitive dissonance or skills that have not yet been acquired.

This set of elements will enable teachers to make the most of the time they have with their learners by enriching their exchanges and offering content that is perfectly suited to the needs of each individual.

5.3 Skills-based Approach

Individualised support requires the construction of skills-based educational databases. When solving a complex task or problem, learners need to call on a range of different skills, sometimes simultaneously.

By collecting user traces (Sulema et al., 2023), it becomes possible to isolate and assess these skills to obtain a personalised portfolio of the learner's skills. At the same time, this advance enables teaching to evolve towards a skills-based approach, co-constructed with teachers.

Building on the MEMORAe project (Abel, 2021), Ikigai and its partners are investigating the use of interactive skills map concepts enabling teachers to describe their teaching unit in the form of a skills tree. The map provides a new data structure for analysing skills acquired or being acquired for individualised support, reconfiguring the approach to learner training.

6. Conclusion

While games and video games are particularly rich tools for learning, whether for learners or teachers, access to this type of medium is not easy. It was with this in mind that the members of the Ikigai - Games for Citizens consortium came together.

Together, they have decided to tackle a series of challenges to ensure that the deployment of video games in education is possible beyond a few isolated cases that act more as demonstrators than everyday tools for educators: a structural challenge at the political level to move towards pooling resources, and a structural challenge at the hardware level to deploy a coherent and efficient network.

By using video games to mobilise commitment, convey knowledge and create data, they are together proposing a new educational approach that will enable individual learners to flourish through the continuous improvement of the resources available to them. Drawing on scientific research in the humanities and social sciences, educational sciences, cognitive sciences and artificial intelligence, the results of the consortium's experiments

will provide learners from all backgrounds with individualised support and more efficient learning in their initial or continuing education.

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Game-based Training of Cognitive Functions: an Exploratory Study Involving Seniors in Switzerland

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Abstract: The aging population is resulting in a worldwide rising prevalence of individuals experiencing cognitive decline, whether it be normal age-related changes or pathological conditions. Game-based training in the form of serious games represents an alternative way to enhance cognitive functions among older people. We developed a set of games to train multiple cognitive functions of seniors, considering that their level of digital literacy can vary greatly. A participatory approach has been applied to the development process, involving a multidisciplinary research team and older people. Interviews, usability tests, and a workshop were run with ten seniors (70+) in Southern Switzerland to explore accessibility, usability, and preferences. This paper presents the development process and the games created. Six different games were designed to stimulate multiple cognitive functionalities (e.g., cognitive flexibility, attentiveness, and memory). The serious games run on a tablet. Following Laamarti's classification, we developed the games to be applied in well-being and health areas, requiring mainly mental activities through visual modalities, played through a touchscreen in a 2D digital environment. Participants appreciated the experience and the challenges provided by the games, understanding the broader aim (cognitive functions training) and the rules, and could complete the required tasks. Feedback was provided on graphical elements (icons and colours), as well as with suggestions for improvements. The tablet appeared to be functional and relatively easy to use, even for first timers. The promising results of this participatory study pave the way for the follow-up phase of the project, which will gather data on the usage of the application and its effectiveness with a greater number of subjects.

Keywords: Game-based Training, Cognitive Functions, Cognitive Decline, Serious Games, Older People

1. Introduction

The rapidly aging population is changing the demographic landscape of countries worldwide, challenging healthcare systems that struggle to fund care for older people (Humphreys, 2012). Data from the Swiss Federal Statistical Office (Ufficio federale di statistica, 2024) reflects a noteworthy increase in the mean age of the population over recent years. Southern Switzerland, in particular, has experienced a pronounced growth, and it now represents the Swiss region with the highest aging rate. As the population ages, cognitive decline emerges as a critical concern. While physiological aging processes contribute to cognitive decline, additional factors such as drug side effects, metabolic changes, and illness-induced delirium can exacerbate the issue. Conditions like depression, subjective cognitive impairment (SCI) or mild cognitive impairment (MCI), and dementia further highlight the complexity of cognitive health in aging populations (National Institute on Aging, 2024). While some of the causes, like depression and medication side effects, can be managed and the cognitive abilities restored, other conditions, such as SCI or MCI, represent possible targets for interventions to delay progression into dementia.

Cognitive intervention is generally intended to 'exercise the brain' in various ways as it is regarded as an effective non-pharmacologic strategy to mitigate risks in neurodegeneration. Computerized cognitive training (CCT) refers to cognitive training programs delivered by means of computers or mobile technology and is effective in attenuating cognitive decline in older adults with MCI or dementia (Hill et al., 2017). Serious games are a captivating and explored tool that shows promising results in addressing pathological and physiological cognitive

decline symptoms. Definitions of serious games vary, but they share a common thread: delivering a meaningful message that transcends mere entertainment, as they serve as a platform for training, teaching, learning, and much more (De Gloria et al., 2014; Michael & Chen, 2006; Rodríguez et al., 2021). Laamarti, Eid and El Saddik (2014), suggest five criteria to classify serious games: the area of application of the game (health, education, etc.); the type of activities (physical, mental, etc.); the delivery mode (visual, auditory, etc.); the human-computer interaction style (joysticks, eye gaze measurement, etc.); and finally, the environment in which the game is played (virtual reality, social presence, etc.). This classification emphasizes how versatile serious games can be, serving a variety of uses in a wide range of circumstances.

Over the past two decades, many researchers have delved into the topic of serious games by exploring their potential applications in addressing cognitive decline among older adults. Specifically, these games serve two primary objectives: the assessment and the training of cognitive functions. On the one hand, assessment games often integrate existing screening technologies to evaluate cognitive abilities. For instance, Nolin et al (2013) proposed a virtual reality game aimed at distinguishing between healthy and MCI participants based on prospective memory assessment. Similarly, another study examined the reliability of computerized touch-panel screening games for diagnosing Alzheimer's disease and MCI. Examples of such games include "beating devils", which simulates tasks similar to "whack-a-mole", focusing on working memory, and the traditional "flipping card" game, which assesses short-term memory skills (Fukui et al., 2015). On the other hand, training via serious games entails sustained engagement aimed at preserving or enhancing cognitive abilities. These interventions can be more effective than engaging in conventional exercises or receiving no intervention in the context of seniors with cognitive impairment (Abd-Alrazaq et al., 2022). Furthermore, cognitive training can be implemented through various games targeting distinct abilities. Memory, attention, and executive functions are among the most frequent capacities stimulated in this context; this trend is tightly related to the neurobiological underpinnings of the aging process, which primarily affect such functions (Peters, 2006). Memory deficit, for example, is one of the most observable and common symptoms among individuals with MCI or early dementia that disturbs the quality of life. Moreover, using a set of games can stimulate multiple cognitive abilities simultaneously. For instance, a study conducted by Simoes et al (2019), tested an older population with a group of serious games designed to maintain and/or enhance various functions such as memory, attention, language, and executive functions. These abilities are engaged through games like "Pairs", a memory game, "Puzzle", requiring attentional effort, or "Whack-a-mole", stimulating sustained attention and inhibition. Similarly, another study led by Ríos Rincón et al (2022) utilized games such as "Whack-a-mole", "Word Search", or "Mahjong Solitaire" to concurrently stimulate selective attention, short-term memory, and processing speed.

For the SIGMA project, we developed a set of serious games targeted to the local population to train multiple cognitive functions of older people. To develop the games, we followed some of the key guidelines of design of games for the seniors presented in Chilufya (2014). Research has shown that digital games can provide enjoyment and relaxation, help escape from reality during times of grief or loneliness, stimulate with the challenge of completing a game and achieving high scores, and enhance one's skills. Digital games offer an opportunity to remain connected with society, add purpose to their days, and engage in brain training. They can also provide the chance to teach others rather than being solely trained by the game and therefore enhance social connectedness and promote interaction (Nap et al., 2009). The novelty of our research is the use of such games not only for the training, but also for monitoring cognitive performances by healthcare professionals in the context of home care services. In this paper we focus on the development process and describe the final games.

2. Study Design

A participatory approach was applied to the games development process by involving a multidisciplinary research team (research nurse, engineers and software developers, a graphical designer), a neuropsychologist, seniors, and geriatric nurses. The study comprises four stages. Firstly, a literature review was undertaken followed by qualitative interviews conducted with both geriatric nurses and seniors to explore needs and preferences. Findings informed the development of six serious games for the cognitive training of seniors receiving home care. Games were included in the beSerious app supported by a platform that allows nurses to monitor changes. Usability tests and a workshop with seniors and geriatric nurses were conducted to gain feedback along the development process. Such approach facilitated the definition of the games' features. In the next phases of the project, the games and the platform will be implemented in clinical practice with home care users and nurses. Ethical clearance was gained by the Comitato etico cantonale Ticino.

3. Qualitative Feedback

3.1 Pre-development Phase

Eight interviews were conducted with older people (4) and the geriatric nurses (4) to explore seniors' relationship with technology, games and mobile games (played on a mobile device like a smartphone or tablet), but also their digital skills and gather insights on preferences and barriers that could inform the games features and the development process. Nurses were of help to investigate technical aspects that needed to be considered for patients dealing with potential cognitive impairment, including the use of bright colours, lights, and sounds. Bright lights and sounds can, in fact, overstimulate older people, especially if they play games late in the evening.

During the interviews we also let seniors play some games[1] on a tablet to gain a more direct and realistic "hands-on" feedback.

The smartphone is the most frequently used device, with all seniors interviewed having and regularly using one. One person regularly uses a PC and other two had a tablet. Smartphones are primarily employed to stay in contact with family and friends, but also to play games; while the tablet is used mostly to play games, do searches, and look for information on the internet. When it comes to gaming, tablets are thought to be the best option because they are easier to use than computers and have larger screens than smartphones. Moreover, evidence suggests that the use of smartphones and tablet can aid cognitive functions, especially executive functions and processing speed (Wilson et al., 2022). Seniors mostly liked the games related to cards and words, which they found particularly stimulating. Moreover, some of the games we showed them were considered too simple or boring from a graphical perspective and not enough challenging. Instead, the curiosity message that showed up at the end of each level in one of the games was well-received by seniors since it increased their interest and taught them something new. Scoring systems and playing against the computer received mixed feedback from the interviewees, as these are seen from some as a motivator to play with points fostering a healthy sense of competitiveness, while for others these represent a source of stress.

Nurses reported that the most important cognitive areas to evaluate are memory, attention, and language, as these provide a general view of a person's cognitive status. Attention is a fundamental element in cognitive assessment, as the sudden loss of this in patients with a cognitive decline indicates a potential worsening in the global cognition. Similarly, a decline in the language areas could hide a rapid deterioration of cognitive functions. The games were seen as an interesting tool for prevention and an additional resource for the nurses to monitor the patient's cognitive status. However, it could implicate additional workload, as the nurses would need to check the platform regularly to ensure effective monitoring. To encourage older people playing, nurses suggested that the games are engaging and that the patient see a benefit in using them. They were concerned that the patients could feel supervised and will stop playing, and that having the same level for all the users could be boring for some of them and too difficult for others. Some interesting and useful data to be collected from the game would be the frequency of playtime, the time they took to finish the level, how many errors have been made, the final score, and which games the users choose to play. They anticipated that if the user would suddenly stop playing, it could be used as an alert.

Findings from this initial phase allowed the research team to identify the games to be developed and some of the features to be included in or excluded from these games. Information gathered were discussed extensively with a neuropsychologist and the team of game developers. Six games were chosen based on the state of the art of serious games targeting older adults, seniors' preferences, and cognitive areas to be stimulated.

3.2 Test Phase

Usability tests and a workshop were used to collect feedback and insights from future target users to be incorporated in the development and refinement of the games.

[1] Games were downloaded from the App Store and were the following: Word of Wonder, Jigsaw Puzzle, Candy Crush Saga, June's Journey, Cooking Mama, and Tetris. Some people played more than one game.

3.2.1 Feedback Usability Test

Two seniors participated in a two-month usability test. They received a tablet with the games and could play freely. We were not interested in quantifying the number of hours the participants played the game. At the end of the test, in-depth feedback was collected. Seniors liked the stimuli provided by the games as they felt they had a higher purpose than simply entertaining, especially the one focusing on language skills. One reason to play the games was their ability to improve several cognitive domains. One participant perceived the set of games as a valuable tool for nurses to identify cognitive issues that might go unnoticed by the individuals themselves, allowing healthcare professionals to intervene on time. The other participant liked attention-stimulating games because they were perceived useful. They found some games difficult to play, but the more they played the easier they became. Overall, they felt satisfied after finishing a game.

3.2.2 Workshop

The 13th of March 2024, we organised a workshop with four seniors to receive feedback on the usability and accessibility of the complete set of six games (Figure 1). Participants are currently receiving some form of home care services provided by the ACD Mendrisiotto, a homecare and assistance association in Southern Switzerland. They varied in age and gender (from 73 to 87 years old, 50% women), health conditions, and in technological competencies. Three out of four were not used to play mobile games. For one participant it was the first interaction with a tablet. We presented the project, the set of games, and the purpose behind such games (cognitive functions training). Participants had the opportunity to play every game in autonomy or with the support of a team-member. We collected feedback, suggestions, questions, but also notes from observing the participants while playing. Participants were also asked to provide their preferences in relation to different graphical elements (e.g., icons and colours used in the app).

Overall, they appreciated the experience and the challenges provided by the games; they understood the broader aim and the rules of the games and could complete the tasks required. The tablet appeared to be functional and relatively easy to use, even for the first-time user. Participants liked to play in couples as they could challenge each other and socialise while playing. The feedback received was used to finally refine the games.



Figure 1: Usability and accessibility workshop with seniors

The project is attracting the attention of various local entities, ranging from services providing care to people affected by dementia, to local media. The Swiss television channel Radiotelevisione (RSI), for example, was present during the workshop and produced a television report on the project[2].

4. Game Design and Development

The beSerious application presents itself as a game where players can traverse Europe's capital cities by playing the games. The journey theme aims to motivate the players to discover more information about European capitals. In fact, by successfully completing three games out of six, the application shows a curiosity about the visited city, and the next country is unlocked.

[2] https://rsi.ch/s/2095283

When launching the application for the first time, the interface prompts a tutorial that explains how the game works, and how players are supposed to play. This was a specific request made by seniors during the workshop, as they expressed concern in relation to the game starting immediately without having any pop-up instruction. The tutorial also explains the functionality of the buttons on top of the interface: hints, difficulty settings, and a “back” button to return to the Europe map screen (home screen).

The application was developed in Unity and is built to gather data on its usage (date and time played, data about the game played, games performances), which are stored on the device and, when Wi-Fi connection is available, securely sent and stored on a university-protected server. Researchers are working on a front-end accessible from the Web which can be used by nurses and caregivers to monitor players’ performances and changes in cognitive functions.

The visual identity for the beSerious app took in close consideration the target users. In particular, the team developed a symbol/icon for the app that includes: a dice to symbolize the game, a smile to express inclusiveness and welcome but also a graphic element of contrast with the concept of games that have a "serious” purpose. These two elements (see Figure 2) led to an icon illustrating a smiling and friendly dice, easily recognizable by end users. Two different fonts were selected for the logo: one with serifs ("be") and one without serifs ("serious") to create contrast, both in bold to increase visibility. Furthermore, the letter "U" has been transformed into a smile, to reinforce the idea of play and cheerfulness. A careful analysis was also carried out on the meaning of colors, together with an analysis on readability by seniors as well as people suffering from color blindness.



Figure 2: beSerious app icon and logo

4.1 Games Developed for the Training of Cognitive Functions

The six developed and implemented games are: “Find the word”, “Remember a sequence”, Jigsaw, Whack-a-mole, “Three towers”, inspired by the Tower of London (Shallice, 1982), and Labyrinth. Above all, such games stimulate executive functions, which are crucial for day-to-day functioning, but typically decline with age. Games are also useful in stimulating attentional and mnemonic abilities (particularly visuospatial). Table 1 shows the cognitive functions involved in each game. Some of them are the main target, while others are stimulated to a lesser extent. Below is a more detailed description of each game.

Table 1: List of cognitive functions stimulated by the six games.

		Find the word	Remember a sequence	Jigsaw	Whack-a-mole	Three towers	Labyrinth
Executive functions	Logical reasoning	ü		üü		üü	üü
	Cognitive flexibility	üü		üü		ü	ü
	Shifting	üü				ü	
	Strategy	üü	üü	ü		üü	ü
	Visuospatial abilities		üü	üü			üü
	Planning		ü	ü		üü	üü
	Working memory	üü				üü	üü
Memory	Short-term memory		üü				

		Find the word	Remember a sequence	Jigsaw	Whack-a-mole	Three towers	Labyrinth
Attention	Sustained attention				üü		
	Selective attention	üü	üü		üü	üü	üü
	Divided attention	üü	üü				

üü - primary stimulated functions

ü- secondary stimulated functions

4.2 Find the Word

Find the word (Figure 3) is a game inspired by the world-famous “Wordle” game. Players are given six attempts to guess a five-letter word, with feedback given through the game interface in the form of coloured tiles indicating a) if the letter is included in the word (green); b) if the letter is included but in the wrong place (yellow), and c) if the letter is not included in the word (red). The game prompts a digital keyboard on the screen. The game has been designed to allow the player to ask for hints. Hints let players ask for the first letter of the word, to reveal one letter on the digital keyboard (highlighted in yellow) that is part of the word, or to insert a correct letter in the attempt. The hints were specifically asked for during the workshop in march, where one participant expressed concern regarding the frustration when looking for a word without finding the first letter.

This game stimulates cognitive flexibility, shifting skills, working memory, as well as attentional functions. It draws inspiration from Verbal Fluency test (Carlesimo et al., 1996) and Wisconsin Card Sorting Test (WCST) (Laiacona et al., 2000). Verbal fluency provides information about the extent of and access to the lexical semantic storehouse, and it is considered a sensitive tool for predicting specific pathologies (such as aphasia, AD or other neurodegenerative diseases).

In the background, the game keeps track of the number and letters of attempts a player makes to find the word, the time taken, and the number and type of hints the player asks.

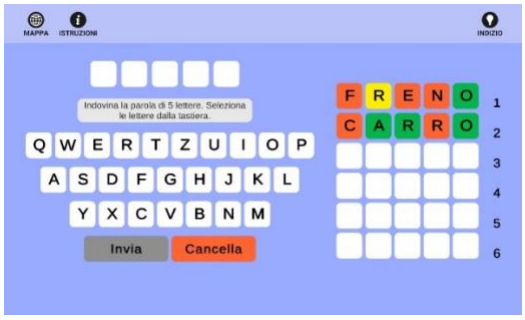


Figure 3: “Find the word” game

4.3 Remember a Sequence

In this game, the player is prompted with five cards. Each card gets coloured following a random sequence (Figure 4). The player’s task is to remember and reproduce such a sequence by tapping the cards in the correct order. This game has no hint functionality implemented.

It stimulates visuospatial abilities, but also strategy and short-term memory. The theoretical reference is the Corsi Block Tapping Task (Monaco et al., 2013), which measures the amount of visual information (span) that can be retained in memory.

The game keeps track of the number of attempts a player makes to win it and the total time taken to finish. A wrong attempt results in a prompt suggesting trying again, showing on the background the cards that were chosen in the correct order (green border) and the ones chosen wrongly (red border). The sequence is shown again, giving players six tries in total. For cognitive function analysis, we will keep track of the time taken to perform a successful attempt.

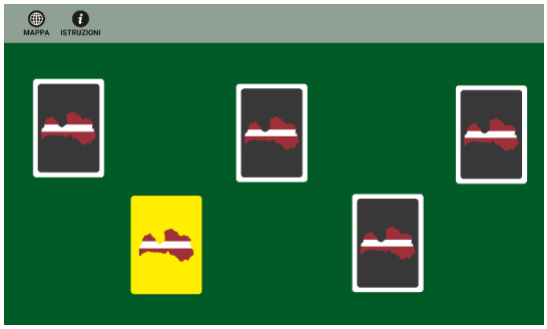


Figure 4: "Remember a sequence" game

4.4 Jigsaw

Players can choose between a puzzle with 16, 36, or 64 pieces. The system picks a random image from a collection of predefined images and generates a random puzzle with the given pieces.

Players should build the image in the empty play area. They can view or remove the backdrop image using a button on the top-right of the screen (this is the only hint present in the game). Players can travel between the pieces using a horizontal-scrolling bar on the bottom and they can drag-and-drop them to the play area. Adjacent pieces have a snap feature that connects and stays together when moved (Figure 5).

The game stimulates executive skills such as cognitive flexibility, logical reasoning, and visuospatial abilities. The difficulty settings chosen and the time to complete the jigsaw are data stored from the game.



Figure 5: "Jigsaw" game

4.5 Whack-a-mole

This game requires the player to tap as fast as possible on moles appearing from underground (Figure 6). There is a time limit of 60 seconds, and players must correctly tap at least 24 moles to pass the game.

Whack-a-mole is a simple game, yet it stimulates attentional skills, especially simple reaction time, i.e., alertness, or, better defined as the ability to act quickly and appropriately to concrete stimuli/environmental demands.

The game keeps track of the number of moles successfully tapped by the player, as well as the coordinates of the taps and the time of the tap, to compute delays in reaction times. Such data could be used in a future version to establish a scoring system and an adjustable difficulty setting that may affect mole speed based on player performance in previous games.



Figure 6: "Whack-a-mole" game

4.6 Three Towers

Three Towers is a Tower of London-themed game (Shallice, 1982). Players start with a three-pegged infrastructure with three coloured discs in a 3D scene. Leftmost peg can hold all three discs, middle peg two, and rightmost one. Players are given a final discs' disposition on the top-right screen and a restricted amount of moves on the top-left screen. The goal is to get from the beginning disposition to the final one. Figure 7 shows the game, composed with three levels to be completed, each with three tries. Players use fingers to drag-and-drop discs between pegs. Only the top disc in a pile can be moved to another peg.

The game primarily stimulates planning, strategy, working memory and logical reasoning, as well as attentional functions. The application keeps track of the time taken to complete each level and the number of attempts. There are no hints.

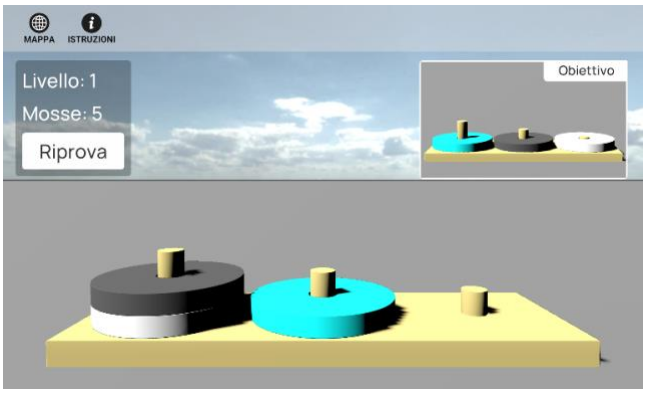


Figure 7: "Three towers" game

4.7 Labyrinth

Similarly to the Jigsaw game, players can choose from three difficulty levels based on labyrinth size. A new game is guaranteed by procedurally generating the labyrinth. To navigate the car from the starting position to the exit, players are given four arrows (these commands can be moved left or right of the screen with a button) (Figure 8).

If stuck, players can reset the labyrinth and start over with an interface button. The interface lets players create a new labyrinth of the same complexity or change levels if the game is too easy or hard.

The game stimulates visuospatial abilities, planning, and logical reasoning, but also working memory and selective attention. In the background, the application keeps track of the difficulty level chosen and the time taken to complete the track.

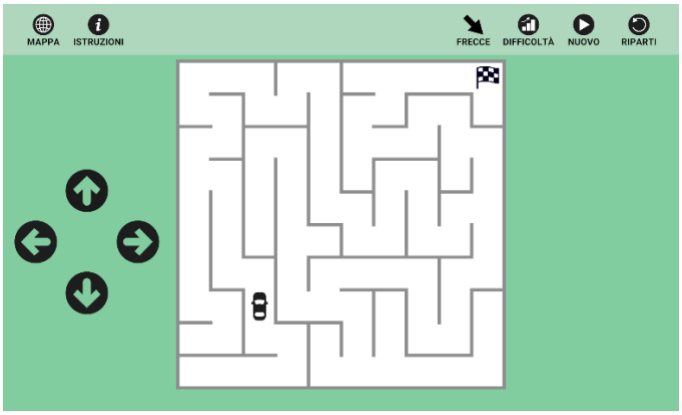


Figure 8: "Labyrinth" game

5. Conclusion

In this paper, we discussed the game design process and final output of beSerious, an application that provides serious games for cognitive training and monitoring of seniors using home care services in Southern Switzerland. Game-based training is used to improve cognitive functioning in older adults. We explored the local environment and stakeholders' demands, designed the games, tested the usability by potential users, and refined the games over a year and a half, from January 2023 to May 2024. Beginning in June 2024, the application will move into the data collection stage.

The promising findings show the importance of involving future target users in game development to explore technology and implementation issues, despite the small number of test users from the same social context and geographical area. The research team anticipated technological and practical issues with this inclusive strategy. Including user feedback and insights early in the development process allowed game designers and software developers to match game-based training products with user preferences and needs to improve uptake and engagement.

In the following phase, 15 to 20 people with none to mild cognitive impairment will play the games for 12 weeks. In a follow-up paper, results will be analysed and presented to show frequency of usage, games played more often, and game performance consistency over time, since long-term home training remains difficult.

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Gaming the Industrial Revolution: Participatory Design with Historical Data For Classroom Learning

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Abstract: Industrial Re:evolution is an educational game developed by a collaborative team of educators, historians, game designers, and developers. The game allows students to hypothesise about the underlying causal mechanisms of the Industrial Revolution while managing population and resources across 19 discrete regions in England and Wales from 1600 to 1851. The game was developed through a series of participatory workshops, which led to a gameplay concept based on a comprehensive model of the Industrial Revolution, centred on key theoretical frameworks. Through role-playing, problem solving, and in-class discussions, students are encouraged to explore various factors that contribute to the Industrial Revolution and their interdependencies. It helps them develop a deeper understanding of the intricate relationships between different causal factors, improving their ability to explain and analyse complex historical events, and promoting quantitative skills. The game is an open-ended historical simulation based on state-of-the-art research, providing students with the opportunity to interact with real historical data. To enhance classroom implementation, the game is provided with structured activities, lesson plans, student booklets, and multimedia materials, while an online platform will eventually offer a community for educators to share best practices. This study describes the design choices and development of the game.

Keywords: Educational Technology, Gamification, Historical Learning, Educational Game Design, Participatory Design

1. Introduction

This article presents work from the research programme 'Gaming the Industrial Revolution' (GIR), which led to the creation of an educational game called Industrial Re:evolution. Designed to support and augment the teaching of economic history - specifically the Industrial Revolution - for secondary school students, the game serves as a hands-on learning tool suitable for classroom implementation. It was developed through research collaboration between the University of Cambridge, the University of Salford, game designers and developers, and a group of history teachers between 2019 and 2023. This collaboration facilitated the incorporation of role-playing, problem-solving, and class discussions into gameplay, providing a comprehensive approach to game design. This project marks one of the first attempts to purpose-build an educational game to measure the impact of gamification on learning attainment, cultural capital accumulation, and the development of higher-order thinking skills.

GIR was conceived to provide a resource that helps students articulate multiple causal chains in a game format, allowing them to explore causal links iteratively through play. Our aim was to assess whether the use of the game would allow students to discover and formalise the relationship between the variables of the games on their own, both in a formal school setting and at home. To build the game, we followed a participatory design methodology that involved the expertise and active participation of secondary school history teachers, historians, education researchers, game designers, and developers from the design stage through testing and implementation.

Thus, the core of the project consisted of a series of gamifications held in Cambridge and Manchester with teachers, game developers, and researchers. These gatherings allowed us to develop a concept, test a prototype, evaluate feedback mechanisms, and elaborate a pedagogical methodology for implementation. Thanks to this, we now have: i) a functional prototype of the game, which is available for free to all schools; ii) a network of schools and educators interested in the use of games for the teaching of history; iii) some tentative measures of engagement and impact used to promote best practices; and iv) strong contacts with institutional stakeholders to promote the use of these resources in the national curriculum.

In this article, we describe the collaborative and participatory processes that led to the creation of the game, the design choices made, and the adopted educational setup. The impact on students' attainment and engagement will be discussed in a future publication, when all the data have been collected. We have therefore not included any measurement or discussion of results in this paper.

2. Rationale for Building a Game

Over the years, there seems to have been a noticeable decline in the number of British secondary school history teaching the topic of the Industrial Revolution. This trend is all the more disconcerting because the Industrial Revolution marks a pivotal point in both British and global history. It is a moment in human history that holds the key to understanding the uplift in living standards over the past two centuries accompanied by growing inequalities, the relationship between demographic and economic growth, the dynamics of European colonial expansion and exploitation, and the extent of the environmental damages caused by the extensive 'mineralisation' of our economies.

Interviews carried out with a panel of teachers selected for this research project revealed that the diminishing emphasis on the Industrial Revolution may largely be due to its perception as a 'dry' and challenging topic by both teachers and students, who often find data-intensive literature difficult to navigate. Compounding this, is the fact that the more recent causal explanations of the Industrial Revolution (Allen, 2009; Wrigley, 2010b; Shaw-Taylor and Wrigley, 2014; Kelly, Mokyr, and O'Grada, 2014) combine complex multifactored and multi-scalar narratives. Thus, even where industrialisation is mentioned in the national curriculum (for example, A-level unit 1F Industrialisation and the people: Britain, c1783-1885), the pedagogical approach in the recommended textbooks is to offer a long list of causal factors, which may reflect the complexity of the historiography, but makes an overarching understanding of causality extremely challenging, as shown in Fig.4, which shows the best attempt at creating such a diagram by the author. No secondary school students could learn from this.

Furthermore, teachers who submitted their teaching material on this subject overwhelmingly adopted a biographical perspective on the Industrial Revolution, illustrating the consequences of socioeconomic changes on the lives of specific individuals, often focussing on children. Although this approach may improve the engagement of the subject based on empathy, the teachers agreed that it made it more challenging for them to provide an understanding of the conceptual and theoretical aspects of the subject. To address these issues, we created a game that offers both an engaging and interactive approach to learning while making it possible for students to formulate hypotheses regarding the underlying causal mechanisms through gameplay.

3. Previous Work

Research supports the effectiveness of game-based learning in improving educational outcomes, fostering 'learning communities' when embedded in classroom teaching, and providing targeted support for less-advantaged groups. We will discuss each of these in the following subsections, and how Industrial Re:evolution was designed to be both engaging and pedagogically robust, while maximising the chances of a positive impact on student learning by ensuring that the game remains inclusive and accessible to a broad range of students.

3.1 Gamification and Learning

The integration of games into formal educational environments, particularly secondary education, has demonstrated the potential to improve student engagement and learning outcomes. Even commercial titles, like Sid Meier's 'Civilization' (Meier and Shelley, 1991), have found their way into history curricula (Botting, 2023). However, existing literature highlights several challenges in adopting commercial games, primarily designed for entertainment, in an educational setting (Taylor, 2003). Our project adopted a different approach by explicitly designing a game as a pedagogical tool for in-class learning. Our design team comprised historians,

history teachers, game designers, and students from our target audience, to produce a purpose-built tool for classroom implementation.

We also considered the recent research on effective game-based learning. For example, Hainey et al. (2011) and Wouters et al. (2013) demonstrated that game-based learning can improve both student motivation and cognitive outcomes. In addition, a meta-analysis by Clark and Greitemeyer (2016) reported that digital games can have a positive impact on learning outcomes, given that the incorporation of effective design features, such as Squire and Barab (2004) also demonstrated that gamification can improve attainment for key demographics. In their study, they showed that underserved urban students who engaged in learning world history through computer simulation games exhibited significantly improved knowledge retention and problem-solving skills. Finally, gamification can support learning beyond information retention and can promote high-level analytical and critical skills. Gee (2003) demonstrated that video games can teach valuable learning and literacy skills by engaging learners through active problem-solving.

In Industrial Re:evolution, we sought to incorporate the three key attributes of successful game-based learning experiences, as outlined in Taylor (2003).

- The game is interactive and allows students to engage with a dynamic representation of the Industrial Revolution and to understand the interplay of economy, geography, and technology.
- The game encourages active participation, progressively fostering a better understanding of the causality chains embedded in the simulation.
- It also promotes empathy by connecting students with historical characters and fostering a deeper comprehension of the multiple forces that shaped their lives.

4. Collaborative and Participatory Design

Crafting game-based experiences which are educational and perceived as ‘fun’ by students is a difficult undertaking. The academic literature on game-based learning has many examples of edutainment titles that do not perform on both fronts, resulting in dull gaming experiences with little educational value (Van Eck, 2006; Prensky, 2001). To prevent us from following the same path, - the project implemented a methodology designed to recognise and articulate the expertise of key stakeholders – scholars, teachers, game designers, and students in our targeted group.

The methodology used to successfully address the different and sometimes conflicting goals of all stakeholders was participatory design (PD), which was adapted for use in educational game design. PD originated in Scandinavian design in the 1970s and has since been applied in various fields such as software design, urban design, architecture, product design, graphic design, sustainability and planning. PD has much to offer in educational game design and has been used by an increasing number of researchers to design game-based learning experiences. However, successful implementation does not happen smoothly or automatically (Khaled et al., 2014)

The participatory design process of Industrial Re:evolution occurred in a series of four workshops held between April 2022 and April 2023. These workshops brought together 17 teachers from 15 schools, five game developers, two artists, three students, and five academics (three historians, one game designer, one researcher in education). During these workshops, we progressively moved from the initial ideas tested using quick paper prototypes to digital gaming experiences. We started this process by defining the key aspects or ‘substantive concepts’ of the Industrial Revolution to be included, as well as the educational objectives of the game. This first conceptual design level prevented us from rushing into designing a game without a clear definition of what students should learn by playing with it. The second phase focused on translating substantive concepts into interesting and meaningful game challenges. To this end, the team quickly prototyped different game mechanics, testing and evaluating the specific type of knowledge embedded in gameplay. Also, a key concern at this phase was to ensure that the game mechanics altered the game states at meaningful points of gameplay, gradually increasing the level of challenge while rewarding the player’s performance.

Two interdisciplinary teams were formed and tasked with producing playable gaming concepts. After several cycles of development, distinct ideas began to emerge (Fig. 1). In the first concept of the game, regions of England and Wales could be developed through resource tokens and by establishing spatial connections between them. In addition, a historical timeline triggered events at each turn, affecting regions locally or globally. The second team adopted a more abstract approach, focussing on the gameplay in a quantitative system defined by the interplay of a discrete set of variables. After testing and discussing the merits and

shortcomings of each prototype, we decided to blend both versions. Although the interaction with an economic model of the Industrial Revolution was deemed crucial from a pedagogical standpoint, the historical timeline and spatial relationships were also considered important. With much to continue working and refining, we finalised our first design workshop with a playable game concept.



Figure 1: Initial game concepts developed in workshop sessions

5. Defining the Pedagogical Remit of the Game

5.1 Content

Teachers surveyed in 2021 overwhelmingly concluded that understanding the notion of the 'Malthusian trap' (i.e., the relationship between demographic change and economic development) was essential for the ability of students to comprehend the revolutionary nature of the Industrial Revolution, but it was rarely taught to students due to its conceptual complexity and the level of pre-required knowledge. To grasp the Malthusian story, students must have some understanding of the concept of wages, core demographic notions such as fertility and mortality, and the notion of marginal decreasing return of labour in agriculture.

Therefore, Industrial Re:evolution was designed for both teachers and students to understand the connections between demography, energy sources, geography, and economic development in a progressive manner throughout the game and repeated directed play sessions. The game can then subtly introduce students to the three most influential meta-narratives of historical change, explaining the origins of the Industrial Revolution (Allen, 2009; Wrigley, 2010b; Mokyr, 2012). Through gameplay, students are encouraged to infer and formulate causal relationships based on these models, thereby transforming them into discursive units in classroom activities.

Our pedagogical survey also outlined 'industrial development before the Industrial Revolution', 'the geography of natural endowments' and 'Empire' as the second most desirable elements in the teaching of the origins of the Industrial Revolution. Based on this, we determined that the temporality of the game would cover the period from 1600 to 1851, and, in doing so, introduced students to early technological developments before the age of steam. Moreover, we added a strong cartographic dimension to the user interface, allowing students to compare maps of soil quality, coal deposits, market access, and waterpower potential to inform their decisions.

Finally, during the workshops, it became clear that for teachers, emphasis on chronology and memorisation was an essential factor in improving students' attainment. Therefore, we decided to develop a user interface with a prominent timeline and regular events that inform students of historical developments that we would like them to remember. We also embedded learning spot checks (see Fig. 2) in the form of quizzes, which allow players to unlock particular technological improvements and increase productivity in a tile or for a particular sector.

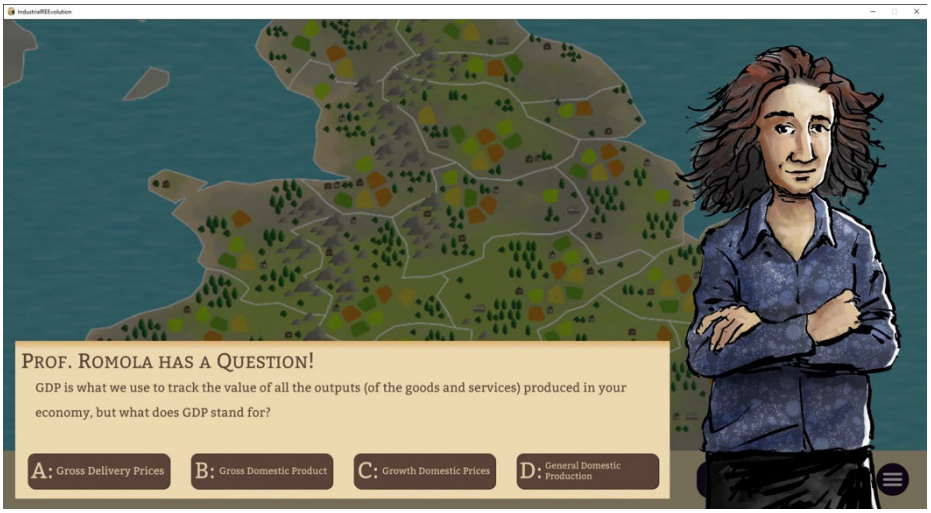


Figure 2: Embedded learning spot checks

5.2 Skills

Industrial Re:evolution addresses several challenges that students face in comprehending historical events, including understanding and articulating complex, interconnected causal relationships, as well as developing quantitative skills, such as chart reading, chronology, and inference making. In traditional history education, students often find it challenging to synthesise and analyse multiple factors and their influences on each other. This problem has been observed in both classroom discussions and written assessments, where students tend to describe isolated events rather than provide a holistic understanding of their causes and consequences.

Therefore, we incorporated various elements and activities that specifically target these skills. For instance, students are exposed to different charts, graphs, and timelines within the game, which requires them to interpret and analyse data, understand chronological developments, and make informed inferences to unlock bonuses, but also to participate in the classroom activities that accompany the game. By actively engaging with these elements, students develop a stronger foundation for quantitative skills, which are essential for understanding complex multivariate causal chains.

6. The Simulation

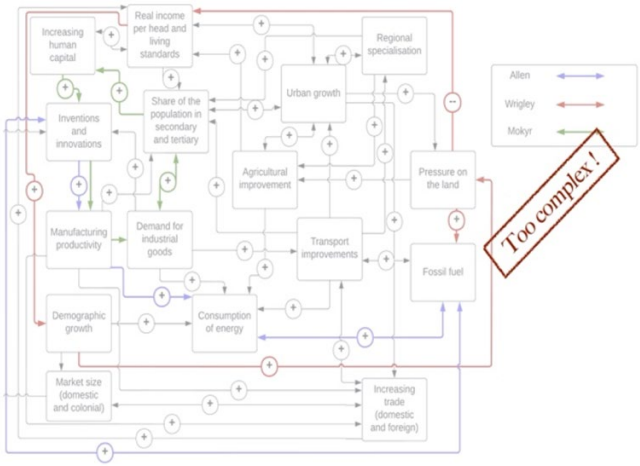


Figure 3: Original causal diagram

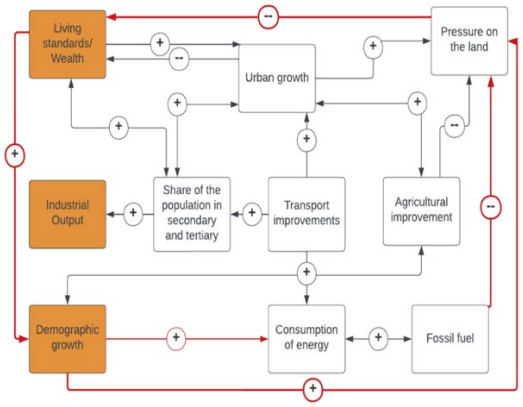


Figure 4: Simplified causal diagram

6.1 Using Historical Data

A unique aspect of this game is that it is based almost exclusively on data produced by researchers, and therefore exposes students to an unprecedented wealth of 'real' historical data. We draw on state-of-the-art historical research (especially from researchers from The Cambridge Group for the History of Population and Social Structure, also known as CamPop) on occupational change (Shaw-Taylor and Wrigley, 2014; Keibek, 2017), demographic growth (Wrigley, 1997, 2004), the role of natural endowment, such as coal, forest cover, water-power potential and soil quality (Wrigley, 2010a; Fuchs et al., 2013), and historical transport networks (Bogart et al., 2021; Alvarez-Palau and Dunn, 2019). We also use historical GDP estimates from the Maddison Project (Bolt and van Zanden, 2020). All character stories are derived from the collection of autobiographies collected by Emma Griffin (Griffin, 2014). Not only is the simulation running on 'real' historical data, but all the underlying data is also visible to the students through entries in an in-game glossary, which details the sources used and offers the students and teachers a more in-depth analysis of the data. For more complex entries, embedded hyperlinks allow students to play with the data in dedicated interfaces, such as www.populationpast.org, www.economiespast.org, and www.travelintimes.org.

Once collated, all historical data were aggregated to match the game's units (i.e. tiles) and benchmark dates (i.e. turns). These data then informed the simulation of each region.

7. Interacting With the Simulation

Once the historical data is encoded in the simulation and narrative components of the game, the following design challenge involves developing a system of rules to allow the player to interact with the data. For this, the design efforts concentrate on defining the internal variables to be exposed in the game interface and designing the modes of interaction to allow the player to affect them meaningfully. According to Salen and Zimmerman (2003), this is the primary goal of game design, the design of the processes by which players take action with the game's designed system and how the system responds to the action.

A further challenge is finding the right balance between procedural understanding and fun. To be used successfully in the classroom and provide a meaningful learning experience, a game not only gives students access to a historical data model but also requires an intrinsically motivating environment to learn. Using the frameworks from Malone and Lepper (1987) and LeBlanc, Hunicke, and Zubek (2004) as references, the team defined four design goals:

- **Challenge:** the game activity is driven by goals which are uncertain and depend on player performance to be achieved (for example, "Can you prevent England and Wales to fall into the Malthusian trap?").
- **Discovery:** the activity is designed to capture the player's attention, modifying their cognitive structures to understand the industrial revolution in a different way.
- **Control:** the game activity provides a range of possible outcomes based on the actions and decisions of the player, a goal closely related to the concept of *meaningful play* developed by Salen and Zimmerman (2003).
- **Narrative:** the game recounts stories and connects players empathically with characters from the past.

7.1 Defining Game Mechanics

Generally, game mechanics can be defined as "methods invoked by agents, designed for interaction with the game state" (Sicart, 2008). Following conventions of strategy games described by Rollings and Adams (2003), the game employs an abstraction model of interaction. The player interacts with the underlying simulation data and statistics both directly and indirectly, has no in-game avatar or agents, and, in an omnipresent role, directly influences the game world via actions that modify the parameters of the simulation. Through a top-down perspective, the game communicates the current state of the simulation and the economic properties of each of the 19 discrete geographical regions (each with variances such as economic sector productivity). The current version of Industrial Re:evolution allows students to interact with the map and, through this set of actions, develop their own version of the industrial revolution, covering a period from 1600 to 1851. The core gameplay mechanics centre on the management of the population and resources (food and energy) and represent the player's toolset for altering the simulation parameters. The map provides a high-level abstraction and visualisation of the simulation (presenting semiotic and numeric data) and provides two of the three core gameplay mechanics, migration of population, and trade of resources (Fig. 5). Upon selecting a region, the game interface displays key economic indicators such as living standards, GDP, population, and unemployed labour, and facilitates the allocation of unemployed population to a specific economic sector. Additionally, icons representing the migration of unemployed population and trade of resources are presented on each region, these can be dragged by the player to another region (combining the selection of the source, the target, and action into a single operation) to quickly execute a compound action. Although the player's agency is restricted to a few possible actions, such as migration of populations, resource trading, and labour allocation, their combination and the emerging effect on each region and the whole map lead to many possible outcomes. During each turn, players can decide how they will influence the game world. They can assign unemployed populations to various economic sectors, relocate them to different regions, or exchange produced resources with other regions connected by transport links. Once the player has made their decisions, they press a button to advance the game. This action advances the historical simulation forward 25 years, initiating events from the historical records that occurred during this timeframe. These events are presented to the player through textual and visual descriptions of what took place—historical famines, civil wars, scientific discoveries, or industry advances—reflected in the simulation and imposing new challenges on the player. Thus, the game establishes a dialogical relationship between the factual historical record and exploratory and alternative versions of the past emerging from the game.

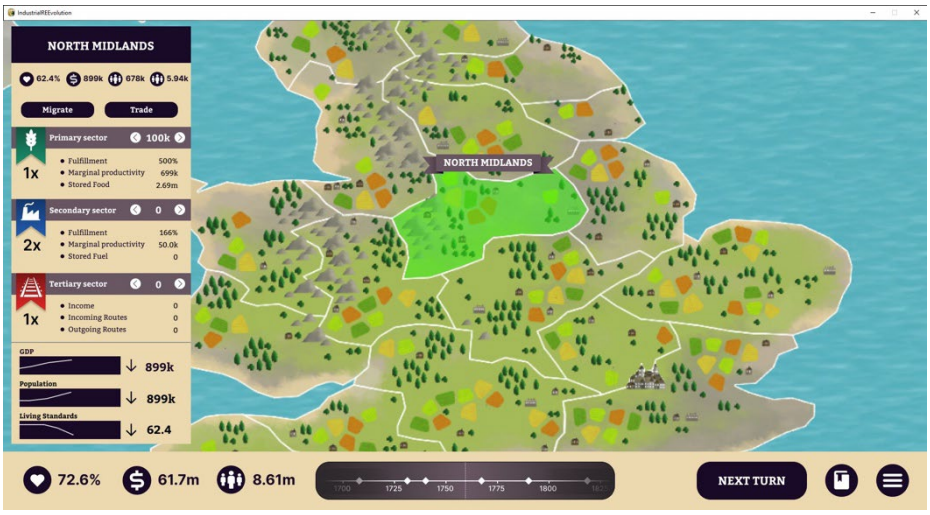


Figure 5: Industrial Re:evolution's main interface.

In this quest to drive the industrialisation of England and Wales, players can access graphical representations of gameplay and historical data. Key metrics such as GDP, population, and living standards were recorded at every turn and displayed in comparison with the historical data for each of these metrics. This allows the player to monitor his or her playing session and raises further questions: What drove the development of certain regions and not of others? By encouraging students to raise and heuristically explore these questions, our goal was to drive them to follow the same processes and modes of thinking as professional historians when interpreting the past.

In its top-down and omnipresent interfacing, the game follows the conventions of 'God games', a perspective criticised by some authors for its depersonalisation of violence (Friedman, 1999) and a lack of empathy. In the case of our historical game, how can we make students care about people's fates when they are only visible to them as abstract quantities? To achieve this goal, we introduce historical characters associated with scripted and emergent events. The characters are designed to connect with players through textual narratives, allowing children to perceive the human effects of decisions taken during gameplay and triggered by historical events (Fig.6).



Figure 6: Example of an exogenous event in the game

7.2 Explainer Animations

We also developed animated scenes for use at various times during the game. In the current game iteration, cutscenes introduce students to key theoretical aspects embedded in the game's procedural dynamics, such as the Malthusian theory (Fig.7), and bring a sense of narrative closure to a full playing session.

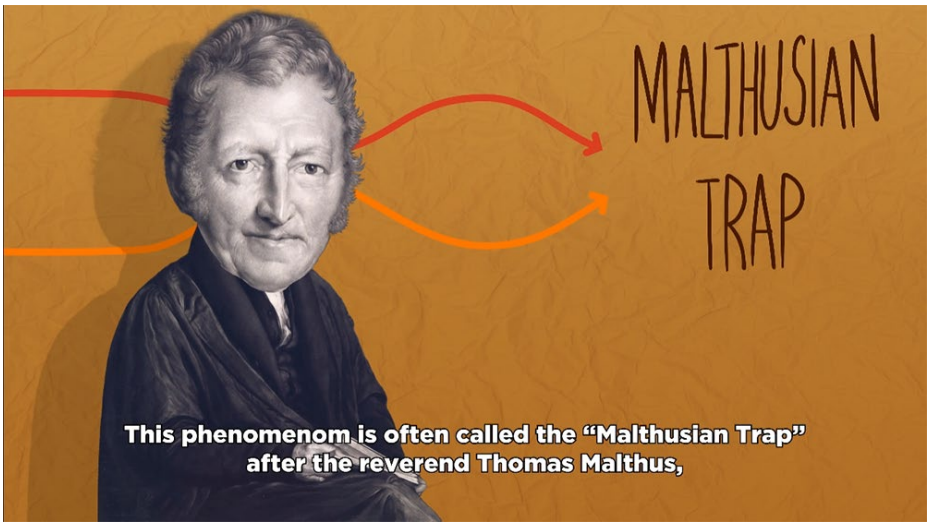


Figure 7: Explainer animation describing Malthus economic theory

Accordingly, when the game timeline ends, the player is rewarded with an animation of London's Great Exhibition of 1851. However, this scene does not adhere to history. Depending on the player's performance, instead of a showcase of industrial progress, the player can see different types of exhibitions corresponding to a non-industrialised agrarian country, society with low living standards, and very high levels of pollution (Fig.8).



Figure 8: Alternative outcomes depending on the player's performance

8. Conclusion

From the perspective of participating schools, Industrial Re: Evolution is an easy-to-implement, comprehensive solution to teach the causes of the Industrial Revolution. It comes with structured activities, accompanying lesson plans, student booklets, and multimedia materials, including embedded lectures by Cambridge academics and selected reading material which teachers can integrate into their existing curriculum or adopt the full educational package provided.

The next step will be to evaluate the efficacy of this new teaching tool, by assessing the academic results and the engagement of two comparable cohorts, one exposed to the game, and the other taught using the traditional textbook material. We are now in discussion with over 20 schools in England to roll out the game and we hope to begin this trial in the academic year 2024-2025.

Data Availability

The current version of the game can be downloaded from our website at www.ireevolution.com.

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Design Insights for Developing Deepfakes Awareness Games for Adolescents

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Abstract: Around a decade ago, significant advancements in the deep learning domain like Generative Adversarial Networks (GANs) started to facilitate the creation of new synthetical content. The development of deepfake algorithms gained momentum due to the increase in computing power and open-source available resources which facilitated broader access to advanced deep learning methods. While initially deepfakes were created by creative pursuits in various media and marketing campaigns, they started to be misused driven by malicious purposes in various social media manipulation campaigns. These campaigns imply spreading disinformation and misinformation for discrediting individuals and creating confusion in relation to specific topics and events and are meant to altering users' beliefs and behaviours. Such facts raised important ethical and societal concerns. Although deepfakes still represent a recent research area, a large body of studies is dedicated to, on the one hand, generation, and detection of deepfakes, and on the other hand, to understanding their implications and consequences for society. At the same time, governmental and practitioner efforts are devoted to containing their use and impact on society by proposing various strategies and programs. Nevertheless, both academic and societal efforts are in an incipient stage and often adopt a generalist perspective. This represents a crucial point in relation to the fact that many users in various social media platforms like TikTok is represented by adolescents that are known to be unaware and more vulnerable to media content in general, and deepfakes content, in particular. This represents the knowledge gap that this research aims to tackle by synthesizing design insights as requirements and guidelines that can be used when developing and deploying deepfakes awareness games for producing and/or enhancing awareness of adolescents. Accordingly, a systematic literature review is conducted and merged with previous experience in this domain by adopting a transdisciplinary research approach that merges methods and techniques from the deepfakes, AI, social media, cyber security, and gamification domains.

Keywords: Deepfakes, Deepfakes Awareness, Social Media, Artificial Intelligence, Gamification.

1. Introduction

"The truth is rarely pure and never simple." (Oscar Wilde)

The advancements in the DL domain facilitated the creation of deepfakes, synthetic media content that convincingly replicates human actions and behaviors. While initially deepfakes were relatively simplistic, they evolved into sophisticated mechanisms that can generate highly realistic and nuanced synthetic media that became harder to distinguish from genuine content to the untrained eye (Shoaib et al., 2023). As believable media artificially generated, deepfakes aim to react or replace dimensions of reality focusing either on one or more aspects of individuals, e.g., voice alteration or mouth, gaze, and pose reenactment (Mirsky & Lee, 2021). This represents a significant threat to adolescents as they are frequent users of various social media platforms such as TikTok and Instagram, by undermining their ability to discern between real and manipulated content (Kilhoffer et al., 2023; Naffi et al., 2023; Maathuis et al., 2023), making them further exposed to threats like cyber bullying and online harassment, which have the potential to result in serious well-being and safety negative consequences. Hence, effective solutions and interventions that deal with the deepfakes threat by equipping adolescents with the necessary digital and human skills start with awareness as this implies and calls for understanding deepfakes, their possible consequences, and being able to further detect them and build resilience against their action (Taibi et al., 2023). Such initiatives play a crucial role in empowering adolescents to become responsible digital citizens in an increasingly complex, interconnected, and uncertain online world. Nevertheless, given these characteristics of cyberspace, an overall deepfakes awareness solution is impossible to build, as would require to be able to account and embed the needs, features, and skills of all possible target audiences. Hence, tailored solutions should be developed for adolescents so that their unique cognitive, emotional, and developmental characteristics are effectively addressed in corresponding deepfakes gaming awareness solutions (Ali et al., 2021). This would also maximize the impact on enhancing digital resilience and fostering a safe online environment for young users. On this behalf, a series of research, practitioner, and governmental efforts start to be developed, nevertheless, this requires a systematic consideration of the design choices and their underlying requirements and principles. To tackle this pressing demand and support the

development of tailored digital educational solutions and interventions, this research aims to capture design requirements and guidelines for building gaming solutions for deepfakes awareness of adolescents. To this end, the following research questions are formulated:

- **RQ 1:** Which deepfakes awareness solutions exist and are addressed to adolescents?
- **RQ 2:** What are the design principles and requirements useful for building deepfakes awareness gaming solutions for adolescents?

To attain this goal, this study proposes a comprehensive set of eighteen design requirements and guidelines for the development of deepfake awareness gaming solutions for adolescents. These insights are distilled from a systematic literature review that integrates perspectives from various disciplinary domains, encompassing artificial intelligence, social media studies, cybersecurity, and gamification, plus drawing upon prior expertise in the field.

The remainder of the article is structured as follows. Section 2 discusses relevant studies that tackle various dimensions of the context of this research. Section 3 presents the methodological approach considered in this article. Section 4 elaborates on characteristics identified on existing deepfakes-related awareness studies. Section 5 captures design requirements and guidelines to be considered when building gaming awareness solutions for adolescents. At the end, the last section discusses concluding remarks and future research perspectives.

2. Research Background

Social media platforms became integral to the lives of adolescents, particularly in recent years, with a significant surge observed during the COVID-19 lockdown. Platforms like YouTube, TikTok, and Instagram serve as vital channels for social interaction, entertainment, and self-expression among adolescents. These platforms employ advanced DL-based algorithms to personalize content delivery, aiming to enhance user experience by presenting material tailored to individual preferences. Nevertheless, while these algorithms are effective in catering to user interests, they also pose various risks, including the formation of echo chambers that reinforce unrealistic and biased perceptions of reality while favouring building a positive attitude and enhancing trust in AI algorithms used, often without fully comprehending their functions or potential biases (Fard & Maathuis, 2021; Theophilou et al., 2023). This lack of awareness leaves them vulnerable to accepting algorithm-generated recommendations uncritically, which may perpetuate systemic biases and hinder the development of critical thinking skills (Ask et al., 2023). Addressing these issues requires interventions to challenge adolescents' blind trust in algorithms, raise awareness of potential consequences, and equip them with strategies to navigate social media platforms responsibly.

As deepfakes' complexity advances, it becomes increasingly challenging to detect them due to the intricate combination of diverse features and mechanisms used in their creation process. Deepfakes typically involve the synthesis of facial expressions, gestures, voice patterns, and even contextual backgrounds to create convincing replicas of individuals in video or audio recordings (Naitali et al., 2023; Masood et al., 2023). Deepfakes rely on deep learning techniques like a) GAN that consist of two neural networks (generator and discriminator) engaged in a competitive process where the generator generates fake content while the discriminator evaluates them to distinguish between real and fake, and b) AU that encode an input image into a latent representation and then decodes it to reconstruct the original image (Ali et al., 2021). Moreover, the proliferation of large datasets and computing power fuels the refinement of deepfake algorithms, enabling them to produce highly realistic and nuanced simulations (Ali et al., 2021; Mirsky & Lee, 2021). Detecting such complex deepfakes necessitates the integration of diverse detection methods, including forensic analysis, anomaly detection, and AI-based algorithms trained to identify subtle inconsistencies. As the literature study conducted in this research shows, this represents a challenging goal that needs to be tackled in a systematic and multidisciplinary manner in an educational setting while adopting a human-centred approach that accounts the needs, goals, and skills of adolescents when building effective and responsible deepfakes awareness gaming solutions for them.

Table 1: Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
AE	Autoencoders
BIPOC	Black, Indigenous, and People of Colour
DL	Deep Learning
GAN	Generative Adversarial Networks
GBL	Game Based Learning
HLT	Hypothetical Learning Trajectory
HCI	Human Computer Interaction
ML	Machine Learning
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RQ	Research Question

3. Research Methodology

As this research aims to capture design insights for building deepfakes awareness gaming solutions for adolescents, the following research questions are formulated:

- **RQ 1:** Which deepfakes awareness solutions exist and are addressed to adolescents?
- **RQ 2:** What are the design principles and requirements useful for building deepfakes awareness gaming solutions for adolescents?

To achieve this aim, a systematic and transparent approach is taken as outlined by Denyer & Tranfield (2009) which encompasses several key stages, including the establishment of clear objectives, the identification of relevant studies, the meticulous selection of pertinent literature, thorough analysis and synthesis of findings, and the comprehensive presentation of results. Adhering to the guidelines set forth by the PRISMA methodology, data collection is conducted using the PRISMA 2020's stage flow diagram for meticulous data collection, screening, and analysis (Page et al., 2021).

In the context of building deepfakes awareness efforts for adolescents, systematic literature reviews serve as essential tools for consolidating and summarizing relevant evidence accurately and reliably. This allows gathering empirical evidence that meets established criteria, enabling researchers to address key questions effectively and make informed decisions and draw meaningful conclusions about deepfake threats. The efficacy of the PRISMA methodology was demonstrated across diverse domains, underscoring its value in informing educational efforts about the deepfakes threat among adolescents and empowering them to navigate digital environments safely.

Accordingly, the core stages taken in this research are further discussed and depicted in Figure 1:

- **Identification**: To find the initial set of studies written in English, search strings were formed based on *deep fakes, deepfakes, awareness, training, security, prevent, prevention, detection, detection, game, gaming, social media, and TikTok* keywords. The search strings were used to query the following seven scientific databases: ACM, IEEE Digital Library, Google Scholar (first 10 pages), SpringerLink, Taylor & Francis, Web of Science, and Wiley. The timeline considered was 01.09.2016 to 31.12.2023. The initial search provided 481 studies (conference and journal articles), out of which 2 duplicates were removed.
- **Screening:** In this phase, the studies were screened based on their Abstract, title, and keywords used and excluding criteria like being irrelevance to the topic or not being addressed to deepfakes. This resulted in the final set of 22 studies to be considered for review.
- **Included:** In this phase, the 22 studies were fully read and analysed, and their scope is captured in Table 2.

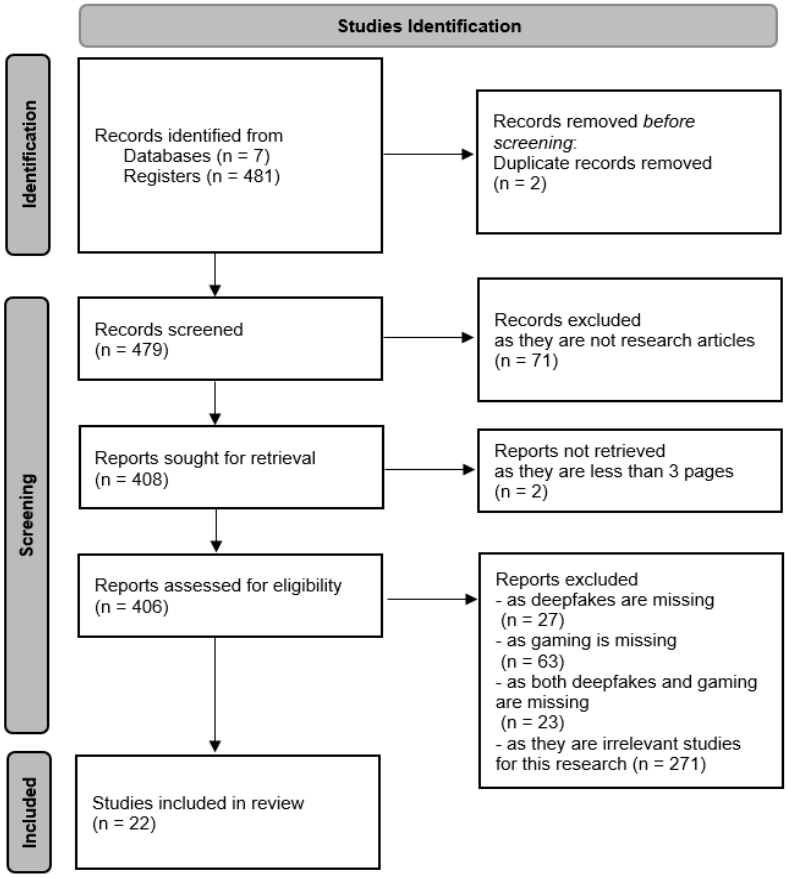


Figure 1: Review process

Table 2: Specifications of the articles selected

No	Title Study	Year	Research Aim	Target Audience	Artefact Type	Reference
1	"How technical do you get? I'm an English teacher": Teaching and Learning Cybersecurity and AI Ethics in High School	2023	To understand how AI ethics and cyber security topics are taught in high school.	K-12 students and teachers	Interview insights	Kilhoffer et al., (2023)
2	The Creation and Detection of Deepfakes: A Survey	2021	To explore the creation and detection of deepfakes.	Review article	Reflection	Mirsky & Lee (2021)
3	What to do about deepfakes	2021	To understand how to minimize or prevent the negative impact of deepfakes.	Position article	Reflection	Johnson & Diakopoulos (2021)
4	Exploring Generative Models with Middle School Students	2021	To design learning activities for non-technical students for understanding the technical composition, applications, and ethical issues of generative models.	K-12 students	Interview insights	Ali et al., (2021)
5	How Do Users Perceive Deepfake Personas? Investigating the Deepfake User Perception and Its Implications for Human-Computer Interaction	2023	To understand human interactions between humans and deepfakes in the HCI context.	General	Experiment Insights based on content created using Synthesia tool	Kaate et al., (2023)
6	Cybersecurity Education in the Age of AI: Integrating AI Learning into Cybersecurity High School Curricula	2023	To design an exploratory curricular initiative that introduces students AI/ML topics in the context of cyber security.	K-12 students	Experiment Insights based on applications created in NetsBlox programming language	Grover, Broll & Babb (2023)

No	Title Study	Year	Research Aim	Target Audience	Artefact Type	Reference
7	Understanding Digital-Safety Experiences of Youth in the U.S	2023	To understand the variety of digital threats that youth experiences.	K-12 students and their parents	Interview and focus groups insights	Freed et al., (2023)
8	Research on Deepfake Technology and Its Application	2023	To analyse security risks of deep forgery for creating public awareness.	Review article	Reflection	Bu, Jiang & Zheng (2023)
9	It's About Time: Attending to Temporality in Misinformation Interventions	2023	To build educational methods for enhancing digital literacy in respect to misinformation engaging BIPOC and rural communities.	K-16 students	Workshop insights	Wilmer et al., (2023)
10	Developing Middle School Students' AI Literacy	2021	To design a workshop on developing AI literacy for middle school students.	K-12 students	Curricula	Lee et al., (2021)
11	The use of an escape room as an immersive learning environment for building resilience to misinformation	2023	To design an immersive environment escape room game for building resilience to misinformation using mechanisms like deepfakes.	General	Immersive learning game	Cho et al., (2023)
12	Empowering Youth to Combat Malicious Deepfakes and Disinformation: An Experiential and Reflective Learning Experience Informed by Personal Construct Theory	2023	To design an educational method that produces awareness to young individuals to deepfakes and disinformation.	University students	Experiment insights using FaceApp, Reface, Impressions, and TikTok	Naffi et al., (2023)
13	Deepfake detection using deep learning methods: A systematic and comprehensive review	2023	To provide an overview of deep learning-based deepfakes detection solutions.	Review article	Reflection	Heidari et al., (2023)
14	Deepfakes generation and detection: state-of-the-art, open challenges, countermeasures, and way forward	2023	To provide an overview of existing challenges depicted from of state-of-the-art deepfakes generation and detection studies and corresponding solutions.	Review article	Reflection	Masood et al., (2023)
15	A literature review and perspectives in deepfakes: generation, detection, and applications	2022	To provide an overview of deepfakes generation and detection applications.	Review article	Reflection	Dagar & Vishwakarma (2022)
16	The profile: unleashing your deepfake self	2023	To design a game that generates ego-based deepfakes to produce awareness and reflection on relevant ethical dilemmas.	General	Multimedia software application	Cheres & Groza (2023)
17	AI Ethics Curricula for Middle School Youth: Lessons Learned from Three Project-Based Curricula	2023	To design a curriculum that builds awareness on AI ethics topics to middle school students.	K-12 students	Curricula	Williams et al., (2023)
18	Integrating Ethics and Career Futures with Technical Learning to Promote AI Literacy for Middle School Students: An Exploratory Study	2023	To design an AI literacy workshop that covers both ethical issues and their potential implications.	K-12 students	Workshop curricula	Zhang et al., (2023)
19	Is This Fake or Credible? A Virtual Learning Companion Supporting the Judgment of Young Learners Facing Social Media Content	2021	To design a web-based learning environment for creating awareness on social media threats.	K-12 students	Game environment	Aprin et al., (2021)
20	The deepfake detection dilemma: A multistakeholder exploration of adversarial dynamics in synthetic media.	2021	To reflect on existing dilemma points in respect to deepfakes detection solutions.	General	Workshop insights	Leibowicz, McGregor & Ovadya (2021)
21	Children as creators, thinkers, and citizens in an AI-driven future	2021	To design a social media game for deepfakes detection and analysis of misinformation effects.	K-12 students	Workshop curricula	Ali et al., (2021)
22	Fakey: A game intervention to improve news literacy on social media	2021	To design a game that enhances news literacy and supports countering social media misinformation.	General	Digital game	Micallef et al., (2021)

4. Awareness Solutions

Based on the systematic literature review conducted, it is evident that research efforts have been directed towards several key audiences, as illustrated in Figure 2. Studies have notably focused on K-12 students, K-16 students, and university students recognizing the importance of educating younger generations about importance of building digital literacy skills together with awareness and resilience against the deepfakes threats and its implications. Additionally, studies have extended to encompass K-12 students alongside their teachers or parents, acknowledging the crucial role of guardians and teachers in safeguarding children and young individuals against potential (digital) harm. Moreover, there has been a notable emphasis on individuals actively developing deepfake detection and awareness solutions, reflecting the proactive approach of researchers and technologists in mitigating the adverse effects of synthetic media manipulation. Furthermore, research was directed towards disseminating knowledge about deepfakes to a wider audience by raising general awareness and fostering digital literacy to empower individuals in discerning manipulated content. Overall, this study reveals the multifaceted efforts aimed at addressing the challenges posed by deepfakes across various societal sectors.

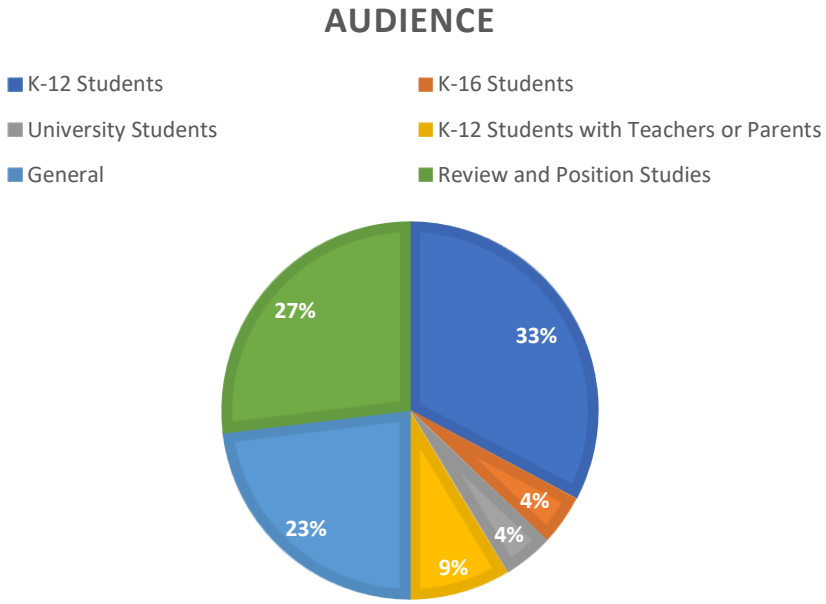


Figure 2: Target audience of the studies analysed

Given their scope and target audience, the application-based studies analysed can be classified in three clusters, as follows:

4.1 Cluster 1: Deepfakes

Kaate et al., (2023), Cho et al., (2023), Naffi et al., (2023), Cheres & Groza (2023), Leibowicz, McGregor & Ovadya (2021), and Ali et al., (2021). This cluster captures important elements of generating and detecting deepfakes, investigates challenges posed by this manipulation mechanism in the digital context, and presents valuable methods for building and supporting awareness and resilience against deepfakes. Specifically, Kaate et al., (2023) delves into user perceptions of deepfakes in design tasks providing insights on how the users' experience could be improved on this behalf. Aligned with this, Cho et al., (2023) emphasizes the pivotal role of addressing misinformation challenges through innovative approaches like immersive games learning by developing an escape room that proves to be effective for increasing awareness of misinformation tactics, including deepfakes, and fostering critical reflection among participants. Moreover, Naffi et al., (2023) and Ali et al., (2021) focus on educational interventions aimed at empowering youth to be aware and counter deepfakes. By providing experiential learning experiences and virtual workshops, these studies equip participants with the skills to discern the validity of online information and resist manipulation, irrespective of its source. Additionally, Leibowicz, McGregor & Ovadya (2021) highlight the importance of considering not only the technical dimensions but also the psychological and artistic aspects of deepfakes when building solutions for deepfakes awareness and mitigation strategies.

4.2 Cluster 2: AI Ethics and Cyber Security

Kilhoffer et al., (2023), Ali et al., (2021), Grover, Broll & Babb (2023), Freed et al., (2023), Williams et al., (2023), Zhang et al., (2023), and Aprin et al., (2021). This cluster focuses on the intersection of AI ethics and cyber security by exploring the meaning and implications of AI technologies for ensuring digital security. Kilhoffer et al., (2023), Williams et al., (2023), Zhang et al., (2023) stress the importance of AI literacy curricula, such as Creative AI and Developing AI Literacy (DAILy), designed to equip students with technical knowledge, ethical understanding, and awareness of AI's societal implications. These curricula employ active learning methodologies, embedding ethics into technical lessons to enhance critical thinking and prepare students for a future where AI is going to play an important role in their activities. Grover, Broll & Babb (2023) introduces the "AI & Cybersecurity for Teens" (ACT) initiative, aiming to integrate AI/ML concepts into high school cybersecurity curricula delving into critical issues like safety and bias, essential for meaningful interrogation of cybersecurity challenges. In this process, Freed et al., (2023) emphasize the importance of accounting the youth voices when building protective digital mechanisms against potential risks, and Aprin et al., (2021) build a web-based learning environment as a dedicated companion that supports students' understanding, critical thinking, and resilience against media threats that include AI-related cyber security risks like deepfakes.

4.3 Cluster 3: Digital Literacy

Wilmer et al., (2023), Lee et al., (2021), and Micallef et al., (2021). This cluster examines the knowledge, skills, and competencies required for individuals to effectively navigate and critically engage with AI-based technologies. While Lee et al., (2021) outline a comprehensive curriculum designed to educate students on various topics like bias and the impact on society and career by incorporating hands-on activities and discussions, Wilmer et al., (2023) emphasizes the importance of community-engaged projects in promoting digital literacy, particularly in rural and BIPOC communities, by augmenting existing temporal structures to foster circumstances conducive to repairing the information environment. Additionally, Micallef et al., (2021) presents the development and deployment of Fakey, a game designed to improve news literacy by simulating social media feeds and encouraging players to discern between mainstream and low-credibility content. Through analytics and user interviews, the study demonstrates that engagement with the game leads to improved recognition of mainstream content without compromising the ability to identify misinformation.

5. Design

Given the scope and the type of artefacts/solutions considered or proposed in the studies, these can be classified in the following three categories, as discussed below, and depicted in Figure 3:

- **Category 1 - Concept:** These studies imply reflecting on various concepts, methods, and techniques that are relevant to building deepfakes awareness gaming solutions either at a theoretical level or by means of aggregating this knowledge with valuable insights gathered from interviews, focus groups, and workshops (Kilhoffer et al., 2023; Mirsky & Lee, 2021; Johnson & Diakopoulos, 2021; Ali et al., 2021; Freed et al., 2023; Bu, Jiang & Zheng, 2023; Wilmer et al., 2023; Heidari et al., 2023; Masood et al., 2023; Dagar & Vishwakarma, 2022; Leibowicz, McGregor & Ovadya, 2021).
- **Category 2 - Tool:** These studies include building software artefacts or instantiating existing ones, as in the form of a digital game, multimedia software application, or directly creating deepfakes using an existing social media platform (Kaate et al., 2023; Grover, Broll & Babb, 2023; Cho et al., 2023; Naffi et al., 2023; Cheres & Groza, 2023; Aprin et al., 2021; Micallef et al., 2021).
- **Category 3 - Curricula:** These studies suppose building a curriculum for understanding, dealing, and countering digital threats like deepfakes in various scenarios (Lee et al., 2021; Williams et al., 2023; Zhang et al., 2023; Ali et al., 2021).

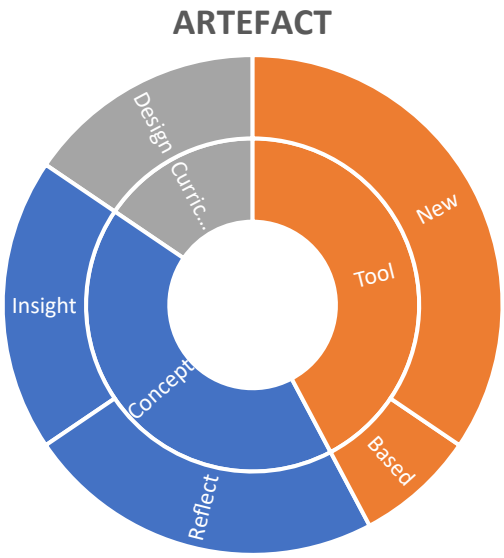


Figure 3: Artefact types in the studies analysed

Furthermore, a set of eighteen technical and educational design guidelines and requirements for building deepfakes awareness gaming solutions are gathered and further proposed. These capture elements that refer not only to the way of building and presenting content to the players, but also methodological aspects referring to the approach taken to develop and deploy the game, as presented in Figure 4 below:

No	Design Guidelines and Requirements	Source
1	Take into consideration the multidisciplinary nature of the deepfakes phenomenon.	Kilhoffer et al., (2023), Bu, Jiang & Zheng (2023), Aprin et al., (2021)
2	Consider a collaborative, iterative, and progressive design process when multiple stakeholders are involved in building and deploying the game.	Cho et al., (2023), Masood et al., (2023), Micallef et al., (2021)
3	Focus on more commonly used social media platforms, e.g., TikTok, Snapchat, or Instagram.	Kilhoffer et al., (2023)
4	Ensure that the game is accessible to students with no prior STEM knowledge.	Ali et al., (2021)
5	Establish clear legal, ethical, and safety boundaries in respect to the deepfakes content used inside the game.	Freed et al., (2023), Bu, Jiang & Zheng (2023), Lee et al., (2021), Cheres & Groza (2023)
6	Consider an HLT approach to develop the game's structure and progression.	Ali et al., (2021)
7	Consider a GBL approach to engage students and enhance their understanding of deepfakes.	Ali et al., (2021), Grover, Broll & Babb (2023), Wilmer et al., (2023)
8	Reduce the cognitive load during gameplay by considering tailored and accessible learning activities and simplifying game mechanics and feedback mechanism.	Ali et al., (2021), Kaate et al., (2023), Grover, Broll & Babb (2023), Ali et al., (2021), Micallef et al., (2021)
9	Integrate educational components into the game to explain how deepfakes work as well as how they can be generated and detected in a way that encourages critical exploration, experimentation, and critical thinking.	Mirsky & Lee (2021), Johnson & Diakopoulos (2021), Williams et al., (2023), Zhang et al., (2023)
10	Use ready-to-use resources that are simplified, clear, and easily understandable by users.	Kilhoffer et al., (2023), Ali et al., (2021), Bu, Jiang & Zheng (2023), Naffi et al., (2023), Aprin et al., (2021), Ali et al., (2021)
11	Adopt a gamified approach that offers challenges, hints, rankings, or tests to users.	Kilhoffer et al., (2023), Mirsky & Lee (2021), Wilmer et al., (2023), Ali et al., (2021), Micallef et al., (2021)
12	Consider the use of multiple scenarios inside the game and realistic narratives that match current trends and anticipate future trends.	Mirsky & Lee (2021), Johnson & Diakopoulos (2021), Grover, Broll & Babb (2023), Cho et al., (2023), Masood et al., (2023), Dagar & Vishwakarma (2022), Cheres & Groza (2023), Zhang et al., (2023)
13	Showcase examples of technical solutions that could be used to detect and counter deepfakes	Johnson & Diakopoulos (2021), Naffi et al., (2023), Dagar & Vishwakarma (2022)
14	Incorporate high-quality interactive, multimedia elements, or mini games that allow players to experience firsthand how deepfakes are created and/or detected.	Bu, Jiang & Zheng (2023), Lee et al., (2021), Masood et al., (2023), Cheres & Groza (2023), Williams et al., (2023), Leibowicz, McGregor & Ovadya (2021), Micallef et al., (2021)
15	Include game elements that refer to the potential implications, consequences, and harm of deepfakes to individuals and society.	Johnson & Diakopoulos (2021), Lee et al., (2021), Williams et al., (2023), Zhang et al., (2023), Ali et al., (2021)
16	Reflect on diverse types and sources of synthetical content, e.g., audio, and visual-based.	Masood et al., (2023), Micallef et al., (2021)
17	Integrate assessment and verification mechanisms into the game when players need to distinguish between authentic and fake content and include post-play assessment.	Johnson & Diakopoulos (2021), Lee et al., (2021), Cho et al., (2023), Leibowicz, McGregor & Ovadya (2021)
18	Implement reporting and help systems that allows users to report their observations and findings and use guidance when needed.	Freed et al., (2023), Naffi et al., (2023), Dagar & Vishwakarma (2022)

Figure 4: Design Requirements and Guideline

6. Conclusions

The emergence of deepfakes which are built using advanced deep learning techniques, has revolutionized synthetic media creation. Initially conceived for artistic and commercial pursuits, the widespread accessibility of advanced deep learning methodologies has democratized the production of deepfakes, particularly evident on social media platforms like TikTok, Instagram, and Snapchat. Nevertheless, the malevolent exploitation of deepfakes for disseminating disinformation and misinformation and inciting societal discord has precipitated profound ethical and socio-political concerns. Of particular significance is the vulnerability and susceptibility of adolescents, constituting a sizable demographic within the social media realm, to the manipulative influence of deepfakes, owing to their limited media literacy and heightened vulnerability to digital content. Despite scholarly, practitioner, and governmental efforts aimed at understanding, detecting, and mitigating the adverse effects of deepfakes, existent research and practical initiatives find themselves in an incipient phase of development and would further benefit for adopting a systematic approach to their design. Consequently, there is a need to develop tailored educational interventions, such as deepfake awareness games, to empower adolescents in discerning and counteracting the (harmful) effects of deepfake manipulation. To this end, this research proposes a series of eighteen design guidelines and recommendations for building deepfakes awareness solutions captured based on a systematic literature review drawing from multidisciplinary perspectives encompassing AI, social media, cyber security, and gamification as well as previous field expertise. This research continues by building and evaluating a gaming solution for deepfakes awareness of adolescents and aims to set a stone when building a digitally aware, safe, and robust future (digital) generation.

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Design Framework for VR Games in the Police Domain

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Abstract The escalation in the number of conflicts poses various implications and consequences to society, demanding a comprehensive understanding from a law enforcement perspective. The surge in conflicts introduces significant challenges related to public safety, necessitating adaptive strategies for both conflict and crime prevention and resolution. Accordingly, effective policing must adapt to the evolving dynamics, employing a nuanced approach that addresses the root causes of conflicts and enhances community resilience to avoid or mitigate them and their broader societal impact. A pivotal role is this direction is played by the ongoing technological advancements that facilitate actions like enhancement of situational awareness, analyzing patterns and anticipating potential hotspots and activities, facts that sustain both proactive and reactive measures. In particular, technological advancements in Virtual Reality (VR) present a valuable avenue for addressing policing challenges, especially in relation to conflict resolution, mitigation, and prevention. Building VR simulations for training purposes offers a controlled yet realistic environment for officers to practice e.g., de-escalation strategies and decision-making under stress. These gaming simulations provide a platform to expose officers to diverse scenarios, fostering adaptability, encouraging communication and collaboration, and enhancing their ability to properly handle conflicts with precision and self-control. At the same time, VR systems can be developed for societal awareness and educational purposes, fostering better understanding and communication between law enforcement and the public. While a broad range of governmental, practitioner, and academic efforts exist aiming at building and incorporating VR solutions for various purposes in the police domain, specific areas that involve other societal forces and bystanders need more attention. It is then the aim of this article to capture existing design and evaluation principles as well as lessons learned from existing VR solutions in the police domain. This is done by proposing a design framework for responsible VR gaming solutions in the police domain following the Design Science Research methodology in a transdisciplinary approach.

Keywords: Police, Law Enforcement, Police Conflict, Police Bystander, Virtual Reality.

1. Introduction

"Science cannot resolve moral conflicts, but it can help to more accurately frame the debates about those conflicts." (Heinz Pagels)

In recent years, law enforcement agencies worldwide have faced a notable surge in both the frequency and complexity of incidents requiring their intervention. Statistical evidence shows a concerning rise in conflict and crime rates, the emergence of new forms of criminal behavior, and the proliferation of sophisticated criminal networks. Moreover, the advent of cybercrime, terrorism, and transnational organized crime has introduced unprecedented challenges, necessitating law enforcement personnel to possess a diverse skill set and adaptability to dynamic operational environments (Interpol, 2022; DHS, 2023; DHS, 2024; CBS, 2024). In light of these evolving threats, there is a pressing need for law enforcement agencies to equip their Police Officers (POs) with advanced training methodologies that adequately prepare them to navigate complex scenarios in an effective and adaptive manner. Virtual Reality (VR) technology emerges as a promising solution, offering immersive and realistic simulations that aprovide POs the opportunity to build their decision-making skills, enhance situational awareness, and cultivate the expertise required to mitigate multifaceted challenges safely, efficiently, and responsibly while being prepared to deal with the implications and consequences of (their) actions in a proper and accountable manner (Cao et al., 2023; Fard & Maathuis, 2021; Marker et al., 2020). At the same time, this approach allows POs to simulate high-stress, low-frequency incidents that are crucial for training but challenging to replicate in real-life scenarios, fact that enhances the preparedness for rare, but critical incidents (All, Castellar & Van Looy, 2021). Nevertheless, given the fact that limited research exists in relation to building such solutions in a systematic way, the objective of this research is to capture research areas that have benefited from the development of VR solutions in the Police domain and subsequently extract design requirements for building responsible VR gaming solutions tailored to the Police domain. To achieve this objective, two research questions (RQ) are posed:

- **RQ 1:** What are the topics tackled in existing VR solutions proposed in the Police domain?
- **RQ 2:** What are the design requirements and principles that could be of use for developing responsible VR solutions in the Police domain?

To address these questions, a systematic literature review is conducted following the methodology outlined by Denyer and Tranfield (2009). In this way, this research provides actionable insights for the development of future responsible VR gaming solutions tailored to law enforcement contexts, in particular, to the Police domain. By capturing design requirements and principles derived from existing VR solutions and synthesizing them into practical recommendations, this study offers guidance for the construction of responsible VR training platforms for POs. Such systems can potentially revolutionize law enforcement training by providing immersive and realistic scenarios that enhance decision-making skills, de-escalation techniques, and cultural competency, ultimately improving officer preparedness and community safety. Moreover, by adhering to principles outlined in methodologies like PRISMA, this research ensures methodological rigor and credibility, enhancing its practical relevance and potential impact on law enforcement training practices. At the same time, this research contributes to synthesizing and consolidating dispersed knowledge in the field, thereby enhancing the scholarly understanding of VR's applicability in police training and operations.

The remainder of this article is structured as follows. Section 2 discussed the methodological approach taken to achieve the aim of this research. Section 3 presents application areas and topics tackled when building VR solutions in the Police domain. Section 4 captures and structures design principles and requirements for building responsible VR solutions in the Police domain. Section 5 discusses concluding remarks and future research perspectives.

2. Research Methodology

This research aims to identify existing areas of research that benefitted of the development of VR gaming solutions and from there to capture design requirements for building future responsible VR gaming solutions in the Police domain. To this end, the following research questions are defined:

- **RQ 1:** What are the topics tackled in existing VR solutions proposed in the Police domain?
- **RQ 2:** What are the design requirements and principles that could be of use for developing responsible VR solutions in the Police domain?

To provide answers to these questions, a systematic literature review is conducted as delineated by Denyer and Tranfield (2009), which involves several essential steps. These include defining precise objectives, identifying relevant research studies, selecting relevant literature, conducting an in-depth analysis and synthesis of the findings, and presenting the results obtained. Following the principles outlined in the PRISMA methodology, data collection is executed utilizing the PRISMA 2020's stage flow diagram to ensure meticulous collection, screening, and analysis of data (Page et al., 2021).

In the realm of developing VR games for law enforcement training, systematic literature reviews play a crucial role in consolidating and summarizing pertinent evidence accurately and reliably. This facilitates the collection of valuable knowledge and empirical data that adheres to predefined criteria, empowering researchers to effectively address pivotal questions and derive informed insights regarding the efficacy of VR training in the police domain. The PRISMA methodology's effectiveness has been showcased across various fields, highlighting its significance in guiding efforts to enhance law enforcement training through VR technologies and equipping officers with the skills to navigate complex scenarios effectively and safely. To this end, the following research activities are taken as part of this process as illustrated in Figure 1 and further explained:

Activity 1 - **Identification of studies:** In this activity, studies have been selected based on combinations of keywords like *VR, virtual reality, law enforcement, Police, policing, criminal justice, police conflict,* and *police bystander.* In this process only articles in English are considered and are searched in the ACM, IEEE Digital Library, Web of Science, Wiley, and the first ten pages from Google Scholar. The timeline was considered between 01.01.2025 and 31.12.2023. Accordingly, the initial results contain 1887 articles from which 76 were duplicates that have been directly removed.

Activity 2 - **Screening of studies:** During this activity, the studies underwent screening based on their abstract, title, and keywords, with criteria such as relevance to the topic and direct relevance to VR and Police domains applied for exclusion. As a result, a final set of 20 studies was identified for further review.

Activity 3 - **Inclusion of relevant studies:** In this activity, the final 20 research studies gathered underwent comprehensive reading and analysis, with their scope summarized in Table 1.

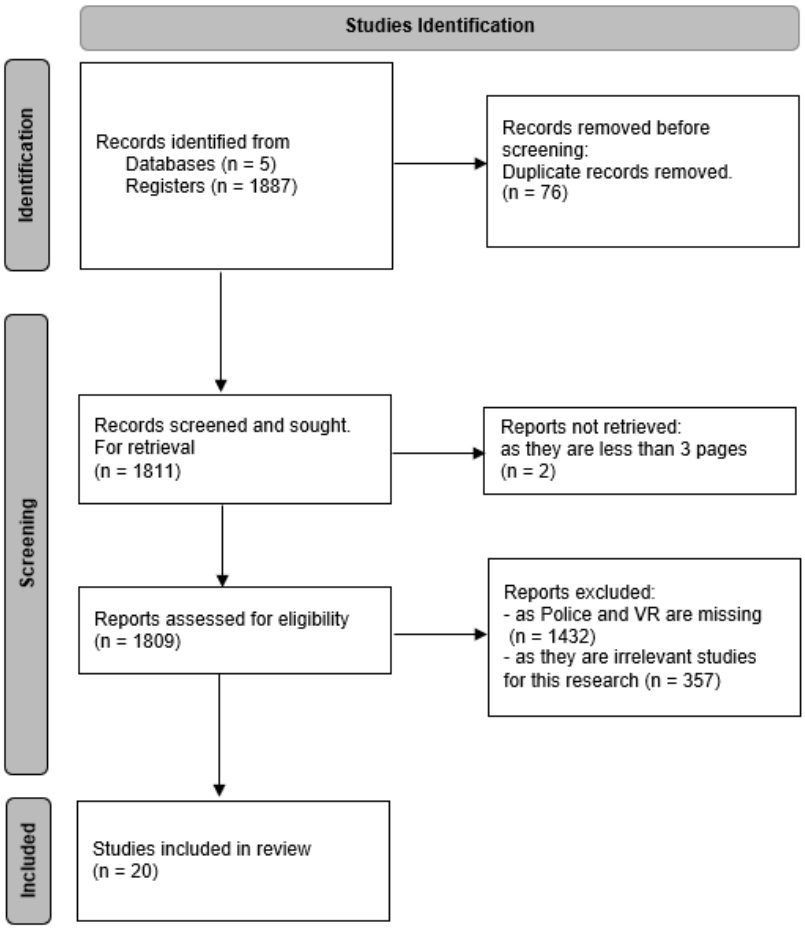


Figure 1: Research Methodology.

Table 1: Information about the studies selected.

No	Title Study	Year	Research Aim	Venue Type	Reference
1	Virtual Reality Training of Law Enforcement Officers in Predicting Terroristic Attacks Indicators	2022	To design a VR-based serious game for Police training for the identification of suspicious terrorist activities.	Conference	Soldatos et al., (2022)
2	Validating Virtual Reality as an Effective Training Medium in the Security Domain	2019	To assess the effectivity of a VR training for LEAs (Law Enforcement Agencies) and first responders, and compare the results in relation to conducting the same exercises without VR in live settings.	Conference	Saunders et al., (2019)
3	Trusted Virtual Reality Environment for Training Security Officers	2023	To build a VR-game for training LEAs and security professionals in the analysis and prediction of potentially terroristic activities.	Conference	Pantazidis et al., (2023)
4	Exploring VR Training for First Responders	2020	To explore VR training challenges and review four public safety VR scenarios.	Conference	Haskins et al., (2020)
5	The Impact of Virtual Reality in the Social Presence of a Virtual Agent	2020	To assess the impact that a social interaction with an Intelligent Virtual Agent has on subjects across different mediums with different	Conference	Guimarães et al., (2020)

No	Title Study	Year	Research Aim	Venue Type	Reference
			immersion levels.		
6	Virtual reality for law enforcement training: a demonstration and implication for dispatch priming	2022	To assess the impact of a VR-intervention in a case of dispatch priming.	Journal	Potts et al., (2022)
7	Virtual reality training for police officers: a comparison of training responses in VR and real-life training	2024	To assess VR SBT in VRT training of POs.	Journal	Kleygrewe et al., (2024)
8	Can a Virtual Reality Training Scenario Elicit Similar Stress Response as a Realistic Scenario-Based Training Scenario?	2024	To assess if a VR training scenarios would elicit a similar stress response as a realistic scenario-based training scenario.	Journal	Martaindale et al., (2024)
9	Deep-Breathing Biofeedback Trainability in a Virtual-Reality Action Game: A Single-Case Design Study with Police Trainers	2022	To assess response inhibition in police-decision making contexts.	Journal	Michela et al., (2022)
10	A Virtual Reality Embodiment Technique to Enhance Helping Behaviour of Police Toward a Victim of Police Racial Aggression	2019	To explore the effectiveness off VR embodiment techniques in reducing implicit racial bias among POs.	Journal	Kishore et al., (2019)
11	The Cycle of Violence: Understanding Individual Participation in Collective Violence	2015	To explore the role of group identity in individual participation in collective violence and the impact of such behaviour on group identification.	Journal	Litman & Paluck (2015)
12	Measuring presence and performance in a virtual reality police use of force training simulation prototype.	2019	To develop a VR training simulation designed to help POs learn and apply use of force policies effectively.	Conference	Garcia, Ware & Baker (2019)
13	Stress out: translating real-world stressors into audio-visual stress cues in VR for police training	2021	To develop and validate a VR training simulation for POs, focusing on improving decision-making in use of force scenarios.	Conference	Nguyen et al., (2021)
14	A concept of a training environment for police using VR game technology.	2018	To design a police training VR-tool for traffic control.	Conference	Caserman et al., (2018)
15	The potential of virtual reality for police training under stress: a SWOT analysis. In Interventions, training, and technologies for improved police well-being and performance	2021	To explore the potential of VR in enhancing police training, particularly in stress management, decision-making, and situational awareness under stress.	Journal	Voigt (2021)
16	Virtual training: Making reality work?	2015	To develop a Virtual Training Environment (VTE) for training police personnel in complex collaborative tasks, with a focus on interactions between police ground forces and helicopter crews.	Journal	Bertram, Moskaliuk & Cress (2015)
17	The desert of the unreal: Inequality in virtual and augmented reality.	2017	To investigate the potential of VR and AR technologies to enhance equality and reduce bias in various societal contexts, including job interviews, law enforcement training, and public privacy	Journal	Franks (2017)

No	Title Study	Year	Research Aim	Venue Type	Reference
			concerns.		
18	An Integrated emotional and psychological assessment for VR-based active shooter incident experiments	2021	To test the effectiveness of an active shooter VR experiment on emotional and physiological responses to evaluate the realism of the active shooter scenario for research or training purposes.	Journal	Awada et al., (2021)
19	A meta-analysis of virtual reality training programs	2021	To explore the effectiveness of VR training programs compared to traditional training methods across various professions, including police and military personnel.	Journal	Howard, Gutworth & Jacobs (2021)
20	A review on virtual reality skill training applications	2021	To evaluate the effectiveness of VR training platforms in enhancing high-level motor skills and ensuring accurate task performance in complex environments.	Journal	Xie et al., (2021)

3. Application Areas

Based on the research conducted, four distinct categories of research lines have emerged in the development and application of VR solutions within the Police domain. These categories encompass a broad spectrum of objectives, ranging from refining procedural skills to addressing counter-terrorism efforts, socio-ethical considerations, and psychological well-being within law enforcement practices. As VR technology continues to advance, these categories offer valuable insights into the diverse applications and potential impacts of immersive training methodologies for law enforcement personnel. Furthermore, each of these categories is discussed and its distribution is represented in Figure 2, as follows:

Category 1 - **Procedural:** This category delves into the operational protocols and training methodologies essential for law enforcement tasks. The studies within this category explore a range of procedural aspects, including the identification and handling of suspicious packages, traffic control procedures at checkpoints, the influence of dispatch information on response dynamics, techniques for effective traffic management, methods to enhance collaboration among emergency responders, and the assessment of VR training program effectiveness through robust evaluation methodologies (Saunders et al., 2019; Haskins et al., 2020; Potts et al., 2022; Caserman et al., 2018; Bertram, Moskaliuk & Cress, 2015; Garcia, Ware & Baker, 2019; Howard, Gutworth & Jacobs, 2021; Xie et al., 2021).

Category 2 - **Terrorism:** This category encompasses research aimed at understanding and combating terrorist activities. The studies within this domain discuss the development and utilization of VR-based serious games for training in counter-terrorism scenarios. They also delve into methodologies and technologies employed for the prediction and detection of terrorist activities, reflecting a comprehensive approach towards enhancing security measures and preparedness in the face of evolving threats (Soldatos et al., 2022; Pantazidis et al., 2023).

Category 3 - **Socio-ethical:** This category addresses critical social and ethical considerations within the Police domain by examining issues related to bias and social dynamics. The articles within this category probe into the complex issue of racial bias in policing, exploring interventions and strategies to mitigate its impact. Additionally, they delve into innovative approaches for reducing bias in law enforcement practices, reflecting a commitment to fostering equity and fairness in policing (Kishore et al., 2019; Franks, 2017).

Category 4 - **Psychological:** This category is centered on the psychological well-being and training of law enforcement personnel. The studies within this category explore training programs aimed at enhancing social skills among officers and assessing their responses to scenario-based training in virtual environments. They also delve into methodologies for evaluating stress responses and implementing biofeedback techniques to manage stress effectively. Moreover, this category investigates the psychological factors influencing individual participation in collective violence, along with the emotional and physiological responses of officers to simulated high-stress situations like active shooter incidents (Guimarães et al., 2020; Kleygrewe et al., 2024; Martaindale et al., 2024; Michela et al., 2022; Litman & Paluck, 2015; Nguyen et al., 2021; Voigt, 2021; Awada et al., 2021).

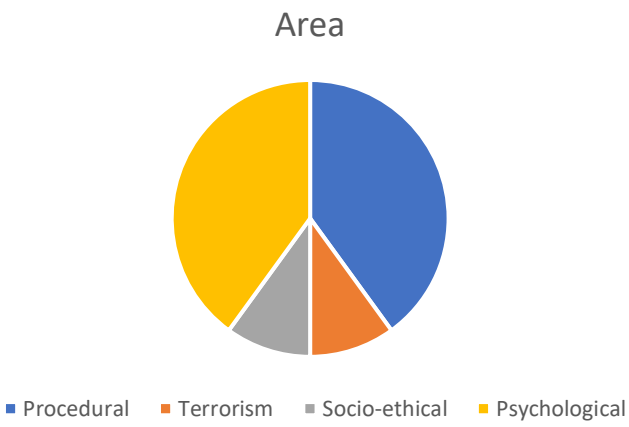


Figure 2: Application areas.

4. Design

Given the potential societal impact and ethical considerations surrounding the development and deployment of VR solutions for policing, the systematic collection and structuring of design requirements and principles are important. Such an approach ensures that future VR solutions in the police domain are developed and deployed responsibly in a human-centered approach (Maathuis, 2023). First and foremost, comprehensive requirements gathering enables the identification of specific operational needs, such as training scenarios, crime scene reconstruction, and immersive simulations for tactical decision-making. Structuring these requirements facilitates the alignment with ethical standards, legal frameworks, and community expectations, fostering transparency and accountability in VR utilization by law enforcement agencies. Moreover, incorporating principles of fairness, equity, and privacy into the design process safeguards against potential biases and abuses of power, promoting trust and legitimacy in VR-enabled policing practices. Thus, the meticulous delineation and adherence to design requirements and principles serve as indispensable safeguards, guiding the ethical and responsible evolution of VR technologies within the Police domain. To this end, six categories of design requirements are gathered and clustered given their purpose, as follows: scenario, hardware, education, data and AI, evaluation, and ethics and security. For each of these clusters, the design requirements are presented below:

Cluster 1: Scenario-based design requirements (Voigt, 2021; Xie et al., 2021; Saunders et al., 2019; Soldatos et al., 2022; Haskins et al., 2020; Bertram, Moskaliuk & Cress, 2015; Bertram, Moskaliuk & Cress, 2015; Kishore et al., 2019):

- The scenario needs to be representative, relevant, and accurate to real-world incidents, and aligned with Police goals and perspectives.
- The context of a scenario needs to be described in detail and needs to replicate real-world situations.
- The scenario needs to enhance user engagement and use VR headsets and peripherical in an effective way.
- The scenario needs to consider (some) degrees of freedom so that the experience is enhanced and supports the adaptation to multiple situations as in the real-world.
- The scenario needs to present opportunities that give an overall safe and controlled experience.
- In comprehensive training, consider multi-player role-based gameplay and collect relevant information.
- If possible, allows users to experience multiple (user) perspectives.
- If successful and desired for training purposes, the scenario needs to respect Police training methodologies and practices.

Cluster 2: Hardware-based design requirements (Howard, Gutworth & Jacobs, 2021; Kishore et al., 2021):

- Choose appropriate hardware based on project requirements and target audience.
- User high-quality VR hardware for an immersive experience.
- Consider modifications of settings to accommodate physical variations of participants.
- Align real movements with the virtual avatar's actions.
- Incorporate plugins for seamless integration of tracking information.

Cluster 3: Training design requirements (Potts et al., 2022; Voigt, 2021; Haskins et al., 2020):

- Consider an adaptable approach in order to tailor the solution to user's skill level and experience to promote cognitive engagement.
- Consider repetitive and iterative steps, adjust to various difficulty levels, and conduct after-action review.
- Incorporate constructive feedback mechanisms to allow users to explore multiple options and coping strategies.
- Incorporate immediate and later/post-simulation feedback mechanisms to enhance knowledge retention and transfer.

Cluster 4: Data and AI design requirements (Pantazidis et al., 2023; Soldatos et al., 2022; Caserman et al., 2018):

- Implement data governance, security, privacy, and quality mechanisms for both contextual and inside game data, e.g., use safe decentralized solutions like blockchain.
- Ensure data consistency and accessibility for demonstration, evaluation, and training purposes.
- Consider the collection and analysis of full-body tracking data and virtual agents' data to enhance immersion and realism and capture relevant information.

Cluster 5: Ethics design requirements (Voigt, 2021; Litman & Paluck, 2015; Franks, 2017; Guimarães et al., 2020; Awada et al., 2021):

- Ensure ethical, security, and privacy mechanisms since the design process.
- Ensure the physical and psychological safety of the participants involved.
- Consider safety measures when dealing with violence or harm and reduce such content when possible.
- Address potential ethical concerns and prioritize respect, consent, and empathy in the design of the solution.
- Assure the diversity, equity, and inclusivity of individuals since the design process and during simulation/training.
- Ensure that users and corresponding agents can dynamically respond to actions and maintain an ethical conduit during execution.

Cluster 6: Evaluation design requirements (Soldatos et al., 2022; Haskins et al., 2020; Potts et al., 2022; Garcia, Ware & Baker, 2019):

- Make evaluation information available to users after playing/engaging with the game.
- When possible, provide the opportunity to users to adjust or provide suggestions to the design of the scenario or solution in order to capture different perspectives and improve the game/solution considered.
- Implement a transparent scoring mechanism and provide tailored feedback based on it.

These clusters provide a comprehensive guide on design requirements and principles to be considered when building future responsible VR solutions tailored to the needs of Police goals and perspectives, considering technological, ethical, and psychological aspects.

5. Conclusions

In the law enforcement domain, numerous challenges persist, ranging from the evolving tactics of terrorism to the complexities of decision-making in high-pressure situations. Traditional training methods have limitations in adequately preparing POs for the diverse and dynamic scenarios they may encounter. Nevertheless, recent VR advancements offer promising solutions to address these challenges by building effective simulation solutions that mirror real-world situations and settings and allow POs to rehearse various enforcement skills, deployment strategies, and critical decision-making models in virtual but realistic scenarios, without endangering themselves or the public (Saunders et al., 2019; Pantazidis et al., 2023; Potts et al., 2022). Additionally, VR gaming solutions offer advantages such as flexibility in scenario creation, detailed after-action reviews, and the ability to train officers independently of specific physical locations (Kleygrewe et al., 2024). This allows the integration of VR solutions into Police training to be perceived as a significant step towards addressing the challenges faced by law enforcement and ensuring that officers are better equipped to handle the complexities of their duties in various contexts and situations.

Hence, to advance the development of responsible VR solutions for the Police domain in complex scenarios and

situations such as Police-bystander conflict, it is important to systematically capture and analyze the design requirements of existing solutions. Such an approach ensures that future VR training solutions effectively address the multifaceted challenges faced by POs while upholding ethical standards and promoting community safety. By studying the design elements of current VR solutions, including their scenario development methodologies and interaction mechanics, engineers can gain valuable insights into what works well and what needs improvement (Dau et al., 2023). This iterative process allows for the refinement of VR training environments to better simulate the complexities of real-world policing, including the unpredictable dynamics of bystander interactions. Incorporating these insights into the design process enables the creation of immersive VR solutions that not only enhance POs' decision-making skills and situational awareness but also foster empathy, cultural competency, and digital responsibility (Maathuis, 2022; Rojas-Sánchez, Palos-Sánchez & Folgado-Fernández, 2023), and de-escalation techniques when dealing with bystander conflicts. This represents the future path that this research embarks on. Other possible future research avenues could consider the integration of a data-drive approach and incorporating LLMs (Large Language Models) and/or a multimodal modal for building and simulating a large set of scenarios that analyze the interaction, relations, and dynamics involved in the process of conflict de-escalation and resolution considering various sources of stimuli. At the same time, another research line could deal with analyzing and modelling diverse ethical, social, and legal dimensions that play an important role when developing, deploying, and using VR applications in police conflict training. Conclusively, by grounding future VR solutions in evidence-based design principles and best practices, this article aims to contribute positively to law enforcement training while minimizing potential risks and ethical concerns.

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A Child-Centred Design Evaluation of a Learning Game to Improve Children's Legal Capability

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Abstract: Children lack awareness and understanding of their rights and the law. There is a need to address this gap and empower children to become advocates for their rights when they encounter law-related issues. A promising approach to achieving this is through the use of games. In particular, games focused on learning have evolved into novel tools that can raise awareness as well as help children acquire essential skills. In this paper, we present a child-centred design approach to evaluating the initial version of a learning game designed to help children across a wide age range (3-15 years) and with diverse characteristics, improve their legal knowledge, skills, and confidence. This study supports the integral role and value of child participation in testing the usability of a law-based learning game and shaping its design. A mixed methods approach, grounded in user-centred principles, was employed to assess the first prototype (P1) of the game. 45 children from various schools and early years settings in South Yorkshire and the Midlands, UK were involved. This included children from: 1) advisory groups, 2) case study groups, and 3) game development groups, with an age range of 4 to 16 years old. School staff were also invited to give their feedback. Quantitative and qualitative data were gathered through questionnaires, and field note observations, and analyses were conducted through both thematic analysis and non-parametric statistical methods. We found the game was received positively overall, but further development was needed to make it accessible and engaging, especially for the youngest participants. Importantly, participants of diverse ages and characteristics shared valuable insights into enhancements to make the game more intuitive, interactive, and enjoyable, and these findings informed the development of the beta version of the game.

Keywords: Game-learning, Evaluation, Child-Centred Design, Children's Rights

1. Background

This work is part of Project FORTITUDE, a five-year project led by author two, and funded by the European Research Council (ERC), which seeks to develop a game to help children, aged 15 years and under, improve their legal knowledge, skills, and confidence (so-called 'legal capability'). This paper presents the usability evaluation of an initial prototype (P1) by adopting a child-led approach and incorporating constructive feedback from children to shape the development of a digital legal learning game. It outlines the methodology and discusses the findings derived from the evaluation.

In principle, children are both protected and empowered by various laws and human rights treaties, especially the United Nations Convention on the Rights of the Child (UNCRC). However, a UK-based study led by author 2 (Watkins *et al.* 2018) found that children possessed limited awareness and understanding of their rights and the law. Recent reports by the Equality and Human Rights Commission (2022) and UN Committee of the Rights of the Child (2023) highlight critical gaps in protections for children in the UK and emphasised the need for further action to prioritise their rights and best interests. Importantly, limited access to information about children's rights, inadequate human rights education prevent children from understanding and addressing rights violations. Therefore, there is an urgent need to address this gap by proactively empowering children to learn about their rights under domestic law and the UNCRC. To address this, learning-based games have been identified as engaging tools to scaffold learning, making them an effective medium to keep players motivated and interested. Designed for educational purposes, these games aim to achieve defined learning outcomes through play and problem-solving scenarios (Quian and Clark, 2016). This approach provides a sense of achievement while facilitating the acquisition of new skills and knowledge in a pleasant and playful manner (Anastasiadis *et al*. 2018).

Article 12 of the UNCRC asserts the rights of every child to "form his or her own views and to express those views freely in all matters affecting the child. These views should be given due weight in accordance with the age and maturity of the child", recognising them as active participants in their lives. There is a significant body of research and practice concerning the involvement of children and young people (CYP) (Lundy *et al.* 2022) in decision-making, particularly in the technology design process to address their needs (Fails, Guha and Druin, 2013). Redefining the role of young children as active agents capable of meaning-making has played a pivotal role in fostering the movement for child participation (Lundy *et al*. 2024; Druin, 2002). A review of the literature suggests that some studies have involved CYP in discussions on children's rights (Barwick *et al.* 2018; Watkins *et al*. 2018; Law *et al.* 2016), wellbeing (Koch, 2018), technology design (Bevan-Jones *et al*. 2020) and curriculum development (Presser *et al.* 2015). Importantly, approaches in the design of game programmes have emphasised the importance of a user-centred approach and the involvement of key stakeholders such as children during the design process (Magkafa 2022; López-Faican, 2020). While initiatives like 'Right Runner' (UNICEF, 2019) and 'Rightsburgh' (Children's Parliament, 2021) empower children through game children's participation in developing legal and rights-based learning games remains limited and relatively uncommon.

A central concept of the project is that CYP involvement should be viewed as "participation with purpose" (Lundy *et al*. 2022, p.6), prioritising their voices. This child-led approach encourages CYP to articulate their perspectives and influence decisions on matters that affect them, such as in the current project, the design of a digital legal learning game. Recognizing games' motivational power (Bai *et al.* 2020), we argue that children can learn about law and their rights through gaming.

2. Methodology

2.1 Two-stage Cycle

The design and evaluation of P1 followed an iterative, child-centred approach to inform the game's design. In collaboration with a gaming company, an initial prototype was built, and feedback was sought at different stages. A two-stage process was developed to test the first version of the game; this process enabled the researchers and gaming company to receive valuable feedback from diverse groups of children.

In the first stage, 21 CYP from three groups provided feedback on the initial concept game ideas. A total of 21 CYP from three groups engaged in a session and offered their preferences for the ideal game concept. Once the game concept was selected, the second stage involved the gaming company developing an initial P1, which was then evaluated by multiple groups of children. It is this second stage evaluation which we report on here. A simple prototype was opted for at this stage to ensure a child-led design and to enable children to offer as many insights as possible to inform the design of the next stage (beta version). It is important to highlight that one of the challenges we encounter is our attempt to accommodate the diverse age range for which the game is intended. The design of the game was guided by the Serious Game Design Assessment Framework (SGDA) developed by Mitgutsch and Alvarado (2012). This framework was specifically chosen because it provides a structured approach for designing learning-based games and serves as a guide for their evaluation. It emphasizes on influencing player behaviour during the co-design process and its five fundamental concepts (mechanics, framing, content, narrative and aesthetics) serve as prerequisites for achieving the game's intended purpose. Informed consent was obtained from the parents and the study was approved by the Ethics Committee of the University of Sheffield, UK.

2.1.1 Description of Prototype 1

P1 is a first-person skeuomorphic game which encourages CYP to interact and explore freely. The concept is that CYP will be able to explore a secret office with a hub and select everyday objects on a desk. The hub appears in front of a desk with a pin board behind it; this is the player's personal game space (Figure 1). Due to time constraints, P1 focused on key interactive elements that were designed to enhance user engagement. By creating a simple interface, we hoped not only to make the game more accessible but also to encourage CYP to contribute their own ideas and feedback, thus fostering a sense of ownership and active involvement in the design process. This approach aligns with our goal of creating a child-led game.

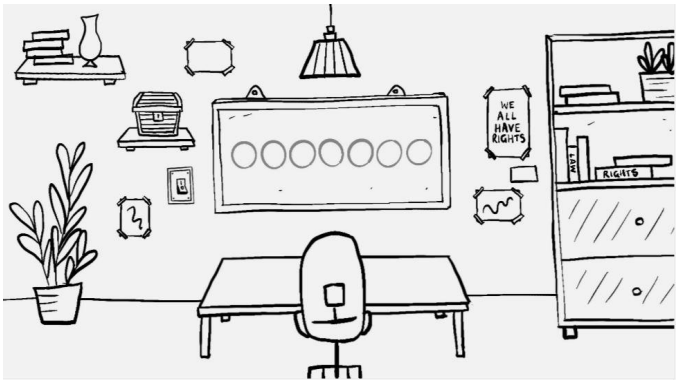


Figure 1: The Hub presented to the player as a personal desk space.

Various everyday objects act as portal keys and represent unique scenarios to which they are thematically linked (Figure 2). Scenarios depict real-world events that present a legal situation or explore a rights violation under the UNCRC, which they may encounter in their daily lives. The selection of the scenarios was informed by a mapping process conducted at the beginning of the project based on the legal educational and pedagogical value. Subsequently, CYP were asked to rank the scenarios. Based on their feedback, the research team refined the scenarios by considering the theoretical framework, learning objectives, and the legal and rights-based issues presented within them. Factors such as overlap of issues and suitability for CYP were also considered during this process.

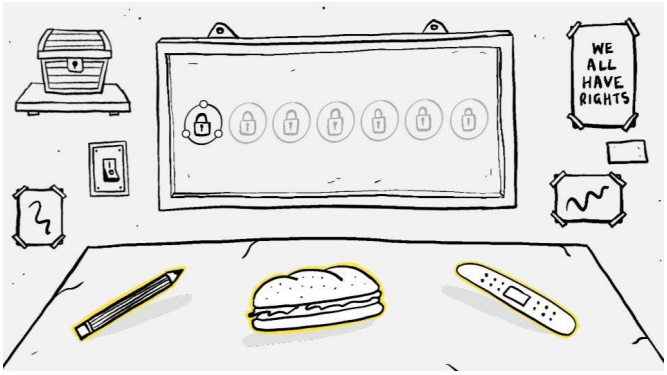


Figure 2: The portal keys which the players need to select.

Once the player selects an object to play, the object acts as a portal key and transports the player out of the hub to show them real world situations (Figure 3). The CYP will then carry out tasks to challenge their perceptions of legal scenarios and encourage exploration and learning. Everyday objects serve as portal keys to facilitate an engaging and intuitive transition between the hub and various scenarios. This design choice allows players to easily understand that choosing an object transports them to a new scenario. The thematic linking of objects to scenarios strengthens the learning objectives.

The player can collect rewards which show up in their hub space. A bar called ‘Lawometer’ tracks the player’s legal capability throughout the challenges (Figure 4). If they select an appropriate answer the bar goes up, indicating an increase in legal capability. However, if they select an inappropriate answer the bar goes down to show their legal capability has decreased. The ‘Lawometer’ provides real-time feedback on player’s legal capability. By visually tracking progress, the Lawometer helps players learn through direct and immediate feedback.

It should be mentioned that due to time constraints P1 was developed without colour. The decision was made to prioritise the development of the prototype’s core functionalities and some interactive elements. The monochromatic design was adopted to create a clear interface with visual elements that guide the player through the game.



Figure 3: Transition scene: After the player selects an object to play.



Figure 4: The Lawometer to show the consequences of the player's actions.

2.2 Data Collection and Analysis

Quantitative and qualitative data were collected through questionnaires and field note observations. Field notes identified issues that participants faced navigating the game that might have been overlooked. The questionnaire combined open-ended and closed-ended questions to capture participants' experiences and thoughts with the prototype (Cresswell, 2014). A Likert scale was used with a range 1 to 4 and the typical 'neutral' response was removed to ensure participants would commit to a response indicating a preferred option.

All data recorded, analysed, and reviewed by the first author. Thematic analysis was applied to analyse the field notes and the open-ended responses. For Likert-scale questions, non-parametric statistical methods, specifically Fisher's exact test, was employed to assess patterns of association between enjoyment and understanding of their rights. Authors two and four reviewed and discussed the data for accuracy. To maintain confidentiality, all participants' names were anonymised. The findings from this stage of the study provided the basis for refinement and were considered priorities for improving the game for the next stage of the development process.

2.3 Participants

The P1 evaluation involved 45 participants from various schools in South Yorkshire and East Midlands in the United Kingdom. We worked specifically with three cohorts: 1) advisory groups (ages 8-15) who have been actively working with us and providing valuable advice throughout the project, 2) case study groups (ages 3-16) involving children from early years settings and those with Special Educational Needs and Disabilities (SEND), and 3) game development groups (ages 8-13) who collaborated with us at discrete stages of the game development process. Our decision to include such varied groups in the testing process of the game is driven by our commitment to inclusivity and diversity.

Table 1 presents the participants' profiles by group, age range, school year, number of participants, setting, and location. School staff from the case study groups also provided feedback on P1.

Table 1: Information about the schools participating in testing P1.

Group	Age Range (years)	School Year	Number of Participants	School Setting	Location
Advisory Group	8-9	Y4	9	Primary School	South Yorkshire
Game Development Group	12-13	Y 8-9	7	Secondary School	Leicestershire
Game Development Group	8-10	Y5	5	Primary School	South Yorkshire
Advisory Group	13-15	Y9, 10, 11	8	Secondary School	South Yorkshire
Case Study Group	6	Y1	2	Primary School	South Yorkshire
Case Study Group	5	Reception	1	Primary School	South Yorkshire
Case Study Group	11-16	Y 7, 9, 11	7	Secondary School	South Yorkshire
Case Study Group	3-4	EYFS[1]	6	Nursery	Nottinghamshire

[1] EYFS refers to the Early Years Foundation Stage.

2.4 Procedure

We invited participants to attend a 10–20' minute session held in a quiet environment either within the IT or activity classrooms of the setting. Equipment usage varied, in some schools, participants used the school's equipment (e.g., PCs, Chromebooks), whereas others used iPad tablets provided by the researchers. The procedure involved one-on-one sessions with researchers observing the participants play the game. When all participants needed to be in the classroom together, researchers worked one-on-one with individual students, while the remaining participants drew their ideas for portal keys (the objects on the desk) either before or after gameplay. Field notes were taken for data analysis. After gameplay, participants and their teachers (in case study groups), completed a questionnaire regarding the game's features and functionality to gather feedback for improvements. Examples of questions included: Was it easy to play the game?, Was the game easy to understand? Did you enjoy playing the game? What was the most/least fun part of the game? What would you like to add/change to the game to make it better? We adapted the questionnaire and adjusted the pace of asking questions to accommodate the broad age range and to ensure participants' understanding. The questionnaires were also reviewed by the teachers of the SEND participants to ensure that the questions were suitable for the participant's cognitive abilities and ages.

3. Results

The analysis of the questionnaire responses and the field notes revealed several important insights and identified consistent themes across all participants' responses. The Likert scale questions reflected an overall positive perception of P1 and indicated its potential effectiveness in enhancing children's understanding of their rights. The recurrent themes provided us with important ideas and allowed us to distinguish areas for further improvement. The main themes identified are discussed below.

3.1 Usability

The majority found P1 straightforward to play (68.9% very easy, and 20% easy) with only a small minority of participants reporting it as 'hard' (4%) or 'very hard' (6.7 %). 51% of participants found P1 very easy and 35.6 % considered it easy to start playing. Some participants faced difficulties understanding what to do and its overall goal due to a lack of instructions, leading to confusion in several instances. A 6- year-old girl repeatedly asked

the researcher "What do I do?", "What do I do?" even after being prompted to look at the screen while an 11-year-old boy wondered how it starts ("What do we do first?"). EYFS participants found it challenging to start playing the game as reported by Teacher 4. According to Teacher 4, the beginning of the P1 was not suitable for this age group.

P1 was accessible for older participants, as evidenced by their ability to navigate and quickly complete the tasks. Some of them noted that correct answers were easy to guess, and after the first activity, became increasingly obvious. For example, one participant commented that the correct answer (speaking to someone) is "always the correct answer" (male, age 15) and this makes it easy.

Field notes and comments made by the participants revealed that the lawometer seemed confusing for them in some cases even if it was perceived as an effective reward mechanism ("The law-meter was a good idea" female, age 15). This was evident when the lawometer filled up, with no indication of the answer's correctness or what was expected to happen next. When a male, age 9 found out that he needed to repeat the scenario for the third time, he expressed his frustration asking, "what do I do? I did this one" and repeatedly querying "what do I do?". In another case, in the first scenario the participant clicked on the wrong response ("tell a friend") and she appeared confused about what to do. After staring at the screen for a few seconds, she asked "Ahhh, did I get it wrong? What am I doing now? Going back? (female, age 14). It is also evident that EYFS participants found it hard to understand the lawometer and the researcher's verbal guidance was necessary for them to progress, as can be seen from the dialogue below:

Male, age 3: Why did it do that?

Researcher 3: I think it's because the answer wasn't quite right. It was a good answer but not the right one. Do you want to try again?

Male, age 3: [*nods]

Researcher 3: [reads options to male, age 3]

Male, age 3: Press it?

Researcher 3: Yes. [reads options] Hide away? Okay that is this one.

Male, age 3: Ohhh.

Researcher 3: I think that wasn't right. [reads options]. I think you got it right, well done. Now press the chest.

3.2 Purpose

Findings were mixed in relation to the game's intended purpose. The majority of the participants highlighted the game's central themes of legal awareness ("Law", male, age 13) and rights advocacy ("I think it's about that we all have rights", male, age 9). They emphasised its educational role in teaching children about human rights and providing insights into the legal aspects of different situations ("Basically showing mostly the younger audience what actions you would take in that situation", male, age 12).

Participants, from the case study group, offered a different perspective and stated that the game primarily focused on emotional wellbeing ("about feelings when you are worried", male, age 13). In this context, P1 was perceived as a tool for helping children deal with worries ("being worried about mums, friends, and doctors", female, age 6) and encouraging them to seek support from trusted adults ("It teaches me to always tell a trusted adult", male, age 14). Additionally, some participants emphasised P1's role in building problem-solving skills and helping children in managing their emotions while navigating various scenarios ("Choosing the more sensible option to react in situations", female, age 14). In contrast, EYFS participants provided neutral responses to what the game was about ("I don't know", female, age 4) indicating a lack of clear understanding of the game's objective.

3.3 Enjoyment

The analysis of responses regarding P1's efficacy in educating children about their rights and their enjoyment of playing the game indicated a strong association between these two variables, (Fisher's exact test = 25.191, $p<.001$). The findings suggest that the game's helpfulness in learning about their rights is closely linked to their enjoyment of the gaming experience. Furthermore, a majority of participants reported enjoying playing the game. In particular, 35.6 % of the participants expressed that they liked it and an additional 44 % liked it very

much. Only 2.2 % felt that the game did not meet their expectations in terms of enjoyment. This evidence is further supported by field notes, which documented the participants' interactions playing the game.

Additionally, there was a clear consensus among the participants regarding the possibility of playing the final version of the game with 62% of them expressing a desire to play the game again and an additional of 24% indicating an interest in a replay. This high percentage of enthusiasm among participants suggests the positive impact that P1 had during the evaluation. There was a significant relationship between participants' perceptions of the game's educational value and their willingness to engage with it once it is fully developed (Fisher's exact = 18.859, p= .004). This indicates that participants who found the game helpful in learning about their rights were also inclined to express an interest in playing the completed version, highlighting the potential of P1 in effectively engaging the target audience.

3.4 Fun

Regarding participants' perception of the game's enjoyment, the overall results remained positive with 37.8 % 'liked it very much' and 33 % 'I liked it'. However, 20 % reported 'it was okay' and 8.9 % expressed 'didn't like it at all'. There was a statistically significant association between participants' perceptions of P1's between learning about their rights and their perception of its fun factor (Fisher's exact test= 18.300, p= .006). This suggests that participants who found the game helpful were also more likely to perceive it as fun to play.

On a positive note, the graphics seemed to capture participants' attention with the transition scenes creating excitement, particularly among young children.

Became excited when he saw the transition scene and made comments like 'wow', 'look', 'wow'

(fieldnotes for male, age 5)

Conversely, one possible reason the participants did not find the prototype enjoyable could be attributed to its limited interactivity. Some participants expressed a preference for more interactive elements in P1. For instance, in the HUB, only three items could be interacted with. This could also be attributed to some functionality issues, which affected the smooth navigation of the game for EYFS children.

Whilst playing he was moving the mouse a lot on the screen and trying to click on different bits that were not interactive (e.g., posters, different parts of the scenario backgrounds etc.) (researcher's 4 fieldnotes for male, age 9)

Several times the children pressed away from the screen which resulted in a new window being opened or the game window being accidently closed. Other apps were also accidently open due to enthusiastic pressing. (researcher 3's fieldnotes).

Participants found various enjoyable elements within the game which contributed to a positive gaming experience, and these include the following:

3.5 Interactive Agency

Participants valued having the agency to make decisions within P1 and highlighted it as a key element of enjoyment. The ease of navigating through choices, such as clicking dots and connecting them, was identified as adding some enjoyment to the game. P1's interactive and realistic experiences effectively engaged the participants. Additionally, the use of badges and the 'lawometer' measuring their understanding of the law after completing a level were also enjoyable features.

"clicking dots, it was the easiest" (male, age 13)

"How the game interacts with the player through interactive and realistic experiences" (male, age 15)

"The badges after finishing [a] level. The thermometer measuring the law strength" (female, age 15)

3.6 Exploration

Unlocking chests and discovering hidden treasures emerged as an exciting aspect for participants; adding an element of unpredictability. Furthermore, participants expressed an interest in the use of scenarios that unfolded after clicking on various objects; this introduced an element of anticipation and curiosity.

"When I had to join the dots, unlock the chest to get into the next level" (male, age 16)

"Waiting for the scenario to happen after clicking on the object-picking the answer" (female, age 13)

3.7 Narrative Learning Component

The narrative component of the game, presented through short stories, played an important role in the overall enjoyment of participants. The use of diverse stories linked to different items contributed to the overall narrative experience.

"The stories. My favourite story is the pencil one" (female, age 9)

Participants also appreciated the educational value of the game. The simplicity of the stories and cards facilitated understanding and acted as a bridge for learning.

"Learning about the rights. Easy to read" (male, age 8)

"The cards easy and read/understand" (male, age 8)

3.8 Rewards Mechanism

The lawometer and the badges played an important role as a reward mechanism.

"The badges after finishing [a] level. The thermometer measuring the law strength" (female, age 15)

Various recommendations and changes were obtained from the testing, which are considered important to 'shape' the game in the next evaluation round. These include:

1. Enhanced Interactivity & Agency

   Increase the number of interactive areas within levels: "More interactive areas within the parts of the levels." (male, age 15)
   Allow the participants to have greater control over their surroundings: "Interactivity around [the] game e.g., the light turning on via light switch" (female, age 15), "So you can control a character to make it more user interactive" (male, age 13)

2. Multisensory Elements

   Participants and teaching assistants highlighted the importance of colour and sound effects as well as adding a narrator to guide the participants: "Colour. Pencil the end pink black stripes yellow. Sandwich-light shaded orange, green lettuce, put some cheese" (male, age 9) "Noise- hear what they are saying", "Some background music" (TA1), "Colour. The option for the words to be read aloud to the child" (TA2).

3. Navigational Support

   Improve the game introduction to capture player's attention: "Guidance" (female, age 14)
   Provide clear instructions to help participants understand the goal of the game: "And easier ways to start the game, instructions but not boring" (female, age 14)

4. Re-playability

   Introduce re-playability features to encourage participants to revisit the scenarios: "add re-playability to them" (male, age 15)

5. Customisation

   Incorporate character customisation features to allow participants personalise their in-game avatars: "Make your own characters" female, age 6)

6. Diverse learning activities & answer options

   Incorporate varied learning activities like card matching, dragging items to diversify the game experience: "more stages to open the chest. It's kind of really easy. It's too easy you just have to click" (male, age 8)
   Increase puzzle difficulty as participants advance through the game: "make the puzzles a bit harder as you go on" (female, age 14)
   Provide different solutions in answer options instead of just telling an adult: "Differently worded solutions rather than just tell an adult" (male, age 13)

7. Graphics

   Replace abstract elements with real pictures: “Instead of squiggles put real pictures” (female, age 14)
   “Picture- sign friendly for our age group” [EYFS group] (Teacher 4)

8. Game length and content

   Extend the length of the game by including more scenarios and challenges: “Make the game a bit longer” (male, age 15)
   Continue the story after making choices with slideshows that recap the consequences of player choices: “At the end add what would happen if you did one of the wrong situations” (female, age 13)

4. Conclusion

This study reflects on the findings gained from user-testing which sought to capture ideas from children to further develop a law-based learning game designed to improve children’s legal capability. We acknowledge that designing a game for such a varied age range presents certain challenges which we seek to address. By actively engaging diverse groups of children, our intention is to develop a user-friendly and engaging game-based tool for intervention to facilitate children’s understanding of rights and the law.

The testing involved participants of various ages and characteristics, who were invited to engage with the prototype and provide input. The findings revealed both strengths and areas for improvement in the P1.

Participants appreciated the exploration features, the interactive elements, narrative learning components, and rewards mechanism. This feedback indicates the importance of embedding engaging mechanics in educational game tools. While most participants found P1 easy to play, some challenges were identified regarding its usability and accessibility across different age groups. For example, younger participants encountered difficulties understanding the game’s objectives which highlights the need for better clarity and clearer instructions in the beginning. Despite these challenges there was a strong association between enjoyment and knowledge acquisition, and this suggests the potential impact of P1 in engaging the target audience.

However, our study has several limitations. The small sample size may limit the generalizability of our findings as it was tested with a limited number of participants. Additionally, the prototype’s simplicity, which featured limited interactive elements, a monochromatic design, and a limited range of stories may have influenced participants’ perspectives. This, in turn, could have affected the evaluation of the game’s quality as the current prototype didn’t appear as a complete game.

Moving forward, P1 evaluation provides valuable insights for implementing essential changes and additions. Key areas for improvement include enhanced interactivity and clarity to better accommodate a diverse age range, addressing usability issues, and refining the game’s objectives to improve its impact and foster engagement and learning outcomes. Continuous iteration and testing with diverse age groups are critical aspects to validating these improvements and ensuring the game’s effectiveness as an educational intervention tool before its launch across the country.

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A Pilot Study: Engineering Students use Generative AI to Support the Development of Playful Educational Technology

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Abstract: This qualitative pilot study provides an example of how generative Artificial Intelligences (GenAI) can be applied in an engineering course focused on the development of playful educational technology. In this context, playful educational technology refers to games or game-like applications designed for educational purposes. We explore various applications of GenAI in creative design processes such as brainstorming, acting as a collaborative partner in design, facilitating image and sound creation, and aiding in the resolution of coding challenges. By examining examples from 36 engineering students' semester-long projects, we highlight the potential and drawbacks of GenAI as an extra teammate in enhancing the design process for developing educational game-based learning experiences. Key findings from the study include: The students opted to use a GenAI as a teammate, whose input required validation. They employed GenAI in areas where they found it effective and where no major ethical issues were involved. It was also surprising to observe the wide variety of AI tools the students incorporated.

Keywords: AI, Design Processes, Educational Technology, GBL, Higher Education, Generative Artificial Intelligence.

1. Introduction

The paper explores the innovative use of generative AI (GenAI) in an engineering course focused on students' development of playful educational technology. In this context, it refers to game-like software applications designed for educational use. It highlights GenAI's role in enhancing creativity and learning outcomes in development processes. The paper offers interdisciplinary insights and suggest future research directions, appealing to a broad audience of educators, developers, students, and researchers in the fields of technology and education.

Since the end of 2022, GenAI has been at the forefront of educational discussions at all academic levels (MYRE, 2024). Initially, there was concern among educators about how GenAI might negatively affect students' competencies. In response, my research group decided to approach GenAI as a powerful tool, analogous to the introduction of calculators to the market in the late 1970s. Recognizing that GenAI will be a part of our students' future work life, we believe it is essential for them to understand and effectively use this tool. They should become knowledgeable about its pros and cons and be adept at leveraging its potential. This means that efforts should be focused on enhancing students' AI literacy (Hammerscmith et al., 2024).

In practice, it will be impossible to ban GenAI in written exam papers, such as semester projects, bachelor's projects, and master's theses, which are prepared over several months. Currently, it is not possible to detect with certainty whether GenAI has been used (Else, 2023). To sum up the reaction to GenAI: (1) banning it, (2) setting rules for something we don't yet fully understand, or (3) promoting student reflexivity and AI literacy. This study explores the third strategy.

Research questions of the paper: How can GenAI be used in the development of game-like applications for educational use? Including, how can we promote students' reflections on GenAI?

We want the students to reflect on the use of GenAI in relation to development of software applications and the usefulness of the tool in the future. Reflection is a central part of learning processes (Kolb, 1984; Kolb & Kolb, 2011). In experiential learning, the alternation between concrete experiments and reflection is a key parameter (Kolb and Kolb, 2011). In this context, the iterative software development process is concrete experiments that students must complete. Experiential learning as a teaching method can advance the understanding of GenAI (Sun et al., 2024).

In the autumn of 2023, 36 third-semester students in the Game Development and Learning Technology engineering program completed a semester project in the subject 'Learning Technology 1'. The theme of the project was the green transition, and the students were required to use generative AI in the design process.

The learning objectives included the ability to plan and implement both physical and digital prototypes for a learning application, spanning from the pre-analysis phase to the digital implementation. Furthermore, students had to prepare a written report that explained the key features of the digital prototype and the design process,

as well as make an oral presentation of key parts of the development process. Additionally, students needed to be capable of explaining central theoretical learning paradigms pertinent to the project, reflecting on didactic and learning theory issues related to the use of technology in teaching contexts. Reflecting on the use of GenAI within design processes was included as an additional learning objective for the course.

The course was conducted with a block of four hours per week for 12 weeks, followed by an additional eight weeks dedicated to completing the project work. All 20 weeks constituted the project work period. Concurrently, students were introduced to the subject area of learning technology. They were required to document the iterative design process, the learning-oriented didactic design, and the technical design of the learning technology equitably. Moreover, students were expected to incorporate GenAI wherever they deemed it useful and to reflect on its use in the project report. The project work were to be carried out in groups of four to six students. The digital prototypes were developed using either Unity or web programming.

2. About GenAI

This brief introduction aims to introduce GenAI. Artificial intelligence (AI) addresses the development of computer systems capable of performing tasks that normally require human intelligence, such as dialogue, visual perception, speech recognition, decision-making, and translation between languages. Artificial intelligence is characterized by adaptivity and novelty, i.e., the ability to adapt to new contexts and situations (Pfeifer, 2001; Majgaard, 2011; Haykin, 1998).

In 2018, Google launched the large language model BERT, which is an extensive artificial neural network and can perform a variety of language-based tasks beyond simple question answering (Søgaard, 2022). These tasks include translation, summarization, content generation, text completion, and the creation of text-based coding solutions. BERT has had a huge impact on GenAI. A key characteristic of these systems is their need for training (Søgaard, 2022). In extensive artificial neural network s like GPT-3, there are 175 billion artificial neurons, surpassing the nearly 100 billion neurons in the human brain. Such a neural network learns by processing input data (prompts) it receives. During training, the network receives feedback on its outputs and attempts to refine future outputs accordingly. The internal workings of what happens between input and output are largely non-transparent and are often described as a 'black box,' since the specific adjustments of individual nodes' weights are not directly accessible. Training data can include a variety of text sources from the internet, such as articles and chats. Learning is a continuous process, evolving with user interactions.

The black box properties in GenAI present a challenge in teaching. These properties result in a lack of links to sources, uncertainty about facts, and a lack of transparency. We cannot see through its way of reasoning. This poses a challenge when we want to understand and work with the students' reasoning in teaching. It also makes it difficult to identify the source of an argument – is it the student or GenAI? Because of this lack of transparency, GenAI can trigger misconceptions and fantasies in the relationship between educators and students.

3. GenAI in Higher Education

Numerous experiments with GenAI are underway across all levels of education. In higher education, there is extensive debate about the use of GenAI (For example Eke, 2023; Dai 2023; Stojanov, 2023 or Liebrenz, 2023). Rules for sound academic use of GenAI are being developed. Researchers and lecturers are divided in their views on this technology. On one hand, some educators believe that GenAI is a tool students should learn to use and will need in their future careers. On the other hand, some lecturers argue that students are not learning what they are supposed to and that they rely too heavily on copying from GenAI. However, this debate has spurred the creation of new rules (e.g. SDU rules on GenAI in education, 2024) and a number of exciting experiments with GenAI. Below are some examples.

In higher education, Yosuf et al. (2024) emphasizes the importance of integrating GenAI, highlighting both its potential benefits and drawbacks. They are concerned about the potential for academic dishonesty with the tool and the need for ethical guidelines. Moreover, they argue that responsible use of GenAI tools can enhance learning processes but stress the need for robust policies.

Chan and Hu (2023) explore university students' perceptions of GenAI technologies in higher education, focusing on familiarity, their willingness to engage, potential benefits and challenges, and effective integration. A survey of 399 students showed a predominantly favorable view of GenAI in teaching and learning. Students identified the potential for personalized learning support, writing and brainstorming assistance, and as well as research and analysis capabilities. Nevertheless, they raised concerns about accuracy, privacy, ethical issues, and the

impact on personal development, career prospects, and societal values were also expressed (Chan & Hu, 2023). Chan and Hu's study is very much in line with the experiences from the MYRE (2024) project and the case presented in this paper.

Barke et al. (2023) explored GenAI for use as a programming assistant. They conducted a grounded theory analysis of programmer interactions with Copilot by observing 20 participants with varying levels of experience. Their theory posits that interactions with Copilot fall into two categories: acceleration and exploration. In the acceleration mode, programmers know their next steps and use Copilot to expedite the process without disrupting their workflow. In exploration mode, the programmers are not sure how to proceed and use GenAI to explore their options or get a starting point for the solution. The interactions in this mode are slow and include explicit prompting and more thorough validation. It was this type of interaction that the engineering students in this study described.

Memmert et al. (2024) investigated the use of GenAI as additional input in brainstorming processes, finding that the combination of GenAI and human input improves performance. Brainstorming is a well-established method for generating problem-solving ideas. This study explores how AI-generated ideas impact brainstorming performance in terms of flexibility and breadth. The analysis is based on data from an experiment with 52 participants who brainstormed under two conditions: (1) human-only (baseline) and (2) human+AI (treatment). In the treatment condition, participants accessed ideas generated by GenAI GPT-3.5. The results show significantly higher performance in the human+AI condition compared to the human-only condition, with a large effect size. The reason for this may be that GenAI made the participants think in new directions, which fertilized the brainstorming process.

Sun et al. (2024) explored the potential of GenAI to support experiential learning processes in a college setting. Experiential learning, a widely recognized theory developed by Kolb (1984), was the foundation for this study. A ChatGPT learning activity flow was designed to align with Kolb's four experiential learning steps: Experiencing, Reflecting, Thinking, and Acting. Inspired by this study, we encouraged students to reflect on their use of GenAI during the different phases of their development process.

The MYRE (More Youth Realize Emerging Technologies) project in Denmark illustrates this trend, aiming to integrate GenAI from primary schools to universities (myre.tech). School leaders and educators are concerned about how the future job market will be affected by GenAI, its integration into educational practices, and its role in exam work. A key issue in the MYRE project is teaching students to use GenAI ethically and avoid merely copying information or uploading without reflection. In this initiative, GenAI is used for brainstorming, as a collaborator in defining problems, for aiming and structuring text and for facilitating ethical discussions (myre.tech). The case study discussed in this paper is part of the MYRE project.

No studies have been found on the impact or enhancement of teaching through the development of playful educational technology prototypes using GenAI. The case study in this paper explores GenAI as supporting toll in the development of playful educational technology prototypes.

4. Methodology

The method used in this study is qualitative and is merely a pilot study. It can be described as design-based research (Majgaard, 2011). Design-based research can be applied to educational research and is inspired by action research (Lewin, 1946; Barab and Squire, 2004). The purpose is to empower students through an iterative process while concurrently collecting data that can be analyzed. The iterative process involves a series of interventions and reflections that are connected to the educational objectives.

Interventions to promote reflections on GenAI included: (1) presentations about the history of AI and the properties of GenAI, as well as workshop on iterative prompting; (2) scholarly papers titled "ChatGPT and the Rise of Generative AI: Threat to Academic Integrity?" (Eke, 2023) and "Learning with ChatGPT 3.5 as a More Knowledgeable Other" (Stojanow, 2023); (3) in-class evaluations and discussions; and (4) requirements for documentation in the semester report in a clause titled "Reflection on GenAI."

In this case study, the data primarily consist of qualitative data in the form of the students' written reflections related to their project work. These data are supplemented by log notes from classroom discussions and an oral evaluation in the class about GenAI, its strengths, and weaknesses.

The data was systematically coded and categorized based on grounded theory principles (Strauss & Corbin, 1998). Grounded theory involves developing a theory directly from systematically gathered and analyzed data.

The identified codes acted as essential tools, facilitating the extraction of key points from the data. Specific words or themes within the text, like “teammate” and “ethics,” were predefined as codes in this case. Additional codes, such as “saving time” and “knowledge,” emerged during the analysis process. This approach allows the theory to naturally evolve from the data.

The groups were anonymized and only quotes from groups were referenced. A total of eight groups was created from the 36 students. Of these, two groups chose not to work with AI.

The results below describe how the students have used GenAI in their software development processes and their reflections.

5. Results

The following describes a few highlights from the students' reflections from the written reports. The digital prototypes were developed using either Unity or web programming. For GenAI, the students employed a wide range of self-selected tools, including Co-pilot, ChatGPT, SchoolGPT, and image generation tools such as Imagine and StableDiffusionXL, as well as the speech generation tool ElevenLabs. However, a few groups chose not to use AI in their project work. The headlines dealt with were: Brainstorming and Customization of AI output; GenAI generated images and colour codes; Potential opportunities for coding; Speech generation saves time and Language improvement. Below is a table of selected quotes from the students' written reflections and the coding of these quotes.

Table 1: Snapshots of coding

No.	Quotes	Code
1	"The AI gave 10 potential titles, which made it easier to agree on which title to use for the game. The group ended up choosing option "Waste Wizard". However, the group was not fond of using the word "Waste", so they changed it to "Trash Wizard".	Brainstorm Editing output
2	“We have used generative AI models as both sparring partners for idea generation and as help for troubleshooting code…By prompting a precise context of what we wanted, ChatGPT were able to give ideas… As with all brainstorms not all ideas are good, but with large language models … it is quicker and broader…”	Teammate Debugging Brainstorm Saving time Knowledge
3	“Our project's main menu background is generated by StableDiffusionXL. We recognize the controversial nature of Stable Diffusion and would not wish to use it in a professional setting. We have also generated early concept art for our game’s crops. We used these concepts to find the general style we wished for and made our own finalized versions fit for our game.”	Images Ethical issues Editing output
4	“When deciding on the color scheme of the product. A draft was produced by ChatGPT. It produced both hex codes and color names. The draft was then altered slightly so that any colors that did not seem fitting were not included in the development of the final product.”	Colour scheme Editing output
5	"Ultimately, the provided code were not used as there was not enough time to make it work as desired, but using GenAI to help write the code made the process much faster …”	Coding ideas Saving time Knowledge
6	“LLMs have also been, a valuable asset when it comes to debugging or clarifying subject matter.”	Debugging Knowledge
7	“…An GenAI voice generator has been used to record the lines that the player will hear through the various minigames. We used Elevenlabs which gave the best voices for Danish speech."	Voice Saving time
8	“ChatGPT was consulted for refining parts of the report to make the text more proper English…”	Proper English Knowledge
9	“We are very aware that LLMs have a tendency to hallucinate and not always be right, but even with double checking its statements, it has been a timesaver.”	Hallucinate Time saving

5.1 Brainstorming and Customization of AI Output

Several of the groups that successfully used GenAI for brainstorming and adapted the outcome of AI's output, see Quote 1 and 2 from table 1.

GenAI functioned as an additional team member, providing suggestions for working titles for the prototype. These suggestions were integrated into the group's process, similar to how ideas from other members were handled.

The students reflected that using GenAI in brainstorming was valuable and emphasized the importance of continuing to develop and personalize the generated output. They also noted that GenAI possessed a broader knowledge of the domain topics than they did. This aligns with Memmert and Bittner's (2024) study, which found that the combination of GenAI and humans enhances the breadth and flexibility of brainstorming processes.

5.2 GenAI Generated Images and Colour Codes

The AI thus makes it possible for the user to create images based on a text-based description of the image, see quote 3 and 4 in table 1. The groups used a variety of image generators such as Imagine.art and StableDiffusionXL to create a background images and sprites for the games. One of the groups used ChatGPT produce a harmonic colour scheme. The students evaluated the outputs, such as colour codes, to ensure they aligned with their own understanding of colour harmonies.

The students utilized GenAI as an additional team member, specifically in the role of a graphic designer. Since graphic design is not a core competency for these engineers, they freely used the graphics generated by GenAI. When they had precise graphics requirements, they often had to customize or create the graphics themselves, as it was also time-consuming to develop the right prompt for GenAI.

5.3 Potential Opportunities for Coding

Some of the groups used ChatGPT to help them write some code. Here, ChatGPT was used as a teammate, where ideas were given to ChatGPT to figure out how to solve a specific problem. See Qoute 5 and 6 from table 1. Examples of coding dialog headlines with ChatGPT were: Coroutine for scaling animations, UI Arrow Line, debugging unmasking an object and shader issues. Clarifying subject matter regarding programming might fall under the category of exploration. Debugging might fall under the category of acceleration since the GenAI helped to solve problems faster (Barke et al, 2023). To get a better understanding of GenAI for coding support better data is needed e.g. in form of interview, better access to dialog between GenAI and the coder.

In summary, GenAI served as a knowledgeable teammate in the context of programming. The students used GenAI to seek help with problems related to development of new algorithms, where they lacked a clear idea of how to develop the necessary logic. They also used GenAI to debug troublesome code snippets.

Since programming is a core competency for the students, they were less precise about their use of GenAI. They emphasized that they did not directly use code from GenAI. Additionally, several students mentioned the difficulty of formulating prompts precisely enough for the generated code to be immediately usable.

5.4 Speech Generation Saves Time

One of the groups experimented with text for audio, which saved the group a lot of time. See quote 7 in table 1. The students gained an extra teammate who could read texts aloud in various Danish voices. Occasionally, they needed to adjust the spelling slightly to ensure the pronunciation was correct.

The students found this method to be much faster than recording multiple takes themselves. Additionally, using GenAI helped them overcome the discomfort of hearing their own voices on recordings, which can be a common barrier.

5.5 Proper English

The students were Danes, and they could write their reports in English or Danish. GenAI was used to improve the Danish students' written English. See quote 8. The students gained an extra teammate who surpassed at correcting grammatical errors and adapting Danish colloquialisms to English equivalents.

The students emphasized that they wrote the texts themselves, using GenAI solely to enhance grammar and language quality.

5.6 Hallucinations vs Knowledgeable Teammate

The students recognized that GenAI occasionally "hallucinates," as noted in quote 9 of Table 1. Consequently, they knew to verify facts and check for any omitted sentences during proofreading. Despite this, students found that GenAI helped them save time. Essentially, GenAI was like a somewhat unreliable knowledgeable teammate whose eagerness to please sometimes outweighed its accuracy.

In many of the quotes, students express how GenAI introduced new knowledge and ideas, ranging from coding ideas to broad overviews of new domains and skills, such as proofreading. Stojanow (2023) discusses how ChatGPT served as a knowledgeable other, offering knowledge that was sometimes superficial and occasionally contradictory. According to Stojanow (2023) the interaction often led to a state of flow (Csikszentmihalyi, 2008), making the students more receptive to the responses at the moment. Consequently, students needed to use

their reflective skills to distinguish between useful insights and superficial or erroneous information, even though GenAI might have lulled them into a state of flow where their critical guard was lowered.

5.7 Reflection in Class About Revolved Around Ethical Issues and GenAI as Sparring Partner

In the classroom, the application of GenAI in software development processes was evaluated through oral discussions, and key points were logged on the white board. Highlights of this evaluation are summarized in Table 2 below.

Table 2: Overview of strengths and weaknesses of GenAI in the students' opinion.

Strengths	Weaknesses
GenAI is an efficient sparring partner Efficient for brainstorming To get an overview of a topic Simulation of user tests Generation graphics, lines, and stories Proof reading Time saver	Sound academic practice vs academic dishonesty GenAI hallucinates One must fact-check We do not know how chatGPT use and store input data. Time consuming to develop efficient prompts.

The students noted that crafting effective prompts was time-intensive and emphasized the importance of fact-checking. There was a lengthy debate about what constituted cheating and how much editing was appropriate for texts written or revised by GenAI. Additionally, they highlighted time savings in areas such as graphic design, brainstorming sessions, debugging, and proofreading.

The students had numerous concerns about the reliability of GenAI's information and its appropriateness for academic work. They were concerned about navigating the fine line between adhering to sound academic practices and committing academic dishonesty. They questioned when a proposal from GenAI could be revised and processed sufficiently to be included in an exam paper. These considerations highlighted complex questions without straightforward answers.

6. Discussion

In the following, I will discuss how generative AI can save time; ethical issues, erosion of our classical competencies and emerging of new competences. In the table below, the results are summarized. The columns display the distribution of efficiency, reliability, and ethical issues across the various themes.

Table 3: Summary of results

	Efficiency	Reliability	Adapting output	Ethical issues
Brainstorm	x	x	x	
Images & colour codes	x	x	x	(x)
Coding ideas	x	x	x	(x)
Speech generation	x	x		
Proof reading	x	x	x	
Hallucinations vs knowledgeable teammate	(x)	(x)	(x)	x

The table indicates that the students utilized GenAI in areas they found effective for time savings, where GenAI proved reliable, and where there were no insurmountable ethical issues. The students avoided using GenAI in areas where they recognized significant ethical dilemmas. For instance, they refrained from having GenAI prepare article summaries, generate core code, or write entire sections of their reports. Engaging in these practices would raise ethical concerns and constitute poor academic conduct.

6.1 Efficiency, Reliability, and Adapting Output

Regarding efficiency, most students agreed that GenAI could save time by making it easier and quicker to brainstorm, gain an overview of a new domain, or generate solutions ideas for programming problems. They viewed generative AI as an additional participant in group activities.

However, obtaining precise results from GenAI that could be used directly, proved to be time-consuming. Students often had to modify the output themselves. Tailoring the prompt to yield an immediate solution was

seen as an unnecessary complication. For instance, when using GenAI to enhance language, the intended meaning could sometimes become distorted, or the development of complex images with both text and illustrations could be time consuming.

About reliability: In connection with evaluation in class and written student reflections, the word hallucination often appeared. The students felt uncertain about GenAI's results. They were generally critical of GenAI and fact-checked results. However, talented students tend to be better at fact-checking and adapting results from GenAI compared to their less adept peers. This disparity presents a potential area for further research. Additionally, it's worth exploring how GenAI can be utilized to enhance the skills of less proficient students and thereby narrow the educational gap. In this context, AI could serve as a personalized learning partner.

Adapting the output was essential for effectively using GenAI. There were three main reasons for this: first, adapting and processing the output allowed students to take ownership of the results, aligning with good academic practices. Second, it was crucial to tailor the output to fit seamlessly with the context of their other work. Third, as noted previously, modifying the output was quicker and more efficient than attempting to get GenAI to produce a perfect result on its own.

6.2 Ethical Issues

There are several ethical issues associated with GenAI. Such as, what is the line between plagiarism from GenAI and text you have written yourself? (Yosuf et al., 2024) This was one of the big questions during the evaluation, it was also difficult to answer precisely. How much do you have to customize an autogenerated text before it is your own? It falls within what is considered good academic practice to be able to find this balance. The students were also worried about how the data they used for input would be used by GenAI.

The students were also worried about how GenAI could be abused on social media with deepfakes, among other things. The extensive debate about GenAI in local Danish media gave the students the opportunity to take a critical view of the technology, informed by their own technical background and experience from the semester project. These ethical issues are also addressed in Chan & Hu's (2023) study.

6.3 Limitations and Future Research

There are several limitations in the collected data, such as the sporadic access to the students' dialogue with GenAI. Access to these dialogues would have provided insights into the number of iterations and how students refined their prompts. Additionally, there was a sense that some students were reluctant to discuss their use of GenAI, possibly due to concerns about being accused of plagiarism.

Discussions about GenAI in education are set to persist. The implications of GenAI on teaching justify ongoing research. Both lecturers and students require deeper knowledge of AI and its application in educational settings. It is essential to create a research-based toolbox for educators, enabling them to better understand AI and incorporate it ethically into their teaching practices.

Exploring whether and how GenAI will erode our classical competencies and foster new ones is crucial. Specifically, it would be valuable to examine if GenAI's integration into educational settings leads to the erosion of existing skills while fostering new ones, such as in programming. A study could be conducted within the Danish context to assess how GenAI supports programming education, investigating whether students might lose certain competencies even as they gain others. In other contexts, this would point at competencies for writing. This research could employ grounded theory and base its findings on dialogues between students and GenAI.

7. Summery and Conclusion

The paper explored the question: How can GenAI be used in the development of playful educational prototypes in engineering programs? Including, how can it promote students' meta-reflections on GenAI?

The paper explored the innovative use of GenAI in an engineering course focused on development of game-based learning prototypes.

It was an eye-opener to explore the many different ways GenAI could be applied in the design and development process, including brainstorming, graphics generation, automated speech, code debugging, text editing, and grammar. The students emphasized that GenAI as a teammate could save time, but also noted that it could be

time consuming to achieve a very refined output if desired. According to the students, they mostly adapted the output from GenAI, were inspired by it, but also often discarded it.

In the project report, they were asked to reflect on the use of GenAI without any special additional requirements. Should we need to run a similar study again, the students must submit links from dialogues with GenAI, making it easier to qualitatively assess how they work with the GenAI tool and how they derive useful outputs.

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Understanding Stakeholder Perspectives: Towards the Design of a Serious Game for Positive Energy Districts

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Abstract: Positive Energy Districts (PEDs) are highly energy-efficient urban areas that manage a surplus production of renewable energy. Recognising the key role they can play in the transition to a less carbon-dependent society, the European Commission launched its PED Programme in 2018, to implement and support the development of PEDs. However, as PEDs are still a relatively new concept, their implementation can be challenging, and local administrators often lack clear guidance and reference points for their design, implementation and evaluation. To address this issue, the Positive RObust PEd Localities (PROPEL) project has among its main objectives the design of a serious game to provide practical insights and user-friendly tools for local administrators interested in implementing and developing PEDs. Indeed, by drawing on the power of digital games to set goals and allow the player to autonomously define a strategy to achieve them within a set of constraints, serious games can be a very powerful tool to support local administrators in their decision-making process, enabling them to explore multiple scenarios and to evaluate the results of their choices. This paper outlines the design principles and the main features of a serious game aimed at supporting local administrators in the implementation of PEDs. These design principles and features are derived from a research process comprising several steps. Firstly, the drivers and barriers to the adoption of a serious game among local administrators were identified. This was done through in-depth interviews with local administrators and PEDs experts from the different countries involved in the PROPEL project, namely Italy, Sweden, and Turkey. Secondly, a comparative analysis of serious games developed for related research purposes was carried out. This provided further suggestions for the features of the serious game. The findings underscore the significance of incorporating real data, adopting a modular structure to emulate the systemic complexity of PEDs, and ensuring accessibility across multiple devices as paramount features that the serious game should have.

Keywords: Serious Game; Design Principles; PED; Sustainability; Case Study; In-depth Interviews.

1. Introduction

A cornerstone of the European Union's efforts in fighting climate change is the transition to a less carbon intensive society, achieving carbon neutrality by the year 2050. A key challenge is the decarbonisation of the energy system and the built environment. Against this backdrop, numerous EU plans aim at creating the conditions for the development of initiatives that accelerate decarbonisation of the sector, while ensuring a high-quality of life for citizens and the achievement of social and economic objectives, such as addressing energy poverty (European Commission, 2020). In this context, the EU introduced the framework of Positive Energy Districts (JPI Urban Europe, 2020).

PEDs are energy efficient and energy flexible urban areas (or interconnected groups of buildings) which produce net-zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy (Hedman *et al.*, 2021). Therefore, the defining characteristic of a PED is a technical and environmental one: Groups of buildings with a surplus annual energy balance and net-zero GHG emissions. However, the PED framework also places heavy emphasis on social outcomes and in particular the quality of life of citizens and tackling energy poverty.

Due to the urban nature of the concept, the task of developing PEDs falls largely on local administrations. However, they face numerous barriers to the implementation of PED policies and measures. Chief among them is the lack of relevant data and tools for monitoring PED development. Collecting data on environmental, economic, and especially social indicators that can inform PED strategies and progress can be challenging for

local administrations, and often proxies need to be used (Caballero *et al.*, 2021). The lack of data can lead to ineffective decision-making and a lack of targeted development towards PED benchmarks across possible scenarios for the district's development.

The PROPEL project aims to address the data limitations of local municipalities through the use of a Decision Support System (DSS). This system aims to operate as a data exchange platform for innovation in processes and business models, providing data-driven analytics. The DSS will allow for the local exchange of granular energy consumption data, allowing consumption forecasts for residential and commercial customers to be greatly improved.

However, such an approach is not without its shortcomings. The use of the tool relies on an antecedent understanding and willingness to engage with the technology. Towards this end, the PROPEL project aims to foster the use of the tool through the inclusion of gamification features. The integration of game elements in the DSS is intended to enhance accessibility and guidance for stakeholders who are not familiar with these types of simulation tools. The objective of this study is to identify the factors that either facilitate or hinder the adoption of a gamified approach as a means of disseminating content related to PEDs and supporting informed decision-making among a target audience of stakeholders.

2. Background

PEDs foster interaction between buildings, users, and regional energy, mobility, and ICT systems to ensure a sustainable balance of social, economic, and environmental factors. There are many possible configurations that a PED can take, and while there is no single consensus on a taxonomy, the European Energy Research Alliance (EERA) proposes the following categorisation: Autonomous PEDs, Dynamic PEDs, and Virtual PEDs. Autonomous PEDs are entirely self-sufficient in energy production and consumption within defined boundaries, while Dynamic PEDs allow for the import/export of energy to balance production and consumption. Virtual PEDs expand boundaries to include energy production and storage outside the district, maintaining a positive annual energy balance. Additionally, there are PED-like areas that aim for energy positivity but may still rely on grid imports or non-renewable sources.

The building blocks of the PED concept can also be varied. The Strategic Energy Technology Plan (SET PLAN, 2018) highlights the following six interdependent elements: Renewable Energy Sources, Energy Efficiency, Energy Flexibility, Electric Mobility, ICT Deployment, and Affordability. These elements work synergistically to support the district's energy goals, emphasising the use of renewable energy, efficient consumption, flexible management, electric vehicle integration, advanced ICT systems, and affordability to ensure a fair transition for all citizens.

Initial EU-level plans for PED development were enshrined in the Commission's plans to develop 100 PEDs by the year 2025(JPI Urban Europe, 2020). The aim is for 100 districts to be in "concrete planning, construction, or operation, synergistically connected to the energy system in Europe by the year 2025" (SET PLAN, 2018). The generally flexible PED framework makes it difficult to conclusively monitor the advancement of PEDs in Europe towards this goal. The PED-Database[1] of the PED-EU-NET, which maps PED case studies included in EU projects, reports 25 entries as of May 2024, while a 2020 publication proposes up to 61 PED-like case studies in Europe (Bossi, Gollner and Theierling, 2020). It is at least abundantly clear that the policy objective at the EU level is for PED areas to significantly increase in the immediate future, alongside other overlapping smart city concepts such as the emergence of Energy Communities.

However, several barriers to the implementation and evaluation of PED projects exist. For example, there is uncertainty about the best incentive structure conducive to PED development, namely under which tariff conditions can an electrified PED be sustained and in what weather conditions (Bruck, Díaz Ruano and Auer, 2022). At the local level, the unavailability of important data to evaluate PED scenarios and monitor the progress of PED policies stands out as a significant challenge. The ambiguity of concepts and the fact that there is no one-size-fits-all solution makes it so that assessing the advancement of a PED at the local level is difficult. Though various projects have attempted to provide frameworks for PED evaluation (Huovila *et al.*, 2017; Caballero *et al.*, 2021) the collection of accurate data on energy consumption, environmental indicators, and social well-

[1] https://pedeu.net/map/

being (reduction in energy poverty), amongst others, represents a significant barrier for local administrations wanting to evaluate their projects against the specific requirements of the PED framework. The PROPEL project aims to develop a tool that can, to some extent, address these data limitations by establishing a data-sharing platform that can support local decision-makers (DSS tool).

Given the crucial importance of decision-making in PEDs implementation, and the need to make it as accessible and understandable to a broad audience of stakeholders, who in some cases are not experts, the PROPEL consortium planned to integrate game elements in the DSS tool.

The implementation of serious games or gamified applications is a frequently employed strategy for the purpose of supporting and enhancing the decision-making process (Mullinix *et al.*, 2013; Rhodes *et al.*, 2017). This is due to the fact that such applications allow for the direct experimentation of decision-making processes, thereby enabling the testing of alternative sets of choices in a cost-effective and non-risky manner (Rissanen *et al.*, 2020). This approach has been adopted in the most diverse fields, like the medical one (Vallefuoco, Mele and Pepino, 2019), the business one (Grund and Meier, 2016) or the environment management one (Furber, Medema and Adamowski, 2018). In the field of spatial planning, the use of gamification has been employed, particularly in the context of environmental adaptation to climate change. The objective is to enhance the comprehension of the underlying logics of negotiations and agreements between stakeholders(Poplin, 2011; Berni *et al.*, 2022; Kavouras *et al.*, 2023). One case where this approach was developed specifically for energy planning is the UrbEN project. The creation of sustainable urban energy systems necessitates the engagement of a broad spectrum of stakeholders from both the public and private domains. It is therefore essential to be able to navigate intricate networks of interactions at regional, national, and European scales.

UrbEN is an educational simulation tool that employs a role-playing tabletop game format to facilitate the study of sustainable urban energy management. This ensures that future urban planners are equipped with the essential competencies and insights to address the complexities of transitioning towards sustainable urban energy systems (Lami *et al.*, 2023).

Although the positive impact of introducing game elements with the aim of facilitating decision-making has been extensively studied (Mullinix *et al.*, 2013; Rhodes *et al.*, 2017; Rissanen *et al.*, 2020), further research is required in terms of drivers and barriers influencing the adoption of such methodology among the specific target of local administrators and PEDs experts. Moreover, in the PROPEL project, stakeholders are principal actors in the design process, with the objective of enhancing the utility and efficacy of the project's final outcomes. Consequently, they were also engaged in the process of delineating the fundamental principles and pivotal attributes that a serious game designed to assist local administrators in the implementation of PEDs should possess.

Therefore, the research questions this paper aims to answer are as follows:

RQ1: What are the main drivers and barriers to the adoption of the PROPEL serious game among stakeholders in the PED field?

RQ2: Which are the main design principles to be taken into account when designing a serious game for stakeholders in the PED field?

3. Method

In order to address the research questions, a qualitative approach was employed, comprising two main steps.

Firstly, the drivers and barriers to the adoption of a serious game among local administrators were identified. This was achieved through semi-structured in-depth interviews with local administrators and PEDs experts from the countries involved in the PROPEL project, namely Italy, Sweden, and Turkey. Furthermore, interviewees were requested to identify the principal characteristics that the PROPEL serious game should possess in order to be beneficial for the final target audience.

Secondly, a comparative analysis of serious games developed for related research purposes was conducted with the objective of identifying the most commonly adopted game elements.

3.1 In-depth Interviews

Six in-depth interviews were conducted with the objective of exploring a range of topics, including: attitudes and expectations, learning needs, and desired features and functionalities. Two researchers were present during

each interview, one acting as the interviewer and the other as an assistant. Each interview began with an introduction about the purpose of the research, then, the interviewer, following an interview guide, asked the interviewee several open-ended questions. The interviews lasted 25–35 min. and were audio-recorded and transcribed verbatim.

Data collected through the interviews were analysed according to the methodological frameworks for content analysis (Weber, 1990; Hsieh and Shannon, 2005; Bardin, 2013). Qualitative content analysis, as described by Hsieh and Shannon (2005), involves the systematic coding and identification of themes or patterns in the textual data for subjective interpretation. The chosen analytical approach comprised six main steps: (1) knowledge of the data through repeated readings; (2) identification of the units of analysis; (3) grouping of the units of analysis into categories (themes) in line with common characteristics; (4) review of themes; (5) determination and naming of themes; (6) composition of the study report. To facilitate data analysis, the software Atlas.ti (https://atlasti.com/) was used. Three reviewers, one with a background in distance learning and educational technology, one with a background in games and gamification studies and one with a background in PEDs, individually evaluated and examined the interviews' transcripts. Afterwards, the results were discussed, and any disparities were addressed to reach a consensus.

3.2 Comparative Analysis of Serious Games

To generate additional insights for refining the design of the PROPEL serious game, a comparative analysis of serious games developed for similar purposes was carried out. An extensive online search was conducted with the objective of identifying serious games developed with the aim of disseminating knowledge on environmental impact, energy conservation, and urban planning dynamics. This search resulted in the identification of ten serious games that shared significant similarities to the one to be designed in the framework of this research. The identified serious games were analysed by two researchers, one with a background in distance learning and educational technology and one with a background in games and gamification studies. This analysis was conducted using the video game structural characteristics proposed by King et al. (2010) as a reference.

4. Results

4.1 Main Findings From In-depth Interviews

After performing the thematic analysis of interview transcripts, the themes and sub-themes presented in Table 1 were identified. The subfields have been proposed based on the literature, but the final list was defined on the basis of basic coding and discussion among researchers.

Table 1: Themes and sub-themes revealed in the content analysis of the interviews

Themes (# of comments)	Sub-themes	# of comments	Sample quotes
Expected advantages and/or opportunities of gamification/serious game (38)	Improves performance and/or learning outcomes	5	"Another [advantage] is awareness of these tools for improvement. Let's say an overview of what the opportunities are, maybe even a cost-benefit analysis or a SWOT analysis to be able to assess the benefits for one's community." (Respondent 4)
	Enhances the level of engagement in the learning process	6	"The key to behavioural change lies with engaging a broad scope of individuals." (Respondent 6)
	Enhances the level of motivation to learn	1	"[To] give a little more element than the classic workshops where one is only asked to brainstorm ideas and to compare but where there is no mechanism of competition or reward for those who work best." (Respondent 3)
	Fosters the adoption of positive behaviours	7	"Because frankly, right now, the decision-makers, they think here, right here, right now, it costs this much. They don't look further down in a few years. So I think that will be really good." (Respondent 5)
	Improves the attitude toward the learning process and/or the subject matter	9	"I believe the engagement strategy is sound for and fitting for the objectives." (Respondent 6)
	Provides immediate feedback	2	"Since the data collected this way supposedly will be digital, it will be much more accurately collected. So it will be more comparably refined." (Respondent 6)

Themes (# of comments)	Sub-themes	# of comments	Sample quotes
	It's more enjoyable and fun than traditional learning	6	"Definitely curiosity. The first impact would be this because the interesting thing is always to try to find an application that brings an input of positivity with respect to something that may be new, hostile, not perfectly in line with the knowledge already acquired, etc. In this case, gamification in my opinion is a good tool to open up new horizons, new knowledge that otherwise a classic approach would still involve more effort." (Respondent 2)
	Suitable for large and diverse target groups	2	"We're a big municipality. We have about. In Sweden, we have about 150,000 inhabitants and we have about 10,000 employees in the municipality, from schools, and elderly care to what I do. And I think we can all benefit from it." (Respondent 5)
Expected disadvantages and/or risks of gamification/serious game (20)	Not suitable for an in-depth analysis	1	"Let's say that perhaps a malus might be a somewhat too superficial approach compared to a tighter and more systematic analysis of the data, which, at least in the start-up phase, needs to be done in order to set up a PED well." (Respondent 2)
	Generates negative emotions (i.e. anxiety, aversion)	1	"[The use of game elements could cause] seeing these issues as negligible or otherwise not generating the impact that gaming and PEDs could have on cities." (Respondent 4)
	May not be well received by some of the participants	10	"On the other hand, on the not-so-good side, maybe, is it working? Can we trust this gamification? Is it too much like a video game? That is just something that we use that people don't trust." (Respondent 5)
	Has technical issues	5	"The issue of privacy is the main one, i.e. the fact that it is not something for personal use, that is, without the data being disclosed in any way whatsoever, etc., in my opinion, it is still useful." (Respondent 1)
	No prior experience	3	"To clarify the definition of PED, which is not clear to everyone and therefore what it means, that you can also get there step by step and this is important, i.e. you can also get close to PED without being perfectly in line with what the requirements are and that it is worth taking a slightly longer view anyway [...]." (Respondent 1)
System Specifications (46)	System purpose	6	"[It should be] a scalable tool or otherwise adaptable to various contexts, even customisable." (Respondent 4)
	Scope/Exclusions	10	"The approach might be the same on all project areas, but different urban-peripheral-rural dynamics should be mentioned when making these comparisons." (Respondent 6)
	Policies/Regulations/Constraints	7	"Sweden, Italy and Turkey examples seem diverse enough in terms of these dynamics, so it would be great if this could be leveraged." (Respondent 6)
	Functional requirements	12	"[...] so let's say we are somewhere between the tablet and the computer, with the advantage that the computer can also be used in a more convivial context." (Respondent 3)
	Non-functional requirements/Quality attributes	11	"Then I think it should be easy and kind of self-explanatory, but also really the hard fact, some balance between that. I'm not really sure how to be, but the extension span of our politicians or decision-makers is really narrow." (Respondent 5)

4.2 Comparative Analysis of Serious Games

Appendix 1 presents a list of the ten serious games that were identified and analysed in this stage of the research process. Table 2 identifies the number of serious games (out of ten) that exhibit each of the video game structural characteristics proposed by King et al. (2010).

Table 2: Most common game structural characteristics included in environmental Serious Games

Feature type	Sub-features	# of analysed serious games including the feature
Social features	Social utility features	0
	Social formation/institutional features	0
	Leader board features	3
	Support network features	6
Manipulation and control features	User input features	0
	Save features	3
	Player management features	7
	Non-controllable features	6
Narrative and identity features	Avatar creation features	0
	Storytelling device features	5
	Theme and genre features	9
Reward and punishment features	General reward-type features	4
	Punishment features	6
	Meta-game reward features	2
	Intermittent reward features	4
	Negative reward features	5
	Near miss features	1
	Event frequency features	9
	Event duration features	7
	Payout interval features	4
Presentation features	Graphics and sound features	6
	Franchise features	1
	Explicit content features	0
	In-game advertising features	0

N=10

The findings revealed that the selected serious games could be classified into three main genres: managerial games, city builders or simulative (urban planning). Indeed, the majority of the games (nine out of ten) adopt a role-playing approach, in which players assume a managerial role and are tasked with improving a specific territory under their control, frequently a city.

Players are usually endowed with resources (Player management features) that can be incremented, managed and spent in order to achieve specific improvements and to accomplish certain goals, always taking into account some constraints (i.e., cost-effectiveness or time limits).

Scripted events (Non-controllable features) are often foreseen as a way of implementing an element of chance in the serious games, requiring for the player to react to unexpected events and challenges and to adjust their strategy accordingly.

Most of the serious games (nine out of ten) are designed to allow for unlimited replayability of the game (Event frequency features) in order to offer to the players the opportunity to experiment different decision paths and therefore evaluate the effectiveness of different strategies.

Often, the selected serious games (seven out of ten) present a modular structure, allowing for brief playing sessions (Event duration features), with the possibility for players to know in advance an estimate of the duration of the single game session.

5. Discussion

To answer the RQ1, it has been noticed that, according to the answers collected for the present research, the perceived drivers (38 quotes) resulted to be more present and relevant compared to the perceived barriers (20). Among the most mentioned advantages, it is possible to highlight the contribution to the improvement of the attitude toward both the learning process and the subject matter, followed by the ability to foster the adoption of positive behaviours. Also, the enhancement of learning and performance are considered to be appealing for the adoption of the PROPEL serious game, as well as the perception of a funnier learning activity. On the other hand, the main concerns regarded mostly the possible sceptical attitude towards a system that includes game elements. Some minor observations implied possible issues in terms of privacy, which is considered a relevant topic in the public administration context. To overcome the scepticism related to the peculiarity of the serious game, some interviewees suggested the use of traditional communication media to introduce the serious game to the final target audience.

Lastly, in reference to RQ2, the conducted interviews highlighted the need for a serious game built on a simulative engine, which the DSS is, so as to be as faithful as possible to the real scenarios implying the implementation of a PED. To achieve the best result from this simulative approach, a modular structure has been suggested, divided into different scenarios, each one representing a specific peculiarity of real PED contexts. Furthermore, given the multi-coloured target, the respondents draw attention to the ease and clarity of use both in terms of mechanics and interface of the serious game. Finally, the most quoted devices to access the PROPEL serious game were tablets or computers. These findings can help us to interpret what resulted from the analysis of the ten case studies. In fact, among the most adopted game features there is “role-playing”(nine out of ten cases) which support the engagement of the target audience, and the unlimited replayability (nine out of ten cases), which can be easily obtained in the simulation thanks to procedural programming based on real data. In this sense, seven out of ten cases allow the management of multiple resources, also expression of real complex systems. Lastly, seven out of ten of the serious games examined foresee a predetermined duration for the game scenario, which is highly compatible with the short amount of time that decision makers usually can devote to these activities.

6. Conclusion

The aim of this research was twofold; on one side it aimed to identify the main drivers and barriers to the adoption of the PROPEL serious game by interviewing a panel of stakeholders in the PED field, and, to inform the serious game design in the field of PEDS, including but limited to the PROPEL one. This has been possible thanks to the information derived from both the stakeholders’ interviews and the analysis of ten serious games, similar in their features to the PROPEL one. The interviews conducted showed that the use of a serious game to support the use of a decision system in the PEDs field is expected to improve the engagement and the adoption of positive behaviours as well as the attitude toward the learning process in general. Minor concerns were expressed mostly regarding privacy management. The most important design feature resulted to be the adoption of a simulative engine, able to replicate real dynamics in the serious game context. Lastly, a modular approach to valorise different PEDs contexts resulted to be much appreciated. These findings matched with the most popular features that emerged from the case studies analysis: the inclusion of “role-playing” elements and the division of the whole serious game experience into shorter scenarios would be appreciated by the target

audience. Lastly, the complexity characterising the PEDs sector can be expressed by managing multiple resources through a simulation engine, the latter also allowing procedural generation of scenarios that could be played multiple times.

In general, these results confirm the general appreciation of serious games as support to the decision-making process, also in regard to PEDs implementation. These insights are the first step of the design process that will guide the creation of the PROPEL serious game. Next steps in this research will imply a first draft of the game design document that will be validated by experts. After this phase a first scenario, to be tested with users, will be prototyped and a testing phase will be conducted. Results will be finally evaluated to verify if the premises discussed in this paper will be confirmed.

Acknowledgements

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Appendices

Appendix 1. List of selected serious games

#	Name
1	Energy Cat
2	Smartainability The Game
3	SimCity BuildIt
4	PowerHouse
5	My Green City
6	Clim' City
7	BLOCK'HOOD
8	Carbon City Zero
9	Anno 2070
10	UrbEN

The Game of Dominoes as Teaching-learning Method of Basic Concepts of Differential Calculus

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Abstract: This paper will present teaching-learning mathematics strategies, specifically differential calculus in a variable, through a fun and competitive space in which action is manifested by the student and not only the repetition of information by the teacher. This action refers to motivate, problematise, summarise, and coordinate a dominoes game whose thematic cards are designed around the basic and main contents of differential calculus. The strategies for teaching this area are diverse and precisely the game of dominoes is one of the most used strategies in the practice of mathematics because it stimulates logical reasoning and mental skills. The objective is to identify the way in which the game of dominoes affects the learning and understanding of fundamental concepts of differential calculus in a variable by means of experimentation carried out on students of the first semester of the School of Engineering and Sciences of Technological of Monterrey. Finally, the results of this study will be presented and the use of this strategy in other topics around mathematics will be recommended to facilitate logical and meaningful learning in students.

Keywords: Collaborative Learning, Educational Innovation, Higher Education, Game-based Learning, Multiple Intelligence, Logical-Mathematical Intelligence.

1. Introduction

The “game-based learning” is an educational approach that uses games as the primary tool for teaching and learning. This method is based on the premise that students learn more effectively when they are actively engaged and having fun and also has been applied in various areas and has generated a variety of fun and committed experiences. A game designed under this methodology is known as “serious game”, which are games whose design has a more educational purpose than entertainment. Moreover, this type of game makes the user explore what interests him and allows him to formulate hypotheses, to suggest and even to create new situations without any imposition. Rajkovic (2020) and Laski (2014) states that the game encourages and develops an attitude with respect to the use of intelligence. Through this, it is possible to develop intelligence in an easier way and many other skills and abilities can be enhanced. In addition, through the game, teaching ceases to be tedious and becomes a strategy of use and discovery of knowledge where multiple skills and abilities are developed and strengthen the integral formation of students. Muñiz (2014) states that learning mathematics can be a motivating experience if we base it on constructive and playful activities. The use of games in maths education is a strategy that allows students to acquire skills in a fun and attractive way.

Specifically, in Engineering, one of its main branches is Mathematics, in which great mental abilities are developed that allow solving problems and making appropriate decisions that occur daily. Within this branch, is the Differential Calculus which, in general, presents a series of difficulties in terms of its learning and conceptual understanding, since students show great difficulty in developing it and, adding the routine strategies used by the teacher, allow the appearance of barriers, which inhibit students from accrediting courses related to this area.

Play a dominoes whose tiles represent conceptual contents of the Differential Calculus, would allow students to immerse a scenario where, in addition to articulating corresponding tiles, they can listen to recommendations from the teacher and even from their peers and thus generate a debate among them in a collaborative, critical and constructive way, which implies the generation of effective environments of collaboration and negotiation in multicultural contexts with respect and appreciation for the diversity of knowledge and, in turn, allows to integrate different types of reasoning in the analysis and solution of problems, with readiness to continuous learning.

The purpose of this research is to propose a different strategy to understand basic concepts of Differential Calculus through the didactic game of dominoes. This new strategy is intended to complement the exclusive and permanent attention of the student with what the teacher explains since, in general, the transfer of knowledge between teacher and students is carried out through routine strategies.

To answer the research question, an experiment was carried out at the Technological of Monterrey with some students from the first semester of the School of Engineering and Sciences.

2. Methodology

2.1 The Focus of the Research

The present research focused on measuring the ability to understand basic concepts of differential calculus since understanding this area of mathematics is considered indispensable for any engineering student. Generally, students entering the first semester of any engineering career need to improve in understanding concepts related to the derivative of a function of a variable.

For this reason, this article is based on a pure experimental design which consists of manipulating one or several independent variables to observe changes in dependent variables in a controlled situation; that is, it is intended to establish the possible effect of a cause that is manipulated. Moreover, the research design incorporates the application of a pre-test and a post-test to experimental and control groups. Specifically, the pre-test was applied on the first day of class in order to measure and diagnose the level of conceptual understanding of students about some important issues of the derivative, such as, constant change rate, critical points, the monotony of functions, concavity of the graph of a function, among others, and also a post-test was applied at the end of the subject in order to measure the level of understanding of the concepts above again. It is important to note that, between the application of the pre-test and the application of the post-test, five weeks pass, in which the teacher explains all the topics related to differential calculus and applies the game of dominoes several times.

2.2 Research Type

The present research was developed under the focus of action research, which allows using various strategies in the professional practice of teachers to provide an improvement. In this sense, Elliot (1993) establishes that "Action research is a methodological option of great richness since, on the one hand, it allows the expansion of knowledge, and on the other, it gives concrete answers to the problems that the participants of the research are raising, which, in turn, become co-researchers who actively participate in the entire research process as a result of the constant reflections that are promoted in this process".

According to this, the use of the domino game is proposed as a didactic strategy to improve the understanding of basic concepts of Differential Calculus in a variable and reduce the difficulties presented by students in this process.

2.3 Population

The population that participated in this study was 90 students, all from the first semester of the School of Engineering and Sciences of the Technological of Monterrey, with aged between 18 and 19 years. Of the total number of students, two groups (30 students each) formed the experimental groups, and 30 students formed the passive control group. Only in the two experimental groups was applied the dominoes game. The designation of the groups was carried out by the teacher randomly.

2.4 The Stages of the Research

2.4.1 Stage 1. Literature Research

A documentary search was conducted, nationally and internationally, on previous research on the application of didactic games as a strategy for learning mathematics to generate a characterization of the problems presented in those previous investigations.

2.4.2 Stage 2. Diagnostic (pre-test)

At this stage, a multiple-choice diagnostic exam was designed consisting of 5 questions related to fundamental concepts of differential calculus, such as, constant change rate, increasing and/or decreasing functions, concavities of a graph, among others, and whose duration was 20 minutes. The pre-test allows instructors to assess the understanding and to measure the knowledge existing of Differential Calculus concepts in the students. The exam was applied to the three research groups (two experimental groups and one control group). The following table describes the contents of the diagnostic test reagents and their respective educational intentions.

Table 1: Description of diagnostic test questions

Reagent	Content	Didactic intention
1	Graphical modelling of the constant average rate of change.	Identify errors in the graphing approach related to the meaning of the constant rate of change.
2	Description of the constant rate of change.	
3	Monotony of functions	Manipulation of mathematical language to express the definition of increasing functions.
4	Critical points of a function graph.	Conceptualization of a critical point from the verbal point of view.
5	Inflection points and concavity of the graph of a function.	Conceptualization of a point of inflection and understanding of concavities of the graph of a function.

2.4.3 Stage 3. Design of the dominoes

De Guzmán (1984) advises using games that present advantages in the psychological and motivational aspects compared to mathematical contents. For this author, the advantages of this type of game do not require lengthy or complicated introductions since what is sought is fun and the possibility of getting into action quickly. Many mathematical concepts, even some intense ones, can have a simple introduction and a possibility of action with very ingenious instrument designs. Cuevas (2013) defines cognitive tools as the acquisition of mathematical knowledge mediated by the action of a material or symbolic tool. In the same sense, dominoes turn out to be a handy tool of this kind for teachers who teach mathematics. The dominoes described below consist of 28 tiles, each with two parts. The difference from the traditional dominoes game we play is that, in this, the objective when joining one tile with another is valid as long as the tiles match, while in our case study (mastered maths), the cards must represent the same mathematical concept. For this reason, for the design of the game cards, the research team selected seven fundamental concepts of differential calculus that students in the first semester of Engineering should understand.

- Constant average rate of change (tokens representing 0).
- Monotony of functions (tokens representing 1).
- Critical points (tokens representing 2).
- Optimization of functions (tokens representing 3).
- Inflection points (tokens representing 4).
- Concavities of the graph of a function (tokens representing 5).
- Derivation rules (cards representing 6).

Once the fundamental concepts have been defined, seven propositions were defined for each one, equivalent to each other and the respective fundamental concept. Subsequently, the game cards were formed by combining each concept's propositions (without repeating them). It is essential to clarify that to define propositions equivalent to the fundamental concept of critical points, only soft functions were considered to avoid defining propositions related to the domain's points where the function's derivative does not exist. Below is an example of how the 28 tiles of the game were formed.

Table 2

Constant average rate of change	Constant average rate of change
The function graph is a line	Monotony of functions
$x \in Dom(f): f'(x) = 0$	$\frac{\Delta y}{\Delta x} = c, where\ c\ is\ a\ constant$
The change of the dependent variable is a multiple of the change of the independent variable	Point on the graph where the function goes from decreasing to increasing or vice versa

They are critical point for the f'' graphic.	The change in the dependent variable and the change in the independent variable are directly proportional
The instantaneous rate of change approaches a constant	$f''(x) > 0 \ o \ f''(x) < 0, \forall x \in I$

The importance of first analysing the game and placing the dominoes correctly instead of just doing it mentally stands out in some studies on brain function. Hannaford (2008) emphasizes that using hands to activate neural circuits to facilitate learning is extremely necessary. Moreover, Hannaford (2011) recommends a sensory environment with many natural stimuli for the ear, touch, smell, and sight. In this sense, Gardner (2014) indicates that it is necessary to extend the concept of intelligence to the concept of multiple intelligences. In this way, the use of a board game as a dynamic didactic tool undoes the traditional way of learning, that is, to be only listening and seeing what the teacher explains.

2.4.4 Stage 4. Game Implementation

During the implementation of the game, each experimental group was subdivided into teams of 4 students at the same table. The teacher explained the rules of the game consisting of the following:

- The game consists of 28 tiles, and all are placed face down on the table.
- Each of the 4 students at the same table randomly select 7 titles of the game.
- The player who starts the game is drawn between the same students who make up the same game table.
- When placing a tile, all students involved at the table must agree that the tile placed is correct and matches the corresponding concept. At this moment, the critical and constructive discussion between the students at the same game table is open.
- If the tile placed by a student on their first attempt is correct, then the player who placed it gets a correct answer and a score of +4.
- If the tile placed by a student on their first attempt is not correct, then the group discussion is opened, a score of -2, but that player can place another tile correctly without counting any positive scores on the second attempt.
- If the student does not have any tile that match with the concepts of the other tiles on the table, it is counted as a pass, and in this case, a score of 0 should be placed. It is not counted as a correct or incorrect answer, and simply follow the next player's turn.
- All players must record the number of correct or incorrect answers and the respective score on each move.
- The winner will be the first player to run out of tiles or, in case the game is locked, and the winner will be the student with the highest positive total score.

It is essential to clarify that the game was applied as a conceptual review after the professor explained all the issues related to differential calculus in one variable. This stage of the experiment was performed twice in each experimental group; that is, the students of the experimental groups played dominoes twice before the last day of class; where a small competition was planned in these groups, where each table consisted of 4 players (students) and extra scores were awarded in the final grade of the subject according to the score obtained at the end of the game.

2.4.5 Stage 5. Descriptive analysis of the results

Three main moments were identified regarding the implementation of the teaching strategy: before, during and after.

The first moment (the before), which took place on the first day of classes, a multiple-choice diagnostic exam was implemented for the three groups involved in the research, which was previously designed by the teacher and was made up of 5 reagents of 20 points each. The information was collected considering correct and incorrect answers. For each correct answer the student obtained 20 points and for each incorrect answer the student obtained 0 points. The results can be seen in table 2 (for the experimental groups) and in table 3 (for the control group). It is important to highlight that the table shows a continuous measure (exam score) and an ordinal measure that indicates the percentage of students in the group who obtained said score.

Later, during the experiment, the domino game was applied only to the two experimental groups, as a way of

reviewing the contents explained by the teacher; while in the control group, the conceptual review of the content was carried out in a traditional way with some exercises and questions proposed by the teacher. This stage of the experiment was carried out twice after 6 weeks of the academic period had elapsed, with a frequency of 2 weeks; That is, the game was applied in week 7 and week 9 of the corresponding academic period. In addition, a competition was planned between the students of the experimental groups that took place during the last day of classes. In this stage, the teacher collected the information through observations made during the sessions to evaluate the level of participation, collaboration and strategies used by the students to understand the concepts of the game pieces.

In the third and final stage of the experiment, after playing the experimental groups, the three groups again answered the same diagnostic test that was applied in the first moment (with the same number and characteristics of the questions). The information was collected in the same way as it was done in the first moment of the experiment. The results can be seen in table 4 (for the experimental group) and in table 5 (for the control group). It is important to highlight that the table shows a continuous measure (exam score) and an ordinal measure that indicates the percentage of students in the group who obtained said score.

To measure the effectiveness of the strategy and the impact it has on improving learning regarding the understanding of the concepts of differential calculus, the results of the post-test were compared between the experimental group (Who played dominoes) and the control group (Who did not play dominoes) to determine if there is a significant difference. For this, a t-test for independent samples was programmed in Python code with a significance level of 5%, resulting in a p-value of 0.003.

Finally, a perception survey of the implemented teaching strategy was administered to the students with the objective of evaluating their perception of the game, their motivation, and how they believe the game has influenced their learning. The results can be seen in table 6.

3. Results

3.1 Pre-test and Post-test Results

Once the diagnostic tests were completed, a descriptive analysis of the scores obtained in each study group was carried out to observe and measure (before and after the game) understanding some basic concepts of Differential Calculus.

Table 2: Report of the score obtained, on a scale from 0 to 100, from the experimental group during the pre-test.

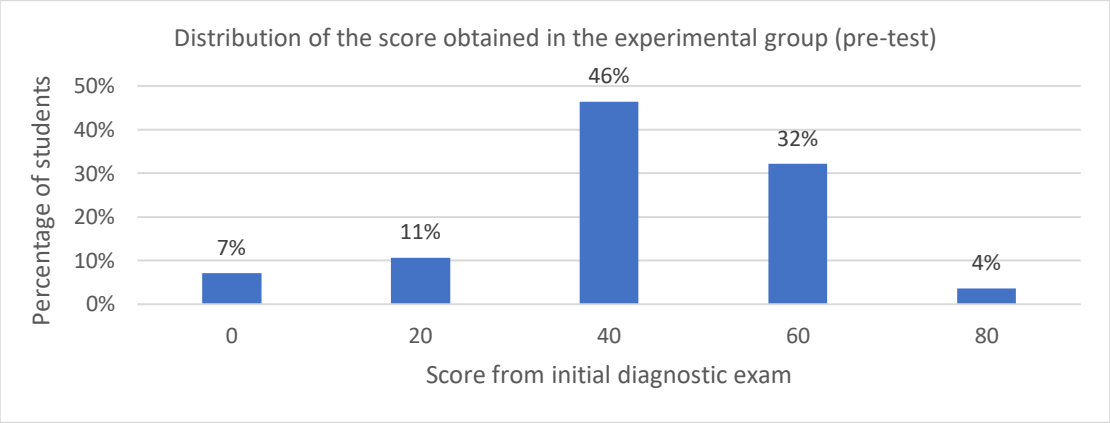


Table 2 shows that only 4% of the students in the experimental group obtained a score of 80 points and can be considered to have a good understanding of the basic concepts of differential calculus. In addition, 64% of students have a very low understanding of these concepts (score less than or equal to 40).

Table 3: Report of the score obtained, on a scale from 0 to 100, from the control group during the pre-test.

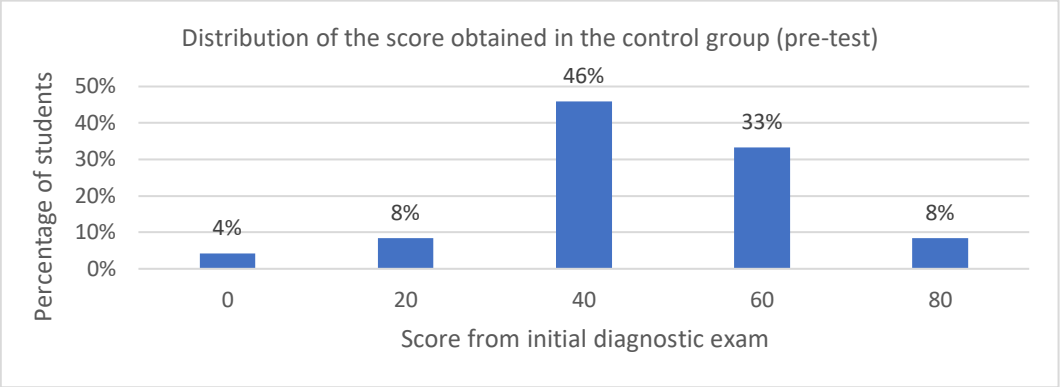


Table 3 shows that only 8% of the students in the control group obtained a score of 80 points and can be considered to have a good understanding of the basic concepts of differential calculus. In addition, 58% of students have a very low understanding of these concepts (score less than or equal to 40).

Table 4: Report of the score obtained, on a scale from 0 to 100, from the experimental group during the post-test.

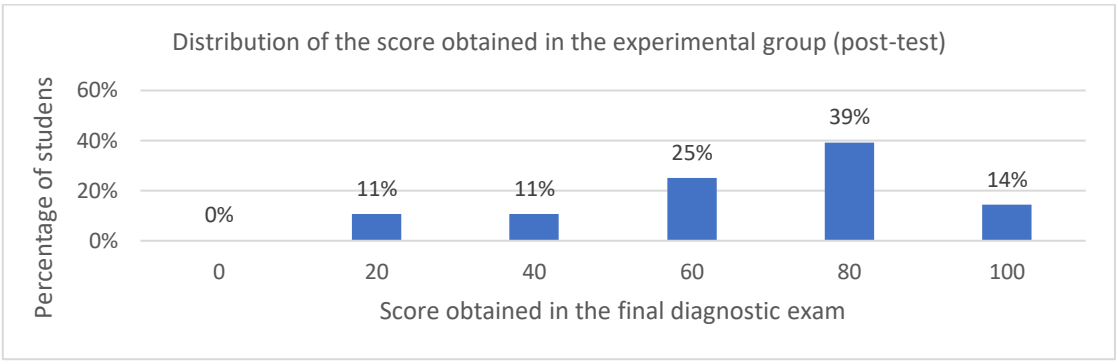


Table 4 shows that 53% of the students in the experimental group obtained a score greater than or equal to 80 points and can be considered to have a good understanding of the basic concepts of differential calculus after having applied the domino game. In addition, only 22% of students still have a very low understanding of these concepts (score less than or equal to 40).

Table 5: Report of the score obtained, on a scale from 0 to 100, from the control group during the post-test.

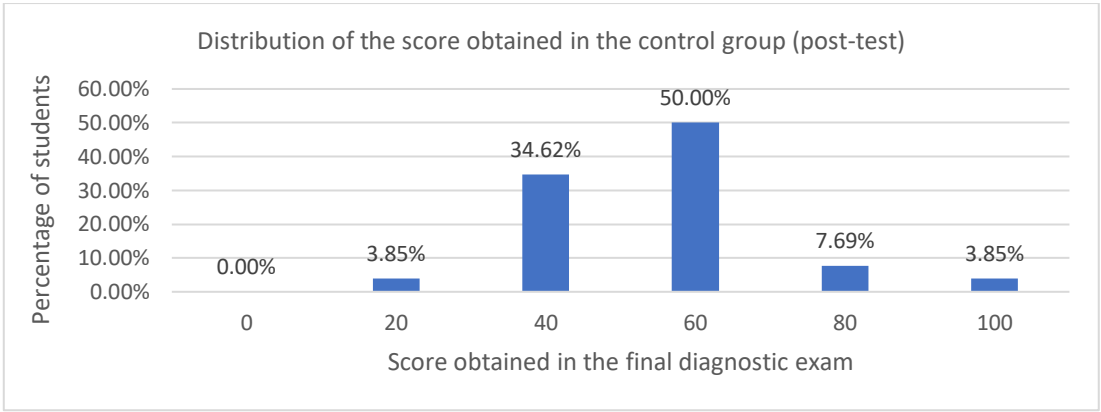


Table 5 shows that only about 11.5% of the students in the control group obtained a grade greater than or equal to 80 points and can be considered to have a good understanding of the basic concepts of differential calculus at the end of the subject and without having applied the game of dominoes. In addition, it can be noted that

approximately 38% of students have a very low understanding of these concepts (score less than or equal to 40) and half of the group has an intermediate knowledge of the concepts addressed.

3.2 Results of the Survey of Student Perception Towards the Teaching Strategy of the Domino

At the end of the experience, a survey was applied to the students of the experimental group on the perception of the didactic strategy of the domino game in order to know, as a group, their impressions about the impact that produces this strategy.

Table 6: Report on the perception and evaluation of collaborative learning through dominoes.

<table>
<tr><th rowspan="2">Experimental Group</th><th colspan="4">Criteria and dimensions</th></tr>
<tr><td>Participation and respect for opinions</td><td>Share responsibility</td><td>Mastery of the game</td><td>Progress in the understanding of concepts</td></tr>
<tr><td>1</td><td rowspan="2">In both groups, all students participate with enthusiasm and without fear which generates an atmosphere of confidence and fun. In addition, there was great respect for the opinions of others and diversity of knowledge.</td><td>In several game teams, only 1 student took responsibility to guide the game in a correct way.</td><td rowspan="2">In both groups, all students understand the rules of the game and the purpose of the game.</td><td rowspan="2">In both groups, the first time the game was applied, several students presented many errors when placing the correct tiles, but at the time of playing for the second time and in the final competition they felt very comfortable, with acceptable handling of concepts and the game flowed faster.</td></tr>
<tr><td>2</td><td>In most game teams, several students took responsibility for guiding the game correctly.</td></tr>
</table>

4. Conclusions

Concerning the numerical results obtained, we can note the progress in understanding concepts of differential calculus of the students who formed the experimental group opposite those who formed the control group. Specifically, when comparing tables 1 and 3 of the experimental group against tables 2 and 4 of the control group, we can observe that at the beginning (pre-test), both groups had similar knowledge of such concepts, which can be inferred that knowledge was relatively low. Later, at the end of the explanation of the content by the teacher, after having applied the domino game three times in the experimental group and after applying the post-test in both research groups, a significant improvement is observed in the students of the experimental group concerning the students of the control group in the understanding of concepts of this area of mathematics. It is important to note that the dominoes that were implemented as a teaching strategy in the experimental groups during the two times of practice (before the final competition), had some advantages and disadvantages from the student's attitudinal point of view. As advantages, we can mention that it allows the development of collaborative work and appreciation for the diversity of knowledge. In addition, the teacher's participation was almost unnecessary since, in each team, the support of the more skilled students towards the less skilled was made naturally due to the debate that they themselves generated.

On the other hand, as a disadvantage, it can be mentioned that some students may tend to delegate their participation to others at the game table. It is necessary for the teacher to emphasize that all players should place their tiles without necessarily expecting feedback from their colleagues and to achieve this the teacher will emphasize that before reaching the day of the final competition must study all the concepts handled during class sessions and will not have any supporting material on hand. In addition, having human material like the gaming table teammates and having the dominoes game as a physical activator, allows students to show the knowledge they are acquiring completely live, and it is not necessary to wait for the date of a partial exam that, in addition to other things, generates stress in students. Playing this domino is a way of creating mathematical meaning of what the student imagines when trying to understand the concepts of Differential Calculus by correctly placing the tiles that solve the game. However, as mentioned above, this requires a series of cognitive activities, among which are: training, treatment, and mathematical representations. This didactic strategy involves cognitive activity and attitudinal activity on the part of the students and therefore, it has been

considered collaborative work among the members of the team in order to promote the initiative of the student to place before the card correct. In addition, students' motivation increases considerably in this type of activity, compared to their usual interest during traditional classes. In this way, we have shown an experience whose objective was maintained in the integration of attitudinal, conceptual and procedural components of learning of the Differential Calculus of one variable in students of the first semester of Engineering careers, and we recognize the inclusion of the dominoes game as an appropriate didactic strategy not only for learning the Calculus Differential but for mathematics in general. Finally, through the bibliographical consultation studied before starting the research, it can be contrasted that this type of didactic strategy has a considerable impact on the learning process, and in particular, the dominoes game is a highly valued tool as a technique to help understand concepts and solve difficulties that are presented to the time to study mathematics.

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Bending Rules, Telling Stories: Convivial Game Design Approaches for Engaging With Futures

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Abstract: Games have been used in civic participation (Lerner, 2014) and civic learning (Raphael *et al.* 2010). Building on the idea of using games for participation, democracy and collaboration, we propose approaching games as tools for convivial learning. First introduced by Illich (1973), the concept of conviviality envisions a society characterised by collaboration and self-determination, underpinned by tools that encourage joyful interaction, creativity and human agency through control over the tools. We believe that games as convivial tools could help bring forth creativity and mutual learning about civic processes and desirable futures. Yet, games' nature as rigid systems of rules (Salen & Zimmerman, 2010) seems potentially at odds with positioning them as tools promoting agency. We propose to use the tension arising between rigidity and agency as starting point for exploring game design strategies for convivial games through *research-through-design*. We ask how games for thinking about the future may be designed that allow players to exercise control over their own experience, and to what effect. Inspired by the concept of critical play (Flanagan, 2009; Grace, 2014) and building on the distinction between *narrative* and *mechanics* as key constituting game elements, we have designed two distinct games for collaboratively engaging with the future. The first, *Narrate*, focuses on letting players invent their own narrative, whilst the second game *Remix* allows for experimentation with game rules and mechanics. We present the design process for each game and contrast the different approaches taken. Each game was tested by two groups and analysed in regards to its capacity to bring forth conviviality, creativity and collaboration. The paper compares and provides a discussion on how suitable the two chosen strategies of experimenting with narrative or mechanics are for (1) facilitating thinking and learning about shared futures, and (2) supporting player agency and bringing forth convivial interactions.

Keywords: Conviviality, Convivial Learning, Creativity, Player Agency, Design Research, Civic Learning

1. Introduction

Over the past decades, games have been increasingly used in civic participation: to engage people in new ways (Rüller *et al.*, 2022), to structure participation or to support motivation to participate in processes such as policy-making or city planning (Ampatzidou, 2019). Scholars have argued that games may not only increase the quantity of participation, but improve its quality, too (Gordon and Baldwin-Philippi, 2014; Lerner, 2014). In this paper, we look at games as means of convivial learning in processes of future-making and civic participation. We examine how they might encourage collaboration and creativity in thinking about shared futures – allowing participants to learn from and through each other whilst playing. Central to participation and conviviality is the notion of human agency, which we find potentially at odds with the idea of games as rigid structures. We use this tension as a starting point for exploration through *research-through-design* (Findeli, 2010): a research approach that falls under the design-based research paradigm (i.e. merging design practice and research) and uses the design process itself to generate knowledge (Christensen & West, 2018; Bærenholdt *et. al*., 2010). Based on the distinction between *narrative* and *mechanics* as means of structuring a game, we designed two analogue collaborative games to explore how games that allow players control over their experience may be designed and to what effect.

We will first explore the concept of conviviality and how it relates to games and learning to frame the role of games and player agency. Then, we introduce our games and present the results of the evaluative sessions for each. We discuss the effectiveness of our design strategies for supporting conviviality, creativity and collaboration for mutual learning and meaningful engagement with futures, and in regards to their potential for supporting feelings of agency.

2. Background

We look at games through a lens of conviviality to help frame how they can facilitate learning in the context of civics and participation. Conviviality was introduced by Illich (1973) and has recently re-emerged, e.g. for imagining post-growth futures (Adloff and Caillé, 2022). In his critique of modern society, Illich urges for society and the tools therein to be built in a way that will encourage and enable each person to freely contribute to it whilst joyfully engaging with others. Such a society would be characterised by interdependence, personal agency and collaboration. Learning in such a society might occur in networks of peers, sharing and creating knowledge

relevant to one's interests (Illich, 1971). Reynolds and Cambre (1997) note how this approach shares similarities with constructivist learning theory, which emphasises learners' experiences, collaboration and problem-solving. Constructivist learning theory is a popular framework in game-based learning studies (Cadiz *et al.*, 2023; Guan *et al.*, 2024). Games – especially collaborative ones – can facilitate experiences in which players contribute individual knowledge, learn about others' perspectives and co-construct meaning.

Various games for civic learning and engagement, particularly in the digital realm, have been designed and evaluated in recent years (Hassan & Hamari, 2020; Stoddard *et al.,* 2016), and some researchers have argued for the consideration of video games for civic learning (Schrier, 2021; Dishon & Kafai, 2019). Whilst projects such as iCivics, that aim to teach civic concepts through games in the classroom, e.g. how public budgets or legal systems work, have been received positively, Stoddard *et al.* (2016) point out that they still fall short in regards to developing civic skills like deliberation or complex decision-making. In a similar vein, Ampatzidou (2019) characterises civic learning as a complex process of social interaction in which people exchange information and views, negotiate and make joint decisions. We believe these ways of engaging with others to be fruitful in the context of thinking about shared futures, where games might help turn conversations about potential futures into meaningful and joyful learning experiences.

Yet, applying the idea of conviviality to games as tools in civic or participatory contexts raises certain questions around agency: Illich (1973) emphasises the idea of control over tools and creativity in using them. This seems somewhat at odds with Salen and Zimmerman's (2010) view of games as having rigidity and being systems of rules. Raphael *et al.* (2010) describe this conflict between structure and agency as one of the central tensions in game design for game-based civic learning. We acknowledge that this might potentially be addressed by rethinking how prescriptive games' rules really are. However, we weight this against the notion that it is the accepting of rules that is important to the creation of the 'magic circle'. Whitton (2018, p. 4) explains: *'This ability to enter a world of make-believe and accept alternate rules and realities is crucial to setting free the imagination and considering the possibilities for what might be and the potentials for what should be.'* This seems vital to creatively engaging with futures (Coulton *et al.*, 2016) and freely making own contributions, as the conviviality concept suggests. Therefore, we propose to address the tension between freedom and rules through the generative means of design research by asking how games may be designed that implement control over the game's structure into the system. Thereby, we hope to contribute to connecting the field of design research with game design (Malazita & O'Donnell, 2023).

What constitutes as structure of the game is a topic of debate: most scholar agree that rules, mechanics and goals structure the play experience (Salen and Zimmerman, 2010; Upton, 2017). The question of their relationship to narrative is still being discussed, with the view that they are deeply interconnected emerging (Suter *et al.*, 2021; Upton, 2017). Whilst the distinction between narrative and mechanics may to some extent be rooted in how games have been analysed in the past (oftentimes informed by either media/textual or game design perspective), Caillois (2001) has argued that both can structure a playful situation and invoke the magic circle. Therefore, it seems that narrative and mechanics could be two ways of approaching game design for increased player influence over game structure: by making space for players to contribute to the story or to alter the rules.

Alternative ways of thinking about games have emerged in the field of 'critical play'. Flanagan (2009, p. 6) conceptualises it as a mode in which players *'create or occupy play environment and activities that represent one or more questions about aspects of human life'.* Grace (2014) points out how games can be used to articulate critique directed at society and at the medium itself through various strategies. Those can go beyond the game by encompassing player values, environment or game device. Flanagan's and Grace's positions show some overlap with civic (game-based) learning wherein players reflect on and engage with matters of civic life. The reflection and critical thinking sparked through playful experiences have the potential to facilitate learning (Gordon and Baldwin-Philippi, 2014). Interestingly, such strategies as putting the game's goals at odds with player values broaden the understanding of what games are composed of to encompass the player, too. This aligns with Upton's (2017) situational view on game design: he argues that games become playful in interaction with the player. Hence, we propose that increased player agency may deepen interaction between game and player and make the experience more impactful. Furthermore, Brown and Douglas (2010) have argued that experimentation and the experiences it brings forth are what makes play an effective way of learning. Therefore, we propose that convivial games for civic learning and engaging with futures should be designed in ways that allow for creative input and experimentation by the players.

3. Developing two Convivial Game Proposals

To explore what such games may look like, we utilised a *research-through-design* approach (Findeli, 2010), which interprets the design-based research paradigm by employing the *designing* of artefacts as part of and mode of inquiry (Christensen & West, 2018; Bærenholdt *et. al*., 2010). Hence, we lay out our design strategies and reflect on them. As outlined above, there is a tension in game design between narrative and mechanics. We took these two sides as entry points into design exploration and designed two games – *Narrate* and *Remix* – that allow players to experiment with and contribute to the story or game mechanics.

We aimed to find strategies to address the objectives of (1) facilitating thinking and learning about shared futures, and (2) supporting player agency and bringing forth convivial interactions. Thereby, the second objective is two-fold, including the aspects of player agency and collaboration. Considering the interconnectedness of game elements and our desire to explore narrative and mechanics in-depth, we designed two independent proposals rather than creating two versions of one, with each using different design strategies to address the objectives (tab. 1).

Table 1: Overview of chosen design strategies

Objective	Narrate	Remix
1. Facilitating thinking and learning about shared futures	Setting, selecting and negotiating the future	Engaging with future goals
2a. Conviviality through agency	Co-creative, experimental storytelling	Bending and inventing rules
2b. Conviviality through collaboration	Collaborative decision-making	Collaborative gameplay

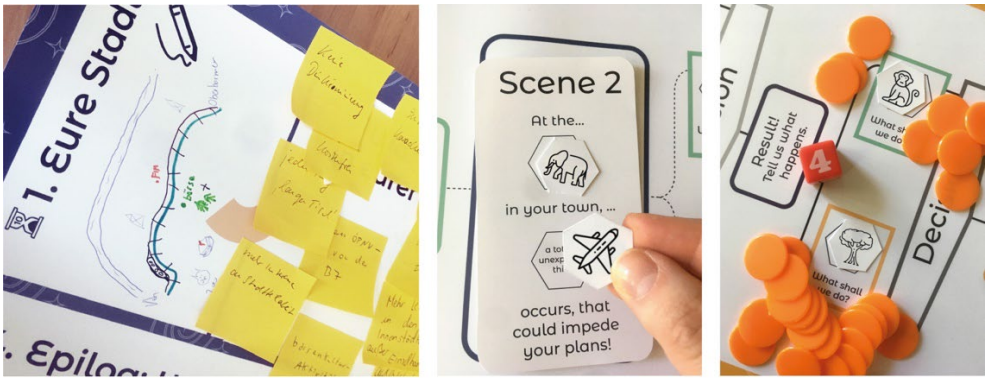
3.1 Telling Stories: Narrate

Narrate is a story-telling game in which players co-create a story about the future of their town, working within fixed rules. We based *Narrate* on a previous storytelling game for thinking about the future (Meshcheryakova & Hemmert, 2023), adopting its basic collaborative story-telling structure and creative scaffolding elements, and added a preparation stage that helps anchoring the game to participants' local issues and new decision-making mechanics.

Setting, selecting and negotiating the future: To anchor the inventive storytelling process to players' real lives, they are asked to collaboratively draw their respective town on the game board and then collect ideas and wishes they have for its future (fig. 1 (a)). One idea is selected as goal for the story they then develop, exploring what it could mean for their future, others' thoughts on it and its potential realisation.

Co-creative, experimental storytelling: The players then take turns to co-develop a story in which they overcome obstacles to achieve the goal. As in the game we built on (Meshcheryakova & Hemmert, 2023), *Narrate* provides a structure of scenes with cloze-style prompts and a variety of pictograms to guide and support players in developing their story (fig. 1 (b)). Randomly selected pictograms such as animals or everyday objects are used to help players imagine scenarios going beyond the expected. By dividing the story into sections, creativity challenges are distributed. Through coming up with their own story, this game encourages players to feel a sense of agency and investment in it.

Collaborative decision-making: Players work together towards achieving the goal selected for their story. At certain points, players need to jointly decide between two proposals of how to move the story forward by placing voting chips (fig. 1 (c)). We combined voting with rolling dice to determine numerically if a chosen action has a positive or negative outcome. In doing so, we hoped to encourage discussion and reward group cohesion (i.e. the more votes are placed on one option, the more likely a positive outcome will be).



(a) (b) (c)

Figure 1: *Narrate* details (a) game board with participants' drawing and ideas, (b) cloze-style promt, (c) voting with coins and dice (icons in images adapted from Flaticon)

3.2 Bending Rules: Remix

Remix is a card-game in which players collaborate to reach certain *goals* for the future (within fixed game content), whilst having the opportunity to invent their own rules and manipulate game mechanics. To develop the game, we examined games that allow to *play* with and invent rules, such as 'Fluxx' (Looney Labs, 1996) and 'Blank' (Hub Games, 2017), combining some of their mechanics with a framing of thinking about the future. In *Remix*, players draw cards, use actions and adjust rules to achieve goals through collecting the two symbols ('*elements*') required for each. The game finishes after four rounds with five goals each.

Engaging with future goals: A central challenge in designing this game was balancing the concept of flexible rules and fixed content with engaging with the future. We addressed this by having players choose and mark their favourite goals, which would then be privileged by game mechanics (fig. 2 (a)). In the beginning, each player selects their favourites from a number of potential goals for the future, some of which lean agreeable, e.g. improved health-care, and others more controversial, e.g. humanity living in space. Later on, when players 'nominate' a goal as one of those to be achieved by placing the card on the game board, they explain to the others what it would mean for society, fostering engagement with the content.

Bending and inventing rules: The game uses two levels of rules – those that frame the overall objective, such as achieving goals through collecting elements, and operative rules that refer to what players do within a turn, e.g. how many cards to play or when to draw one extra. Operative rules are represented on cards that players can play out, thus changing the rules in a dynamic fashion during the game. At a later stage, blank cards are introduced that invite players to invent their own rules that then get implemented, aimed at creating a sense of agency (fig. 2 (b)).

Collaborative gameplay: Players complete the game as a team. Tension comes in the form of '*crises*', i.e. cards that block goals, to be resolved together (fig. 2 (c)). Hence, players are put in a position of playing against the deck, not each other. This is underscored by featuring numerous action cards that benefit more than one person, e.g. giving extra cards to others or exchanging resources.



(a) (b) (c)

Figure 2: *Remix* details (a) nominating goals, (b) placing rule cards on the game board, (c) overcoming crises (icons in images adapted from Flaticon)

4. Evaluation

Each game was evaluated by two groups ranging from 3-8 persons per session, with 5 who played both games and 12 that played just one. Participants were aged between 17 and 74 with an average age of 38 and a 13:4 female to male ratio. To recruit participants, we collaborated with two local civic organisations: a centre that acts as platform for citizen and cultural initiatives, and an initiative that organizes cultural offerings primarily for Ukrainian families and refugees. Both invited members of their communities to our sessions (fig. 3), which were conducted in German and Russian by a native-speaking researcher who acted as facilitator. The sessions lasted for 2-3h including obtaining participants' informed consent, playing one of the games and a semi-structured focus group interview. In the latter, participants were asked to discuss their experiences, thus opening up space to engage in collective sense- and meaning-making. Considering the importance of reflection in playful civic learning (Gordon and Baldwin-Philippi, 2014), we see the reflection which occurred at this stage as part of the overall learning experience.

Audio recordings of the focus group discussions were transcribed verbatim and analysed, along with observation notes, applying thematic content analysis (Gareth *et al.*, 2017) in a deductive way, following the method described by Braun and Clarke (2006). The design strategies were used as 'theoretical' overarching themes, allowing us to organise the data along these strategies and relate participant experiences to them. We approached the data with those aspects in mind and, after reviewing it in full, used semantic coding to generate initial codes (Braun & Clarke, 2006) in the software MAXQDA. These codes were then repeatedly reviewed and organised in an iterative process of developing a structure of sub- and overarching themes from which descriptions and interpretations of participant experiences could be constructed.



(a) *(b)*

Figure 3: Participants playing (a) *Narrate* and (b) *Remix*

4.1 Key Results

4.1.1 Telling Stories: an Effective Mode of Engaging With the Future

Participants playing *Narrate* developed multi-faceted stories set in their town and found inventing stories with the help of creative scaffolding to be engaging, frequently stating that they felt it '*opened up*' their minds. The stories featured elements ranging from mundane (a city planning meeting) to unconventional (using zoo animals to improve public transport or AI conducting a strike). The game had participants switch between thinking individually and expressing ideas or making decisions together. Participants felt that this rhythm supported not only learning *about* others' ideas, but also about *how* they view certain concepts. For instance, the concept of time felt intuitive to use as an obstacle for one participant, but surprised another who later reflected on time being a blind spot of theirs. Generally, participants reported enjoying observing what desires others had and how they built on ideas.

Participants voiced mixed feelings about using coins to make decisions, with some of them appreciating this as a system of collective decision-making in its own right, whilst others were confused about their impact. Some also felt that there was no way to lose the game, as high cohesion made the risk of a negative story outcome dismal. They missed elements of risk, finding some aspects of decision-making arbitrary.

Overall, participants felt engaged by co-creating a story and reported having meaningful interaction with the group, e.g. stating how they appreciated hearing views from different age groups. Anchoring the game in the participant's town allowed for them to relate to the story on a personal level, frequently reflecting on what certain turns in the story would mean for their lives.

4.1.2 Bending Rules: Shifting the Focus to Game Mechanics

Remix attempted to direct participants' creative thinking towards its rules. Whilst some participants reported enjoying hearing how others viewed certain goals, e.g. discussions around which goals relating to climate change are more impactful, the content faded into the background over time with focus shifting to the mechanics. Some participants noted that they initially felt tension when contemplating to 'nominate' goals they disliked for the sake of tactics, but would increasingly do so anyway.

Participants made little use of the ability to manipulate the game's rules. In both sessions, once a rule that participants felt suited the group's needs had been invented, no further attempts to come up with more were made. The game's visual design and embodied interactions with the cards were found to be engaging, but participants reported feeling low personal involvement. For instance, when in the second sessions a player left early and was replaced by another person, others felt this had little effect on the game. They voiced that the collaborative nature of the game made individual decisions feel unimportant. This may be related to how participants would increasingly make decisions together, feeling that collaboration superseded their personal responsibility. When asked about feelings of control, players that had taken advantage of inventing rules replied more positively than others, but generally answers skewed towards low feelings of control.

In the focus group interview, many of the participants presented and co-developed a myriad of complex ideas on how the game could be made more interesting, including adding complexity to the goals, a scoring system to make individual contributions visible or hidden player roles. Overall, suggestions focused on increasing feelings of impact or making the game more closely reflect the complexity of future-making in the real world.

5. Discussion

We initially framed players' influence on narrative or mechanics as two potential ways of realising increased player agency for convivial games that enable civic learning about futures. In designing and evaluating the resulting games, we have found these approaches to be unequal. Playing with narrative allowed participants to engage with ideas about the future and each other in meaningful ways. Playing with mechanics resulted in an experimental game that was more difficult to navigate – rather than enabling substantial amounts of own experimentation that would have sparked discussion and learning. Directing player's attention *and* creativity toward mechanics proved a great challenge, as the open nature of the game at times resulted in a disjointed experience. Having players choose whether they want to apply new rules was intended to give them choice, but resulted in participants focusing on optimisation rather than experimentation. Here, *Narrate* was more successful due to its heavier reliance on player input, making meeting the creative challenge vital. A great focus on game mechanics led participants to engage less with the content in *Remix*.

Brandt *et al.* (2012) have proposed *telling, making* and *enacting* as modes of engaging with futures in participatory design. It seems that the mode of *telling* worked well when applied to a convivial game, as it allowed participants to co-produce meaning and seemed to make for a more universally accessible way of connecting with a topic. Although *Remix* featured some elements relating to *making*, this was not fully realised in the game as it still relied on pre-defined content and overarching rules to make it so it can still be played as a game. We find it particularly interesting that while participants made little use of the affordance to invent rules, many of them expressed and co-developed a multitude of creative game ideas in the subsequent focus group interview. This may indicate that the game's affordances did invite participants to think creatively about the game, but provided too small an outlet for their ideas. It also highlights the value of providing space to reflect and make sense of an experience together.

Through the evaluation and the design process, we have seen that it is difficult to evoke strong feelings of personal agency in collaborative games. It may be worthwhile to consider alternative ways of framing agency other than 'freedom of choice' to explore this further. Tanenbaum and Tanenbaum (2010) have suggested broadening the view of agency to include players' decision on whether engage with the narrative and allow themselves to be emerged within it. Following this, it seems that co-creative storytelling and decision-making could be effective in getting players to commit to narrative and experience strong feelings of agency that could

serve to facilitate meaningful learning. Overall, participants' responses seem to support that engaging with the story produced stronger feeling of agency than making decisions on tactical actions and rules.

6. Conclusion and Future Work

We tested two approaches for convivial games for thinking and learning about the future in a civic context. We found focusing on player-generated narrative a more impactful approach for generating feelings of agency than allowing players to influence game mechanics, as the former fostered meaningful engagement among the groups and learning about each other's views. Conviviality proved a useful framework in the design process for considering how certain design strategies facilitate collaboration, agency or creativity and could help designers looking for frameworks to move games for learning in an engaging direction in the future.

For researchers aiming to explore the idea of 'bending rules' in games for thinking about the future, we recommend that many instances of discussion be built into games. It were those instances of dialogue in which participants felt they could most meaningfully engage in learning about others' ideas and views in our study. Furthermore, researchers could lean more into the aspect of *making* by – rather than having participants complete a game – allowing sessions to flow into game-making workshops. Therein, participants could further develop the game, experiencing increased agency through *making,* and find opportunities for experimentation and deep reflection.

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[ai] Explore!: An Educational Game for Developing Programming Skills and Algorithmic Thinking

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Abstract: The game [ai] explore! was developed to introduce the algorithm behind the popular science exhibition. The idea behind the [ai] explore! exhibition was to show the application of mathematics and computer science in solving real engineering problems by creating the exhibit using the mathematical algorithm Heat Equation Driven Area Coverage (HEDAC). The algorithm is based on scientific research and has many applications: exploration and search in unknown space, painting, planning agricultural spraying, scanning 3D objects, etc. The exhibits show the process by which the algorithm paints objects with a virtual brush and explores their shape. By surveying the high school students, it was shown that new mathematical and engineering results can be explained and turned into a playable game. After playing the game, students respond positively to the game presented and state that they have a good understanding of the HEDAC algorithm presented and how it works. This motivated us to investigate [ai] explore! as an educational game for teaching mathematics and computer science. The aim of the research described in this paper is to investigate the potential of the developed game as an educational game. The game-based learning (GBL) approach is increasingly used to increase student motivation and engagement in STEM lessons. The main research question is: How do primary school teachers and students perceive the usefulness of the game [ai] explore! in supporting teaching and learning of computer science concepts? We have developed and implemented teaching scenarios on how the game [ai] explore! can be used as an educational game in computer science lessons. We show that the game has great potential to teach primary school students programming. In addition, the game promotes algorithmic thinking and computational thinking skills in general, which are valuable not only in computer science but also in other fields such as mathematics, where a systematic and analytical approach to problem-solving is required.

Keywords: Educational Game, Game-Based Learning, Algorithmic Thinking, Programming Skills, Mathematics

1. Introduction

Computational and analytical thinking should be encouraged in STEM education as they are crucial in various fields such as math, engineering and science. The use of algorithms and mathematical principles underlies many scientific concepts, and for this very reason it is important to foster an interdisciplinary approach to education and raise awareness of the connections between disciplines.

Today's education faces many challenges. The traditional approach to education does not sufficiently promote computer literacy, so new learning and teaching methods need to be developed.

The game-based learning (GBL) approach is increasingly being used to increase student motivation and engagement in STEM lessons.

Games have been part of the educational process since ancient times (Vankúš, 2005).

From an early age, children learn through play. This form of teaching can be integrated into formal education. Game-based learning and teaching uses the motivation and competition that naturally arise during play to achieve the goals and outcomes of the lesson. There are numerous studies that show many positive effects of this type of learning (Ku et al., 2014), (Vankúš, 2021), and although some of the articles report mixed results and the challenges teachers face with this type of teaching, no study reports negative effects.

The most used tools for game-based learning are computer games and board games. There are examples of the implementation of game-based learning in mathematics (Deeb and Hickey 2019), (Mikulić Crnković, Traunkar and Crnković, 2022), (Seebauer, Jahn and Mottok, 2020), (GAMMA, 2020) and in computer science (Holenko Dlab et al., 2020), (Tonbuloglu, 2019), all of which report very positive results. The effects of serious games in mathematics education shows a significant improvement in mathematical skills in different grade levels and class groups (Hieftje et al., 2017), (Fraga-Varela, Vila-Couñago and Martínez-Piñeiro, 2021).

Introducing programming concepts and improving programming skills is a challenge at all levels. As early programming lessons are seen as crucial to stimulate students' interest in these areas (Wong et al., 2016), GBL

is widely used as an innovative method (Topalli and Cagiltay, 2018), supported by tools with graphical elements to create programs such as Scratch 3.0 (2019) to increase students' motivation and engagement (Lau, 2018), (Holenko Dlab and Hoić-Božić, 2021). In addition to activities supported with information and communication technology, unplugged GBL activities can also be used to support the development of algorithmic thinking and programming skills in students of different ages (Jagušt at al., 2018).

This paper presents the game [ai] explore! and the results of a study conducted to investigate the potential of the game for the development of programming skills and algorithmic thinking in primary school. The research presented contributes to the field of GBL by designing and implementing a teaching scenario for computer science lessons that involves the use of [ai] explore! as an educational game and examining its perceived usefulness for the development of programming skills by primary school teachers and students. In addition to developing programming skills, the game also promotes the development of algorithmic thinking and computational thinking skills as well, which are valuable not only for computer science but also for other fields such as mathematics, where a systematic and analytical approach to problem solving is required. Therefore, the paper also discusses the connection between mathematics and computer science in the context of developing programming skills and algorithmic thinking.

2. Background

2.1 Computational Thinking and Programming

The development of computational thinking begins in preschool by engaging kids in different activities that strengthen pre-mathematical skills (Botički, Pivalica, and Seow, 2018): sorting, comparing and grouping objects, following multi-step instructions, working with patterns, orienting in space and evaluating. Similar essential 21st-century skills should continue to be developed set as the child enters school (Sneider et al., 2014.; Yadav et al, 2016; Ogegbo, A. A., Ramnarain, U. 2021).

Computational and analytical thinking involves breaking down complex problems into smaller, manageable pieces and developing algorithms to solve them (ISTE & CSTA. (2011)). More precisely, computational thinking is a set of skills and processes that enable students to tackle complex problems. It is a cognitive process that involves the following: abstraction, problem decomposition, algorithmic thinking, evaluation, and generalization (Shute, Sun, and Asbell-Clarke, 2017).

A part of computational thinking is algorithmic thinking. Algorithmic thinking is a cognitive process in which we arrive at a solution to a problem step by step, so the process can be repeated by humans or computers and is necessary for successful problem solving in computing. Algorithmic thinking is necessary for successful programming, *i.e.* the management of digital tools by students with the goal of having the digital tool solve a problem (Wing J. M., 2006).

Programming is an excellent way to learn, understand and apply mathematical principles while developing computational thinking. It is well known that there are many positive effects of cooperative learning where students learn together, learn from each other, etc. However, learning mathematics through programming can be interpreted in a similar way (Yadav et al.,2018). Successful programming requires communication between the student and the computer in a language that the computer understands, with the student giving sufficiently clear instructions to enable the computer to perform a mathematical procedure independently.

By applying interdisciplinary approach in mathematics and computer sciences education, both fields can prosper. Many mathematical applications involve the use of technology for analysis, simulation, and modelling. By incorporating technology and linking it to computer science topics in math class, students gain experience with tools and techniques that are relevant in the real world (Basu et al.,2013). This bridges the gap between theory and application and helps students understand the importance of math to the world around them.

Mathematical thinking complements computer science thinking, and many mathematical topics interact with computer science topics (Baldwin, Walker, and Henderson, 2013). That is way, solving mathematical problems fits naturally into the computer science classroom and helps develop programming skills.

2.2 Game [ai] Explore!

Exhibition [ai] explore! is an interdisciplinary activity aimed at explaining the results of scientific research and their application to the interested public and students.

The popular science exhibition [ai] explore! presents visualisations of engineering problems from the field of civil engineering as well as some computationally demanding scientific research examples. Each visualisation shows the process of the algorithm that creates the given image, with different default settings (brush settings, etc.). Figure 1 shows an exhibit, i.e. a visualisation. Each exhibit has a QR code behind which you can read more about the engineering problem that the exhibit shows, walk through the exhibit and read more about the mathematical algorithm that painted the exhibits.

The visualisation was created using the mathematical algorithm HEDAC (Ivić, Crnković and Mezić, 2017) and (Ivić et al., 2019). The HEDAC algorithm was introduced to control and coordinate the actions of a multi-agent space exploration system, but it has been used in several very different applications, such as spraying plants, painting pictures, controlling a robotic arm with 6 degrees of freedom, 3D scanning, maze exploration, and more. (Löw T., Maceiras J., Calinon S., (2022); Ivić et al., 2023., Bilaloglu C., Löw T., Calinon S., 2023; Crnković B., S. Ivić, M. Zovko. , 2024).

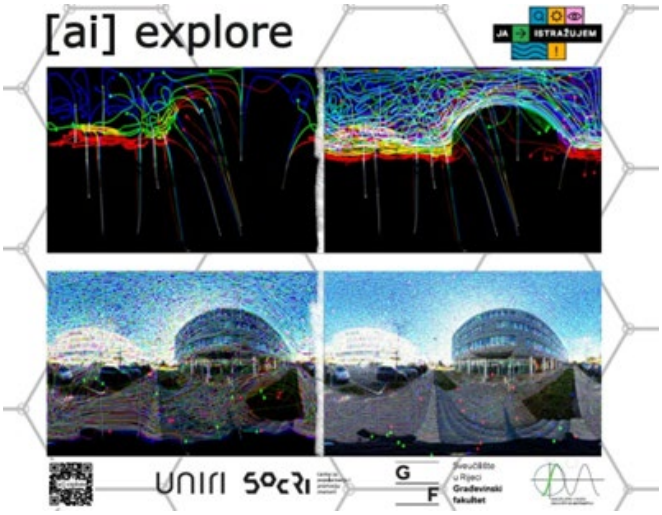


Figure 1: Exhibition [ai] explore!

More details about the exhibition can be found in Crnković, Mikulić Crnković and Traunkar (2024).

To complement the exhibition, two educational [ai] explore! game that illustrate how the mathematical algorithm works were developed: a game using GeoBoard and a game using micro:bits.

The aim of the [ai] explore! games is to illustrate the algorithm behind the exhibition and to put the students in the decision-making situation in order to motivate them to develop the strategy, i.e. the algorithm for playing the game. In order to play successfully, the players must follow the steps of the developed algorithm. The process of playing the games involves decomposing a problem, dealing with uncertainty, organising, planning, developing a heuristic algorithm, simulating and evaluating the results, all of which are fundamental to the development of computational thinking.

2.2.1 [ai] Explore Game Using Micro:bits

Micro:bit is a pocket-sized computer with a 5x5 grid LED light display, two buttons, sensors and many input and output functions that you can programme and interact with. This version of the game shows the application of the HEDAC algorithm for catching Pokémon. The playing field is a 5x5 board with micro:bits placed on some nodes of the board. Each micro:bit indicates the probability of the Pokémon being on that node. This is indicated by the level of heat, which is shown by the LED lights in a level from 1 to 5. The micro:bits are programmed so that the heat increases by one level every 4 seconds and cools down again by pressing the button on the micro:bit.

The rules of the game are simple: every 4 seconds, indicated by the sound of the main micro:bit, the student must take a step to the left, right, up or down to the next node towards the hottest group of micro:bits on the board. If there is a micro:bit on the node you stepped on, you must check whether there is a Pokémon there by pressing the button (thus cooling the micro:bit). The game ends after 20 moves (80 seconds) and the number of Pokémon collected is displayed on the main micro:bit, which is located outside the playing field. The game can

be played by several players and the students must follow the rules described and develop the best algorithm for co-operation and individual tactics when choosing the next moves in order to collect the most Pokémons.

2.2.2 How to Play and Generate the Game Using Geoboard

A GeoBoard is a board used primarily in primary school mathematics education to explore concepts in geometry. It is a square board with a certain number of pegs arranged in an orthogonal grid pattern and comes with rubber bands that are stretched around the pegs to create different shapes (Figure 2).

In the original version of the [ai] explore! game, the GeoBoard was modified by assigning different colours to the pegs. Each colour has assigned a numerical value that depends on the warmth of the colour, which corresponds to the wavelengths of light assigned to the colour. This ranking of colours is intuitive for most people, as they can compare this order to the colours of the rainbow. The rules of the game are very simple: connect the starting peg in the top left corner to the bottom right peg by a continuous shortest path with the maximum sum of peg values along the path. This means that you can only move down and to the right from any position.

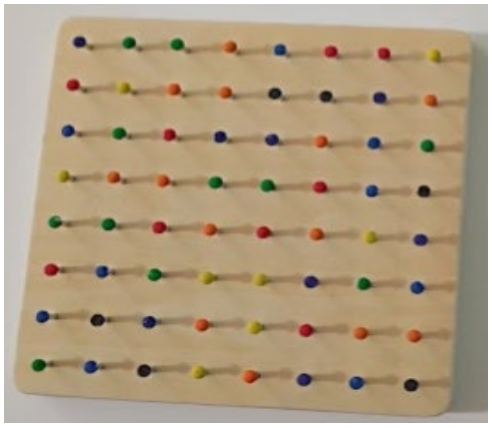


Figure 2: GeoBoard with 8 pegs in each row and column

The total number of possible paths depends on the number pegs in each row (or column) and is easy to calculate. This number is equal to the number of (n-1) subsets of a set of size 2(n-1), where n is the number of pegs in each row or column. The number of possible paths grows very quickly with n, but the number of optimal paths (shortest path with maximum sum) depends on the choice of board and the number of different colours. To find the optimal path, student needs to develop the tactic to collect the highest number of points, and following the developed tactic they choose the next step of the path.

The difficulty of the game depends on the size of the board. In the original implementation, the GeoBoards with 8 and 11 pegs in each row and column, coloured with 7 colours, were used (Figure 2). For example, there are exactly 3432 different shortest paths connecting opposite corners of the 8-peg GeoBoard. The colours of the board were randomly generated and often there is more than one optimal solution and several near-optimal solutions (1 point less than the maximum weight path). The Python programme with a recursive algorithm was used to generate all possible paths and rank them according to their total weight. Figure 3 shows the number of different paths and the distribution of near-optimal paths for two randomly generated boards. Although only a tiny fraction of all possible paths are optimal paths, students can find them in a reasonable amount of time. Students who find near-optimal paths can see from these graphs how close their solution is to the optimal solution and what percentile it is in.

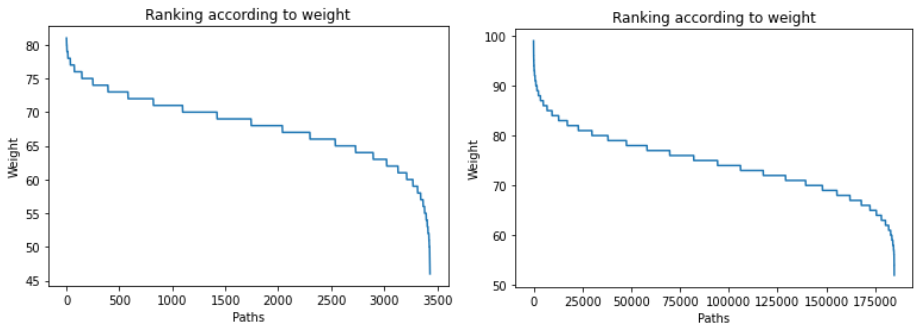


Figure 3: Distribution of all paths by weight for 8 and 11 peg GeoBoard with 7 colours

2.2.3 [ai] explore as Educational Game

After the presentation of the exhibition and the games to the students, a short survey was conducted among the students about their experiences and attitudes. The survey contained four statements (I found the game interesting; I would like to play the game again; I would recommend the game to friends; I understand how the algorithm presented works) and responses were measured using a 5-point Likert scale. A total of 66 high school students took part in the survey.

The results of the surveys were compared, for 3 different implementations of the [ai] explore! game: for a group of students playing [ai] explore! game with micro:bits, for a group of students playing [ai] explore! game on GeoBoard, and for a group of students who played both games. More details about the survey can be found in Crnković, Mikulić Crnković and Traunkar (2024).

From the survey results, the general impression is that the students react positively to the games presented. Most of the students themselves state that they have a good understanding of the algorithm presented and how it works. The results are slightly better when only one game is presented, and the inclusion of micro:bits and teamwork in the game makes it slightly more interesting for the students. However, implementing a game with digital tools in the classroom can be challenging for teachers in many ways. The authors reported that the reactions and interest were really positive during the European Researchers' Night 2023 in Rijeka, where up to 1000 kids and adults tried out the game for themselves. From this, the authors concluded that the developed educational game on GeoBoard has good playing characteristics, is very practical and can be easily used in different environments and situations, including classrooms.

3. Methodology

The game [ai] explore! was developed with the aim of teaching mathematics and explaining the HEDAC algorithm. Motivated by the results of the survey described in the previous section, the aim of the study presented in this paper was to investigate the potential of the game [ai] explore as an educational game for the development of programming skills and algorithmic thinking. The main research question was: *How do primary school teachers and students perceive the usefulness of the game [ai] explore! in supporting teaching and learning computer science concepts?*

To illustrate how the game [ai] explore! can serve as an educational game, a teaching scenario for one lesson in programming was developed and implemented with students from two primary school classes as part of regular lessons in Computer Science/Informatics subject. During the execution of the scenario, the researchers were present in the classroom together with the class teacher.

3.1 Context and Participants

Learning objectives related to the development of computational thinking and programming skills are implemented in Croatian schools in the subject Computer Science/Informatics according to the "National Curriculum for the Subject of Computer Science/Informatics for primary schools and secondary schools – gymnasiums". One of the four domains of the National Curriculum in which the learning outcomes and course content are organized is Computational Thinking and Programming. Computer Science/Informatics is a compulsory subject for students in 5th and 6th grade and an elective subject for students in 7th and 8th grade.

Teachers are autonomous in choosing the programming language for teaching programming. The most used languages are Scratch, Logo and Python.

The participants of the study were students (NS=35) from two primary schools in Rijeka, Croatia, together with their teachers (NT=2). The students involved in the study were from two mixed-gender classes aged 11-12 years (5th grade in Croatian schools). Both teachers involved in the study have extensive experience in teaching computer science and serve as mentors for pre-service teachers (i.e. computer science students) from the University of Rijeka during their practical lessons in schools.

3.2 Teaching Scenario for Using [ai] Explore! Game in Combination with Scratch

Developed teaching scenario demonstrate how the game [ai] explore! can be used as an educational game for teaching conditional statements (if-then-else) in Scratch.

After completing the lesson, students are expected to:

- correctly implement conditional statement in Scratch
- recognize situations in which is necessary to use conditional statement

The duration of the lesson is 45 minutes. Students are expected to be in the computer lab. During the lesson, the teacher should guide the students through the activities included in the scenario.

For this lesson, GeoBoards have been prepared with 5 squares in each row and column, coloured in 5 colours: red, yellow, green, blue, and purple with assigned values 5, 4, 3, 2 and 1, respectively. The prepared game has two optimal solutions out of seventy possibilities (all paths connecting the upper right point with the point in the lower left corner). The two optimal paths, i.e. the shortest paths that connect the upper right point with the point in the lower left corner so that the path has the maximum possible sum, are shown in Figure 4.

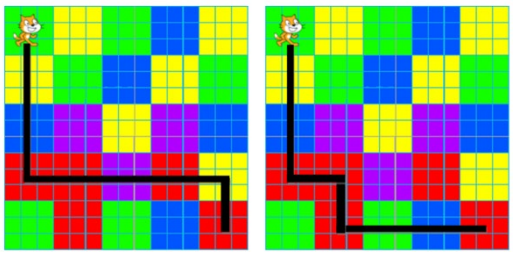


Figure 4: Two optimal solutions on the GeoBoard

The first part of the lesson is playing [ai] explore! game. Each student should have a GeoBoard, rubber bands, and instructions for playing. After all students have found the optimal solution on the board (any of them), the teacher moves on to the second part.

In this part, the students have to implement the algorithm they developed by playing the game [ai] explore! on the GeoBoard in Scratch to move the game character along the optimal path in Scratch. With this goal in mind, we prepared a stage in Scratch that looks the same as the GeoBoard (Figure 5).

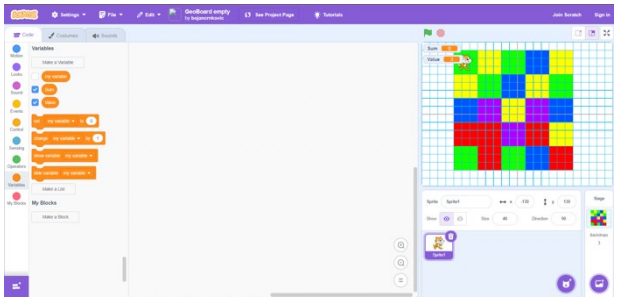


Figure 5: Prepared Scratch file

Creating and following the algorithm while playing the [ai] explore! game on GeoBoard is a preparation for implementing the algorithm in Scratch. The task in Scratch is linked to the game, i.e. the student is asked to

implement the path they have chosen on the GeoBoard, but takes into account the programming skills the students are developing in this lesson (namely conditional statements and variables).

In the second part, the students are given the following task:

Create a programme in Scratch in which your character follows the path you specified on your GeoBoard, step by step (each rubber band is one step). As it moves, the character counts points depending on the colour of the square it is on. In addition, your character thinks about how warm or cold it is on each field (depending on which filed it is on, cold colours are purple, blue, green, and warm colours are yellow and red).

Teacher should instruct the students to the use conditional statements and variables to add up points. Example of one possible realisation of such code can be seen in Figure 6.

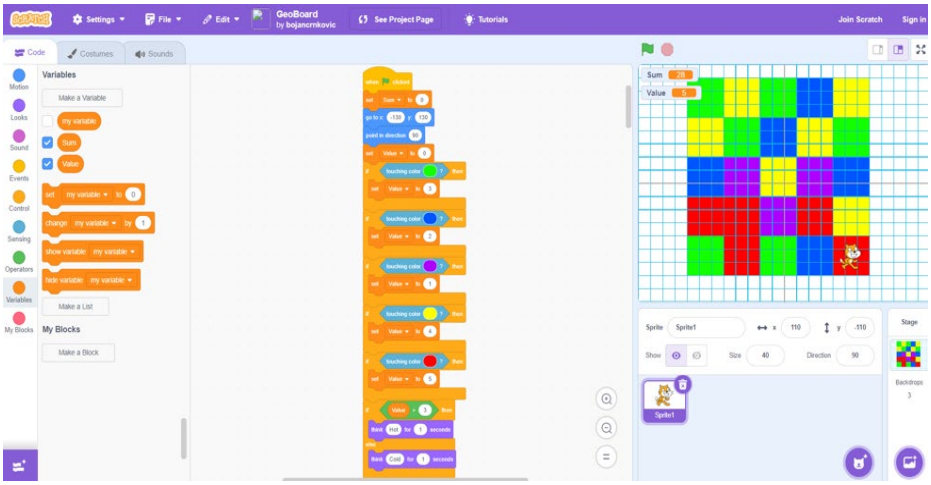


Figure 6: Part of the solution in Scratch

It should be noted that this lesson is intended as part of a series of lessons. It is anticipated that students will recognise the need for more advanced concepts (i.e. loops and procedures) during this lesson, so teachers can also use this example to introduce advanced programming concepts.

In addition, students can create a more advanced version of the game in the next lessons, e.g. by adding control buttons to move the game character, etc.

3.3 Instrument

A combination of quantitative and qualitative research methods was used to answer the research question. A questionnaire with a list of statements on a 5-point Likert scale (1 – strongly disagree, 5 – strongly agree) was developed for the study (see Tables 1 and 2) to measure students' attitudes. After the activity, students were asked to complete a questionnaire and indicate their attitudes towards their experience. The first set contained statements about the game [ai] explore! and its potential to support the learning of programming concepts. The second set of questions contained statements about their more general attitudes towards participating in the activity which involved using the [ai] explore! game in combination with Scratch.

In addition to the questionnaire, a short interview was conducted with the computer science teachers teaching students in two classes that participated in the survey. The teachers were asked about their observations and opinions on the game [ai] explore! in combination with Scratch and its potential to support the teaching and learning of programming concepts using the following questions:

- How would you describe the general atmosphere during the activity and students' engagement?
- In your opinion, how did the game-based learning activity and the GeoBoard help the students to solve the task in Scratch?
- Do you think the game could help students solve more complex problems in Scratch?
- How do you think such activities motivate students compared to more traditional teaching methods?

4. Results and Discussion

4.1 Results of Questionnaire for Students

Table 1 presents the results of responses gathered from students (N=35) regarding their attitudes towards the [ai] explore! game. Each statement was rated on a Likert scale ranging from 1 - Strongly Disagree to 5 - Strongly Agree.

Table 1: Attitudes towards the game [ai] explore!

Statements	N	AVG	SD	MIN	MAX
I found the game interesting.	35	4.57	0.77	2	5
The rules of the game were clearly explained to me.	35	4.57	0.77	2	5
The game made it easier for me to find a solution to the task in Scratch.	35	4.20	1.24	1	5
The geoboard helped me find the path that the character in Scratch should take.	35	4.49	1.05	1	5
I would like to solve more complex problems in Scratch using the game [ai] explore! on the geoboard.	35	4.26	1.08	2	5
I would like to create the game [ai] explore! in Scratch.	35	4.03	1.36	1	5
I would prefer to learn programming using games rather than normal tasks.	35	4.49	1.11	1	5

The results indicate a positive attitude towards the game [ai] explore! and its potential to enhance the learning experience. Students found the game interesting and expressed satisfaction with the clarity of the game rules (the average rating for both statements are 4.57). This result is important since providing concise instructions for educational games can contribute significantly to a positive student's experience.

The majority of students found the game to be a helpful tool for solving the task in Scratch and agreed that the GeoBoard was an effective tool in helping them find the path that the character should take in Scratch (AVG = 4.49). This shows that the integration of tools such as the GeoBoard can improve the application of programming concepts in a visual and interactive way.

Students also expressed an interest in further exploring the game [ai] explore! In combination with Scratch and creating more complex projects (AVG = 4.26), as well as a preference for learning programming through games rather than traditional tasks (AVG = 4.49), highlighting the potential of GBL approaches to increase student engagement and motivation.

In addition to exploring the attitudes towards game [ai] explore!, general attitudes towards participation in the activity using the game [ai] explore! in combination with Scratch were examined as well. The results are presented in Table 2.

Table 2: Attitudes towards participation in the activity using the game [ai] explore! in combination with Scratch

Statements	N	AVG	SD	MIN	MAX
I think I can learn something new through activities like this.	35	4.20	1.30	1	5
There are not enough activities like this in class.	35	4.49	0.87	2	5
Activities like this motivate me to study mathematics and computer science.	35	4.31	1.14	1	5
It was fun for me.	35	4.51	0.80	2	5
I would like to participate in similar activities in the future.	35	4.31	1.14	1	5
I would recommend other students to participate in similar activities.	35	4.63	0.64	3	5

Students expressed the opinion that they can learn something new through activities like this (AVG=4.20), indicating a potential of the activity for acquiring new knowledge and skills through hands-on, interactive learning experience. The perception that there are not enough activities like [ai] explore! Game in class was prevalent among participants (AVG=4.49). This indicates a desire for more engaging and interactive learning opportunities in the class. With an average rating of 4.31, participants indicated that activities like this serve as

a source of motivation to study Mathematics and Computer Science. This suggests that integrating GBL experiences into these subjects can positively influence students' attitudes and interest in these subjects.

Students found the activity fun (AVG=4.51) and expressed a desire to participate in similar activities in the future (AVG=4.31). They would also recommend such activities to other students (AVG=4.63). This suggests that teaching scenario that included the [ai] explore! game in combination with Scratch was well received by students and holds promise for promoting learning, motivation, and fun in math and computer science education.

To summarize, student responses indicate a very positive attitude towards this activity, suggesting that it has the potential to enhance learning experiences and foster motivation among students. These results indicate that the [ai] explore! game has the potential to support students in learning computer science concepts.

4.2 Teachers' Observations

According to the teachers' observations, the atmosphere was pleasant and the use of the game in the learning process has triggered excitement and curiosity among the students. The students were engaged throughout the activity, and all completed the task successfully. These observations were confirmed by researchers.

Teachers commented that the GeoBoard proved to be a tool that helped students visualize and navigate the path their character should take in Scratch. After the students physically manipulated the rubber bands on the GeoBoard, they mapped movements in their Scratch projects using conditional statement.

Both teachers expressed the attitude that this game, which includes hands-on activities, can be used to tackle more complex challenges in Scratch. The teachers mentioned that they are interested in exploring the activities that can be built on top of this teaching scenario. They also said that creating the game [ai] explore! in Scratch would be an enriching experience for the students as it would allow them to demonstrate their understanding of programming concepts in a fun and interactive way.

Teachers' observations also support the conclusion that the game [ai] explore! has the potential to support students in learning computer science concepts.

5. Conclusions and Plans for Future Work

The aim of the research described in this paper is to investigate the potential of the developed game as an educational game.

Teaching scenarios on how the game [ai] explore! can be used as an educational game in Scratch lessons were developed and implemented. The results of the student survey clearly show that the students find the game fun, interesting and captivating, that they would like to learn programming with this game and would recommend it to other students. The teachers' observations confirm that the games have generated excitement and curiosity among the students and that they should be used to master more complex programming challenges. From the responses of the teachers and students, it can be concluded that the game has great potential for teaching primary school students programming. In addition, the game promotes algorithmic thinking and computational thinking skills in general, which are valuable not only in computer science but also in other fields such as mathematics, where a systematic and analytical approach to problem solving is required.

The results of the survey suggest that this approach and the [ai] explore! game have the potential to be used in game-based learning in other areas of computer science and mathematics with topics of varying levels of difficulty. This indicates one direction for future work motivated by this research.

The development a series of learning scenarios for teaching programming in Scratch, from simple to more complex commands and tasks, using the [ai] explore! game is planned. Since computer science teachers in Croatia can choose programming language they want to use in the classroom to develop students' programming skills it would be useful, in addition to scenarios and Scratch lessons, to develop teaching materials and programming lessons based on the [ai] explore! game in Logo and Python.

In order to evaluate the effectiveness of the proposed teaching scenario, future work will include a comparative study comparing the learning success of an experimental group after programming lessons based on the described game-based approach and the game [ai] explore! with the results of the control group that will be taught in the traditional way.

Acknowledgements

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Game Lab Innovations in Education: Insights from a Board Game Design Project

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Abstract: From the perspective of educators, game development has great potential as a teaching method, as it promotes group collaboration, project-based learning and the development of content tailored to a given target group. This paper is based on a study that was carried out through an international project, implementing an educational game development concept called Game Lab into an educational context. The study explored professional development topics such as game-based learning, game development, and game testing, along with the Game Lab method focusing on group dynamics, progression, and creativity. It employed an abductive analysis of written responses from twelve teachers who participated in the Let's Play project, which involved a Game Lab component. The teachers, ranging in age from their thirties to their sixties, represented all levels of education from preschool to upper secondary school. They responded to a survey with open-ended questions and reflection notes, providing insights into their experiences with game development methods as pedagogical tools. Their responses were analyzed to identify key themes and patterns. Findings suggest that this approach has broadened participants' perspectives on utilizing diverse games and game development techniques in education, aligning with prior research on production pedagogy. It underscores the importance of integrating in-game content with real-world contexts as a modern teaching method. Participants also highlighted that effective game-based learning supports a constructivist approach to teaching over behaviorism. The participants emphasized their increased insight and understanding of game development and game systems and how the combined effect of educational game design and the Game Lab method (working in teams) resulted in a more valuable learning outcome than they would have experienced alone. They also reported an improved understanding on how working with the development of a board game made them dig much deeper into the topic at hand. In addition, they found that this increased their motivation for learning, knowing that this was going to be a product that was to be tested and played by others (pupils and teachers). Furthermore, the participants highlighted the role of group dynamics in fostering teamwork and consensus during the collaborative game development process.

Keywords: Educational board Games; Group Dynamics Game-based Learning; Game-development; Motivation; Assets of use Value.

1. Introduction

This paper presents key findings on teachers' experiences with learning to utilize game development processes as methods for teaching and learning. It is based on a year-long process carried out through a project cooperation between a game development bachelor program at a university in Norway and practicing teachers from Poland. The project was titled Let's Play. It was funded by the EEA grants and based on approaches to motivating learners through artifacts production. Rather than the artifact alone being the end goal, the learning process of making a game about a certain, clearly outlined topic, is a key component of the end goal.

Through over a decade of running a bachelor program within game development, as well as several international projects on game development, programming, learning through construction and more, the university partners in the project have seen that game development has great potential. Applying game development as a learning process has turned out to increase the engagement of participants. This study was conducted to further explore this approach.

In the Let's Play project, the group of participating teachers first went through a 2-day on-site seminar, including lectures and workshops, to learn about the basics of educational game development. Through the ensuing Game Lab process, they took part in the development of analog board games. They worked in teams and were given bi-weekly feedback on the progression of the project, through the Game Lab model.

Game Lab is an international concept, describing a development environment linking people with different roles, such as technologists, artists, teachers, students, companies, researchers etc., in a game development process (Munkvold, 2017). In Game Lab, students are offered insight into the basics of professional life. The concept is often organized as a business simulator, where student teams form small, functional game development companies and assume various roles and responsibilities, while supervisors act as clients or investors. This concept has a clear framework and rules for implementation.

Other than optional initial presentations, the Game Lab approach is free of traditional classroom teaching. It begins with the student teams each pitching different game ideas. Then, in collaboration with supervisors, the teams choose one of the project ideas. The teams then work on that concept for the rest of the semester. The teams receive constructive feedback from the supervisors through regular meetings. The game development progress is monitored, guiding teams towards a fully developed game by semester's end.

This study contributes valuable insights into the integration of game development processes as innovative educational tools. By examining teachers' experiences within the Let's Play project, our research expands the understanding of how educational game design, and the Game Lab method, can enhance learning outcomes. Through exploration of these methodologies, this study aims to provide practical implications for educators seeking to engage students through immersive and collaborative learning experiences in both analog and digital realms. Empirical data was gathered a survey with open-ended questions and reflection notes written by participants towards the end of the semester, providing their insights on using game development as an educational approach, working in teams and developing a board game on a given subject. Their responses were analyzed to identify key themes and patterns.

2. Theoretical Background

Constructivism and behaviorism are central learning theories in game-based learning (Hense & Mandl, 2014; Egenfeldt-Nielsen, 2006). Constructivism emphasizes active learning where the student creates knowledge themselves, while behaviorism focuses on reinforcing desired behavior. Motivation is a key concept, with external and internal motivation as important factors (Lei, 2010; Plass et al., 2015; Shaffer et al., 2005). In game-based learning, external motivation can involve external rewards, such as points and prizes, while internal motivation refers to games based on curiosity, excitement, or the joy of solving challenges (Oudeyer, Gottlieb & Lopes, 2016).

Constructivism highlights individual knowledge construction, experiential learning or learning by doing (Mayer, et al., 2002; Molina-Carmona and Llorens-Largo, 2020 and Shaffer et al., 2005). It varies whether, or to what extent, experiential learning is considered independent of constructivism. The term is descriptive; students should learn by construction; working on realistic tasks instead of reading about such tasks or acquiring abstract knowledge. Digital games are often seen as useful options for integrating approaches to experiential learning in the classroom (Mayer, Mautone, and Prothero, 2002; Molina-Carmona and Llorens-Largo, 2020). Previous research has also underscored the positive sides of students as game designers (Slussareff and Bohácková, 2016), and how this benefits knowledge acquisition.

Using game development features (GDFs) as a base for the process of teaching and learning opens a range of possibilities and can help improve students' learning outcomes in classroom teaching (Wu and Wang, 2012). Czauderna and Guardiola (2019) furthermore address the Gameplay Loop Methodology as a Tool for Educational Game Design and how the methods of player-centered design ensure the relevance and quality of the final product.

Navarrete (203) and Thumlert et.al (2018) examined what and how young people learn through game design and critical thinking. They have found this way of learning, through production pedagogies, to be effective, providing deeper understanding through designing artifacts that have use value, and that matter to their makers. This is further supported by Yanes et.al (2019) who also highlight the importance of giving learners the opportunity to participate in processes of inquiry, meaning-making and design work, through action and interaction and by engaging in a process of learning where students' own interests are central.

Munkvold et al. (2017) have tested several interventions and researched the topic of Learning through construction (see also Kolås et.al., 2017; Kolås and Munkvold, 2017 and Sindre et.al., 2018). Munkvold (2017) emphasizes the importance of the making of an artifact/outcome driven development and how testing the game with players (target audience) increases the motivation for working with the project, aligning with the principles of production pedagogies (Thumlert et.al., 2018 and Chamberlin et.al., 2012). There is further support that the process of getting there, working systematically in teams, having regular meetings with the supervisor, observing others testing and playing the game and the fact that one is making a product that is interesting and relevant to a given audience, are mentioned as a combined set of motivational factors (Munkvold, 2017). This is also supported in previous research by Chamberlin et.al (2012) and Li (2010), emphasizing how collaborative work and group dynamics have positive effect regarding understanding and learning the game design process, and how it increases participants' insight on the subject matter and the generic skills.

3. Method

The learning activities were carefully designed, following the steps from the Game Lab concept, the game development process, to ensure progression in each of the teams' projects. The figure below gives an overview of the process, using Game Lab as the educational approach.

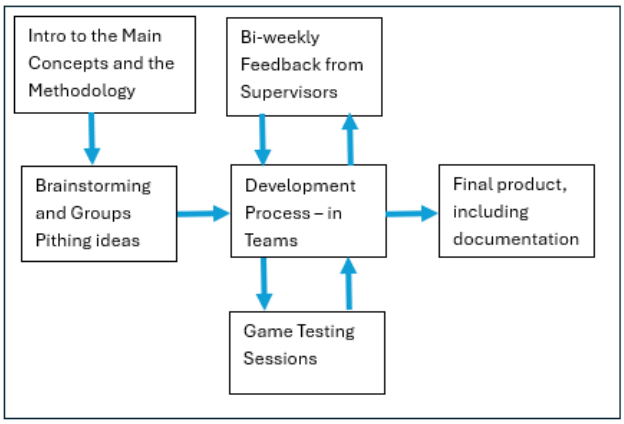


Figure 1: Game Lab as basis for the Game Development Process

To address our exploratory research, we conducted a comprehensive analysis of written in-depth reflection notes provided by the group of teachers who participated in the Let's Play project, which included a Game Lab component. The participants also answered an assignment-survey with open ended questions, where they provided their insights on learning experiences and motivational factors when using games and a game development process as a pedagogical tool for learning activities.

A total of twelve teachers, representing a diverse age group from their thirties to their sixties, with the majority being women and only three men. Their responses captured the participants' insights into learning experiences and motivational factors when utilizing games and a game development process as pedagogical tools in the learning activities. Since many of the responses were initially written in Polish, accurate translations to English were provided by the Polish project coordinators.

The texts provided by the teachers were analyzed using an abductive approach, which aims to explore thematic patterns and emergent insights from the data (Reichertz, 2007). Abduction enables the integration of deductive reasoning based on theory with the outcomes derived from inductive data coding.

Regarding limitations, it is important to acknowledge that the teachers in this study had voluntarily enrolled in the Let's Play project, indicating a potential bias toward an interest in game-based learning approaches. This, and the fact that there were only three men out of twelve participants, may limit the generalizability of our findings beyond this specific population. Furthermore, all the teachers provided their consent to their responses being used for research purposes. They have also received a presentation of the main findings.

It is important to note that both the authors of this paper were involved in the project. However, we do not view this as a conflict of interest, as our focus remains on analyzing the experiences of the teacher participants.

4. Findings & Discussion

Two main themes emerged from the participants' responses, when they were asked about the most useful/inspiring things and the most motivational factors during the game development project. These themes were educational game design on one hand, and the Game Lab method on the other hand. Within each of these categories, their responses further reveal three main sub-categories:

Table 1: Main findings

Educational Game Design	The Game Lab Method
• Game based learning	• Group Dynamics
• Game development	• Progress
• Game testing	• Creativity

The *educational game design* theme evolved around increased professional knowledge and skills regarding these three prominent sub-categories. Within the sub-category of *game-based learning*, participants commented that the project had given them a broader perspective on using diverse games in education, highlighting the importance of connecting in-game content to the real world and how this is a suitably modern approach to teaching. Some also commented that when successful, game-based learning provides precious opportunities to approach teaching from a constructivist angle rather than a behaviorist one.

Regarding the *game development* sub-category, the participants emphasized their increased insight and understanding of game systems. They also reported improved insight into game development.

In the third sub-category the participants highlighted the importance of *game testing* for their professional development and how they had come to discover this as an obvious, yet surprisingly potent approach. They further emphasized the importance of conducting testing sessions with the appropriate target audience (their own pupils in this case) and how the results from this were essential for the further development of their own games.

A quote from one of the participants is a good example on how they felt that the *educational game design* approach in the Let's Play project supported their own professional development:

> *"Already during the lecture, I realized that for more than 13 years of my work as a teacher, what I have really cared about, what I have strived for and what I have learned was to transfer knowledge, to achieve some educational goals 'by the way'. At various stages of our team's work, we returned in our conversations to the fundamental premise of moving towards constructivism rather than behaviorism when developing a game."*

In the *Game Lab method* category, the first sub-category was *group dynamics*, where the participants emphasized teamwork and the ability to negotiate and reach consensus. They appreciated meeting like-minded, passionate people, as well as discussions and reflections during the game development process regarding both motivation and learning outcomes.

In the *progress* sub-category, participants called attention to the key role of experiencing the games' natural, yet structured, development through sequential stages in the development process. They felt that experiencing this with the Game Lab approach was a highly engaging process, resulting in a valuable learning experience.

The sub-category that we call *creativity* puts the spotlight on the significance of creating something and being creative. Being open for "surprise turns" during the development process was emphasized. The respondents felt that this supported the innovation, freshness and novelty of the product and how it increased the participants' motivation for working on the project. In one of the responses that emphasized the focus on creativity, the respondent referred to how one of the lectures in the on-site seminar had inspired them, *"as it encouraged me not to be afraid of my ideas and to experiment with my imagination."*

To summarize and reflect on the findings considering relevant previous research and theories, we can say that the participants valued their increased insights and understanding of game-based learning, game development and game testing as vital elements for educational game design, and their own professional development through the project. This approach was seen as a modern and effective way to foster constructivist learning environments, as also stated in previous research by Munkvold (2017), Thumlert et.al. (2018) and Yanes et.al (2019). The respondents reflected on this in relation to their own professional work situations, accounting for a broad spectrum of relevant factors, ranging from educational theories to the simple reality of helping their pupils understand somewhat abstract ideas related to real world topics, through something as tangible as an analog board game.

The participant's reflections on shifting from a behaviorist approach to a constructivist one aligns with the theoretical emphasis on constructivism in game-based learning (see for example Hense & Mandl, 2014; Egenfeldt-Nielsen, 2006). This transition underscores the value of active, experiential learning, where students construct knowledge through realistic tasks, resonating with the participant's realization of the importance of engaging students in meaningful learning experiences.

When it comes to the other main theme in the participants' feedback, the Game Lab method, the participants highlighted group dynamics, which is in line with Chamberlin et.al (2012) and Li (2010), the observable progression of the game and the creativity that the method both allows for and, at the same time, is dependent on. Their personal experience and motivation were prominent in their responses regarding Game Lab, while their reflections also reveal an understanding of how the elements that made Game Lab valuable for them, can

also be applied to create valuable learning experiences for their own pupils. This is also supported by Thumlert et.al (2018) and their emphasis on the positive motivational effect of producing assets of use value.

5. Conclusion

The research findings reveal two main themes that significantly impacted the participants: educational game design and the Game Lab method – both connected to production pedagogies as a motivating learning approach and further grounded in constructivist learning theories. Each theme comprises several sub-categories that further elucidate the participants' experiences and insights.

In conclusion, the project enabled participants to enhance their professional skills and knowledge in educational game design, particularly through game-based learning, development, and testing. They reflected on how these elements could be integrated into their teaching practices to help pupils grasp complex concepts through both playing and developing tangible analog board games.

The Game Lab method further enriched their experience by emphasizing the importance of group dynamics, structured progress, and creativity. Participants' personal experiences and motivations were deeply influenced by these elements, and they recognized the potential to apply these insights to create valuable learning experiences for their own pupils. The project suggests that educational game design and the Game Lab method may synergistically support professional development and innovative teaching practices.

The following quote, addressing the role and effects of *group dynamics,* provides a fitting conclusion for this paper:

"Alone you go faster, but together you go further."

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Beyond the Digital: Analogue Games´ Creative Potential in Deepening Data Literacy

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Abstract: In an era where digital technology often dominates the educational landscape, the enduring appeal and educational potential of analogue learning games remain significant. These traditional, non-digital games, offer a tactile and interactive approach to learning that is both unique and impactful. Unlike their digital counterparts, analogue games require physical presence and direct interaction, which bring benefits to the educational process (Ribeiro, 2019; Medeisiene et al., 2021). This small case study explores, through a sociocultural lens, how analogue learning games influence creative learning processes in Continuing Education students. The results of a questionnaire to 43 participants enrolled in a course on Data Literacy in Norway, show that analogue learning games promote active engagement, foster social interaction, and stimulate innovative thinking connected to the course content when the setting around the activity feels safe for the participants. Participants also expressed that the tactile and social nature of analogue games encouraged more profound group discussions, leading to diverse perspectives and novel ideas. This resonates with findings from Medeisiene et al. (2021) who highlight the pedagogical value of game-based learning in enhancing engagement. These interactions not only bolstered creativity but also enhanced and deepened understanding and retention of knowledge from the Data Literacy course content. Moreover, the study highlights the importance of context and facilitation in maximising the benefits of analogue games for Continuing Education students. The findings suggest a promising avenue for further exploration into using analogue games in educational contexts. The study concludes with advocating conducting more research on the integration of learning games into continuing education curricula as a strategy to leverage the benefits of social interaction and active engagement, and to enhance creative learning that can deepen learning of course content.

Keywords: Analogue Learning Games, Creative Learning, Psychological Safety, Continuing Education, Data Literacy

1. Introduction

Analogue games demand physical participation, playing a vital role in bolstering creativity in the educational process. This reflects a long-recognised connection between play, creativity, and learning, which is one of the most studied relationships within a sociocultural approach to learning. Creative learning is a concept that advocates nurturing one's creativity while simultaneously enhancing the ability to absorb and integrate new knowledge (Mestre, Ness & Glaveanu, forthcoming). Creativity is one of the essential skills of digital literacy: the ability to use, access, filter, evaluate, create, program, and share digital content; manage and protect information, data, and digital identities; and entrepreneurship; imagination, strategic thinking and problem solving, critical and constructive reflection in the context of evolving creative processes and innovations, and the ability to collaborate both as individuals and in teams (Boghian et al., 2022, p.89).

According to Anderson et al. (2009) there is a synergistic potential of blending digital and traditional game-based learning in adult education for both students and teachers, as outlined by Caffarella (2002). However, despite the growing dominance of digital technologies in educational settings, analogue games continue to offer unparalleled interactive and hands-on experiences that enrich learning in ways digital mediums cannot match.

This paper reports from a small case study of analogue game play and creativity in continuing education students participating in a data literacy workshop at the University of Bergen, Norway. This guiding research question was formulated:

How do analogue learning games influence creative learning processes in continuing education students?

Our study revealed many benefits in integrating analogue learning games into a workshop as part of a course on data literacy and we argue that enhancing creative learning processes when playing games also deepens learning of the course content.

2. Games in Education

In our study, we investigate the role of analogue learning games in influencing the creative learning processes of adult students in continuing education. Games have long been recognised as powerful tools for facilitating learning experiences (Breien, 2023; Sousa et al., 2023). Game-based learning (GBL) has in recent years gained significant attention in adult education due to its ability to incorporate playfulness into learning, emphasising creativity in learning and personal growth in education (Jensen et al., 2022; Heidari-Shahreza, 2024). GBL utilises the social dynamics of gaming within an educational setting (Susi, et. al., 2006), enabling educators to implement gaming principles that encourage engagement and support a variety of defined learning outcomes (Plass et al., 2019).

Frossard et al. (2012) highlight the widely accepted notion in educational research that creativity can be taught, referencing seminal works in the field of creativity (Kaufman & Beghetto, 2009). They emphasise that for students to cultivate their creative abilities, educators themselves must embody creativity and foster an environment that cherishes creative expression (Craft, 2005). Analogue learning games, including board games, tabletop games, card games, and dice games (Sousa, et al., 2023), offer a tactile and interactive experience that has been a part of educational practices long before digital technologies became prevalent. These games naturally facilitate creativity by actively allowing students to explore and implement new ideas, linking them to the early development of human culture and society, similar to narratives and storytelling (Breien, 2023, p. 52).

Moreover, when using games in educational settings, it is crucial to balance and integrate educational content with game elements to optimise the learning experience (Barendregt & Wasson, 2016).

3. Theoretical Framework and Key Concepts: A sociocultural Perspective on Learning

This study is framed within a sociocultural approach to learning which emphasize the role of language, cultural norms, and tools in shaping cognitive development, viewing learning as inherently collaborative. Knowledge is constructed dialogically and through participation in communal activities, deeply influenced by the cultural and social milieu (Vygotsky, 1981; Wertsch, 1991). Key concepts include:

Mediation: Vygotsky's concept of mediation is crucial to understanding the interaction between learners and their environment. He asserts that human action, both individual and collective, is mediated by tools and signs, such as language, various systems of counting, mnemonic techniques, and symbolic systems like algebra, art, and writing. These tools, often referred to as "psychological tools" play a pivotal role in the cognitive development process by shaping and supporting the learners' interaction with their world (Vygotsky, 1981; Wertsch, 1991).

The Zone of Proximal Development (ZPD): ZPD further elaborates on how learning unfolds within social settings. Defined by Vygotsky as the difference between what a learner can achieve independently and what they can achieve with guidance from more knowledgeable others, the ZPD underscores the importance of cooperative learning environments. Such settings utilize cultural tools and social interaction to scaffold learning, facilitating the co-construction of knowledge (John-Steiner & Mahn, 1996; Vygotsky, 1978).

Creativity: Creativity in learning is a multifaceted concept that can manifest as both a process and a product. Rooted in the act of creation, it may involve conceiving entirely new ideas, recombining existing knowledge in novel ways, or producing tangible outputs. Creativity spans from minor personal insights ('little c') to transformative innovations ('big C') that can significantly impact broader societal contexts (Kaufman & Beghetto, 2009; Craft, 2005). Contemporary research in creativity emphasizes the dynamic interplay between the individual and their social environment, suggesting that creativity is not only an individual trait but also a collective phenomenon that flourishes in socially supportive settings (Moran & John-Steiner, 2004; Ness, 2020).

Psychological safety (PS): PS is not being afraid to contribute (Edmondson, 2019) and asking "silly questions". Psychological safety in teams contributes to increased knowledge and innovation (Ness, 2017). According to Marjanovic-Shane et al. (2010, p. 225) the way learning environments are organized fosters or dissuades the emotional and relational conditions for creativity. Positive relationships will stimulate engaging in creative work which results in novel insights and accomplishments for all participants. Emotional safety and respect are essential conditions for creativity (Ness, 2016).

Deep learning (DL): DL is characterised by a learner's active engagement with content in a manner that fosters a profound understanding and meaningful interpretation of the subject matter. According to Smith & Colby (2007) this educational approach involves students actively engaging in analysing the relationships between

different facets of the content, generating hypotheses, and forming well-grounded beliefs about the underlying structures of concepts. Such engagement typically leads to an intrinsic interest in learning and understanding of the material. Additionally, educators play a crucial role: those who structure their lessons to challenge students intellectually, provide constructive feedback, and set tasks that encourage critical thinking and problem-solving are more likely to promote deep learning (Hattie, 1998).

4. Methods

To investigate how analogue games influence creative learning processes among Continuing Education students, we designed a case study, approached as a focused and responsive inquiry into a situated and finite number of incidents (Yin, 2018), around a university-level data literacy course.

As part of the course design, the students were invited to take part in one of six non-mandatory, 3-hour face-to-face workshops designed to foster interdisciplinary collaboration when engaging with the complexity of data literacy. The analogue learning games used in the workshop were created as part of an Erasmus+ project, DALI[1] that aimed to support basic data literacy for citizenship (Castañeda et al. 2024). Our case study was conducted across four of these workshops, attended by 43 adult students from diverse professional backgrounds from both public and private sectors.

During each workshop, groups of three to five students played two analogue games for data literacy from the DALI project[2] chosen as they raise awareness and understanding of data (Castañeda et al. 2024). The students were grouped strategically, ensuring that each group represented a mix of backgrounds, expertise, and professional experiences. First, Game of Phones, a card game, had students using mobile phones to search for information, share stories, and discuss the use and creation of data. Second, Data Iceberg, a card game, involving finding card pairs and categorising them by data type on individual player boards.

At the conclusion of the game sessions, students were given a qualitative questionnaire (Braun, et al. 2021), designed to probe their experiences with the analogue games as a supplement to the digital course and the potential influence on their creative learning. The questionnaire comprised two open-ended questions: 1) How can games promote creative learning processes? and 2) During the games, in what way did you have to be creative? Additionally, they were given the opportunity to provide further feedback and reflections.

Responses were collected via paper questionnaires to maintain anonymity and the students were verbally informed that answering was voluntary (Klykken, 2022; NESH, 2024). All 43 students chose to provide their insights, giving the dataset that formed the foundation of this study.

4.1 Analyses

Drawing upon this qualitative survey dataset, we explored how analogue learning games influenced the students' creative learning processes. According to Braun et al. (2021) qualitative surveys offer something unique within qualitative data collection methods - both the opportunity to have a wide-angle lens and get rich and focused data (p. 643). Our analysis employed an inductive approach (Hatch, 2002) grounded in sociocultural theoretical principles, which guided the formulation of survey questions, and the interpretation of how analogue games stimulate creative learning. This was complemented by a hermeneutical interpretation method, as recommended by Kvale and Brinkmann (2009, pp. 213-218), allowing for a deeper understanding of the textual data. The research team analysed the transcripts from the surveys, focusing on responses to open-ended questions and integrating observations to identify meaningful themes relevant to our research question. Through this rigorous examination, we categorized the data into several key themes that describe the influence of analogue games on the participants' creative learning processes. These categories included Active Engagement, Physical and Interactive Elements, Social Interaction, Innovative Thinking, Fun and Safe learning environments, and Deep Reflection. Once these categories were established, we synthesized our findings to present a comprehensive view of how analogue games enhance creative learning, detailed in the results section.

4.2 Findings

The study revealed that analogue games influenced the creative learning processes through: *Active engagement* and *Social interaction*. Further, we found that the physical and interactive elements of analogue games were encouraging various perspectives fostering *Innovative thinking* and *Deeper learning*. However, participants indicated that the success of game-based learning activities hinged on the creation of *a safe setting*, which are essential for stimulating creative learning processes.

The first finding was that analogue games influence the creative learning processes through active engagement: Analogue games, by design, require participants to be physically and mentally present, fostering a hands-on and minds-on approach to learning. This engagement is not merely about keeping students busy; it's about deeply involving them in the learning process, encouraging them to explore, question, and connect with the material in a meaningful way.

One of the participants reported: "By playing together with people of different backgrounds, ages, and professions, we learn from each other in conversation."

The findings reveal that analogue games excel in making the learning process interactive and engaging, fostering an environment with active and also emotionally and intellectually invested students.

The second finding was on how creative learning happened through Social interaction. Through the collaborative gameplay, the students negotiated and shared ideas. The students reported: "Social interaction during games can lead one to question their immediate thoughts and think anew."

Another response was this: "By being forced to think in new ways, one also gets to exercise creativity. Additionally, receiving input from others (both people and processes) can change one's own mindsets and ideas."

Analogue games foster a collaborative environment where social interactions contribute significantly to the learning process, enhancing it through continuous peer engagement and communication.

The third result was that analogue games seemed to influence creative learning processes leading to Innovative thinking. Sparked by the creative challenges connected to Data literacy presented in the analogue games, this pushed the students beyond traditional learning boundaries. The students navigated the rules and strategies within games. In this way students were encouraged to think outside the box and apply knowledge in new and imaginative ways.

The students reported that the games helped them to: "…Think outside the box and see the whole picture in other and new ways, and also 'go deeper' (deep learning)". This form of learning is also crucial in today's rapidly changing world, where the ability to adapt and innovate is as important as the knowledge itself.

Fourth, the exposure to diverse perspectives, enriching the learning experience by incorporating a variety of viewpoints, resulted in a deeper exploration of topics. Through gameplay, the students reported that the games led to deeper learning: "The games contributed to better and deeper learning of the course content – we needed to apply the theoretical knowledge in a practical setting".

Fifth, the results showed that there were some underlying conditions involved for the adult students to succeed with their creative learning with games. The effectiveness of game-based activities relied significantly on creating an environment that fostered fun and safety. The students expressed that: "Good, safe frames for the game setting, even if it was hard , it was "not important" to win"

Further, the students reported that it was fun to play games: "It was fun to play in groups. I enjoyed that the games were analogue – gave more room for discussions and social interaction."

Such a fun and safe setting was paramount for unlocking the creative potential within participants, as it encouraged them to share ideas without fear of judgment. This atmosphere enabled them to speak their minds, which is a crucial component of the creative process. In these environments, students felt supported in exploring novel concepts and engaging in discussions around data literacy, leading to a richer learning experience.

5. Discussion

In this section we will discuss how the analogue games influenced creative learning processes through: *Active engagement* and *Social interaction*. Further, how these were fostering *Innovative thinking* and *Deeper learning*. Finally, we will discuss how some conditions were involved in the success of creative learning: *the creation of a safe setting*, and present a visualization of the processes: "Psychological safety in Creative Learning Processes through analogue games". (See figure 1).

5.1 Active Engagement & Social Interaction

The findings underscore how the analogue games promoted active engagement among the participants. By requiring physical and social presence, these games created a hands-on learning, tactile environment that

encouraged the students to engage deeply with content. This goes beyond keeping participants occupied; it shows the potential to involve them profoundly in the learning process, through prompting them to explore, question, and connect with each other and the material in meaningful ways.

Quotes from the data suggest that playing with individuals of varying backgrounds enhances mutual learning. The playful nature of games contributed to making tasks more enjoyable and intellectually stimulating, which in turn supported engagement and learning as a socially mediated process (Vygotsky, 1981). We interpret the analogue games as mediating artifacts facilitating interactions between students and the educational content (Plass, et.a., 2019). The games used in the data literacy workshops served as both cognitive and cultural tools, bridging the gap between abstract concepts and tangible experiences. The diversity of backgrounds among the students brought various cultural perspectives into the game, enriching the learning experience. As expressed by the players the game can introduce new ways of thinking and understanding, contributing to a richer, more comprehensive collective knowledge base. Active engagement opens up for creative learning (Beghetto, 2016; Mestre et al., forthcoming). In other words, the findings align with previous studies that indicate playing analogue games can, in particular, nurture soft skills such as creativity, whilst supporting the call for further research into the potential for analogue games to enhance the learners' ability to absorb and integrate new knowledge (Sousa, et al., 2023).

The findings also highlight social interaction facilitated by analogue games. Quotes indicate that being challenged to think creatively and receive inputs from others can transform one's own ideas and thought processes. For instance, questions raised during gameplay encouraged rethinking of initial assumptions. As such, gameplay can help students to collaborate and learn creatively through sharing ideas and exposure to diverse perspectives. This aligns with Vygotsky's (1981) Zone of Proximal Development (ZPD), where learning is optimized through collaboration with more knowledgeable others . G ames have the potential to facilitate this zone (Plass, et.a., 2019), shown in our data through the students' reporting the exchanging ofideas. This collaboration provided a scaffold for students, allowing them to achieve more than they would independently. In this case, the adult students came from different backgrounds and could thus shift on the role of being the more knowledgeable other (Ness, 2016).

5.2 Leading to Innovative Thinking and Deeper Learning

Continuing education students reported that analogue games enhanced their ability to think outside the box and apply knowledge in innovative ways. As they played, the diversity within the groups introduced new perspectives that stimulated creative knowledge processes. Creative knowledge processes pans from generating entirely new ideas to recombining existing knowledge into novel outputs (Ness & Søreide, 2014). Typically, such creativity at the 'little c' level involves minor personal insights, while transformative 'big C' creativity impacts broader societal domains significantly (Kaufman & Beghetto, 2009; Craft, 2000). Although the students mainly engaged at the 'little c' level during games, these interactions are crucial for fostering 'big C' creativity and innovation. The gameplay also prompted participants to challenge conventional thinking, which in turn fostered a culture of innovation and critical inquiry. This demonstrates how analogue games can catalyse creative and innovative thinking, encouraging students to reimagine knowledge in new ways. The shared cultural tools and symbols within the games allow students to construct new meanings and solutions, a process deeply embedded in the sociocultural context of learning (Plass, et.a., 2019).

Moreover, the tactile and interactive aspects of analogue games promoted deeper group discussions, enhancing understanding of data literacy. Such dynamics align with Medeisiene et al. (2021), who noted that game-based learning significantly boosts engagement and satisfaction. The tangible elements of these games not only enrich the learning experience, but also underscore the sociocultural importance of tools in cognitive development (Plass, et.a., 2019)., thereby deepening students' comprehension and facilitating a more engaged and creative learning environment.

5.3 A Need for: Creating a Safe Learning Environment

The students emphasized the importance of creating a safe and supportive environment where winning is not prioritized, underscoring the critical role of psychological safety in learning environments (Ness, 2020; Edmondson, 2018). Such an environment fosters sharing of ideas, essential for creative learning, and necessitates proactive educator involvement to engage students fully. Observations during game sessions revealed that laughter and humour reduced apprehension about speaking up and encouraged open sharing, enriching discussions. Games have been argued to foster safe learning spaces through introducing new rules and

novel options for interaction (Whitton, 2018). Frossard, Barajas, and Trifonova (2012) note that games enhance creative learning environments by promoting question-asking and incorporating humour. Friendly interactions, positive emotions, expressed through laughter, significantly enhance learning experiences by facilitating emotional bonds among participants (Ness, 2020; Klykken, 2023). Research by Crocco et al. (2016) indicates that enjoyment during lessons correlates with deeper learning outcomes, enhanced whether games are used or not. Craft and Wegerif (2006) also describe collaborative creativity as involving both verbal and non-verbal communication, contributing to deeper interpersonal connections.

The facilitation team's awareness of maintaining a positive environment encouraged everyone's active participation. Marjanovic-Shane et al. (2010, p. 225) argue that well-organized learning settings support emotional and relational dynamics conducive to creativity. Positive relationships stimulate risk-taking and creativity, leading to significant insights and achievements within the learning community (Ness, 2016).

Taken together, analogue games appeared to influence creative learning processes through their tactile nature expressed as Active engagement and sharing ideas in Social interaction, leading to innovative thinking and deeper learning of the course content on Data literacy, aided by psychological safety. (See figure 1).

These observations resonate with Medeisiene et al. (2021), highlighting the pedagogical value of game-based learning in enhancing engagement. The interactions not only boosted creativity but also deepened understanding and retention of Data Literacy content. This study underlines the importance of thoughtful integration of analogue games into curricula to optimize their educational impact for Continuing Education students.

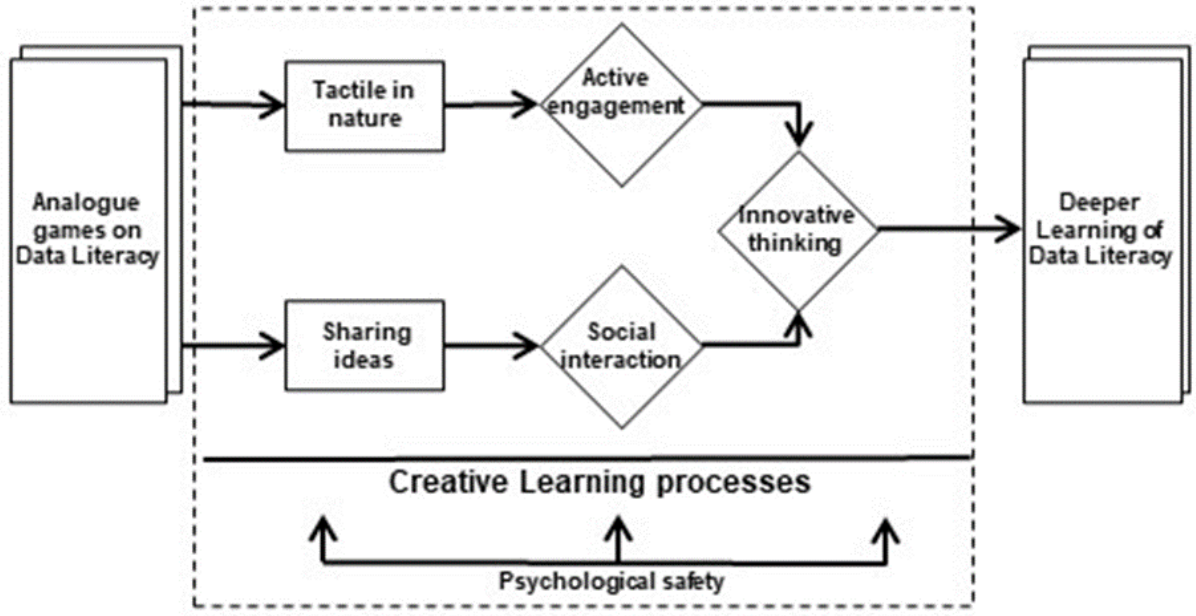


Figure 1: Deeper learning of Data Literacy through Creative Learning Processes in analogue games

6. Implications and Conclusion

Our study underscores the importance of context and facilitation in leveraging the educational benefits of analogue games, highlighting the educator's role as pivotal. From a sociocultural perspective, educators structure the learning environment to foster exploration and creative learning and ensure inclusivity and psychological safety. This strategic approach appears to contribute to the analogue games potential to enhance continuing education programs by promoting a collaborative and engaging learning environment. The study underscores the multifaceted benefits of analogue games in a course on data literacy, highlighting their potential role in promoting active engagement and social interaction, leading to more innovative thinking and deeper learning. Crucially, the success of these game-based activities depends on establishing a safe atmosphere, thereby enhancing the educational experience significantly. The findings suggest a promising avenue for further exploration into using analogue games in educational contexts. The study concludes with advocating for conducting more research on the integration of learning games into continuing education curricula as a strategy to leverage the benefits of social interaction and active engagement, to enhance creative learning processes that can deepen learning of course content.

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What Educational Escape Rooms can Learn from the World's Best Rooms

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Abstract: In the context of playful learning, escape games have the potential to enrich learning experiences through interactive problem-solving and narrative engagement. However, educational escape games differ significantly from the commercial offerings they reference in name and game mechanics. They often draw on the concepts of escape rooms that were popular a decade ago, relying primarily on traditional puzzle types such as code deciphering and number locks. Meanwhile, commercial escape rooms have evolved significantly over the past ten years, now offering highly immersive experiences based on captivating stories, convincing scenographic presentations, and well-thought-out tension arcs. Each year, enthusiasts vote for the top 100 escape rooms in the world. To investigate which best practices from these rooms can be applied to educational games, my master's thesis, which forms the basis of this paper (Neubig 2024) analyzed 38 of these award-winning games in detail. This analysis covered the gameplay, puzzle typology, room design and player guidance, as well as interactions with the game masters. Significant patterns were identified in all these areas that can be utilized in the design of educational games. Simultaneously, it reveals the types of challenges that the world's best games almost entirely avoid, despite their popularity in educational games. The study provides detailed insights into the diversity of puzzle types used, their variations throughout the game, and identifies particularly effective puzzle combinations. Escape games as a method of knowledge transfer have been adopted worldwide in schools, universities, museums, and libraries. They are used in various ways, such as recruitment tools, as orientation aids for institutional services, or to promote specific or generic knowledge and skills (Veldekamp et al. 2020). This work emphasizes the necessity to adapt educational games to the latest developments in the escape game industry if they are to be classified within this genre. In doing so, they can fully leverage the potential of escape games to create an engaging and motivating gaming experience.

Keywords: NextGen Educational Escape Rooms, Game-based learning, Puzzle Types and Factors, Spatial Elements and Effects

1. Introduction and Background

Escape rooms are now a popular leisure activity available in practically every city: you book a slot with a provider and then try to escape the room within about an hour by solving tasks. Nowadays, the versatility of the genre is hinted at by the broader term "games," although for recognition purposes, the original term "escape" has been retained, despite most games no longer involving an escape scenario.

An escape game is an interactive game in the real or virtual world where a group solves various puzzles and challenges, experiencing a scenario with a clear objective.

The group solves puzzles, combines clues, or completes tasks. For planning reasons, the game is often time-limited, but time pressure is not an essential component. No preparation or prior knowledge is needed, but participants are supported with hints if they get stuck. Players are guided by a game master who explains the rules and assists with any uncertainties during the game. To motivate players, it is crucial to present a clearly defined goal from the start. This goal may organically change during the mission but serves as a starting and orientation point for those embarking on a new mission.

Commercial escape rooms have significantly evolved over the past ten years, now offering highly immersive experiences with captivating stories, convincing scenographic presentations, and well-thought-out tension arcs.

Since 2018, the best escape games have been awarded annually in the "Top Escape Rooms Project Enthusiasts' Choice Awards" (TERPECA). Only enthusiasts—those who have played at least 200 escape games—are allowed to nominate games. Individuals with over 100 verified games can then rate the nominated games. In 2023, 1,114 enthusiasts with a total of 314,782 played rooms participated in this evaluation, providing a representative overview of the most popular rooms worldwide. It is worth noting that the rated rooms are still predominantly located in Europe, Australia, and the USA/Canada, despite escape games being a global phenomenon.

This paper investigates the best practices from commercial escape rooms to improve the design of educational escape games.

2. Research Design

In analyzing 38 rooms that have won TERPECA awards over the past three years, I identified both similarities and differences. The rooms were anonymized for the thesis as content confidentiality is crucial in the escape room community. These rooms qualified as exemplary through their ranking positions.

The following aspects from game theory were closely examined in the analysis:

Gameplay:

- Player reception and game conclusion
- Dramaturgy and associated intensity curve
- Presence and use of a feedback system
- Hint delivery and interaction between game masters and players

Room-Related Elements:

- Game path guidance
- Number of rooms
- Use of effects
- Physical challenges for players due to structural features
- Special spatial situations (e.g., darkness, isolation)
- Measures to enhance immersion

Story Design:

- Narration
- Act structures in the experienced story
- Existing roles for players or game masters

Puzzle Factors:

- Number of intermediate steps (Micro loops)
- Types of puzzles used
- Preferred combinations of puzzle types
- Puzzle sequence progression
- Use of meta-puzzles

The content spectrum of the games ranges from fairy tales to horror experiences in abandoned factories. They vary greatly in game duration and character interaction but are characterized by attention to detail and skillful use of audiovisual effects. TERPECA rooms also set new standards in narrative, confronting players with complex stories and not necessarily offering a happy ending even if the game is completed on time.

3. Findings

3.1 Gameplay Structure

Typically, players are greeted, informed about their mission (macro mechanic), and then solve a series of smaller challenges (micro mechanics) to ultimately complete the mission. They are then received outside the scenario and, after a brief closing conversation, returned to reality. This pattern is also evident in the 38 analyzed games, differing only in minor details.

3.1.1 Greeting

Players are welcomed by the game master, who introduces them to the game world and explains the rules. They receive all important facts, the scenario, and their roles in advance and are welcomed as part of the scenario. Safety instructions are given in a way that does not break the illusion. Only 24% of the analyzed games had a non-integrated greeting by the game masters. Winning rooms distinguish themselves by giving more importance to immersive introductions, with 76% welcoming players as part of the game and 53% additionally using an embedded audio or video message to introduce the game.

3.1.2 Micro Mechanics in the Game

Upon entering the game, players encounter an insurmountable obstacle referred to by Erol Elumir as a "gate" (Elumir 2019). These barriers are often locked doors or boxes. Players look for clues that are ideally visibly connected to the gate, combine them, and solve the puzzle as a team to overcome the gate. This leads them to new clues, game items, or rooms needed to overcome the next gate. The three steps of micro mechanics can also be divided into Discover/Infer/Act, as Jon Ingold suggests in his analysis of narrative-heavy detective games (Ingold 2022). Like video games, players usually remain in this loop until they successfully complete the task (Bauer 2018). This micro loop typically lasts between 4 to 8 minutes. All analyzed games applied the described micro mechanics. The number of micro loops (which equal puzzle intermediate steps) varied significantly, averaging 15 intermediate steps per 60 minutes of gameplay. Horror-themed games required fewer intermediate steps (six to ten per 60 minutes) compared to story-driven games.

3.1.3 Macro Mechanics of the Game

Players often receive an overarching quest with a predefined goal. In a 2015 survey of escape room operators, the most common answer was escaping from an unpleasant place and the second goal was scenarios with abstract tasks and no overarching narrative (Nicholson 2015). An analysis of over 450 scenarios in Switzerland revealed that games without a quest goal no longer exist. Escape scenarios still top the list (16%), closely followed by scenarios involving retrieving an object (15%), a scenario not mentioned in Nicholson's study.

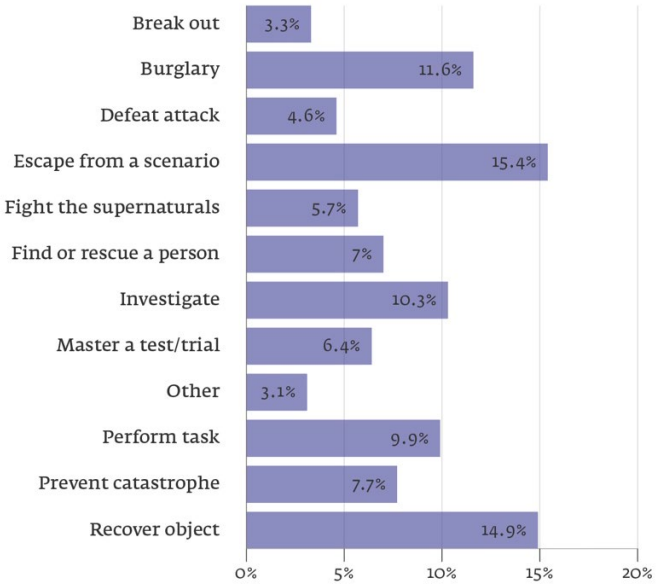


Figure 1: Scenario goals of 451 Swiss escape games

It should be noted that the analysis always refers to the apparent or communicated goal. In many of these rooms, the goal will change during the game. To achieve this overarching goal, players repeatedly perform the cycles of micro mechanics, which are connected by a narrative frame, until they approach the final goal. It is important that the group truly earns their success. It is possible that an escape game will not be solved before time runs out and will then end without a successful conclusion. This can have a negative impact on the narrative.

3.1.4 Transition to Reality

After completing the game scenario, players are usually (84%) greeted by the same person who welcomed them at the beginning. This person is no longer part of the game but serves as the host, congratulating players on their success or consoling them in case of failure, clarifying open questions, and reviewing the gameplay. In 95% of cases, team photos are taken as souvenirs.

3.1.5 Tension Levels

The analysis of the 38 games revealed recurring patterns in intensity and tension curves. Tension is often intense from the start, driven by players' expectations and possible fears about the upcoming game, which is further heightened by a driving atmosphere and narrative pressure. This allows for a quick and direct immersion into the

story, with players less likely to question the events and more focused on the mission. Even games that start calmly and "safely" often have a twist within the first few minutes that shifts the story in an unexpected direction. This method of unreliable narration helps involve players more quickly in the game.

Games typically provide moments of calm after nerve-wracking passages, allowing players to reorganize their thoughts. This mix of challenging moments and reward situations (Schäffer 2014) ensures that players do not rush through the game mindlessly but remain aware of the story and atmosphere. Another identified pattern is that the most challenging moment of the game occurs just before the end, giving players time to process the climax while still in the game before returning to reality. Players often describe room transitions as particularly exciting.

3.1.6 Difficulty Level

Compared to other commercial games, the puzzle difficulty of TERPECA rooms is relatively low. This is usually due to well-thought-out game design, where the group always knows what they are working on due to clear connections between clues and gates. Additionally, the puzzle components are well-tested and adjusted, resulting in little frustration for players and maintaining the flow. Few rooms on the TERPECA list boast a low success rate for groups.

All games begin with relatively simple puzzles to familiarize players with the designers' thinking, similar to a tutorial level in a computer game. After the easier introduction, the difficulty gradually increases, peaking just before the middle. At this point, players already know what the game expects of them and still have enough mental freshness to be intellectually challenged. The difficulty then decreases again, allowing players to feel capable until the end. Horror-themed games almost entirely avoid complex puzzles as players have less capacity for complex thinking while simultaneously fearing for their lives.

3.1.7 Feedback Systems

All rooms have their game masters integrated as hint providers within the game. In 89% of scenarios, the game master is part of the game and communicates within the game world. 76% welcome players in character and introduce the contact person for questions. Communication methods vary: classic walkie-talkies are used in only five games, while specially designed devices (45%) that assist with the quest are often provided. 66% of rooms have a direct feedback system for correctly performed actions, triggered by another action in the game or by visual or acoustic signals. This teaches players that correct solutions trigger confirmation. Hints can be provided in video, text, audio form, or by directing attention: a light or sound highlighting an area in the room can guide the group in the right direction.

3.2 Spatial Elements and Effects

In all analyzed games, players move through classic interior spaces, which vary greatly in floor area. Games over 100 m2 are notably large, often located in outer districts or industrial areas due to space requirements.

3.2.1 Rooms and Hidden Connection Doors

The number of rooms in the analyzed games ranges from five to ten rooms per hour of gameplay, with an average of six rooms. Smaller half-rooms, such as crawl spaces, are counted as half. 76% of rooms have 40% or more of their doors hidden, playing on the uncertainty of where the room continues. About 70% of analyzed rooms use intermediate floors and different height levels to further disorient players spatially.

3.2.2 Lighting

Light is used strategically to guide players through the room or to the right spot. Most games (82%) use dim lighting at least temporarily to create atmosphere. A third of the rooms have moments of complete darkness, challenging the sense of touch or patience until the light returns. Only safety instructions such as panic buttons, escape routes, and exit doors are marked with official signage.

3.2.3 Room Effects and Physical Challenges

37% of analyzed escape games use movable walls, floors, or ceilings, prioritizing player safety. In 63% of games, players must climb over obstacles, and 82% of rooms have passages requiring players to crawl. Seven rooms have situations where players can get wet, and 14 rooms have active hiding spots. In 13% of rooms, a previously

opened door no longer leads to the same room, and in 18% of scenarios, it is the same room but in a changed state. Sometimes running is appropriate (24%), but caution is advised as the floor is often uneven (34%). Another special feature is rooms that surprise players with a slide (16%).

These physical challenges mean that the games are hardly playable for people with significant physical limitations or wheelchair users. Only one game among the 38 seems to be fully accessible, with two more offering to omit certain challenging passages upon request. In a quarter of the crawl passages, only one person needs to be able to crawl through a narrow passage. Many providers inform about expected obstacles on their websites. Nonetheless, these special spatial elements that attract some players exclude certain groups.

3.2.4 Immersion and the Use of Sound and Effects

Sound effects and appropriate background music are used in all analyzed games to enhance immersion. Similarly widespread is the use of artificial fog (84%). Artificial weather situations such as wind, rain, or artificial snow are occasionally found in rooms, while around a quarter of games incorporate larger water sources. Half of the games (50%) use scents or build their sets with materials that naturally smell appropriate. 37% use pyrotechnic effects to make the scenario more realistic. In six scenarios, room temperature is deliberately changed to make the experience more authentic.

It may be tempting to reduce the room to only the necessary items to be used. However, this is at the expense of immersion and the joy of discovery. The analyzed TERPECA rooms have shown that this reduction is not useful. On the contrary, the desired action can only be performed if the room design presents it as clearly as possible: "a hide-and-seek game needs hiding places, and an adventure game needs an environment worth discovering" (Götz 2018). As long as player guidance is clear and unambiguous, the game can be both dense and atmospheric without losing orientation.

3.3 Storytelling

Escape games follow traditional narrative structures but the game's actions are only narratively significant if they can be attributed to human motives and it is clear who initiated the action and who benefits from it (Götz 2023). Players should identify with both the story and the mission. The narrative should not be obvious and predictable from the start. Games are often narratively intriguing when players gradually piece together the story from found clues and information snippets (Suter 2021). This structure, where players must assemble what exactly happened over time, is used in over half the games. Moreover, a story thrives on moments of challenge, subsequent reward, and periods of calm.

3.3.1 Roles of Players and Game Masters

In 76% of the analyzed games, the group is welcomed in a fitting role, often that of the mission giver. This way, players learn what is expected of them during the adventure as part of the game. In about half the games, the game masters were present as actors to give small tasks or hints or represented the antagonist. 53% of rooms used costumes, with every fifth room also dressing up the players. Moreover, over two-thirds of players receive mission-related items like scanners, occult devices, or communication tools such as phones or walkie-talkies.

In 61% of cases, players are engaged as experts for the upcoming mission. The game master grants them basic competence in the problem to be solved. When the assigned role requires significant expertise (e.g., trained ghost hunters or FBI agents), it is made clear from the start that it is an exceptional situation requiring special problem-solving. This prevents the group from being overwhelmed. Sometimes, the group is simply at the right place at the right time, such as when they unexpectedly find themselves in a situation instead of an expected job interview.

3.4 Puzzle Factors

In the detailed examination of the 38 games, over 1,500 individual puzzles divided into 718 puzzle intermediate steps (micro loops) were analyzed. These were classified into 19 different puzzle types. The analysis allows conclusions regarding the types of puzzles used, the most popular combinations, and the number of puzzle intermediate steps in relation to game time.

3.4.1 Classification into 19 Puzzle Types

The preliminary analysis of 50 escape rooms identified 19 different puzzle types. The subsequent detailed analysis of the 38 TERPECA rooms showed their frequency during a game and the different combination types used. All occurring puzzles can be fully classified into these 19 types.

Examining the puzzle types reveals differences in terms of combinability of multiple puzzle types, story potential, frustration potential, required teamwork, contribution to tension, necessity of communication, and whether the puzzles are physically or mentally demanding. Depending on what a puzzle aims to achieve, different types may be more suitable.

- **Assembling**: Putting together several components to form a whole.
- **Assigning**: Recognizing patterns or connections and abstracting this knowledge to find the solution.
- **Counting**: Counting elements in the room that have a specific feature.
- **Decoding**: Applying a key and method to decode a message to obtain a solution. The work of decoding is usually elaborate and time-consuming.
- **Dexterity Exercise**: Performing a task that requires precision and control over a longer period.
- **Finding Features in the Room**: Recognizing or finding deviations or features in the room that might be significant for a puzzle. Through this, players learn to decide which aspects are relevant.
- **Finding Objects**: Searching for and finding hidden objects or information in the game area.
- **Following Instructions**: Players follow a step-by-step guide.
- **Identifying Anomalies**: Players become aware of elements that deviate from a norm.
- **Logical Puzzles**: Solving a logic puzzle through deductive reasoning.
- **Mathematical Puzzles**: Solving a challenge that requires mathematical thinking and numerical understanding.
- **Memorizing**: Memorizing sequences or information.
- **Narrative Elements**: Players consume and interpret parts of the story based on puzzle components, often in the form of documents, audio files, and videos. These can include relevant parts for progression or aspects of the backstory.
- **Ordering**: Arranging a set of objects in a specific, intended order.
- **Performing a Task**: Completing a clearly defined task that requires no further interpretation.
- **Physical Challenges**: Completing physical challenges to overcome an obstacle and reach the solution.
- **Role-Playing**: Players interact in their role, for example, in dealing with an acting person.
- **Separated Communication**: Players are spatially separated and have access to parts of the necessary information, which they must describe to the other person as clearly as possible.
- **Using Senses**: Players need to touch, smell, taste, or listen closely to solve the task.

Designing a good puzzle involves many challenges. Players must first understand that it is a task for them to solve. According to Breda, Cable, and Laurutis, most locks they encountered require two pieces of information: the numbers to use as the code and their sequence (Breda/Cable/Laurutis 2022). Closer inspection shows that designers need to provide additional information, even if self-explanatory or intuitively grasped.

- What is the players' current goal?
- Is this lock part of that goal/puzzle?
- How do players recognize what are clues in the game?
- Do these clues and this specific lock belong together?
- Do players know when they have all the clues needed to solve the puzzle?
- What must they do to arrive at the correct answer (the numbers)?
- How do they input their solution into the lock (sequence and additional steps like pressing certain buttons on a digital lock)?
- What are the consequences of entering an incorrect solution?
- Do they recognize when they have solved the puzzle correctly?

Geers also emphasizes in his talk on high-quality escape games: "Time should be spent solving the puzzle – not finding out what the puzzle is" (Geers 2019). Mark Brown goes even further, stating that players should clearly know what they need to achieve in a puzzle game: "The player shouldn’t be figuring out what to do - just how to do it" (Brown 2018). Many designers initially approach this skeptically, fearing it would hand-hold players through the experience. However, the point is to encourage players to actively engage and motivate solution-oriented thinking by finding the path to the solution.

3.4.2 Frequency of Puzzle Types

The analysis of over 1,500 individual puzzle types showed "Performing a Task" (16%) as the most common type, followed by finding objects (15%) and recognizing features in the room (14%). These three types combine well with others, leading the list of puzzle combinations involving two or three types. Noticeably, many puzzle types favored in educational contexts are rarely or never used in award-winning rooms. The puzzle type "Decoding" (cryptography) appears only once, while mathematical puzzles (math puzzles) make up just 1% (Nicholson/Cable 2021). Popular museum game puzzles like "Counting" (0.3%) and "Ordering" (0.6%), and the often-used "Memorizing" (1%) in learning games play a marginal role. Here, educational games can evolve: the high quality of puzzles in escape games offers immense possibilities for modern, entertaining educational games.

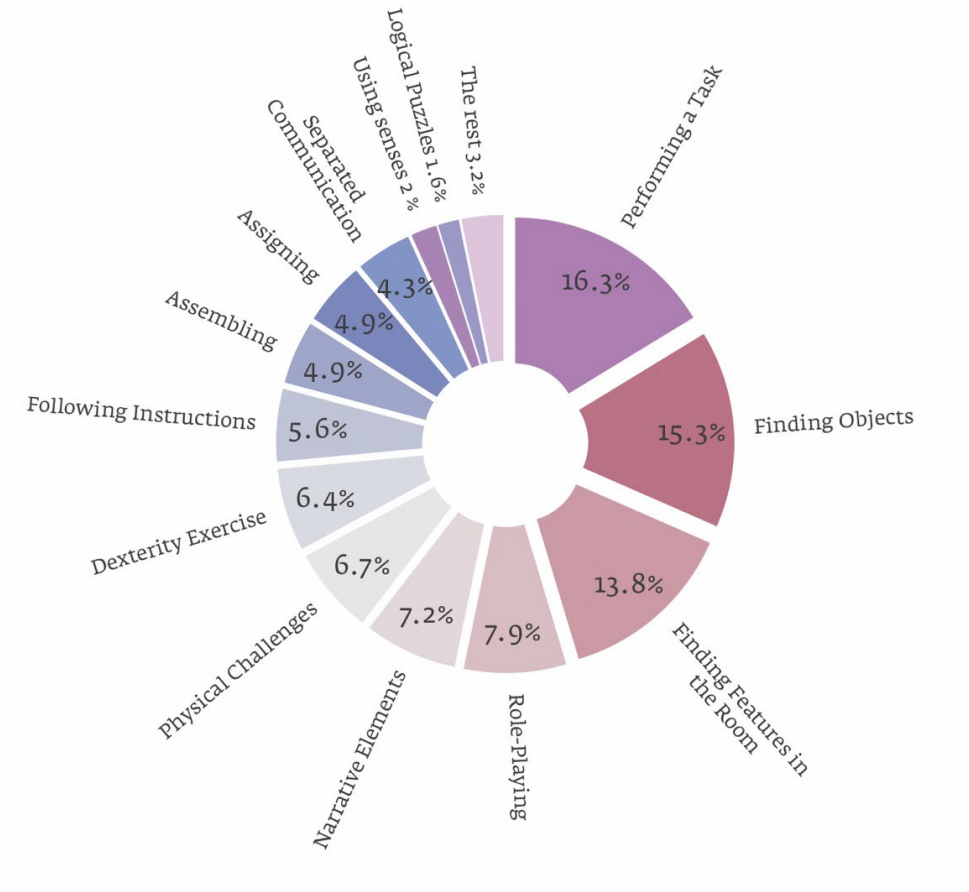


Figure 2: Distribution of puzzle types in 38 TERPECA escape games

3.4.3 Puzzle Intermediate Steps

Micro loops in an escape game are always a series of interconnected puzzle types that players must solve to progress. In 26% of cases, an intermediate step consists of only one puzzle type. Popular choices for these are role-playing (22%), dexterity exercises (15%), performing a task (15%), finding objects (14%), and physical challenges (14%). These tasks often require full concentration or can involve multiple people simultaneously.

40% of puzzle intermediate steps consist of a combination of two types, 27% from three types, and only 6% from four different puzzle types. The most common puzzle combinations include "recognizing features in the room," "finding objects," and "performing a task," leading both the two-type and three-type combinations.

"Finding features in the room," "Finding objects," and "Performing a task" lead both the two-type and three-type combinations. The 40 most common puzzle combinations are also those that have appeared at least four times.

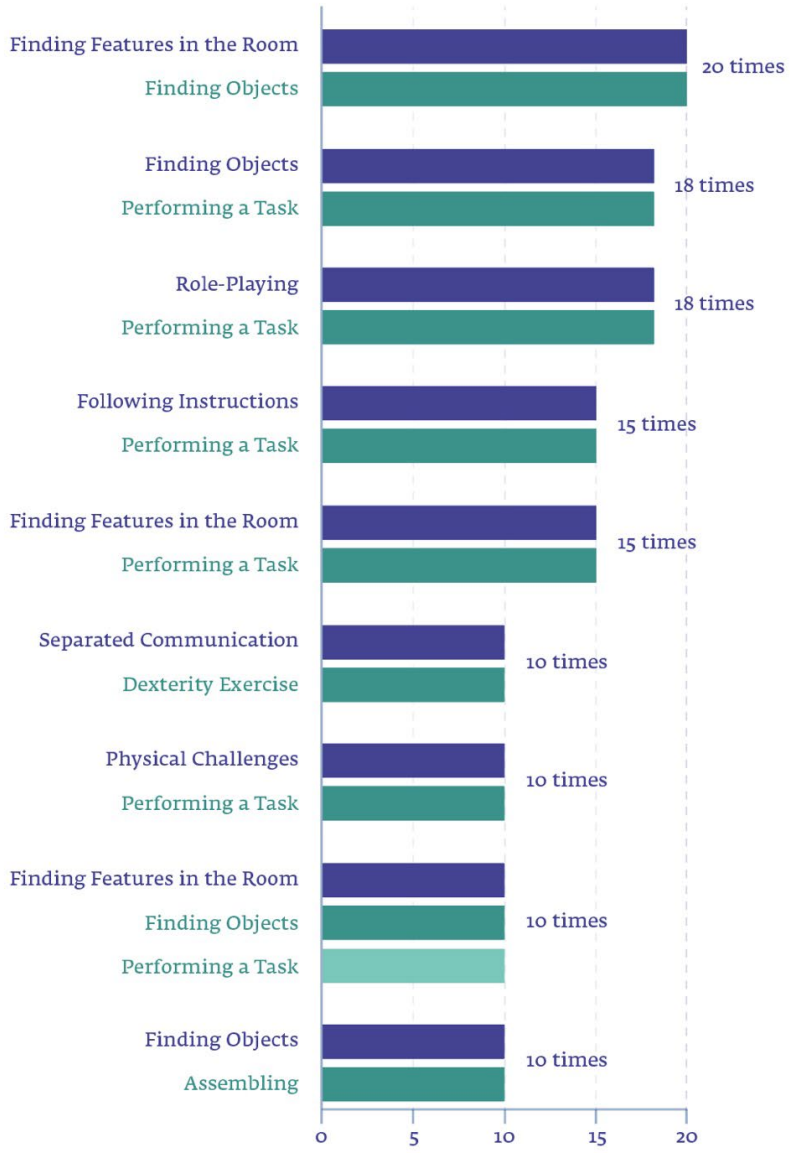


Figure 3: The most common puzzle combinations

It is crucial to ensure that a puzzle has only one solution, guiding players to the predetermined outcome and the intended path. Playtesting and observing test subjects often reveal unexpected solutions not anticipated by the designers. Consistent puzzle design within the established game world and learned mechanics is essential. Designers must see themselves as supporters of the players, with the primary goal of creating a coherent and fulfilling gaming experience.

The development of a learning game is a balancing act. Many new designers tend to want to pack too much content into a game (Boller/Kapp 2017). This often comes at the expense of fun and leads to overly complex processes.

For learning games, two puzzle types should be highlighted. Separated communication fosters team cohesion and is easily implemented in educational settings by ensuring not all participants see all information simultaneously. Logical puzzles, although infrequent in the analyzed rooms, are highly valuable for knowledge transfer, promoting deep content engagement through deductive reasoning.

3.4.4 Which Puzzle Type Suits Which Learning Content?

In 1956, Benjamin Bloom published a framework for categorizing educational goals, which was revised in 2001. According to Fotaris and Mastoras, educational escape games can cover all six categories of cognitive processes

in Bloom's taxonomy. Puzzles can be designed for players to understand concepts, apply knowledge, analyze information, evaluate solutions, and create new ideas (Fotaris/Mastoras 2021).

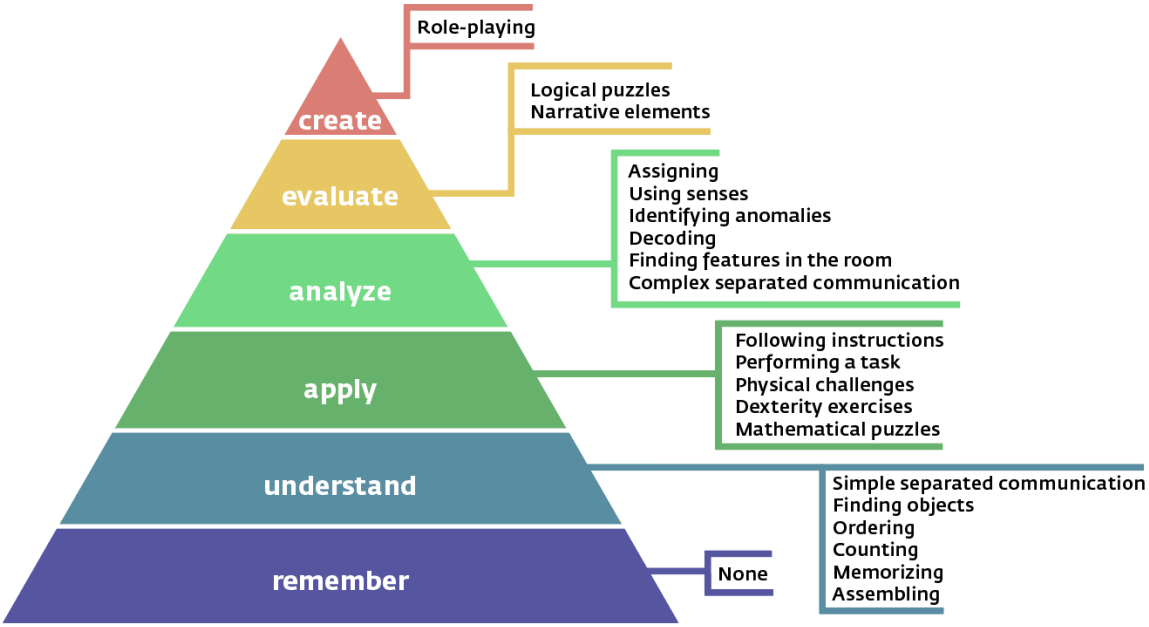


Figure 4: Ordering of puzzle types in the revised Bloom's taxonomy according to Krathwohl

(Adapted from Vanderbilt University Center for Teaching, 2022)

This also applies to the 19 puzzle types. Due to their diversity, they can be assigned to the individual steps of Bloom's taxonomy.

Remember Players recall facts and information from outside the game to solve puzzles. This aspect of recalling factual knowledge is only present if the educational game requires prior knowledge not found within the game itself, which goes against the principle of classical escape games.

Understand Players restate ideas and concepts in their own words, identify and describe problems. They understand the game mechanics, recognize clues, and as a group comprehend which points in the game are relevant for progress.

Apply Players apply their newly acquired knowledge to a context and begin solving problems (puzzles). Tasks are performed, and information is linked.

Analyze Players relate information to each other or break it down into parts to find causes. They experiment, combine objects and knowledge, question, and test them.

Evaluate Players evaluate information, weigh it by importance, and develop new approaches.

Create This point is only reflected in one puzzle type: role-playing. In this puzzle type, players make decisions, develop stories, and adapt knowledge to future situations, which promotes high self-responsibility.

The Swiss curriculum divides learning competencies into knowledge, skills, and will. Knowledge includes understanding what students need to solve a task, skills include the ability to apply this knowledge, and will includes the willingness to acquire and use the first two. That corresponds also to Bloom's taxonomy and the principles of escape games: acquiring knowledge, applying it, and being motivated to use it.

4. Conclusion

It is challenging to adapt an educational game to match the level of a commercial offering. But by following a few principles, it is possible to improve the quality of the game: Designers must consider from the start how the game ties together with a story, how to incorporate various puzzle types, and how the interaction with the game master will look. Many spectacular effects in commercial rooms can be adapted using simple tools like remote-controlled lights and music. Additionally, designers must plan how to integrate direct confirmation of correctly solved

puzzles without relying solely on frequently used number locks. The knowledge content should not be too complex, but the puzzle mechanics must fit the content.

Escape games offer great potential for all forms of educational institutions. This study has shown that it is worthwhile to take an extra step and expand these games into immersive experiences. While this requires significant effort from designers, only then do the games reach their full potential. On the developers' side, this means being willing to perform tasks during the game that sophisticated technology would handle in commercial games. However, with the targeted use of light, sound, and well-designed props, it is possible for an individual or small team to create an immersive experience, whether in a museum or a classroom.

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Game-Based Learning as a Tool for Teaching Ethical AI to Youth: Insights from the CHARLIE Project

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Abstract: The pervasive influence of Artificial Intelligence (AI) and Machine Learning (ML) technologies in everyday life has underscored the critical need for addressing inherent biases in big data. The CHARLIE project, an *"ERASMUS+ KA2"* initiative involving six partners across five European countries, is a beacon of innovation in addressing the critical need for algorithmic biases and ethical education in AI and ML. Our project objectives centre on enhancing the capacity of Higher Education (HE) institutions to deliver socially responsible and ethically informed tech education, particularly in AI and ML domains. By integrating digital and engaging pedagogical strategies, we aim to increase tech students' social and ethical competencies and equip educators with effective tools for teaching these critical topics. CHARLIE focuses on cultivating an ethical, human-centered perspective in technology education, specifically targeting the youth demographic. One of the practical outputs from CHARLIE is the development of a competency matrix and the 'Algorithmic Bias' course. This course, designed with a blended learning approach and complemented by a 'Digital Game' to assess learning outcomes, is a testament to the project's real-world applicability. Additionally, the project focuses on creating effective linkages between HE, Adult Education (AE), and Youth sectors to facilitate widespread adoption and recognition of ethical AI curricula. This method is chosen for its potential to engage young learners in complex subjects by integrating learning with interactive, scenario-based gameplay that reflects real-world dilemmas. The games complement theoretical knowledge with practical decision-making exercises that promote critical thinking and ethical reasoning. Our paper will outline the development process of our digital games, discuss the pedagogical frameworks that underpin them, and share preliminary results from their implementation across various educational settings in Europe. We will also explore the broader implications of our work for integrating game-based learning in ethical tech education and its potential to transform educational practices in Higher Education, Adult Education, and beyond.

Keywords: Game-Based Learning, Ethical AI, Youth Education, Digital Games, Bias in AI, Technology Education.

1. Introduction

1.1 Background

Artificial Intelligence (AI) and Machine Learning (ML) are deeply integrated into our daily lives. These technologies influence numerous aspects of society, from facial recognition systems used in public security to algorithms determining the advertisements we see on social media. However, despite their mathematical foundations, AI and ML systems are not infallible; they often perpetuate biases in their training data. Addressing these biases is crucial, as large tech companies' widespread adoption of AI and ML—primarily driven by profit motives—raises significant ethical concerns.

Human bias, extensively studied by social scientists, emerges from implicit associations and unconscious prejudices. These biases can lead to adverse outcomes, from perpetuating stereotypes to reinforcing systemic discrimination. AI and ML systems, designed to make predictions based on existing data, inherently reflect and amplify these biases. Without an inherent mechanism for ethical decision-making, these technologies often perpetuate and exacerbate existing societal issues.

The sophistication of AI technology presents significant ethical challenges, necessitating stringent risk management procedures to ensure quality delivery. It is crucial to maintain flexibility that respects human values as AI advances, promoting sustainable innovations (Nguyen et al., 2023). In response to this need, UNESCO established global standards for AI ethics, endorsed by its 193 member countries on November 25, 2021. In the document presented, they acknowledge the "profound and dynamic" impact of AI while also highlighting the associated risks to cultural, social, and ecological diversity (UNESCO, 2021).

Incorporating AI tools in the educational sector has become a driving force in transforming learning experiences, encouraging innovation, and equipping individuals for the digital era. Despite this encouraging prospect of AI in education, there needs to be more literature addressing the ethical challenges involved (Abulibdeh et al., 2024). AI chatbots, like ChatGPT, have attracted significant attention and can alter various educational facets dramatically. Nevertheless, their implementation brings up ethical dilemmas, necessitates the redesign of curricula, calls for strategies to facilitate ongoing learning, and requires synchronization with industry norms. Additionally, although it is widely recognized that education must align with the changing demands of Industry 4.0, there still needs to be more research on how academic institutions can effectively partner with industries to close the gap between education and industry requirements. This encompasses ethical considerations related to AI-generated content, the development of students' critical thinking skills, the competencies of both teachers and students, concerns about data privacy, and potential biases (Abulibdeh et al., 2024).

Regarding generative AI, most created content is favourable or potentially beneficial to groups. However, a significant peril exists wherein these systems might inadvertently propagate profoundly harmful content. These emerging generative AI frameworks can propagate misinformation, distortions, prejudices, and hazardous content. It is crucial to note that with the advancement of generative AI tools, producing such content becomes cost-effective and more accessible. Furthermore, pre-existing harmful content could serve as a blueprint for generating even more harmful material (Fedele et al., 2024).

Trustworthy AI, in this sense, is the capability of an AI-driven system to optimize its advantages while mitigating and forestalling potential risks. This principle was initially outlined in the Ethical Guidelines for Trustworthy AI (EC, 2019), which outlined its three fundamental characteristics: legality, ethicality, and resilience.

1.2 Problem Statement

The European Commission (EC) has articulated a vision for "ethical, secure, and cutting-edge AI made in Europe," emphasizing the importance of human-centered AI development (EC, 2019). AI can potentially transform society positively by promoting gender equality, tackling climate change, enhancing health and mobility, and supporting sustainable development goals. However, to realize these benefits, AI systems must be developed and implemented in ways that prioritize human welfare, freedom, and the common good.

AI systems present significant opportunities and risks. To maximize their benefits and mitigate their risks, AI development must be guided by ethical principles (Khan et al., 2022). Trustworthy AI, which incorporates ethical considerations into its design and implementation, can provide a competitive advantage to its producers and foster public trust in sociotechnical systems.

Higher Education (HE), Adult Education (AE), and Youth sectors require innovative curricula addressing AI and ML's ethical implications. Educational programs that equip learners with the knowledge and skills to develop and deploy AI systems ethically are critical (Slimi et al., 2023). The Digital Education Action Plan highlights the necessity of addressing ethical challenges in AI and data usage within education and training frameworks.

The first identified need is societal: the need for a fair society where embedded technology does not replicate societal biases and prejudice against minorities. The rapid advancement of new technologies brings inherent risks and challenges, necessitating innovations such as AI in educational contexts that are ethical, inclusive, and equitable. Psychologists identify approximately 180 cognitive biases, some of which may influence AI algorithms' design, including racial bias, gender prejudice, recruiting inequity, and age discrimination (Schwartz et al., 2022).

Individuals suffering from biases, such as machismo, sexism, racism, xenophobia, and other forms of discrimination (e.g., minorities and disadvantaged groups), urgently need technology to help level opportunities rather than perpetuate existing biases. For instance, AI could exacerbate challenges such as job interview disparities and biased criminal identification, disproportionately affecting non-white individuals.

While many universities offer ethics courses within social sciences, these often need an interdisciplinary approach. An interdisciplinary approach is essential for students to graduate with comprehensive knowledge

and skills applicable to their careers (Kayyali, 2024). Higher education teachers also need enhanced skills to provide effective online learning opportunities, moving beyond essential tools like PowerPoint presentations in Zoom or Microsoft Teams to true eLearning methodologies. CHARLIE will promote DigComp awareness among educators and recommend methodologies to identify, understand, and avoid biases in teaching, linking bias with AI ethics and producing state-of-the-art educational materials. Additionally, HE administrators responsible for IT management of eLearning (e.g., managing Moodle) need clear instructions on adopting eLearning methodologies and courses from both technical and pedagogical perspectives.

Adult education providers and universities need a more collaborative approach to supporting adult upskilling and reskilling (Lang, 2023), especially in AI, which offers significant employment opportunities for disadvantaged adults. However, adult education providers often need more expertise to develop engaging eLearning tailored to adult learners' needs.

Youth, particularly those aged 12-18, young women, and those from disadvantaged backgrounds, must be aware of potential futures in emerging technologies and AI. There is a pressing need for awareness initiatives targeting this group and developing engaging and fun Open Educational Resources (OERs) for youth organizations.

1.3 Project Overview

The CHARLIE project, an *"ERASMUS+ KA2 (2022-1-ES01-KA220-HED-C461966C)"* initiative, seeks to confront biases in big data utilized by AI and ML technologies. The project emphasizes the critical need for a comprehensive and ethical approach to Technology Education (techEd). CHARLIE aims to revolutionize tech education in Europe's HE, AE, and youth sectors by raising awareness of the negative impacts of a lack of ethical consideration in AI and ML. Coordinated by Universitat de les Illes Balears (UIB) in Spain, it involves partners from ISQ e-learning (ISQe) in Portugal, Innovation Training Center (ITC) in Spain, Helixconnect Europe (HELIX) in Romania, Aarhus Universitet (AU) in Denmark, and OY Vaasan Ammattikorkeakoulu—Vasa Yrkeshögskola AB (VAMK) in Finland, with IMPACTsci—Portugal as an associated partner.

CHARLIE's objectives are multifaceted. It seeks to augment the capacity of Higher Education institutions to deliver online learning opportunities that not only cater to societal needs but are also tailored to the diverse learning requirements of students. Charlie aims to elevate tech students' social and ethical competencies, enabling them to engage positively, critically, and ethically with AI and ML technologies. Furthermore, it aims to equip teachers and professors with digital and engaging approaches to teaching these topics, focusing on online settings effectively. The project also endeavours to foster collaboration between Higher Education, Adult Education, and youth organizations in AI ethics education. It aims to transfer academic courses on AI biases to the Adult Education and Vocational Education and Training (VET) sectors. Lastly, increasing societal awareness of the ethical implications of AI and ML is a critical goal.

The CHARLIE project pioneers several innovative outputs aimed at reshaping ethical AI education. Some of the key project outputs include:

- Competency matrices for "Algorithmic Bias" (EQF6), "Ethical AI microcredential" (EQF4), and the Serious Game (EQF2).
- A blended learning "Algorithmic Bias" course with a digital serious game for assessment.
- A toolkit for synchronous sessions and guidelines for university administrators.
- A self-paced, online "Ethical AI Microcredential" for adult learners.
- A digital serious game for youth aged 12-18, targeting disadvantaged groups and promoting gender representation in STEM.
- Policy recommendations to recognize the microcredential for facilitating access to HE courses in technological fields.

1.4 Purpose of the Paper

This paper aims to analyse the effectiveness of the game-based learning approach in achieving the project's educational goals by looking at various structural pedagogical design elements of ethical AI frameworks in higher education. In particular, the paper will outline the development process of our digital games, discuss the pedagogical frameworks that underpin them, and share preliminary results from their implementation across various educational settings in Europe. The paper will also explore the broader implications of the named project for integrating game-based learning in ethical tech education and its potential to transform educational practices in Higher Education, Adult Education, and beyond.

2. Methodology

The project is structured into five Work Packages (WPs):

- **WP1—Project Management and Evaluation:** Coordinates and supports all partners, ensuring timely goal achievement and compliance with obligations.
- **WP2 - Competency Matrices for Algorithmic Bias:** Establishes learning goals for HE students, AE learners, and youth through the "Algorithmic Bias" course, "Ethical AI" micro-credential, and serious game.
- **WP3 - Algorithmic Bias Toolkit for HE:** Develops OERs and tools to help HE institutions adopt ethical AI and ML curricula.
- **WP4 - Transfer of Products to AE and Youth:** Upskills adults and youth, raises awareness about ethical AI, and provides tailored digital OERs.
- **WP5 - Communication and Project Promotion:** Disseminates project activities and results to a broad audience, emphasizing HE institutions' role in addressing AI biases and promoting awareness.

The CHARLIE project partners have designed WP2 Competency Matrices for learning programs aligned with EQF levels: EQF6 for Higher Education, EQF4 for Adult Education, and EQF2 for youth. They are now working to achieve the project's expected outcomes.

2.1 Target Groups

As to our targets, the CHARLIE project seeks to foster a comprehensive and inclusive approach to AI education, addressing the needs and challenges of various demographic groups across HE and AE institutions and the youth sector:

Higher Education (HE) Institutions: The project aims to enhance the capacity of HE institutions by developing and integrating ethical approaches to AI and ML into their curricula. This includes creating competency matrices, courses, toolkits, and guidelines for HE students, teachers, and administrators. The goal is to equip these institutions with the resources to address and mitigate algorithmic biases effectively.

Adult Education (AE) Institutions: The project also focuses on adult learners by providing specialized resources and learning pathways tailored to their needs. This includes the development of an Ethical AI micro-credential and competency matrices aligned with EQF4. The aim is to upskill adults in ethical AI practices, enabling them to engage with and understand the implications of AI/ML in their professional and personal lives.

Youth: The CHARLIE project targets young people, particularly those aged 12-18, focusing on young women and youth from socially disadvantaged backgrounds. The project aims to raise awareness and interest in ethical AI by developing a digital serious game and competency matrices aligned with EQF2. By engaging youth in a fun and interactive manner, the project seeks to inspire the next generation to consider careers in ethical AI and understand the societal impacts of technology.

2.2 WP3 - Algorithmic Bias Toolkit for HE

In this work package, the partnership focuses on developing comprehensive resources and tools to help HE institutions integrate ethical considerations into their AI and ML curricula. CHARLIE employs a collaborative and co-creation approach to develop its educational resources focused on six core Competence Units (CUs): Algorithm Models and Limitations, Data Fairness and Bias in AI, AI Privacy and Convenience, AI Ethics in Practice, and Case Studies and Projects. The partnership has designed an effective collaborative and co-creation approach, as illustrated below in Figure 1.

Course Architecture Development	ISQe develops the course architecture and templates and then presents them for partner approval.
Template Completion	UIB, AU, and VAMK complete templates with learning outcomes based on the five CUs.
Peer Review and Multimedia Development	ISQe handles multimedia development, validation tests, and final adjustments.
Template Finalization	Partners fill templates; ISQe finalizes multimedia and delivers the toolkit, including PowerPoint templates.
Webinar Guidelines and Organization	HELIX provides guidelines and finalizes the webinar agenda; partners organize outreach events.
Translation and Delivery	ISQe distributes translation templates; partners complete translations and deliver results in all relevant languages.
Pilot Course Implementation	UIB, AU, and VAMK implement the "Algorithmic Bias" pilot course with 90 participants total.
Quality Check	ITC and all partners conduct a quality check to ensure standards are met.

Figure 1: WP3 Workflow

2.3 WP4 - Transfer of Products to AE and Youth

WP4 promotes ethical AI practices across various demographics, particularly in the AE and youth sectors. Led by ITC and supported by ISQe, this phase includes developing educational resources like an Ethical AI Microcredential and a Digital Serious Game. The aim is to equip learners and stakeholders with essential knowledge and skills to foster responsible AI usage. Additionally, efforts are directed towards creating a toolkit to support adults and youth in Ethical AI upskilling. The project aims to equip learners and stakeholders with essential knowledge and skills through these endeavours, fostering a responsible approach to AI technologies.

The CHARLIE project is structured around six core competence units: CU1 focuses on understanding algorithmic bias, CU2 addresses the principle of non-maleficence, CU3 emphasizes accountability, CU4 highlights the importance of transparency, CU5 covers human rights and fairness, and CU6 provides a practical approach to AI ethics. These competencies are integrated into the Digital Serious Game, designed as an escape room with four thematic rooms. These rooms cover the introduction to AI and potential inequalities, basic mechanics of AI systems and algorithmic biases, identifying and addressing algorithmic bias, and ethical considerations in AI, including policy agendas and global impact. Figure 2 illustrates a mapping diagram of how the six competence units are integrated into the four rooms of the Digital Serious Game.

Room 1: Introduction to AI and Potential Inequalities	CU1: What is Algorithmic Bias?
Room 2: Basic Mechanics of AI Systems and Algorithmic Biases	CU2: Non-maleficence CU4: Transparency
Room 3: Identifying and Addressing Algorithmic Bias	CU3: Accountability CU6: AI Ethics, a Practical Approach
Room 4: Ethical Considerations in AI: Policy Agendas and Global Impact	CU5: Human Rights and Fairness

Figure 2: Mapping Diagram for Competence Units to Game Rooms

The game combines EntreComp, DigComp 2.0, and GrenComp competencies to ensure comprehensive learning, engaging students through interactive challenges and feedback. Figure 3 summarizes the workflow of the WP4.

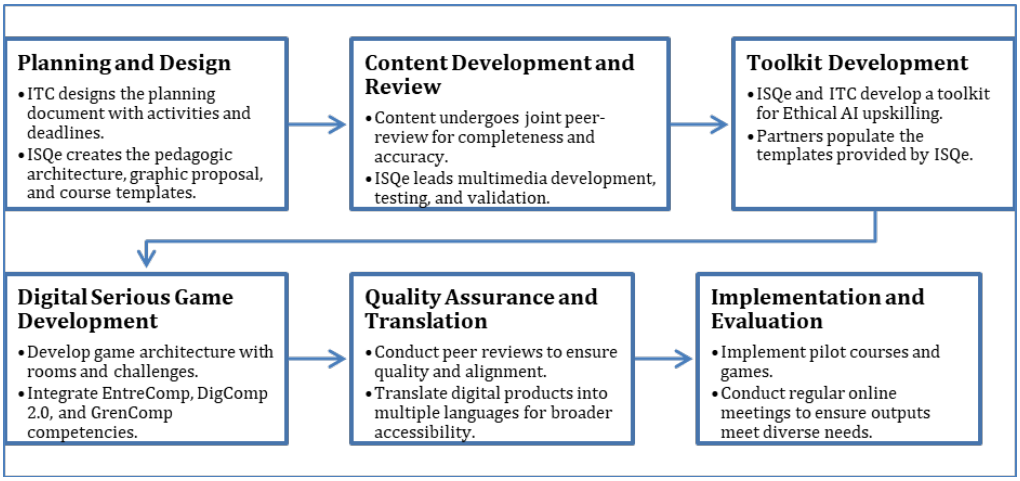


Figure 3: WP4 Workflow

3. Educational Framework and Implementation

To create a more engaging and interactive learning experience, the “Algorithmic Bias” course was developed as an integrated blended learning course with a digital roulette game for formative assessment. The course includes flipbooks, quizzes, project-based exercises, expert videos, concept maps, and a support toolkit for trainers. Thorough research and iterative testing ensure that the materials meet learners’ needs and that serious games create dynamic learning environments that enhance engagement and practical understanding. This approach helps to bridge theory with practice, thereby equipping learners to tackle algorithmic bias effectively.

3.1 Course Development

To address the Algorithmic Foundations and Ethics in AI, an instructional design team has set themselves on making a comprehensive course that uses blended learning and builds on it with a digital roulette game in addition to multiple choices questions and scoring as a final formative assessment exercise, to address Algorithmic Foundations and Ethics in AI. This innovative course structure aims to provide an engaging, interactive, and effective learning experience. The pedagogical architecture is the starting point of creating the "Algorithmic Bias" course. Clear learning objectives are established to ensure learners understand algorithmic bias, its implications, and mitigation strategies. The curriculum incorporates various eLearning components such as interactive screens, flipbooks, multiple choice quizzes, project-based exercises, short expert videos, interactive concept maps, and the roulette game.

Such pedagogical architecture also entails developing a range of support tools for trainers, including:

- **Support PowerPoint Presentations:** These will help deliver key concepts consistently by providing structured content during synchronous sessions.
- **Handbook:** This detailed guide covers course objectives for trainers, content summary teaching strategies, and troubleshooting tips.
- **Multiple Choice Quizzes:** Designed to support synchronous sessions, promote learning, and engage learners in real-time.
- **Case Studies:** Statements for exercises of real-life examples that show how algorithmic bias works, encouraging critical thinking and discussion.
- **Formative Assessment Exercises** require learners to articulate their understanding and apply concepts in writing to receive detailed feedback.
- **Expert Videos:** Curated videos offer industry leaders and academics insights into the topic area, giving the learner a wider understanding of the subject matter.
- **Project-Based Exercises:** Project exercises mimic actual applications of course materials, promoting practical skills and teamwork.

The course itself is built around key elements tailored specifically for this target audience:

- **Interactive eLearning Screens:** These screens enhance engagement by allowing learners to interact directly with the content, fostering a deeper understanding through active participation.
- **Interactive Flipbooks:** Flipbooks present information in a visually appealing and easily navigable format, incorporating multimedia elements to accommodate varied learning preferences.
- **Roulette Game with Multiple Choice Questions:** This digital game makes tests more exciting and, at the same time, involves learners enjoyably and interactively. The roulette game provides immediate feedback to students and helps them determine their level, making learning fun and effective.

The materials are tailored for instructional objectives and accessible on various devices. Prototyping and pilot testing involve internal checks and sample group feedback. An instructor training guide ensures efficient delivery and support systems aid students with technical or content issues. Synchronous sessions foster real-time interaction and cooperation. The "Algorithmic Bias" class, featuring a digital roulette game and interactive components, offers a comprehensive blended learning experience. A toolkit for trainers ensures effective delivery and continuous learner support.

3.2 Game-Based Learning

The CHARLIE project uses serious games as an innovative training strategy to educate and engage students on complex topics. These games increase motivation and facilitate learning by making it dynamic and interactive, especially for disadvantaged youth in STEM. They provide a safe environment for exploring and learning from mistakes, which is essential for developing critical and ethical skills. By connecting theory to practice, serious games demonstrate the relevance of ethical principles and technical skills, ensuring an inclusive, engaging learning environment to address AI and ethics education challenges.

Serious games enhance engagement and motivation by making learning dynamic and interactive, especially for disadvantaged youth in STEM. These games provide a safe space to explore and learn from mistakes, which is crucial for developing critical and ethical skills. They connect theory to practice, demonstrating the real-world relevance of ethical principles and technical skills. This ensures an inclusive and engaging environment, effectively addressing AI and ethics education challenges. The CHARLIE project fosters an innovative and effective pedagogical approach to complex topics by integrating serious games.

4. Results and Discussion

The developed the "Algorithmic Bias" course using a blended learning approach, which includes synchronous sessions, asynchronous eLearning, and a digital game for formative assessment, which will be pilot tested in three HE institutions, UIB, AU, and VAMK, in Spain, Denmark, and Finland, respectively, and will involve 90 participants. The course features interactive screens, flipbooks, quizzes, project-based exercises, expert videos, concept maps, and a digital roulette game to provide a comprehensive learning experience. We expect feedback to highlight the effectiveness of the interactive elements in enhancing understanding and retention. The digital roulette game aims to make learning enjoyable and provide immediate feedback, helping students gauge their comprehension in real-time.

4.1 Anticipated Results and Effectiveness of Game-Based Learning

The CHARLIE project anticipates significant benefits from its digital serious game, designed as an escape room with four themed rooms for youth aged 12-18. This game integrates EntreComp, DigComp 2.0, and GrenComp frameworks to introduce AI concepts, highlight biases, and explore ethical considerations. High engagement and positive reception are expected.

The scenario-based approach is anticipated to facilitate critical thinking and ethical reasoning, helping students understand algorithmic biases in everyday technology. Game-based learning will enhance ethical AI education by engaging students, fostering critical thinking, and promoting practical understanding. Immediate feedback and real-world applications help students internalize ethical principles and understand algorithmic biases.

To evaluate the effectiveness of our game-based learning approach, we will use a combination of quantitative and qualitative metrics. These performance metrics include pre- and post-assessment scores to measure knowledge gains, engagement levels to track student participation and interest, and participant feedback to gather insights into the learning activities' user experience and perceived value. Additionally, we will analyse the completion rates of the game-based modules and the time spent on each activity to understand learner engagement better. Surveys and focus groups will provide qualitative data on the learners' perceptions of the

effectiveness and enjoyment of the educational games. These comprehensive metrics will help us assess the overall success of the proposed setup and identify areas for improvement, ensuring that the game-based learning approach meets its educational objectives and effectively enhances students' understanding of ethical AI.

4.2 Broader Implications for Educational Practices

The CHARLIE project's innovative approach has broader implications for integrating game-based learning into ethical tech education. Digital games, when complemented by well-structured eLearning courses and comprehensive support for educators, could serve as powerful tools for teaching ethical concepts. The project's focus on creating linkages between HE, AE, and Youth sectors is crucial for the widespread adoption and recognition of ethical AI curricula. The interdisciplinary and collaborative approach facilitated by the project is expected to serve as a model for other educational initiatives aiming to address the ethical implications of emerging technologies.

While the CHARLIE project focuses on a European audience, the framework can be adapted for non-European environments by considering local cultural norms, educational systems, and technological access. For instance, additional support and training may be necessary to ensure effective implementation in regions with lower digital literacy. Moreover, cultural differences may affect how ethical issues are perceived and addressed, necessitating tailored content that resonates with local values and norms.

For example, in many Asian countries, collective societal values may influence how ethical considerations are taught and understood, contrasting with the individualistic approach often found in Western education. Thus, educators need to incorporate community-focused ethical scenarios to make the learning more relevant and impactful.

4.3 Challenges and Solutions

The CHARLIE project faced several challenges during its development and implementation phases. Addressing these challenges was crucial for success. Key challenges and solutions are summarized in Figure 4:



Figure 4: CHARLIE's Challenges and Solutions

Additionally, the technological infrastructure in non-European regions can vary significantly, impacting the delivery and accessibility of digital game-based learning tools. In areas with limited internet access or older technology, offline or low-bandwidth versions of educational games may be necessary. Collaborating with local educators to understand and address these challenges can help ensure the framework remains effective and inclusive. Adapting the CHARLIE project's framework for non-European environments involves a multifaceted approach considering cultural sensitivities, educational practices, and technological limitations. By doing so, the framework can be universally applicable, promoting ethical AI education globally.

Potential confounding factors that could impact the study's results include varying levels of digital literacy among participants, differences in educational infrastructure, and socio-economic disparities. These factors could skew the effectiveness of the game-based learning approach. To mitigate these issues, we will implement standardized training sessions to level the playing field, ensure that all participants have access to the necessary resources, and use control-group studies to isolate the effects of our intervention. By addressing these

confounding factors proactively, we aim to ensure the validity and reliability of our findings, providing a clear picture of the framework's effectiveness.

5. Implications and Future Work

Due to rapid developments in AI technology and the evolving ethical principles associated with them, it is crucial to update the knowledge and contents of the course continuously. While the game remains relevant, one must stay prepared for rapid advancements in this field. Continually updating the content and the game is essential to keep pace with these changes. Furthermore, games are advancing rapidly, as are the methods by which people engage with them, necessitating agile approaches to educational game design and implementation.

5.1 Educational Impact

In the project's current phase, before pilot testing the game, the expectations are primarily theoretical and aim to fulfil the predetermined learning outcomes. Numerous studies on the educational impact of game-based learning highlight its varied effects on students' motivation and ability to absorb information better. For instance, a study by Krath et al. (2021) examined 118 theoretical foundations and revealed that no single theory explains the effectiveness of game-based approaches. However, it did show that game-based learning has a high potential for improving effect and motivation, behaviour, and learning outcomes.

In the context of ethical AI and algorithmic biases, transforming ethical principles, frameworks, and guidelines into practical tools is challenging, and many frameworks lack contextual application (Morley et al., 2020; Prem, 2023). Morley et al.'s (2020) study revealed a gap in tools that effectively address the ethical impact of AI on individuals or society, possibly due to the complexity of translating human behaviours into universal tools. Introducing a gaming concept can bridge the gap between abstract ethical principles and practical application, helping students grasp the real-world implications of these issues on individuals and society.

The effectiveness of the proposed method may vary across different demographic groups, such as age, social status, gender, and prior exposure to technology. Learning styles, cultural backgrounds, and educational experiences can significantly influence learning outcomes. To address this, we plan to conduct targeted studies that examine these variations in detail. By understanding diverse groups' specific needs and challenges, we can tailor our educational approach to ensure inclusivity and equity. This may involve developing different versions of the educational games, providing additional support for certain groups, and creating culturally relevant content to enhance engagement and effectiveness across all demographics.

5.2 Implications for Future AI and Tech Education

A primary goal is to incorporate a human-centered approach into teaching technical subjects. Project Charlie aims to enhance empathy-based methods in AI and technology education and boost proactive efforts in fostering individuals' sense of responsibility and civic engagement. Utilizing a game-based approach allows for engaging a broader audience within higher education and across various age and educational groups. Introducing ethical considerations through a human-centered approach in future AI and technology education represents a strategy to embed ethical principles into AI solution development from the initial stages.

6. Conclusion and Future Directions

The CHARLIE project's game-based approach primarily targets individuals aged 12 and up, but rapid digitalization exposes children to AI technologies at much younger ages. Introducing ethical considerations early could enhance understanding and foster inherent empathy and ethical sensibilities, proving beneficial in the long term, significantly if these individuals eventually develop AI solutions. Through serious gaming, users can test the consequences of their actions on others and the environment, thereby gaining empathy.

Despite the advantages of game-based learning, critical assessment is needed to determine its effectiveness in increasing empathy. While some studies suggest potential desensitization from violent game content (Andersson & Bushman, 2001), others indicate that game-based approaches can enhance empathy (Wulansari et al., 2020). Comparing empathy levels elicited by different media—movies, books, and games—could provide insights into creating engaging content. As education increasingly adopts digital solutions, sophisticated approaches are necessary to engage effectively.

Our study needs to account for the potential variances in adopting game-based learning to teach AI ethics at the country level. For example, disparities in digital skills among European children (Mascheroni et al., 2020) could lead to unequal opportunities for technological advancements. Addressing these disparities and cultural differences is essential when designing educational games to ensure effective connectivity and empathy towards avatars and game elements.

The CHARLIE project's game-based efforts are directed toward young women and youths from socioeconomically disadvantaged backgrounds. While engaging these groups is crucial, it is equally essential to ensure that those leading AI development—often not from disadvantaged groups—consider the ethical implications for minorities disproportionately affected by these technologies. Reaching this target group could significantly enhance the project's impact. By fostering early ethical education and inclusivity, the CHARLIE project can ensure that future AI developments are empathetic and socially responsible, paving the way for a more equitable technological landscape.

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Game-based Learning for Science Education in Institutional Care Settings in Northwestern Mexico

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Abstract: Play has been key to knowledge acquisition, creativity, and innovation. In education, game-based learning (GBL) is a physical and digital environment that enhances learning outcomes in students. This paper presents the results of observational research on game-based learning in science education as a motivation for young students from two institutional care settings in Northwestern Mexico, in the State of Sonora. The observational research touched on 1) game-based learning in science, technology, engineering, and mathematics (STEM) education, and 2) learning motivation in vulnerable student groups. This paper focuses on the authors' experiences, most of them early researchers focused on science education, their purpose of promoting game-based learning in STEM education, and interviews with representatives from both institutions. We found that game-based learning was seen as a novelty, innovative, and motivational way of engaging young students from institutional care settings to learn and become curious about the STEM field. We also designed and created games focused on STEM subjects in both institutions. Students living in institutional care settings face even greater obstacles regarding education. In some instances, the lack of mentorship or follow-up tutoring activities can determine their academic outcome or lack thereof. With the ever-changing world of technology, industries demand highly qualified people in STEM fields. Nonetheless, international organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Organisation for Economic Co-operation and Development (OECD) have reported that school systems around the world are not equipped with the proper teaching methodologies for students to acquire basic skills such as mathematics nor critical thinking. In Mexico, public school systems and institutional care settings often lack teacher training or mentorship approaches to promote STEM education. This paper concludes with a reflection on the benefits of GBL in STEM education in such settings and suggestions for student-led collaborations with children and youth in such settings.

Keywords: Educational Innovation; Game-based Learning; Higher Education; STEM Education; Tec 21 Educative Model.

1. Introduction

Teaching science, technology, engineering, and mathematics (STEM) disciplines can be an obstacle for some educators. In students, there is a motivation gap between STEM subjects in lower academic grades and higher education enrollment. Some studies have mentioned that a lack of interest or engagement in such disciplines occurs in students which can be difficult to reverse. Therefore, different educational approaches should be used when engaging students with STEM education.

In 2023, the World Economic Forum noted that STEM industries worldwide need human capital with the proper credentials and knowledge. Nonetheless, “many countries have tried to bolster enrollment in STEM to aid important growth industries like medtech, digital services, mobility or computer sciences. However, countries have had varying success in the matter”. In a study, Yan, Yu & Chen (2024) noted that “ China boasts the largest number of STEM graduates in the world, and the number of STEM graduates is increasing every year as China's higher education becomes more accessible. [Nonetheless], the percentage of traditional engineering graduates has declined in recent years'' (p. 397)

According to Arztmann, Hornstra, Jeuring & Kester (2023), students from low socioeconomic backgrounds need greater motivation when engaging with STEM education and at an early age. The authors note that “games should be implemented early on to be most effective, particularly to improve students' motivation for STEM subjects which might help to intervene with the general decrease of interest in these subjects later on” (p. 132).

This decrease is highly notable in the number of women deciding on a STEM career. The United Nations Educational, Scientific and Cultural Organization (UNESCO) mentioned in their Global Education Monitoring Report 2024, Gender Report: Technology on Her Terms that women “are particularly underrepresented in science, technology, engineering and mathematics (STEAM) education - women make up only 35% of STEM graduates, a figure unchanged in ten years - and consequently, in STEM careers” (UNESCO, 2024).

The United Nations has reported that 6 out of 10 children and adolescents do not reach the minimum level of critical thinking skills; and that "by including methodologies in the learning process that aim to motivate and engage student learning, such SDG can be achieved by 2030 with the aid of professors and institutions alike" (Olivas, Velázquez & Duarte, 2023, p. 351).

The different factors impacting young learners during their formative years are only enhanced in difficult socioeconomic situations and family dynamics. Furthermore, the lack of representation among ethnic and gender minorities in STEM fields, as indicated by a National Science Foundation (NSF) analysis spanning from 2006 to 2016, stands as a contributor to the dwindling motivation among schoolchildren. To encourage interest and curiosity among these groups, additional educational tools should be implemented when teaching STEM education (Strayhorn, 2013).

Education should aid in eliminating these disparities. Gender inequality, lack of representation, and receding motivation and accessibility for children to pursue a place in the STEM workforce are present globally. In the case of Mexico, the Organisation for Economic Co-operation and Development (OECD) reported that it has one of the lowest school enrollment rates among 15 to 19-year-olds (OECD, 2014). Both public and private sectors must collaborate in igniting interest in fields such as engineering, biology, and applied mathematics. It is paramount for both to collaborate and design programs, such as those involving game-based learning, to lessen the impact of gender gaps, and lack of representation for minorities, and to encourage young boys and teenagers in institutional care settings to become involved in the STEM fields.

Game-based learning studies are mostly focused on its performance in educational institution settings (Wernet & Benjamin, 2023; Juric, Bakaric & Matetic, 2021; Ameerbakhsh, Maharaj, Hussain & McAdams, 2019). However, afterschool programs, community clubs, organizations, or other types of institutional settings also offer educational programs that enhance and promote STEM activities among young learners. Oftentimes, these other settings allow learners to receive a more personalized learning experience since the number of participants in them is on the smaller end.

This paper is intended to focus on the authors' experiences as volunteers in STEM activities in an institutional care setting in the Northwestern region of the State of Sonora, Mexico, and how game-based learning can aid in promoting and encouraging young learning in such fields. This is to analyze how game-based learning can aid young learners in specific contexts. The paper explored how early contact with activities and game-based learning can encourage learners to know more about STEM and become involved in these fields.

1.1 Game-based Learning in STEM

Studies have shown that "game-based learning has drawn international interest and has been reported as an effective educational method that can improve students' motivation and performance" (Stohlmann, 2023, p. 27). By targeting students with different learning needs, game-based learning in STEM can be a useful educational tool in attracting young learners to these fields.

Classrooms are made up of different socioeconomic backgrounds, genders, ages, beliefs, and family histories, among other characteristics. It has been noted that some of these students are more prone to face academic difficulties than others. Moreover, previous studies regarding the effects of game-based learning are needed to determine if they can contribute to promoting learning outcomes related to STEM in such student populations (Arztmann, Hornstra, Jeuring & Kester, 2023).

To some, game-based learning is a synonym for digital games in the classroom. However, when targeting specific demographics of young learners in institutional care settings, connectivity to the internet and availability of electronic devices can be limited. As some studies have noted, "students are capable and well-versed in digital games but [some schools] do not have the proper funding nor infrastructure to obtain such equipment, teacher training, or licenses to implement them in their classrooms" (Olivas, Velázquez & Duarte, 2023, p. 353).

1.2 Literary Review

In the last five years (2018 - 2023), there have been several studies regarding games-based learning in STEM. In particular, we searched the Scopus database to identify final publication research papers; we used the following keywords: games-based learning, and STEM. In our search, we came across 54 open-access research articles in English. Most studies were from the United States of America (16), Malaysia (8), Spain (6), and the United Kingdom (4). Meanwhile, 39 studies were from Social Sciences, 25 were from Computer Science, 14 were from Engineering, 11 were from Psychology, and the rest were from various regions.

Some of the main themes in previous studies on game-based learning in STEM were related to overall practices with digital game-based learning to teach specific courses or topics. Another pattern we identified in these studies was the use of game-based learning to teach topics in mathematics. Such studies noted how such an educational approach can aid in presenting mathematics in a more attractive light, whether it is by implementing a QR-based card game, a serious game, or another activity (Yung, Junaini, Kamal & Ibharim, 2020; Gil-Doménech & Berbegal-Mirab, 2019; Nurnberger-Haag, Wernet & Benjamin, 2023; Juric, Bakaric & Matetic, 2021; Ameerbakhsh, Maharaj, Hussain & McAdams, 2019; Zainal, Din, Majid, Nasrudin & Rahman, 2018).

However, taking into consideration that most institutional care settings do not have sufficient digital connectivity, nor the proper digital infrastructure, we focused our attention on studies that used non-digital-game based learning to complement the learning process of STEM education among students (Assapun & Thummaphan, 2023; Gui et al., 2023; Farihah, Norawi & Jahan, 2021; González-Tablas et al., 2020).

Some studies showed how implementing game-based learning helped students enhance their problem-solving skills in STEM education (Assapun & Thummaphan, 2023). Meanwhile, Farihah, Norawi & Jahan (2021) noted how it can aid in the learning outcome in science and mathematics (González-Tablas et al., 2020). As expected, most studies focused on educational settings and not in institutional care settings or after-school programs. However, a need to supplement or enhance learning and promote education in general often occurs in such settings outside of educational institutions.

Other studies touched on digital game-based learning, especially in the form of educational apps and their ability to aid educators in evaluating learning outcomes in young learners (Papadakis, 2021); some even included the use of game-based learning hands-on activities and software but in preschool education participants (Kalogiannakis et al., 2018). As mentioned, most of the game-based learning research we found was centered around educational institutions and digital platforms.

1.3 Objectives, Research Questions, and Hypothesis

The paper highlights the observational experiences of some of the authors, and their exploration into possibly answering the following research questions: 1) Is game-based learning in science, technology, engineering, and mathematics (STEM) education a proper approach to motivate learning? and 2) can game-based learning motivate young students from institutional care settings?

We suppose that game-based learning can be seen as a complement to after-school programs for young learners in institutional care settings. Also, we presume that STEM education can benefit from it when engaging with young learners from different sociodemographic backgrounds. There is an open debate about whether these specific groups of students do not show more improvement in evaluations after game-based activities. Nonetheless, we suppose that by offering STEM education with this component, they can become involved in one of these fields.

1.4 Justification

As noted by Olivas, Velázquez & Duarte (2023) “some factors that affect students' performance [in STEM sciences] are the lack of interest in learning, the reduced number of hours that STEM programs offer, and the lack of resources available (...) to promote (...) learning activities” (p. 352).

Additionally, the authors mentioned that “in the case of [several countries, as well as in Mexico], to implement education games, educators must think outside of the box and use the resources they have available to them (whether they are physical material, creativity, or funding)” (Olivas, Velázquez & Duarte, 2023, p. 253). By promoting active learning activities such as game-based learning, more students can become motivated to engage in STEM education (Crow and Henning, 2020).

2. Theoretical Background

Observational research has been used to understand and comprehend students' dynamics with material, subjects, activities, and pedagogies, among other categories (Anwar & Menekse, 2021). In this study, we understand observational research as one that “examine[s] affect phenomena in group interactions” (Jones, Volet, Pino-Pasternak, 2021, p. 349). We also considered how such research can leave out important data from the final analysis or perception of the authors (Lee et al., 2021).

Comprehending that observational research may present bias or surface-level interpretation of processes, we were interested in capturing the approach of the teachers and instructors in such game-based learning activities. As Sundberg, Kirk & Lindahl noted (2021), "observations show what teachers actually do in their lessons. Accordingly, classroom observation seems a suitable method to assess teachers' approaches to foster [self-regulated learning]" (p. 500). Game-based learning can aid in introducing STEM to students from different sociodemographic backgrounds (Stohlmann, 2023, p. 27).

3. Materials and Methods

To carry out our observational research, we looked for activities that focused on STEM education, specifically biomedical engineering. The game-based learning activities were implemented in two institutional care settings in Northwestern Mexico, in the State of Sonora in December 2023. At the time, both institutions had young boys and teenagers (male) between the ages of 6 years old up to 17 residing on their premises. In this activity, 32 male participants interacted with game-based activities (22 from one institution, and 10 from the other).

We asked permission from the institutions to conduct the events; written and oral information regarding the event and its activities was provided. Participation was voluntary, and the identities of the people present were kept anonymous. Additionally, our focus of the study was on our (authors) experience as volunteers in a game-based learning activity.

The games were set in stages and would rotate participants every time one of the activities concluded: Jeopardy, *Abremente*, Hedbanz, *Lotería*, and others. The activities were planned by high school students of a STEM group, *Juventud Biomédica* (Spanish for Biomedical Youth), with the guidance of one of the authors. We introduced the games during winter break due to the accessibility of the members and the willingness of both institutions. We held the events on a weekend, one day per institution, from 11:00 a.m. to 3:00 p.m. The games and their presentations were the same for both institutions. They were arranged the following way: in a station rotation model, the students could win a small prize (small foam play balls with a series of attractive designs, ranging from sports themes to planets and colorful ones).

In the first stage, we used the board game named "*Abremente*" (See Image 1). The original game provides cards with questions about a variety of topics according to the age of the players. For observational research purposes, the cards were STEM-related. The game included a board that had a path of squares to follow, a dice, and five tokens. Two members of *Juventud Biomédica* led the activity and assigned an order to the players' group. The members proceeded to read the questions out loud for all participants to hear them (the questions were selected depending on the participants' age). Each player could advance one square for every correct answer they had. The winner was the one that ended nearest the finish line after each stage ended.



Figure 1: "*Abremente*" board game (STEM-related) photographs.

For the second game, we adapted the board game Hedbanz to STEM-related content (see Image 2). Two members from the STEM group designed all of the cards, replacing the original objects with elements such as a 3D printer, a cell, a pill with an integrated camera, DNA, and a heart, among other STEM-related content. Additionally, we provided a card with base questions including "Can I detect diseases?", "Am I a human body part?", "Do I serve as ___ ?" among others.



Figure 2: "*Hedbanz*" game (STEM-related) photographs.

Each participant had a timeframe of 90 seconds to guess the element in their card by asking key questions. The STEM group member in charge of this stage answered the questions and gave the students a play coin for every element guessed. The winner was the one who accumulated more coins. We understand that a system of rewards can be somewhat controversial to some; however, we perceive that encouragement and prize recognition among such young learners (in orphanages) can be a motivation.

In the third stage, we followed the same process but with the Mexican game of "*Lotería*". The game included 32 different element cards and 5 player cards. Each player card contained a random and unique selection of 16 STEM-related elements. These STEM group members designed the cards and led the activity. To play, the members randomly selected one element card at a time and read it out loud. Following the same instructions as the Mexican game, if the participants had the element announced in their player cards they needed to mark the image with a token. The winner was the first person that completed a full card with sixteen tokens and shouted out "Lotería".

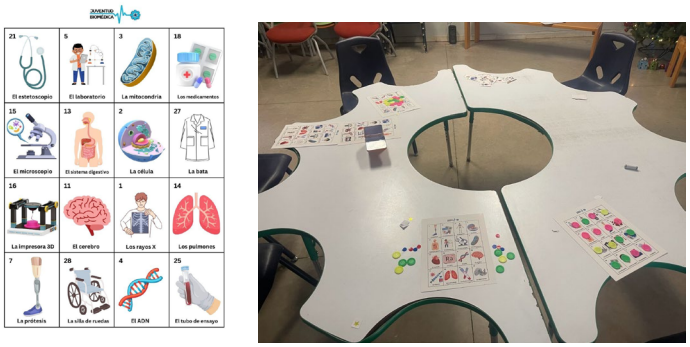


Figure 3: "*Lotería*" game (STEM-related) photographs.

Furthermore, we designed a fourth game. Even though it was rather simple, it gained recognition among the players. The game consisted of a Jeopardy-like dynamic, where STEM-themed questions were asked to the participants, and whoever pressed the button at the center of the table first earned the right to choose one of the multiple-choice answers. The questions that were included had the purpose of teaching about the functions and elements that encompass biomedical engineering, as well as its relationship with other STEM disciplines. One of the observations that we would like to emphasize was the natural competitiveness and eagerness to learn that was shown by the participants when trying to gain points and win.

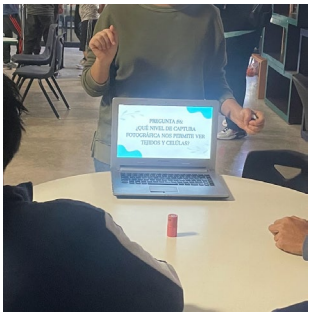


Figure 4: "*Jeopardy*" game (STEM-related) photographs.

For the final stage, we aimed for an immersive engineering practice and presented them with the robotic hand project. Each hand was created using recycled cardboard, straws, linen thread, hot silicon glue, scissors, a pencil, and a ruler. To avoid risking student safety and adhere to our tight schedule, we preassembled a base hand with cardboard and straws. During the event, the leading member of the stage paired the participants and provided them with one base hand, linen thread, and a ruler. The couples worked together, using the materials and their creativity to make their hand functional. After that, the challenge was to create a pyramid with three plastic cups by only using the robotic hand. The winning team was the one that finished the pyramid first.



Figure 5: "*Robotic hand*" project (STEM-related) photographs.

To execute the station rotation model, participants were divided into groups of four and five members in the appointed stages. The games of scientific Jeopardy and *Lotería* were planned to last fifteen minutes, while the robotic hand and scientific Hedbanz lasted thirty minutes. At the end of the designated time, all the participants were free to play in the stations they were more interested in. This model was adopted to maximize their interaction and experience with all of the games prepared.

Game-based learning was used to incentivize the student group to learn about STEM in an engaging manner. Furthermore, we thought of adapting the content to already existing board games as most of the participants in the age range were already familiarized with them and their rules and dynamics. Our priority consisted in transforming them into STEM-related content. "*Abremente*" was meant to give general science and math information through the questions asked based on age. Scientific Hedbanz aimed to awaken participants' curiosity by making them formulate questions to guess STEM elements. Likewise, the scientific theme "*Lotería*" intended to enable students to identify elements and to relate them to their correct labels. Meanwhile, Jeopardy sought to test their current knowledge in a manner that endorsed eagerness to learn through the dynamic of questioning, answering, and enhancing their critical thinking skills. Finally, the robotic hand project aimed to apply their knowledge about biological movements and their creativity to create a functional device.

4. Results and Discussion

This paper intends to present the experiences of the authors as volunteers in two institutional care settings, implementing game-based learning activities. We must note that other studies present mixed findings, where using game-based learning among different sociodemographic populations of students did not show significant improvement in evaluations. Nonetheless, it is fundamental to study further such methodologies to teach STEM and their long-term impact on young participants.

4.1 Game-based Learning in Science, Technology, Engineering, and Mathematics (STEM) Education as a Motivator in Learning

This observational research integrated game-based learning in science education. We witnessed these activities' impact on participants from both institutional care settings. STEM content was accurately adapted to games, allowing participants to acquire knowledge in engaging ways. After playing and understanding the event dynamic, they willingly participated.

We observed a higher motivation, particularly in knowledge-based competitions, such as scientific Jeopardy and Hedbanz. In the robotic hand project, we were impressed with how participants went beyond the game´s objective and thought of new challenges (they brought classroom materials for assembling higher towers with the hand in the least possible time).

In this activity, we noted how the robotic hand could be a hands-on approach activity that may potentially develop or enrich their curiosity, and motivation in learning about STEM fields (Kalogiannakis et al., 2018). We believe that such results could be potentially enhanced if we complement the activity with another one that has a digital element to it. Also, we noticed how the participants kept playing after the designated time ended. Game-based learning introduced students to a new way of interacting with STEM-related content, awakening their curiosity and interest as they mentioned to us.

4.2 Learning Motivation in Vulnerable Student Groups

In 2014, the OECD noted that Mexico's annual expenditure on spending per student was already well below the OECD average. Nonetheless, in 2017 the budget directed to public education was cut by 11%, and the funding aimed for teacher training programs was radically reduced by 40%. Taking into account the aforementioned challenges, we approached the task of offering children in institutional care settings in the city of Hermosillo, Sonora, the opportunity to learn simple yet rich educational content that they do not usually review in class.

Throughout the execution of the distinct activities, we perceived the students' eagerness to learn new, STEM-related content. Even after the station rotation concluded, they wanted to extend the timeframe set for each activity and continue playing. It was visible and rather endearing that they expressed their gratitude for being able to be involved in the activities, gaining a new sense of motivation and aspirations. As noted by Stohlmann (2023), game-based learning can enrich or develop a motivation to learn among young learners about the different STEM fields. There have been studies performed with such populations of participants and the response was positive, just as it was in the case of our research.

5. Conclusions

This study sought to forge the application of game-based learning in STEM by organizing events for orphans at two institutional care settings in Northwestern Mexico. We observed that an environment of curiosity was achieved with the help and support of the youth group, *Juventud Biomédica.* In essence, we believe we made a positive impact on them.

We understand that one of the limitations of our observational research was the reduced sample size of participants. We are aware of potential variations in the findings of broader studies. Additionally, technological limitations in both institutions made us avoid using technology in the games. Despite this, we found that game-based learning was considered a novelty, innovative, and motivational way of engaging young populations to learn and become curious about the STEM field. We interpreted their willingness and enthusiasm as an affirmation of an enriching experience with game-based learning for science education.

To further the practice of game-based learning in STEM education, it is essential to continue to broaden studies to more institutions. We are eager to see how this can be applied to different contexts or locations (schools, recreation centers, workshops, etc.) and analyze its impact. It would also be beneficial to create and apply measurable tools with the capacity to evaluate this outcome. Contributing to the improvement of game-based learning and participation in STEM, we are encouraged to expand this study and develop innovative ways of learning.

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Declaration of generative AI and AI-assisted technologies in the writing process:

During the preparation of this work, the author(s) used the free version of Grammarly to check the correct grammar of our original text, since our native language is not English but Spanish. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Game-based Pedagogy in Teacher Training: Results of a Pilot Course

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Abstract: Game-based learning (GBL) and gamification can improve the learning experience of students by making learning more fun, interesting, and motivating. However, integrating games in practice is challenging for many teachers as it requires competences that not necessarily are part of their teaching repertoire. Game-based pedagogy (GBP) refers to the teaching methods and learning processes involved in learning with games. Research stresses the need for adequate professional development and teacher education on GBP. However, there is a lack of empirical knowledge on effective methods to prepare pre-service and in-service teachers for using game-based learning. The aim of our research is to gain insight into the design of effective GBP learning experiences for teachers. The guiding research question was: What design elements of a course on GBL impacted in-service teachers' GBP competences and teaching practice? We investigated this question in the context of a teacher education program in the Fall 2023. We conducted an empirical study in which a course on GBL was designed, implemented, and evaluated in practice. The participants were 16 in-service secondary teachers from different disciplines in secondary education, from which 13 agreed to participate in this study, and three course leaders. We investigated participants' and course leaders' experiences, participants' competences in GBP, the impact on participants' teaching practice and the way design elements contributed to it. The data consisted of participant reflections, transcripts from participants and course leaders' interviews and answers to a questionnaire. The data was collected and analysed using quantitative and qualitative methods between January and April 2024. Results reveal that in-service teachers' improved their competences on GBP and increased their use of GBL in practice. Qualitative data analysis provides insight into the course's design elements and on participants' learning process. This study contributes to GBP-education by offering a possible design solution and framework for developing effective teacher education.

Keywords: Game-based pedagogy, Game-based Learning, Gamification, Teacher Education, Course Design

1. Introduction

The potential of game-based learning (GBL) and gamification for education is widely recognized. Digital games improve the learning experience of students by making learning more fun, interesting, and motivating by engaging students in active learning or by involving students in new ways of learning (Barz et al, 2024; Luarn et al, 2023). However, integrating GBL in ways that fulfill these expectations is challenging for teachers (Hayak & Avidov-Ungar, 2020). It requires skills and knowledge that may not be a part of their teaching repertoire, such as being able to determine which games are suitable and/or can be easily adapted to their goals; to introduce the game activity to students and support students' learning while they are playing; and to attend to whether learners are connecting gameplay with the learning content and goals (Bado, 2022; Nousiainen et al, 2018). Several researchers (Foster & Shah, 2020; Bado, 2022) have called attention to this issue and the need for developing teacher education programs that introduce practicing and future teachers to the methods and knowledge required for GBL.

In the literature it is possible to find some heuristics for designing curricula for teachers on game-based pedagogy (GBP) (e.g., Bado, 2022; Avidov-Ungar & Hayak, 2023; Foster & Shaha, 2020). However, designing effective teacher education for GBP is complex and the methods and knowledge available for teacher educators is limited (Foster & Shah, 2020; Molin, 2017). For instance, there is little knowledge on evaluation instruments to guide student-teachers in the development of game-based pedagogy competences (e.g., Nousiainen et al, 2018) or to allow teacher educators to evaluate student progress and improve the course (Foster & Shah, 2020). In addition, teacher educators need training and support to develop their own pedagogical competence in game-based pedagogy (Avidov-Ungar & Hayak, 2023).

In the faculty of education of the Amsterdam University of Applied Sciences, a fully gamified one-semester course on game-based pedagogy was designed in the spring of 2023 for the master program of teacher education with the goal of introducing teachers to the pedagogical use of games. This course was built on a previous training track for mathematics teachers on GBP, the design of which was informed by the guiding

principles of Foster and Shaha (2020) and the competence framework of Nousiainen et al (2018) that was used to guide and evaluate competence development.

The aim of this study is to understand how the course impacted participants' competences on GBP and teaching with games. The course was followed in the Fall 2023 by 16 in-service teachers from different disciplines in secondary education. Through qualitative research methods we investigated how design elements of the gamified course and interaction with course leaders engaged participants in GBL and competence development. The guiding research question was: What design elements of GBL course impacted in-service teachers' GBP-competence and teaching practice?

2. Research Background

2.1 Game-based Pedagogy

Game-based pedagogy refers to the study of methods for instructing through games or gamification, encompassing both instructional objectives and the strategies employed to attain them. In the educational context, the instructor needs specific competences encompassing knowledge, skills, attitudes, and values to effectively teach with games or gamify activities, lessons, and courses (Nousiainen et al, 2018). These competences involve a favorable outlook on games, possessing subject expertise, employing effective teaching methodologies, and use diverse methods of incorporating games into the educational setting (Hayak & Avidov-Ungar, 2020). Nousiainen et al (2018) identified four main areas of teacher competence in GBP and respective dimensions. *Pedagogical area* involves curriculum-based planning or understanding how to effectively convey curriculum content through various GBL methods. *Tutoring* in GBL refers to guiding learners through game-based activities, incorporating motivational techniques and supporting students' autonomy. Assessment in GBL encompasses evaluating student learning and engaging in reflective discussions with them. *Technological area* requires knowledge of games and available tools and the ability to continuously evaluate tools (because sometimes ideal solutions are only found after less successful attempts) and flexible handling of technical obstacles. *Creative area* includes adopting a playful stance that allows one to see playfulness in almost any learning activity and it entails exploration and improvisation, where one can freely experiment with novel tools and approaches. It also involves creative orientation to self-development, a willingness to constantly refine one's skills in GBP while reflecting on and refining their teacher identity. *Collaborative area* encompasses the ability and willingness of teachers to collaborate and co-create within the school and the ability to share and co-develop outside the school and network.

2.2 Guidelines for Teachers' Professional Development in GBP

Research on teachers' use of GBL provides directions about the content for teacher education on GBP. A few directions that can be deduced include: planning for integrating GBL in the curriculum with analysis of the strengths and limitations of a game in relation with curricular goals and in relation to the school ecology (Herbert and Janson, 2019; Foster & Shah, 2020); playing games often and of a wide variety so teachers can develop a sense of familiarity with games and their potential for supporting curricular goals (Molin, 2017; Foster & Shah, 2020); distinguishing between different approaches to GBL (entertainment, educational, making games) and gamification of learning as requiring different pedagogical approaches (Nousiainen et al, 2018); and introducing teachers to pedagogical activities specific to GBL and systematic procedures that can guide them through the different aspects of using games before, during and after game-based lessons (Bado, 2022). Having teacher educators modelling the use of games has been found to be a factor that positively influences teachers to use games in their practice (Avidov-Ungar & Hayak, 2023). These findings suggest that an effective way to expose teachers to game-use is by having them participate in a gamified course.

2.3 Gamified Design of a Course on GBP for Teacher Education

The design of the course was based on theory about gamification, which is defined as the use of game design elements in non-game contexts (Deterding et al, 2011; Luarn et al, 2023). From a designer perspective, gamification includes elements from games (e.g., choice, competition) but not a full 'game proper' such as in the cases of serious games and entertainment games. From the user perspective, such a system can be experienced as 'games proper' and enact gameful and playful experience. Game design elements are meant to create gameful experiences and can be identified on varying levels of abstraction. Ordered from concrete to more abstract, Deterding et al (2011) distinguished: (i) interface design patterns; (ii) game design patterns or game mechanics;

(iii) design principles, heuristics or lenses; (iv) conceptual models of game design units; (v) game design methods and design processes.

In the design of the course, we used several design elements (see section 4.2). One of them was a skill tree, which is a collection of gamified pathways integrating educational objectives and content and organized in a playful way (Backlund et al, 2021). The skill tree offers multiple options to go from start to end, providing freedom to players to pursue their interests, fostering agency (Backlund et al, 2021). In the course the tasks in the skill tree were connected with points, levels, and scores to improve the gamified experience. Figure 1 shows a simplified version. To see the full skill tree (in Dutch) go to https://edu.nl/jrwya.

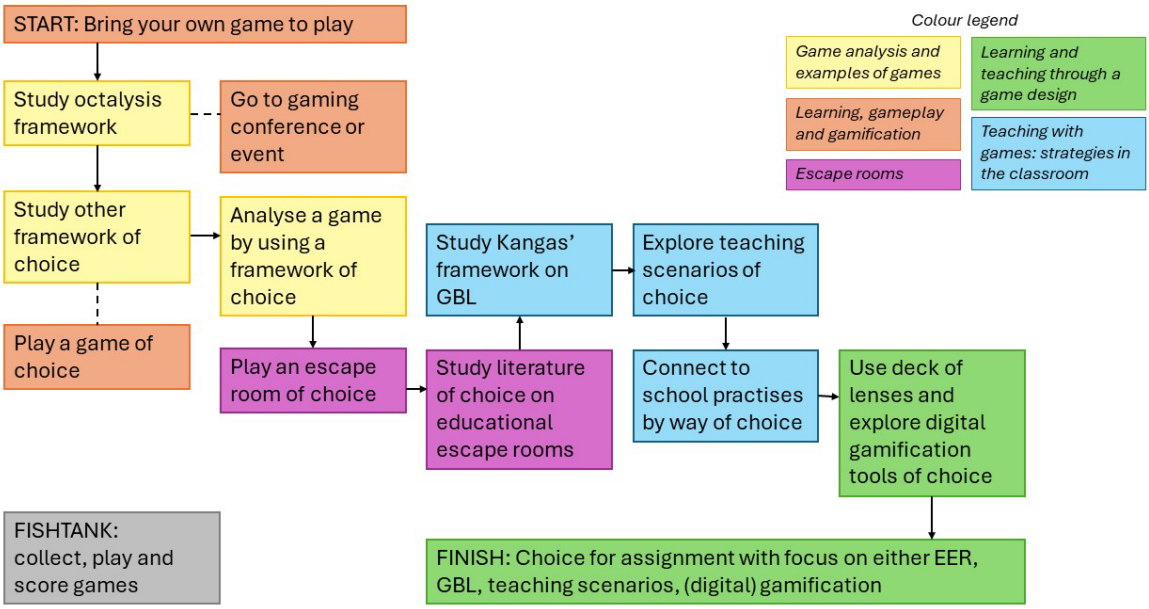


Figure 1: Simplified version of the skill tree

3. Method

3.1 Participants

The study participants were 13 of the 16 in-service teachers participating in a master's course on GBP and the three course leaders. They were experienced teachers (6 to 20 years) in secondary education from different disciplines. For the rest of the paper, reference to teachers means "in-service teachers." The course lasted one semester (September 2023 to January 2024); the participants had lessons every fifteen days and were expected to work in transdisciplinary teams of four on designing and developing their own game during the off weeks. The skill tree (Figure 1) was used to guide both the lessons and independent group work. The final assessment consisted of the developed game and an individual reflection.

3.2 Data Collection

The data was collected using instruments that were developed in a previous research and adapted by the research team: individual reflection, teachers' competences questionnaire, participants' interview guidelines, and course leaders' interview guidelines.

Individual reflections are text documents in which the participants reflect on their learning process within a transdisciplinary team. The reflection instrument has been used by the teaching education program for two years.

The *competences questionnaire* was a digital document containing the description of the GBP competences (see 2.1). In the first question, the participants could choose one of the options (not, few, some, fairly, a lot) to indicate the extent to which they felt competent in each of the GBP competences. In the second question, they could indicate to what extent the course had contributed to their development in the same dimensions. In the

last question, the participants could indicate which components in the course had contributed to their growth in GBP competence (open question).

The *interviews with the participants* were designed to get a deeper understanding of the design elements' impact on their competence growth, and school practice, and to collect additional information about the their background.

The *interviews with the course leaders* focused on their experience with the course and the roles of the different elements and activities in it.

The participants' individual written reflections were collected after course completion, in January 2024. In February 2024, all participants were invited via email to answer a questionnaire and participate in the interview. Ten participants answered the questionnaire and five of them agreed to be interviewed. The interviews of the teachers and course leaders were conducted individually in March-April 2024 and took about 30-50 minutes. They were video or audio recorded and transcribed.

3.3 Data Analysis

The analysis of the competence questionnaire was quantitative, the reflections and transcripts of the interviews were analyzed qualitatively. In the first step, we went through the documents and identified text passages regarding each of the four variables in study. The result is a document that provides a rich description of each teacher's experience with the course, their actual competence on GBL and feeling of competence growth, actual use of GBL in their own practice and on the elements of the course that they considered to have contributed to it. Each participant got one single code; we used the letter 'S' followed by one number to designate each in-service teacher (e.g., S2) and we used the letters 'CL' to designate the course leaders. In the second step we focused on the design elements and for this we used the definition of design elements (Deterding et al, 2011) and levels of game elements.

4. Results

4.1 Impact of the Course

4.1.1 Teachers' Experience with the Course

Teachers indicated that they enjoyed and learned a lot from the course: 'All in all, I thought it was a complete course in which attention is paid to the literature and the substantiation of why you could do this. There is also a lot of room to try something out experimentally and to see what the effect is and where are the snags' (S2). The good atmosphere in the classroom and within the teams and the relationship with the course leaders was much appreciated. For example, S3 tells how in her group they share their passion for playing and could count on each other: "The atmosphere was relaxed, with a lot of humor, understanding for each other and especially enthusiasm. All of us have made a positive contribution to that." S10 mentions how he had fun designing their game and learned new content from it: "We searched for typical medieval names to hang our story on. That brought with it the necessary funny moments. In addition, we also had to look for typical medieval customs and cultural aspects to give our story 'body'."

Teachers described gameful experiences: "Getting a sea of ideas and then unpacking what you like" (S15) and "There was an element of play in every lesson, an opportunity to share or exchange something with the group" (S3). They also mentioned feeling connected as a community: "By working in this way, you form a community in which you can share, learn, question and give feedback and I think it's great that I am part of that" (S3). The way of working with a lot of freedom of choice to delve into what they found interesting was much appreciated. But there were also moments of uncertainty and tension. For example, it took time for S11 to get used to the freedom for experimentation and discovery and S10 felt out of his comfort zone because he worked with multidisciplinary teams, while in his school he gravitates towards his own department. Frustration was also experienced in very small sizes. For instance, for S2 the fact that their game was not finished was a shame: "Too much time was put into it and yet it didn't work". S11 also had a negative experience with the assignment, although her group made a full game, she says it took too much time to design.

4.1.2 Teachers' Competence Growth

The results of the competency questionnaire are given in Figure 2. Teachers reported growth in all four areas. Most of the growth concerns the *Tutoring,* which is the implementation of game activities (pedagogical area), *playful stance* (creative area) and analyzing *game and tools* (technological area). Teachers referred in the interviews and reflections that analyzing games and tools provided them with more knowledge about the background of games and underlying learning processes. For example, S11 now sees that games rely much more on problem-solving skills and S15 finds himself more skilled in examining games and identifying why something works or does not work. Regarding *curriculum-based planning,* teachers mentioned their difficulty in implementing full games: "It takes a lot of time, and it is difficult to link with the content" (S13).

The least growth was in the *flexible use of ICT* and *networks outside the school*. When asked for the reason, teachers mentioned that these skills were not really incorporated in the course.

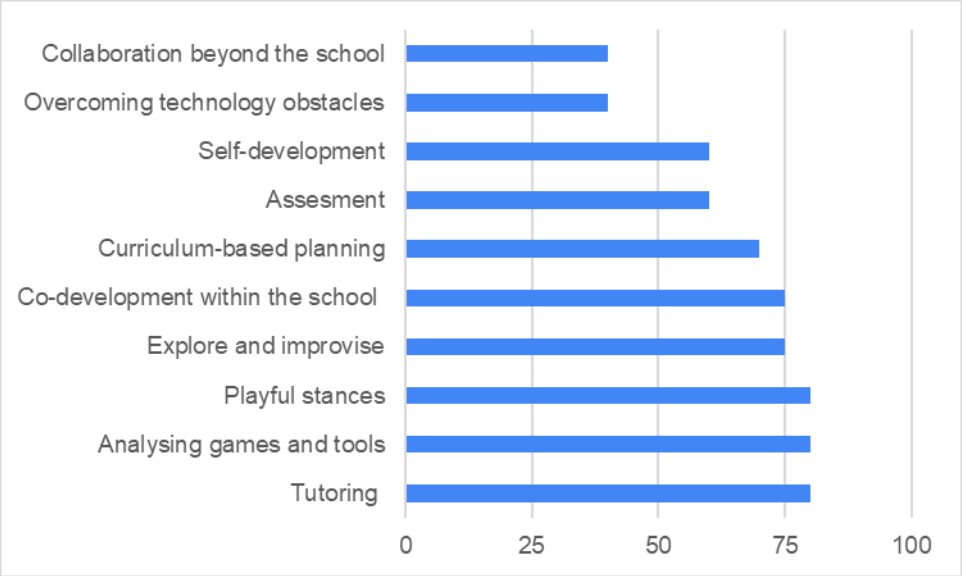


Figure 2: Growth by competence dimension

4.1.3 Teachers' use of GBL in School Practice

Several teachers used the same or similar game activities offered by the course leaders in their own classes. For instance, S1 adapted the break-in room activity and used it with her own students as exam review. Some teachers integrated modified game activities in their actual teaching: "Two weeks ago I recreated a board game of 30 Seconds with the Roman Empire in the background" (S2). The 30 Seconds game was developed by one group of teachers during the course. Teachers have also created new games themselves and/or together with other teachers at school. For example, S11 has made a board game about exploration with a geography teacher, and she has made a trivia board game for history herself. S11 regularly uses the online tool Genially in her lessons to create escape games with her students. Her students make the questions and answers, and S11 finalizes them into an escape game for the class.

Teachers also experience obstacles when trying to implement GBL in their practice: "It is difficult to work within a team, because you would like to develop something together but how do you take a team that doesn't want to cooperate?" For this, S2 feels that he has been offered few tools or strategies during the course.

4.1.4 Course Leaders' Experience With the Course

All course leaders were positive about their course experiences. Some aspects that could be further improved in the course design include more scaffolding during the design of the games, the layout of the skill tree, and further aligning the assessment with the content of the course.

When asked what kinds of elements or activities they found most useful and why, the course leaders noted: "The whole combination had a nice effect" (CL1); the variation was impactful because "...we wanted to expose the students to as many variations of gamification as possible" (CL3); and the skill tree because it allowed for

"pursuing individual interests" (CL1) and "promoted autonomy" (CL2). The collective game activities were important as they "led to engagement, teachers experienced more fun, interaction, and challenge, and learning beyond their own perspective" (CL1). Also, there were spontaneous activities coming up themselves and all course leaders embraced them: "Leaving space for such things to happen is important" (CL1). Finally, chance elements, e.g., using dice or doubling points by surprise are important because chance is a very important element in many games (CL2).

4.2 Design Elements for Teachers' Professional Development in GBP

Teacher learning experience and impact on their school practice were analyzed in relation to the course's design elements as explained in the method section. This led to the categorization presented below. Each design element described was mentioned by at least one teacher.

*Game interface design patterns c*onsist of design components and design solutions, including prototypical implementations. Teachers referred to the *point count, leaderboard* f*or each class and prizes* and a *skill tree*. These elements had a strong effect on the gameful and playful experience: "There was a play element in every lesson" (S3); "The lectures started with game music" (S15). They also impacted teachers' school practice, for instance S11, a history teacher, adopted the idea of points and prizes, sometimes a chocolate bar, sometimes a carrot, in her teaching. The skill tree "felt like a game" (S15) but it had a deeper impact on teachers' learning: "We were able to deepen the theory at our own pace because of the skill tree. This creates freedom and gives opportunities to gain your own insights about the various parts within GBL" (S1). The skill tree element was mentioned by almost all teachers for similar reasons.

Game mechanics involves parts of the design of a (game) activity that concern gameplay for learning. Teachers referred to seven mechanics: (1) G*o deeper into any subject of own interest* within GBP. They could choose one of the many activities in the skill tree or add their own; in both cases they would get points for it. Teachers' choices were varied. For instance, S3 went deep into the theoretical background about GBL through seeing videos while S9 preferred to read the book *A Theory of Fun*. (2) *Analyzing a game* was modeled in the lesson. Teachers could then use other models presented in the skill tree. S11 used Octalysis to analyze the game Assassin's Creed because she was curious to know about the learning value of this game for her discipline (history). (3) *exploring examples of gamified activities* with digital tools, such as Blooket and Genially presented by the course leaders and other tools at their own choice. (4) *Activities connected with informal contexts*. For instance, S13 liked the activity bring your own game "because then everyone shows their own game and you also learn from that analysis." (5) *Playing a variety of games* was perhaps the most present mechanic throughout the whole course: "The course started with a kind of escape room where you had to look for a code to enter the room. It was an unexpected first lecture which immediately fueled my enthusiasm and curiosity for the coming weeks" (S1). (6) *GBL modeling*: "We played an escape room together, in which the offered theory of game-based learning was incorporated. Our teacher had made this [escape room] with everyday materials like cups and folders and easy games like memory to show how simple such a thing can be. I immediately took her idea and applied it to a grammar lesson in French about conjugating verbs" (S3). (7) The *questionnaire on GBP competences,* was used by the participants in one lesson activity to get insight into the competences of their team. S2 found this activity "very instructive because it forces you to start thinking, 'Where does your affinity lie and what can you already do?'"

Game design heuristics are evaluative guidelines to approach a design problem or analyze a given design solution. The objectives of the course-design were *enacting gameful and playful experience*; *competence growth* and foster teachers' *Integration of GBL in school practice; collaborative learning* across disciplines. The first three heuristics have already been extensively discussed in section 4.1. Regarding the collaboration aspect, the participants learned a lot (and had fun) from working together: "It was instructive to see how others approach something, such as making a puzzle for an escape room, but also how pressure is handled".

Learning-by-games models refers to the conceptual models relating components of games, learning and gameful/playful experience. Teachers referred to the Smiley (Weitze, 2017) and Octalysis (Chou, 2019) models, both introduced in the lessons in connection with game analysis. For instance, one teacher found the Smiley model a good basis to understand the value of games for education, "to see what games do and how we could possibly use it".

Game design methods consist of game design-specific practices and processes. In our case: (1) *playtesting own designs in class with fellow students:* "I shared with the group how I had handled this, how much time it had taken, how the students had reacted to it and what I learned from it. By working in this way, you form a

community" (2) *Experimenting with (own) games in own school practice*. An example is that S11 carried out the assignments from the skill tree related to educational escape rooms with her students. In addition, during a project week, she gave her students the assignment to build an escape room themselves. (3) Teachers' could *present their projects* or working progress or any game activity that they had tried in their practice or would like to do: "I thought it was great that we all got the chance to use part of the lesson for a short presentation/workshop/game so that you also knew how the other groups approached things and you could get feedback yourself".

An overview of the design elements mentioned by the teachers and organized per level is presented in Table 1.

Table 1: Levels and elements for the design of a course on GBP

Levels of Elements	Game Design Elements
Game interface design patterns	• Point count, leaderboard, and prizes • Skill tree (on paper)
Game mechanics	• Deepening own interest • Analysing a game • Exploration (e.g., tools for digital games) • Connection with informal context • Playing a variety of games • GBL modelling by course leaders and group members • Scanning GBP-competences
Game design heuristics	• Gameful and playful experience • Competence growth • Integration of GBL in school practice • Collaborative learning: other perspective or strategy, responsibility; choice
Learning with game models	• Smiley model (Weitze, 2016) • Octalysis model (Chou, 2019)
Game design methods	• Playtesting own designs in class with fellow students • Experimenting with (own) games in own school practice • Teachers' presentations

5. Discussion and Further Research

The aim of this study is to understand the way design elements of a course on GBP for teachers impacted their competences on GBP and teaching with games in practice. First, through qualitative analysis, we identified a set of design elements (Table 1) that contribute to this. These design elements are in line with research on gamification (Luarn et al, 2023). We extend previous research by providing knowledge on how these design elements encouraged learners' motivation, perseverance and socialization which is needed to develop effective gamified courses. Effective gamification elements go beyond merely adding points, levels, and rewards to content. It also provides challenges and feedback, along with interaction, which encourages learners to play for mastering content and skills, to overcome difficulties, and to socialize with others (Luarn et al, 2023). Our hypothesis is that the level categorization of the design elements supported with the examples developed in this study can provide guidance for designing gamified teaching programs. Future research should explore and test this supposition.

Second, we increased our understanding of how design elements engage learners and course leaders throughout the course. One major challenge in designing motivating GBL interventions is to integrate learning content seamlessly with game elements (Barz et al, 2024). We found out that *game interface design patterns* provide scaffolding of the course content, helping the learner to structure their own learning path and make decisions aligned with the course goals. This finding resonates with Luarn et al's (2023) suggestion that a gameful design means to help students gain more control over their performance and progress. G*ame mechanics* (e.g., deepening own interests, playing a game) enacted learners' gameful- and playful-ness (Deteringen, 2011), which

probably intrinsically motivated the learners to work towards the learning goals (Luarn et al, 2023). *Learning with game model elements* (e.g., Octalysis) has helped learners to understand the learning mechanisms behind games. *Game design heuristics* defined not only the design of the course but the way course leaders interacted and supported learners through the course. For instance, by modeling game-based learning (e.g., playing an escape room in the lesson) and gamification (e.g., the skill tree) course participants get first-hand experience, leading to increased confidence with GBL (Avidov-Ungar & Hayak, 2023). *Game design methods (*e.g., experimenting with games) provided space for learners to experiment and share experiences. Giving space for learners to contribute to the lesson even when unexpected seemed important for participants' engagement. The course leaders praised any attempt of the learners to share or to contribute to the lesson and had allocated time in the meeting for this when asked. This could be included as the fifth design heuristic in Table 1.

Reflecting on the methodology in the current study, the small sample and the fact that the participants chose to attend a course on GBL likely resulted in a sample that is already interested in, and potentially biased toward, GBL practices. In addition, the teacher educators had experience using GBL in their practice, which is not representative of teacher educators in general (Avidov-Ungar & Hayak, 2023). An additional study using mixed methods would be valuable to understand the impact of the course by a more representative sample of in-service teachers and teacher educators.

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When Games get in the way: Gamification Approach for Teaching Maths – A Case Study With Undergraduate Tourism Students

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Abstract: Planning more dynamic and motivating lessons for students is the goal of any teacher, especially maths teachers, a subject where the lack of interest and motivation to learn is so evident and a major concern. Several studies highlight the positive impact of the adoption of gamification strategies in teaching/learning, both in student motivation and in the development of soft skills (teamwork, creativity, decision-making, leadership, communication, and critical thinking). Game-based learning thus promotes students' interest and involves them in this process. In this sense, one of the authors of this study chose to use several (non-digital) games to support the teaching-learning process in her classes. The games used were developed by the authors and have been thoroughly designed to address specific maths topics. The games took various forms, including card games, board games and other hands-on activities. The participants in the study are first-year undergraduate students from a Portuguese higher education institution and encompassed the course of "Quantitative Methods". The aim of the study is to investigate students' perceptions of the use of gamification in the maths teaching-learning process. To gather information about students' insights on the use of games in math classes a quantitative survey was conducted. Similar studies have shown that higher education students are usually receptive to the use of games, finding it useful to increase their motivation and consider game-based learning can positively impact learning. Our findings are in line with those studies.

Keywords: Educational Games, Gamification, Non-digital Games, Mathematics Education, Pre-service Teachers.

1. Introduction

Maths education is crucial in today's educational landscape. However, it has raised concerns due to persistent academic and educational failures, as documented by various researchers (e.g., Pais, Cabrita and Anjo, 2011; Faulkne, Hannigan and Fitzmaurice, 2014; Pais and Hall, 2021; Santos et al., 2021; Maharjan et al., 2022; Morando and Turconi, 2022; Morando and Spreafico, 2023). Studies highlight a lack of student interest and motivation in mathematics as a key factor contributing to this failure (JMCUK, 2011). This is particularly evident for students in non-maths-focused programs, such as tourism degrees (Pais and Hall, 2021; Santos et al., 2021).

Game-based learning (GBL) can be a pedagogical resource and a good strategy in the classroom to support mathematical learning and, at the same time, reveal the pleasant and stimulating perspective of learning thus motivating students to learn maths (Pais and Hall, 2021; Morando and Turconi, 2022; Morando and Spreafico, 2023). A systematic review carried out by Erşen and Ergül (2022) highlights that teaching with games increases academic performance, has a positive impact on attitudes toward mathematics, and that students positively evaluate the use of games in the mathematics teaching-learning process.

With the aim of seeking strategies to foster interest in mathematics, motive student enthusiasm and make the learning process itself more engaging, the first author of this work decided to use several (non-digital) games to support the teaching-learning process in her classes. The games used either pre-existing educational games or adaptations of original games by mathematicians Maria Luisa Spreafico and Paola Morando, known for their expertise in designing maths games (La Fortuna et al., 2022; Morando & Turconi, 2022; Morando & Spreafico, 2023). All the games were meticulously planned to address specific mathematical topics. The games took various forms, including card games, board games and other hands-on activities.

The study here presented involved the students of "Quantitative Methods" (1st semester of 2023/2024), a first-year course in the "Restaurant and Catering Management" bachelor's degree, offered by a higher education institution specializing in undergraduate degrees in Tourism.

1.1 Non-Digital Game Based Learning

Oldfield (1991) defines a mathematical game as a social activity with rules, structure, goals and specific mathematical cognitive objectives.

Non-digital games are those that don't depend on any electronic device to be played. They can range from puzzles, card games, board games to hands-on activities (Connoly, Stansfield and Hainey 2007).

Despite the numerous advantages of technology, inclusively when used in gamification activities, the authors opted to use non-digital games instead of digital games. In today's digital/technological world, young people are surrounded by screens and spend countless hours “looking” at them. The excessive use of technology is compromising the quality of social interactions, leading many of our young people to social isolation and difficulties in communicating and establishing relationships (Paiva and Costa, 2015). Thus, the authors deliberately wanted to provide their students with a break from the digital world and screens. In addition, non-digital games have other benefits (Ramos, Knaul and Rocha 2020), such as: (i) improving social relationships; (ii) promoting teamwork and cooperation; and (iii) face-to-face interaction and communication with others.

2. Methodology

2.1 Research Aim, Procedure, and Instruments

This study investigated whether integrating game-based learning strategies throughout the "Quantitative Methods" course could increase student motivation and engagement, particularly for students in the Tourism program, when learning mathematics. To achieve this, the authors employed a case study with primarily exploratory objectives.

Bearing in mind the aim of the study, the authors developed a questionnaire for the students who attended the course under evaluation, described and analysed in Section 4.2. A preliminary version of this instrument was analysed by two higher education teachers, tested with three individuals from the same group, and modified based on the suggestions collected and difficulties detected during its completion. Since one of the authors of this article was the teacher responsible for the course in question, the technique of direct observation was also applied, using field notes.

At the end of the semester, students were asked to fill in the questionnaire. The questionnaire was distributed online to the students who attended the classes and aimed to assess the students’ opinion on the changes made to the way the course was taught. After data collection, qualitative analyses were carried out, quantified whenever necessary and possible. A descriptive analysis was performed, using heatmaps and graphical representations of responses as well as the calculation of the mean and standard deviation of quantitative responses. The analyses were performed with Excel.

2.2 Participants

The case study was conducted at a higher education institution in the central region of Portugal. The participants were undergraduate students majoring in “Restaurant and Catering Management”, specifically enrolled in the “Quantitative Methods” course during the first semester of the academic year 2023-2024. The case study included a total of 12 students, with 9 of them completing the questionnaire. Among the respondents, 6 (66.6%) were female, and 3 (33.3%) were male. The age of the participants ranged from 18 to 21 years. It is important to note that this was a convenience sample, meaning that the participants were easily accessible to the researchers.

2.3 Study Description

The course content was divided into three main topics: elementary mathematics applied to restaurant and catering management, applied mathematics for management, and statistics. The course consisted of 22 two-hour classes, and games were incorporated into 9 of these classes.

The first topic primarily involved reviewing basic mathematics concepts from elementary school. It was divided into four subtopics: arithmetic operations, decimals and fractions, ratios, proportions, percentages, and units of measurement. Due to students' lack of prior knowledge, eight classes were dedicated to this topic (two classes for each subtopic). Games were used in four of these eight classes, in the second half of the last class for each subtopic.

The second topic covered polynomial functions, exponential functions, and logarithmic functions, as well as their applications in financial modelling. Eight classes were required to cover this topic, two per subtopic. Game-based learning was used to practice problem-solving in two of these classes.

The last six classes were dedicated to the third topic: descriptive statistics and linear regression. Games were used in two of these six classes – one after completing the classes on frequency tables, graphical representations, and sample statistics (central tendency and dispersion), and another in the last class for practicing problem-solving.

A total of five different games were used: "SuperTmatik"; "Fractions Dominoes"; "Math Twins" (in two different setups); "Problem Basket" (in three different setups); and "StatPictionary". Table 1 specifies which games were used to address each of the program topics.

The purpose of using the games was to provide students with a better learning experience, engaging them in the learning process and promoting their interest.

Table 1: Games played

Topics	Game	Contents	Class number and game version
Elementary mathematics applied to catering and restaurant management	SuperTmatik	Review of arithmetic operations	Class 2
	Fractions Dominoes	Review of decimal numbers and fractions	Class 4
	Math Twins	Review of decimal numbers and fractions	Class 4 Version 3
		Measurement units	Class 6 Versions 2 and 3
	Problem Basket	Review of ratios, proportions, and percentages	Class 8
Applied mathematics for management	Problem Basket	Polynomial functions	Class 11
		Exponential and logarithmic functions	Class 16
Statistics	StatPictionary	Frequency tables, graphs, statistical measures (central tendency and dispersion)	Class 20
	Problem Basket	Dispersion statistics, linear regression	Class 22

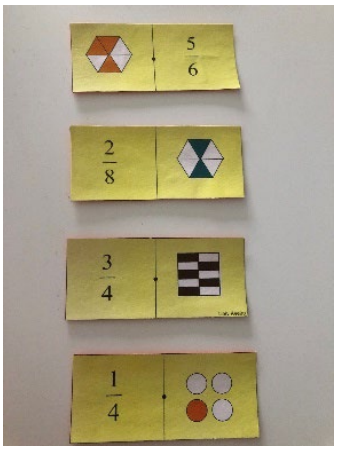
3. Presentation of the Games Played

Out of all the games played, only one was not developed by the authors of this paper – "SuperTmatik" – an educational game developed by Eudactica, widely used in school settings since 2005, with national school competitions held in various countries.

The games were developed considering the principles of educational game design and development described in the diverse existing bibliography (Whitten & Moseley, 2012; Kapp, 2012; Nicholson and Cable, 2020). Next, each of the four games adapted by the authors is described.

3.1 Fraction Dominoes

This game is a variation of the popular Dominoes. It features pieces with a number (fractional or decimal) on one side and a corresponding diagram on the other (see Figure 1). Players take turns matching either the number or the diagram with the pieces already played on the table. The first player to get rid of all their pieces wins.



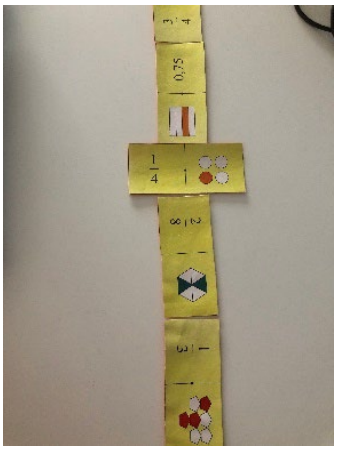


Figure 1: Examples of pieces and chain of "Fraction Dominoes"

Materials Needed:

- one set of dominoes for each group of 4 players;
- a die.

Game instructions:

- Four players form a group.
- The 28 pieces are shuffled, and each player draws seven.
- To determine the starting player, everyone rolls a die. The player with the highest roll begins.
- On their turn, players must attempt to place one of their pieces on either end of the existing domino chain. They can strategically choose which end to play based on their hand.
- If a player successfully places a piece, their turn ends, and play moves to the next player.
- If a player has no piece that fits either end, they must pass their turn without playing.
- The game ends when one player gets rid of all their pieces, or when the game becomes deadlocked (no player can play a piece). In a deadlock, the winner is the player with the fewest remaining pieces.

3.2 Mathtwins

"Mathtwins" is a variation of the popular memory game where you must find pairs of identical elements or elements that are matched in some way.

Materials Needed:

- a deck of cards paired in pairs.
- a timer.

Game instructions:

Version 1 (Game for a large group):

- Match the number of cards to the number of players (which must be even) by removing some pairs from the deck if necessary.
- Deal the cards, one to each player.
- Silently, each player must find his pair.
- The first successful pairs of players earn a reward.

Version 2 (Game for 4 teams of 1-2 players):

- The number of cards in the deck must be an even multiple of the number of teams.
- Deal the whole deck to the teams.
- Each team must check if they have any pairs in their hand and put them aside. They have one minute to do this.
- Then, simultaneously, each team draws a random card from the team next to them and checks again if they can form a pair. They have one minute to do this.
- Repeat this step until one team has no cards left. That team wins the game.

Version 3 (Game for a large group divided into teams):

- For this version you must have as many decks as teams.
- Each team receives a deck and displays the cards on a table.
- For 3 minutes (or another time stipulated by the teacher), the teams must look for pairs in the deck.
- The team that has found the most pairs at the end of the time wins.

"Mathtwins" was played in two different classes, exploring two distinct topics: measurement units and rational numbers. The first deck comprised pairs of corresponding measures expressed in different units, as illustrated in Figure 2 (left). The second deck involved pairs of rational numbers that add up to 1, with one number in fractional form and the other in decimal form (see Figure 2, right).

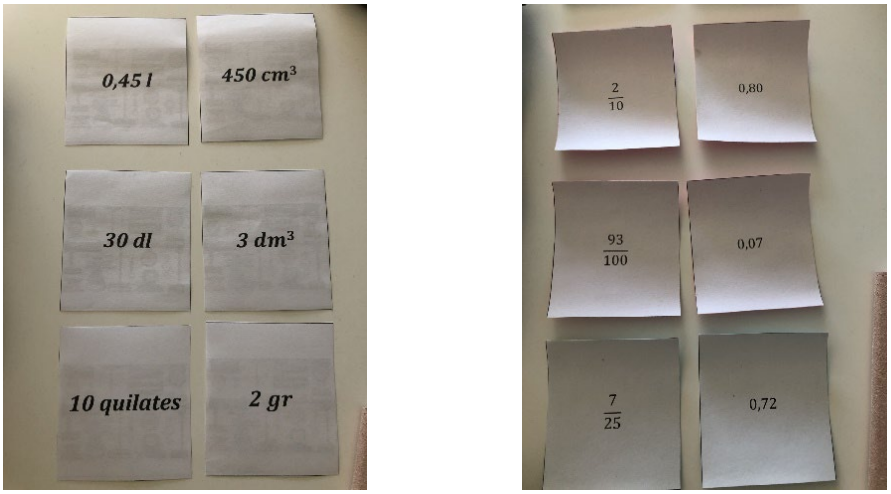


Figure 2: Examples of pairs of cards from "Mathtwins – Measurement Units" (left) and "Mathtwins – Rational Numbers" (right)

3.3 Problem Basket

This game is a treasure hunt-style game that challenges teams to solve a series of problems. The solutions to these problems lead to the discovery of a magic word. The game aims to develop problem-solving skills while exploring probability calculations in diverse situations.

Materials Needed:

- A box containing various objects and mathematical tools (ruler, calculator, etc.) accessible to all teams.
- Several identical boxes or baskets containing problems written on rolled-up pieces of paper. Each paper roll should be attached to an object.

Game instructions:

- Divide the participants into teams.
- Place the box of objects and mathematical tools in a central location.
- Distribute the problem-filled boxes or baskets among the teams.
- Explain the rules:
    - Each team must solve the problems on the paper rolls.
    - Teams can use the objects and mathematical tools in the central box to solve the problems.
    - As teams solve problems, they should arrange the paper rolls in ascending order based on their answers.
    - On each paper roll, they should write the first letter of the object attached it.
    - The word formed by the sequence of first letters is the key to the game.
    - The first team to correctly identify the magic word wins the game.

As reported in Table 1, "Problem Basket" was played in four different classes addressing three different topics. Figure 3 shows two details of the game in action.



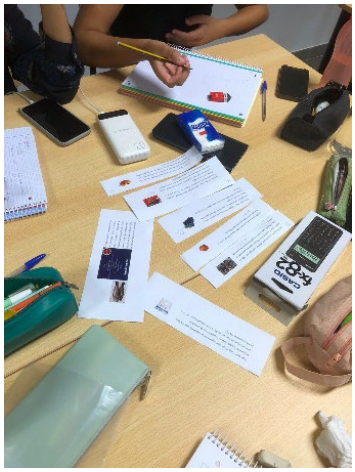


Figure 3: "Problem Basket" in action

3.4 StatPictionary

Inspired by the popular game Pictionary, "StatPictionary" focuses on descriptive data analysis. The game aims to solidify students' understanding of various types of graphs, frequency tables and sample measures as outlined in the mathematics curriculum.

Materials Needed:

- A deck of 24 cards featuring graphs/tables and questions (each card with one chart or frequency table and six numbered questions).
- Two notebooks containing (only) the graphs/tables presented on the cards.
- A white board.
- A die, a 3-minute timer, and two calculators.

Game instructions:

- Form Teams: Divide the class into two teams, ideally with 4-6 members each.
- Provide each team with a calculator and one of the notebooks.
- Teams take turns. On their turn, each team must choose a representative who:
    - draws a card and announces its number so that everyone can identify the corresponding graph/table in their notebooks. (Alternatively, project the graph onto a screen.)
    - sets the timer and rolls the die.
    - uses the whiteboard to draw a representation of the question from the card (corresponding to the number rolled on the die) in an attempt to have their team guess the question.
- If the team correctly guesses the question, they have the remaining time (at least 1 minute) to answer it.
- If their answer is correct, they earn 2 points and pass the turn to the other team.
- If their answer is incorrect, the team earns only 1 point (for guessing the question correctly), and the opportunity to answer the question passes to the other team. The other team has one minute to answer the question. If their answer is correct, they earn 1 point.
- The turn moves to the other team and the game continues as described above.
- The team with the most points after a predetermined number of rounds (equal for both teams) wins the game.

It is not allowed (i) to use words or abbreviations; (ii) to redraw the graph or any part of it; (iii) to use the values from the graph. It is allowed (i) to draw on the board; (ii) to use symbolic mathematical language; (iii) to use colours; and (iv) to use a calculator during the response phase to the questions.

Figure 4 shows the game in action.



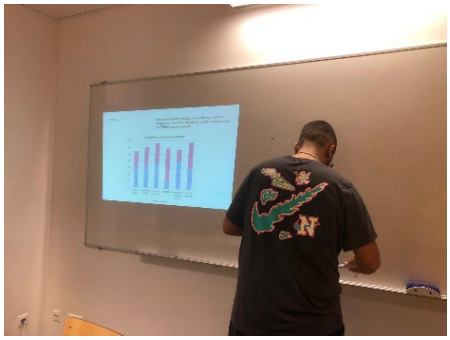


Figure 4: "StatPictionary" in action

This game demonstrates particular creativity. In closing, we would like to make some final remarks on its didactic aspects.

Learning to read: The graphs presented in the game address many different forms of data representation commonly used in statistics. In this way, students approach them in a playful and engaging way, learning to read and interpret information expressed in different ways.

Learning to ask questions: The game aims to familiarize students with the language of statistics. Players should not only answer a question (as usually happens when more traditional statistics exercises are offered), but before that, they must formulate the question correctly, encouraging them to think about the language and specific terms of this discipline, using them critically.

Effective summarizing: By experiencing the difficulty of predicting the question just by looking at the graph, students understand how an appropriate graphical representation of data allows for the transmission of a lot of information.

Let's make our own deck: After playing a few times, it may be interesting to suggest to students that they create new cards, inspired, for example, by graphs found in newspapers, and challenge them to come up with fun situations in which these graphs can be used.

4. Findings

This paper intends to investigate if the use of non-digital educational games in maths classes can contribute to increase students' motivation and involvement regarding mathematics learning.

To reach this goal, field notes and analysis of a survey were the main instruments used.

Regarding the objective stated previously – investigate if the use of game-based learning strategies contributes to increase students' motivation and involvement – several results may be reported.

4.1 Field Notes Analysis

The teacher (simultaneously the first author of this article) observed that the students thoroughly enjoyed and found the games activities to be highly enjoyable and entertaining. According to the students' feedback, this type of active and dynamic classes proved to be more appealing compared to a traditional approach. Mathematics, in particular, was perceived as a more engaging and positive subject through the use of game-based learning activities. Some participants expressed their enthusiasm, stating that the classes became much more enjoyable and interesting with this approach. These facts support a positive answer to the established objectives: evaluate if the use of game-based learning strategies contributes to making the learning process more interesting and to promoting a more positive attitude towards mathematics.

4.2 Questionnaire Analysis

To collect information about students' insights on the use of non-digital games in maths classes a questionnaire was delivered at the end of the semester. From the 12 students who took part in the activity, 9 answered the questionnaire.

Using a five-point Likert scale, students were asked if they enjoyed playing educational games in maths classes. As figure 5 shows, most students responded positively and there were no negative responses.

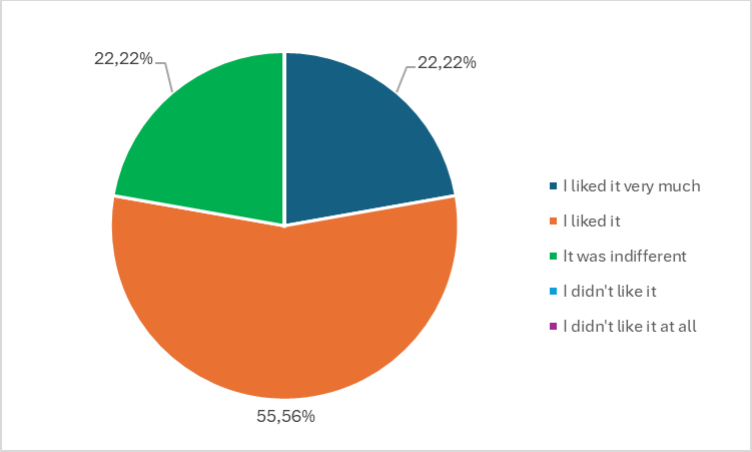


Figure 5: Pie-chart of responses to the question "Did you enjoy the educational games in maths classes?"

Through another two five-point Likert scale questions, all surveyed students considered the use of games to be relevant in the teaching and learning process of Mathematics and recommend the use of games in Mathematics classes. Regarding the questions "Did the use of games in mathematics classes help you to enjoy mathematics more?" and "Do you like the competitive aspect associated with games?", the results are identical: 55.6% of the respondents answered yes; 44.4% answered indifferent and none answered negatively.

The results regarding student game preferences are presented in Figure 6. "Problem Basket - Ratio, Proportion and Percentage" was the preferred game, followed by "SuperTmatik".

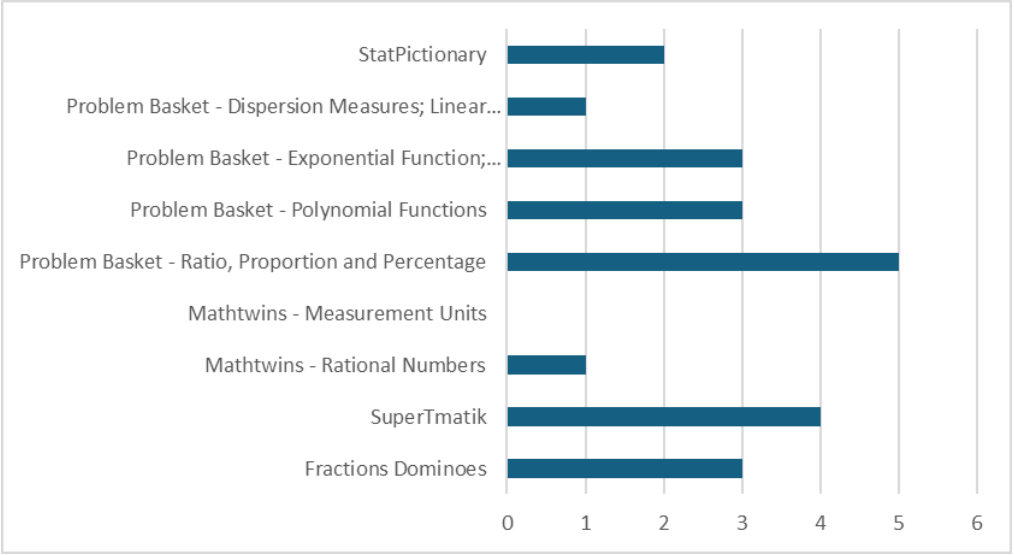


Figure 6: Frequency table of responses to the question "Which games did you enjoy the most?"

Students were asked to rate their agreement on a five-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree) with a set of statements concerning the use of educational games in class. The results are presented in the heatmap of Figure 7, which also includes the mean and standard deviation (sd) of the responses. We can see that, overall, the results are very positive and very few respondents disagreed with any of the statements. These results are in line with what the teacher could observe during the semester.

The use of educational games in maths classes contributed to:	1	2	3	4	5	mean	sd
making learning more interesting.	0	0	2	3	4	4,2	0,7
making learning more interactive.	0	1	1	3	4	4,1	1,1
making classes more stimulating.	0	1	1	2	5	4,2	1,2
involving the students in the learning process.	0	0	1	3	5	4,4	0,5
increasing student motivation	0	0	2	3	4	4,2	0,7
a more positive view of mathematics	0	1	2	4	2	3,8	0,9

Figure 7: Heatmap of responses related to the use of games in maths classes.

When asked what they would keep in the planning of the course for the incoming year, the most common answers were "everything" and "the games". Concerning what they would change, the respondents said they wouldn't change anything.

5. Final Remarks

The main limitation of this study is its small sample size. However, despite this limitation, the study's results demonstrate that incorporating game-based learning activities in maths classes enhances student engagement and motivation for learning by making the learning process enjoyable. These findings align with similar studies conducted by Chiang and Qin (2018), Pais and Hall (2021), Morando and Turconi (2022), Morando and Spreafico (2023). Furthermore, students perceive the game-based learning as an effective tool for promoting learning and recommend it as a pedagogical methodology.

Based on the results of this study, we conclude that the use of non-digital game-based learning activities in maths classes promotes a positive attitude towards mathematics and thus fosters motivation to learn it. Therefore, we recommend the use of non-digital game-based learning activities in classes. It is a means of helping students improve their interest in the class, their motivation for learning, and, consequently, their engagement in the learning process. Overall, it contributes to a positive environment for learning.

This study can be valuable not only for all teachers but specifically for mathematics teachers, as it provides insights into game-based learning activities. The findings can serve as a foundation for educators who aim to create a fun and engaging learning environment in their classrooms.

For future research, it is recommended to include a larger sample size to further validate the results and enhance the generalizability of the findings. Additionally, investigating other aspects related to game-based learning, such as their impact on specific learning outcomes, different subjects, or different student populations, would be beneficial for expanding our understanding of their effectiveness in education.

Acknowledgments

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Abuzaharen's Challenge: Building Sustainability Competencies through Science-Fiction Narratives and Game-based Learning

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Abstract: This paper presents a case study of the evolution of science-fiction themed game-based learning across two Masters units in a higher education course on sustainable development. The authors created three sustainability games to be played by classes in live workshop settings – a card matching game about urban challenges, a hackathon-style sustainability innovation challenge, and a systemic change analysis game - to build students' capacity to think about systems, sustainability values, and strategies to advance positive change. The story of a bumbling, but well-intentioned, alien protagonist, Abuzaharen, serves as a dynamic backdrop to the games, which see students 'transported' to an alternative reality to complete time-bound challenges in a rigorous yet engaging manner in order to find their way 'home' to Earth. This paper documents how each game's narrative, storytelling, design, and play evolved through multiple iterations over four years, drawing on critical reflection, evidence of engagement and student feedback. The paper also reflects on the affordances of generative artificial intelligence (GenAI) for game-based learning designers. One of the games has integrated GenAI to make Abuzaharen a real-time character in the delivery of the game, including judging student's innovation pitches and generating live narrative content about game outcomes. The GenAI alien agent subsequently appears in 'regular' learning content as a course tutor. Qualitative feedback and educator observations suggest the games increased active class participation, built peer connections, fostered skills in problem-solving, promoted collaboration, and modelled creativity. The games also challenge existing narratives about negative impacts of GenAI on tertiary education by illustrating productive and creative uses of GenAI for students and educators. This paper argues that immersive, narrative-driven approaches, coupled with the strategic use of GenAI, can significantly enrich higher education for sustainability and other educational experiences by scaffolding selected competencies and applying complex concepts to real-world challenges in a light-hearted way. It concludes with practice-led insights and directions for future exploration of interest to sustainability educators, designers of interactive learning, and those experimenting with GenAI in narrative-based games.

Keywords: Game-based Learning, Education for Sustainable Development, Generative Artificial Intelligence (Genai), Science Fiction, Narratives, Sustainability

1. Background

This case study focuses on the development and evolution of a series of games that used a common fictitious character and narrative world to enhance learner engagement with complex sustainability concepts. The case is set within two units (subjects) of a postgraduate degree, the Master of Environment and Sustainability (MES), at Monash University, Australia. This interdisciplinary degree has a very diverse learner cohort (Abbonizio and Ho, 2020) and is taught by educators from three Faculties (Science, Arts, and Business and Economics), as well as, the Monash Sustainable Development Institute. The two units in the case are *ENS5340: Transforming Cities for Sustainability* and *ENS5510: Innovation to Influence System Change*, with enrolments between 20-50 per iteration. The units attract students primarily from the MES, but also include students studying business, public policy, urban planning, media and communication and more.

Transforming Cities for Sustainability was first run in 2021 and was developed and taught by the authors of this paper. However, Melbourne, the host city of Monash University, was facing sporadic and sometimes extended lockdowns due to the COVID-19 pandemic, forcing the unit to run primarily online. We were faced with an educational and design challenge of engaging diverse students, who were experiencing isolation, with complex content about wicked problems and sustainable urban management strategies. Our aspiration was to create a fun, social, virtual classroom experience, which we sought to achieve through experimentation with game-based learning (GBL). From this initial challenge, a game (based on card matching) and science-fiction narrative to drive the gameplay was created.

At first, the narrative that underpinned the game was intended to add intrigue, uncertainty, drama and humour. The alien protagonist, Abuzaharen, was a desperate being from a far-away world on the brink of collapse after generations had ignored warnings about the same sustainability challenges currently facing Earth. Over a period of four years and a total of seven iterations of three distinct sustainability-themed games, this storyline has remained as a narrative driver, but the nature of Abuzaharen's character, prominence in the game design, and

the character's relationship with the educators evolved over time. This paper will first set a theoretical foundation for game-based sustainability learning, then describe the three games, then examine the case of Abuzaharen, drawing out critical reflective insights of relevance to educational game design and sustainability learning practice.

2. Theoretical Framing

We frame the contribution of this paper as triangulating three aspects of game-based sustainability learning: the benefit to students; the impact on educators; and the relationship with the attainment of sustainable development competencies.

2.1 Game-based Learning for Student Engagement Gamification

The popularity and acceptance of GBL as an effective tool for learning has been growing as educators look for ways to increase student engagement and motivation (Dicheva et al. 2014). Oliviera et al. (2021), in a review of gamification literature, found that gamification could enhance student motivation, engagement and satisfaction with education, with particular reference to online learning. Tavares (2022) found in a systematic literature review, that GBL improved relationships, enhanced short-term knowledge and learning retention, and had high levels of student engagement and motivation. Mawasi et al. (2021), found, in an article that explored narrative-based learning with digital games through an affordance perspective, that narratives could also enable the development of mental models. This selection of literature shows that GBL can, depending on the type of game, have a range of benefits and the use of a narrative can be particularly impactful.

2.2 Game-based Learning for Educators

Adoption of game-based learning by educators faces a range of barriers, including development time, educational suitability, and evidence of impact (Lester et al. 2023). However, Hung et al. (2017) show that the process of engaging with gamification can encourage meta-awareness of teaching and learning approaches in faculty, potentially leading to benefits accruing not just to students in their direct experience of a particular game, but to the learning culture of the organisation and the wider educational practices of the teachers. Frossard et al. (2015) describe a wide variety of potential benefits to both students and educators when game-based approaches are adopted, which manifest in-class, as well as, in the wider practices of educators. These include fostering a clear focus on student-centred learning necessitated by the game design process, and that tailored games encourage the production of customised learning materials to suit the target cohort. Specifically, the notion of creative educational practice is examined, and the research found that game design and implementation enabled teachers to enact most aspects of creative pedagogy.

2.3 Game-based Learning in Relation to ESD Competency Development

Scholarship in education for sustainable development (ESD) over the past decade or so has converged upon a broadly-agreed set of competencies to inform program design and implementation (Brundiers et al. 2021). These are values thinking, futures thinking, strategic thinking, interpersonal competence and systems thinking (Wiek et al. 2011), along with implementation and intrapersonal competencies (Brundiers et al. 2021) to form an 'integrated problem-solving competency'. Current literature highlights the need for research into effective educational implementation of this competency framework in courses, with a particular emphasis on pedagogies which enable simultaneous or synergistic development of multiple competencies at once (Wiek and Redman, 2022).

In the context of this case study, the two units prioritise student development of strategic, anticipatory, interpersonal, and normative competencies (cities unit) and systems thinking, strategic and interpersonal competence (innovation unit). Lozano et al. (2017) identify game-based learning and serious games as holding promise for supporting student engagement with sustainability learning. Existing research and experimentation with serious games for sustainability, or game-based sustainability education, tend to focus on single-game cases rather than contextual integration of multiple games into a learning process, and there are also few explicit connections made between competency development and sustainability game-based learning to date. Further, there are more papers reporting on gamification of education using tools such as points, badges, levels and

leaderboards than aspects such as storytelling (Dicheva et al. 2014). As such, this paper is novel in its focus on a single fictitious character and narrative which spans multiple sustainability-themed games.

3. Methodology

This paper presents a case study from a process of ongoing educational practice innovation, emerging from the shared interests of the authors in game-based learning, creative pedagogy, and education for sustainable development competency building. Stake (2013:2-3) describes a case as "entities … an arena, host or fulcrum to bring many functions and relationships together for study" and argues that "the most meaningful data-gathering methods are often observational—both direct observation and learning from the observations of others".

Here, the case entity is, literally, a fictitious character - Abuzaharen the alien - and their integration across multiple game-based learning experiences as a narrative device. The case was not initiated as a direct product of structured research inquiry. Rather, the character was invented and deployed as one of many small educational experiments in the shared practice of the authors. The character and narrative gained traction and grew in utility and educational impact over a period of several years, and it only became clear that this particular experiment warranted more thorough critical reflection and analysis when the character made a successful 'leap' from its original context (the initial card game about cities and sustainability) to a new one (the innovation challenge game). We see this as an example of "making to know", after Buchman (2021:37), who articulates how practitioners use the foundation of their existing skills and knowledge to reach for new possibilities, but that, "until we are in the actual process of creating [an uncertain thing], we can't fully know what it will be".

As such, data gathering for this case study did not have a fixed and formal starting point. In order to understand, evaluate and learn from the case study, we combined qualitative data from the range of sources outlined in Table 1.

Table 1: Data sources collated for analysis in the production of this educational case study.

Data gathering method	Cities Card Game	Innovation Challenge Game	Systemic Change Game
Collation of detailed game designs, creative collateral, such as, narrative scripts, and prototyping artefacts for analysis and reflection	X	X	X
Educator meetings to reflect on and discuss games, class observations and student feedback, documented through rolling meeting notes dating back pre-case inception	X	X	X
Formal educational research into learner creativity (including observations, reflective materials and assessment artefacts) - human ethics obtained		X	X
Reflection on in-class live evaluation and student insights using digital feedback tools, such as, polls		X	X

Our combined analysis of this data took place through a series of dialogue meetings between the authors in 2024 in which we reviewed and critically reflected on the collated data above, which had been gathered across the time period of 2021-2024, and engaged in recorded discussions around three core research questions:

RQ1: How do narrative-based games enhance learning about complex challenges?

RQ2: How do game characters and narratives enable educators to innovate?

RQ3: How can game-based learning contribute to the development of specific ESD competencies?

During this process, we discussed the educational challenges we sought to address with the invention of these games and the character; how and why we made certain choices in the evolution and transfer of the narrative across multiple units and games; our understanding of the impact of the game on student engagement and

learning; thematic learnings we have derived as sustainability educators; and future directions for exploration. A transcript of these recorded dialogues was used to structure the remaining sections of this paper.

4. Game Designs

This section describes three sustainability-themed games across two Masters units, their design and content, and the role that the character of Abuzaharen and the surrounding science-fiction narrative played in these games over time. Oliviera et al. (2021), in a review of educational gamification literature, identified seven gamification elements that can stimulate learning, of which four are common to all of the games described below. These are: challenging and clear missions; narrative and fantasy; competition and social engagement; and feedback and reflection. Figure 1 provides an overview of the game structures and aligns their gameplay phases to ESD competencies articulated by Brundiers et al. (2021).

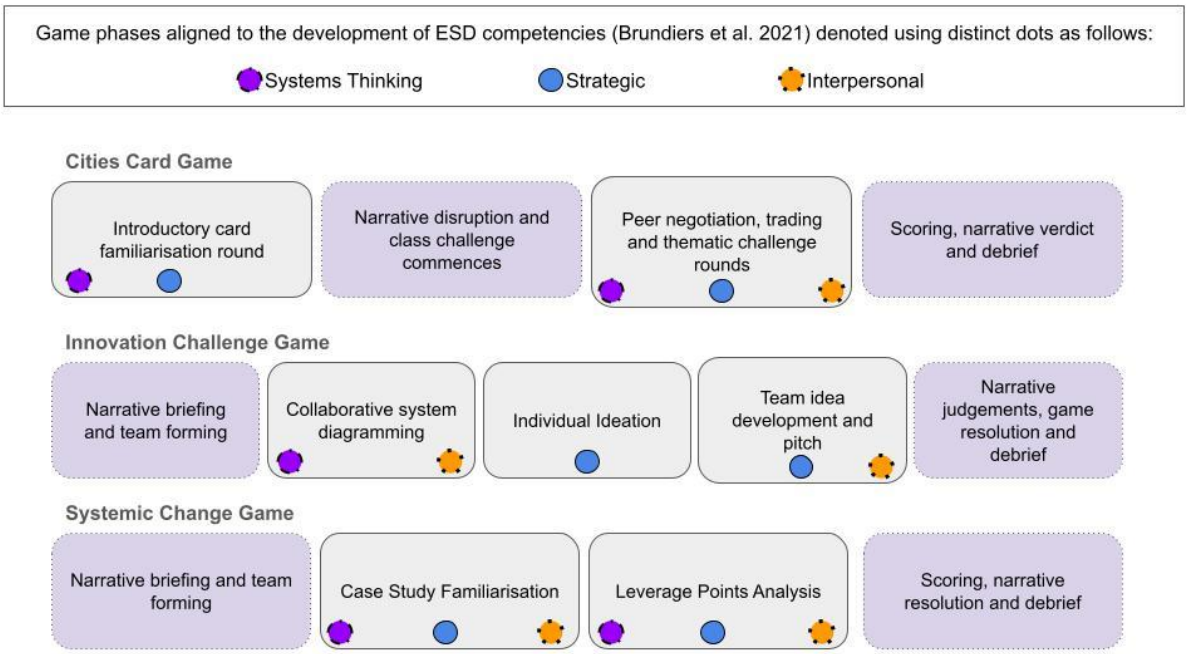


Figure 1: Basic game flow of the three sustainability game-based learning experiences. Boxes with dotted borders denote key narrative components, all others indicate periods of student gameplay. Distinct dot types map ESD competencies onto game-play phases.

4.1 Cities Card Game (2021-2022)

This online card game enables students to explore interactions between challenges cities face and the strategies they can adopt in response. Each student is allocated a Google slide containing five cards that reflect urban challenges (e.g. habitat loss, social inequality) and five that illustrate possible strategic responses (e.g. top-down planning, high density development). Faced with being 'trapped' in an endless temporal loop if they do not meet Abuzaharen's needs, the aim is for player to find positive card alignments (e.g. matching 'bottom-up planning with communities' with addressing 'social inequality') and minimise negative interactions (eg. when 'urban sprawl' is matched with 'habitat loss'). Challenge cards were randomly allocated levels of severity to reflect the uncertainties and complexities of the real world. Students have several rounds to negotiate with other players and trade response cards and can earn bonus points by correctly answering trivia questions based on course content between rounds.

Overall, this was a game of collaboration as well as strategy, because the outcome of the game and the 'fate' of all the students was determined by a combined class score. Players used a tailored scoring system to tally their individual scores from which the educators calculated the class average. If it fell close to the maximum possible result, the class would be 'returned' to Earth.

4.2 Innovation Challenge Game (2023-24)

The Innovation Challenge Game is designed in a hackathon-style format where students are presented with a sustainability challenge, and its original iteration, designed in 2018, is described by Bos and Robertson (2023). Teams follow an innovation process to understand their system of interest, generate an innovative idea for change and deliver a short pitch. In 2023, the students were tasked with developing potential innovations that would improve the sustainability of a large building located on the Monash University campus. In 2024, the students faced a new challenge, with Abuzaharen seeking ideas that would make higher education learning more inclusive, engaging, memorable and interactive, and revive their failing alien society.

Students taking part in these iterations of the game would be returned to Earth if their ideas satisfied Abuzaharen. The alien's feedback was created by GenAI (ChatGPT 3.5) which was prompted on the task requirements and innovation parameters before the workshop. The key criteria given to the GenAI in 2023 required students to show the proposed innovations were more than gimmicks and that they had the potential to create real sustainable change, while the 2024 cohort had to show that their ideas were original, effective and practical.

4.3 Systemic Change Game (2024)

The Systems Change Game was designed to help students identify targeted leverage points used by a range of case studies attempting systemic change, based on a framework proposed by Meadows (1997). During the on-campus class, the students read, discussed and ranked the case studies with the aim of matching the ranking of the class educators. However, we felt a strong narrative hook was needed for the game to work effectively in an online workshop, so we introduced a new storyline for Abuzaharen that set up and landed the game. In the new narrative, a relaxed and happy Abuzaharen wants to reward the students for their success in the Innovation Challenge Game that was played earlier in the unit, by transporting them to his world so they can study the case studies. However, things (again) do not go as Abuzaharen planned and a video shows the portal collapsing to leave the students stranded on an unknown planet. The only way they can 'return' home is by synchronising their thoughts with their on-campus peers, which will allow Abuzaharen to open and direct a portal home. They must achieve this by discussing the provided case studies and assessing their potential to create change. If their scores align with those of the on-campus teams, Abuzaharen can 'send' the students off with a final GenAI-created monologue where the alien expresses their pride and happiness at the result.

5. Evolution of the Abuzaharen Narrative

The overarching narrative of a powerful alien using an appeal for help to save their home planet from sustainability challenges has remained consistent across most of the games. However, Abuzaharen's personality - and therefore the type of tension they brought to the scenarios - has changed. Initially Abuzaharen was a malevolent force willing to use manipulation (ie. 'controlling' the educators against their will) and ultimatums. In the first iterations of the game, the alien protagonist explained that they had 'transported' the class to Xanax (or was about to do so) so the ruling Overseers could use the students' urban sustainability knowledge to save the planet. This is accompanied by a warning that failure would result in students being banished to live out their lives in an endless temporal loop, and Abuzaharen ending the message by telling them to "do not disappoint". However, while still maintaining an authoritative tone, Abuzaharen, in the most recent iterations, possesses a more benevolent presence as a well-meaning, but bumbling, protagonist. In the Systems Change online game, Abuzaharen is seen happy and relaxing on a Xanaxian beach after the success earlier in the unit of the students' ideas to revive the planet's failing education system in the Innovation Challenge Game (although Abuzaharen remains prone to errors that could leave the class in peril).

The method of telling Abuzaharen's story has also become more sophisticated. In the first iteration of the Cities Card Game, the Abuzaharen persona was delivered in a relatively rudimentary manner, with one of the educators setting the alien's image as their Zoom background and attempting, but not entirely succeeding, to hide themselves from view, while reading a short script. This prompted us to pre-record Abuzaharen's parts in the subsequent games, rather than performing them in real time. New scripts and recordings were created for most of the games, which allowed for refinements and to better reflect an increasing range of game narratives. This also allowed for world building as science-fiction themed images and digital footage were sourced, voice modulating tools were experimented with to produce Abuzaharen's voice, and GenAI was integrated as a real-

time participant to play parts of Abuzaharen's role in a more dynamic way. In 2024, we also used visuals generated by GenAI platforms, such as DALL-E, which allowed us to further develop the story's imagery. Figure 2 shows some of the workspaces/game slides used by the students and gives examples of images that were generated to illustrate the recorded and live narrations of Abuzaharen's instructions and judgements.

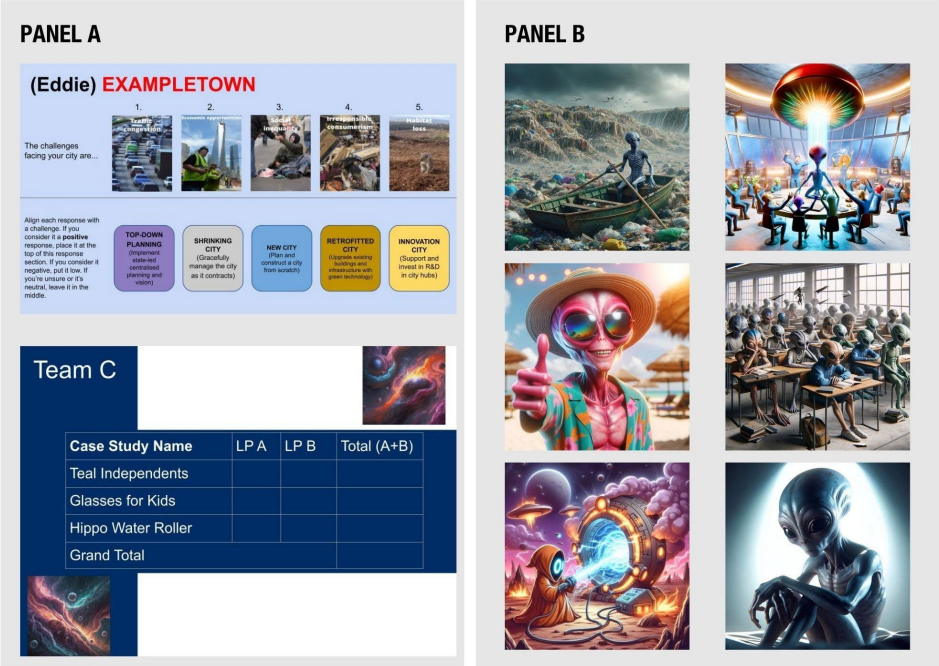


Figure 2: Student workspaces and game images. Panel A, shows, at top, an example of the playing card used by students in the Cities Card Game, and, at bottom, an answer sheet for the online Systemic Change Game. Panel B, clockwise from top left to middle left, shows a Xanaxian rowing a boat among an 'island of plastics', scientists celebrating a discovery before the Xanaxian societal collapse, a classroom of bored alien youth, and a sad Abuzaharen contemplating the fate of their planet (Innovation Challenge Game); and Abuzaharen attempting to power up a faulty portal and a 'thumbs up' from a happy, and relaxed, Abuzaharen on a Xanaxian beach enjoying their society's recovery (Systemic Change Game). The images in Panel B were generated using Gemini (bottom left), and DALL-E, facilitated by ChatGPT.

6. Discussion

In this discussion section, we address the research questions in turn, drawing on analysis and insights from our reflective process.

6.1 RQ1 How do Narrative-based Games Enhance Learning About Complex Challenges?

Learning about sustainable development can be daunting for students, and without careful integration of content and pedagogy, students may not grasp the complexity of the subject matter or may distance themselves from it (Seatter and Cuelemans 2017). The initial intention of introducing a bumbling alien character and sci-fi universe was to enable students to fully engage with the content of a sustainability game without self-censorship and feeling the need to be 'correct' in all of their interpretations of complex material. Setting the culture of the class as one of play and exploration aligns to a guiding principle of the Inner Development Goals project, that "we are far more effective advocates when we are having fun … just because these things are serious doesn't mean they need to be boring" (Inner Development Goals, n.d). In a sci-fi universe, a student may feel more empowered to experiment with combinations of ideas or suggest options that go beyond their current confidence or understanding - a freedom to fail enabled by the game, as described by Oliviera et al. (2021), and explicitly modelled by Abuzaharen, who makes repeated mistakes in their well-meaning attempts at communication with the group.

A specific contribution of the narrative element was the adjustment of traditional classroom roles, which we believe made them more effective than an equivalent game without the narrative aspect (i.e. as a

straightforward card game or hackathon). The first role change is that the Abuzaharen narrative positions the class collectively as themselves, but *themselves as heroes in another dimension with agency over their fate*. This 'permission to be heroes' granted by Abuzaharen comes alongside a second function: the traditional educator-student relationship is disrupted by Abuzaharen, who acts as judge, director, and instructor in the class, while educators have the role of guides and supporters in the game journey - a relationship we believe is appropriate for sustainability learning and in seeking to cultivate wider learning processes in these units. This aspect of games on educators is noted by Frossard et al. (2015), who describe the shift of an educator to a moderating role when games are in progress.

We saw the efficacy of the game-based narrative approach in a variety of ways. One was strong student engagement and motivation in-class. For example, in the four instances that Abuzaharen games ran fully online via Zoom, every student had their cameras switched on throughout the gameplay - in contrast to more conventionally-run classes, where often one third to two thirds would switch cameras off, depending on the type of learning taking place (lecturing, peer discussions, etc). Also, the classes have 'won' every Abuzaharen game - and given that the victory conditions are set to require engagement from all participants with the specific sustainability materials integrated into the multiple phases of each game, and often depend on quite advanced judgement or novelty in interpretation, we can be confident that they have been effective vehicles to provide motivation and engagement.

Student discussion during class debriefs has generally reflected the diversity of benefits of game-based learning. As educators, we lead debriefs with a simple open question: "Why did we do this?". Themes suggested by students across game iterations include:

Becoming comfortable sharing with peers

Creating a sense of belonging

Encourage a sense of responsibility in working together

Being more open to ideas

Bring fun and creative thinking to the class

Think differently about solutions beyond what they consider practical

Generating peer dialogue and debate

Thinking critically about the sustainability topics in the games

This shows students appreciate a mixture of academic and social benefits afforded by the game-based approach.

6.2 RQ2: What did we Learn About the Power of Narrative and how it Influenced the Design of the Learning Activities?

The most surprising aspect of this case study was not that the games were effective - both educators had prior experience with various game-based learning approaches. It was the power of the specific character of Abuzaharen and the science-fiction narrative, and what it afforded us as practitioners over time. After our initial experiment showed promise and the students responded well, we were able to enrich and expand the narrative aspects, and this evolution of Abuzaharen's story has delighted us in many ways. Our confidence in 'selling' the narrative and its value have grown over time, and both authors genuinely embrace science fiction as a genre, which encourages students to place trust in our approach and, therefore, enrol in the games. Students see we are having fun with the narrative while setting serious and productive tasks in-game. We encourage educators to reflect on narrative genres or styles that they authentically enjoy, and use them as a device to transport students to a game-world.

Another lesson we have learned across game iterations is that a narrative approach does not require perfect technology integration or high-fidelity supporting materials. The immersion needs to be sufficient - but striving for perfection may actually undermine the overall success of the experience. Even as our creative artefacts such as videos, imagery and story were refined, we retained some 'rough edges' which are visible to students, such as deliberately cliched imagery and cheesy humour (Abuzaharen's appearance also changed slightly each time a new GenAI image was created as it was not possible - and we did not attempt to - ensure complete

consistency). We believe this is important in modelling a 'safe to fail' environment and freedom to explore. It also means we can develop and adapt the games more quickly - sometimes even live in-class - to respond to the educational needs of different cohorts - reducing the known barrier of development time per iteration (Lester et al. 2023). We have termed this enough-fidelity or 'e-fi' - neither low fidelity or high fidelity - and believe this is both pedagogically effective and supportive of rapid educational experimentation.

The 'e-fi' approach has been important in our experimentation with GenAI. We have deployed ChatGPT 3.5 and Gemini in the games to 'act as' Abuzaharen and provide live-generated judgements, awards and tailored narrative descriptions in the innovation game. GenAI has proven, when given appropriate structuring prompts, capable of delivering surprising and interesting narrative content, often faster and more creatively than the educator team feel they would be capable of in live settings, as well as acting as a dynamic judge of student game outcomes.

However, GenAI can be highly unpredictable - the same set of prompts piloted with one tool ahead of a class may provide different responses when used live. For example, in the Innovation Challenge game, we used ChatGPT to generate a secret target score which student innovations needed to exceed to win the game. This worked in testing, but when identical prompts were used in-class the following week, the software refused to generate a secret number on the grounds that it could facilitate gambling. Rather than ruining the game, we were able to use this as a teaching moment about the pitfalls and drawbacks of GenAI, and show that we, like the students, are on a learning journey about constructive use of these tools. Because Abuzaharen's character (played by the AI) is already established in the narrative as unreliable, we could laugh off this visible failure, pivot to a qualitative judgement method, and continue using GenAI to embody Abuzaharen and move the narrative forward.

Further extending the affordances of Abuzaharen as a character, we have integrated tips and hints throughout curriculum materials in the innovation unit on how to critically and constructively engage with GenAI, using "Ask AI-buzaharen" prompts. Students are encouraged to think of Abuzaharen the alien as a metaphor for AI as a learning tool - potentially super-intelligent, often lacking in 'human common sense', and sometimes flat-out wrong. Thus, as educators, our sustained engagement with this alien character and narrative world has offered us creative approaches to emerging educational challenges well beyond the initial learning intention.

6.3 RQ3: How can Game-based Learning Contribute to the Development of Specific ESD Competencies?

The games have shown strong potential in serving multiple learning functions in relation to education for sustainable development competencies. We designed the games carefully to fit within a wider curriculum design and learning sequence of each sustainability unit. The card-matching cities game synthesises earlier, traditionally-structured online learning content about complex challenges and urban development strategies - that is, it 'tests' students ability to apply what they have learned in novel ways. The Systemic Change Game is similar, but instead of bringing together two content-driven sections, students analyse real-world case studies using a previously-introduced theoretical framework, 'testing' their ability to bring theory together with practice examples. These two games served to support the development of strategic and systems thinking competencies. The novelty, collective challenge, time pressure, incomplete information and dynamic peer interplay meant that the games were vehicles for what Wiek (2011:204) identifies as competence development: "a functionally linked complex of knowledge, skills, and attitudes that enable successful task performance and problem solving".

The innovation game, on the other hand, is the first learning activity in the innovation unit's curriculum and serves to build foundations for later learning. It builds class connection, models safe-to-fail innovation, gives a sense of fun, and previews the later, larger tasks, such as, system analysis. While it touches on systems and strategic competence, its primary function is the development of interpersonal competence and establishing the desired collaborative culture of the class for the upcoming semester. The game is played in teams, each working on distinct aspects of the challenge, and the success of the entire class is used to determine whether victory is achieved. This is a microcosm of the endeavour of sustainable development - a myriad of collaborative projects and processes, with collective success the aim.

As such, we feel this case study shows the potential for game-based sustainability learning to both 'set up' or 'land' aspects of sustainability competency development, and encourage educators and game designers to

explore relationships between game-based learning and more traditional components of curriculum and learning activities in student learning progression.

7. Conclusion and Future Directions

Overall, the case study of Abuzaharen and the application of a sci-fi narrative across three sustainability game-based learning experiences has demonstrated the potential of this approach for driving student engagement and motivation, synthesis and application of learning materials, and to promote interpersonal connection, collaboration and exploration of strategic ideas in relation to complex challenges. It has also demonstrated ongoing benefits and opportunities for the educators, stimulating creativity and enabling engagement with emerging technologies, such as generative AI, in constructive ways.

We feel that future directions for exploration and research include more rigorous evaluation of the efficacy of specific games in relation to targeted learning outcomes and interpersonal abilities. We also believe that generative AI as a game-play agent/character and dynamic narrative generator could have strong applications in more realistic sustainability or other learning contexts, such as organisational simulations, especially when the generative AI agent enables educators to adopt new or different roles in relation to students to enhance the overall learning experience.

A specific example of an intention we have is to use a generative AI character and notions of time travel in the cities unit to support students in exploring real-world urban contexts on a live field tour. We are exploring the potential of a character-driven, time-travel narrative challenge, to build anticipatory (futures-thinking) competency and the ability to 'see' the present, past and future of a place in creative ways, bringing the game-based learning out of the classroom and into even more complex and rich learning contexts.

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Sustainable Sip: Learning Concepts Of Business Sustainability Through A Hybrid Game

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Abstract: We present *Sustainable Sip*, a hybrid multiplayer round-based game designed to provide an experiential learning environment for university-level students at the University of Queensland, Australia. It aims to facilitate literacy around the fundamental concepts of business sustainability, specifically the tensions and interplay between economics and sustainability, and systems thinking. This paper represents stage 1 of this project (design, development, testing). Impact assessment will be covered by stage 2 (application), which is outside the scope of this paper. Each player manages a coffee shop in a competitive market, seeking to maximise their customer base, whilst minimising the production of waste (unsold coffee tokens). Each round, players must decide how much coffee (inventory) to buy from the wholesaler, and the price to sell coffee to customers. Players aim to balance the dimensions of economic performance, environmental sustainability, and customer loyalty; the player that best achieves this wins the 'Sustainable Sipper' award. 'Customer loyalty' is a central concept, calculated in the app for each player and is influenced by the shop's coffee price, quantity of waste the shop produces, and a player's ability to meet customer demand. The game design explicitly draws from system thinking, user-centred and hybrid design, and from self-determination theory (motivation). *Sustainable Sip* has undergone early testing with preliminary feedback highlighting that the gameplay is simple, intuitive and interactive, aspects that are attributable in part to the game design and the hybrid approach.

Keywords: Sustainability Literacy, Coffee Shop, Hybrid Game, Systems Thinking

1. Introduction

Sustainable Sip is a round-based hybrid serious game designed to provide a motivating environment for end-users to learn fundamental concepts of business sustainability and systems thinking. Serious games are known to facilitate knowledge acquisition through active modes of learning (Madani et al., 2017). A pedagogical shift towards active learning is facilitated by the demand for a more activity-based learning environment (Arias-Calderón et al., 2022), increased prevalence of social media (Bohyun, 2015), ubiquity of computers in the classroom (Southgate et al., 2017), widespread popularity of videogames (Morikawa, 2023), and the emergence of "digital natives" with high expectations about teaching models that use digital technology (Jukes et al., 2010).

The aim of *Sustainable Sip* is to provide an experiential and dynamic mechanism for teaching concepts of sustainability and systems thinking using two learning objectives. The first learning objective is to teach tertiary-level students about core concepts of systems thinking (Sterman, 2000), specifically, how system behaviour is informed by system structure (Sterman's 'dynamic hypothesis'). The second objective is teaching tertiary-level students about the social, ecological and economic dimensions of business sustainability. In this paper, we focus on the design of *Sustainable Sip* that draws upon these two learning objectives, and upon the construct of 'motivation'. This paper does not cover testing the impact of the game (ability to meet learning objectives) – this will be the focus of later research.

2. Design Framework

The design of a serious game typically focuses on promoting active participation and interaction (Pappa and Pannese, 2010) whilst balancing educational content and entertainment elements (Aydin et al., 2022). There is numerous literature on game design (e.g. Pappa and Pannese, 2010; Killick 2022), making the process somewhat challenging (Söbke and Streicher, 2016), although design often includes standard elements e.g. mechanics, story, game flow, aesthetics and technology (Killick, 2022). Having clear learning objectives is also important for serious games (Redhead and Saunders, 2019). To guide the design of *Sustainable Sip*, we employed the framework presented in Figure 1, which scaffolds the core considerations of the process in a manner that is similar to Crotty's (1998) research design framework.

2.1 Design Focus

The foundation of designing *Sustainable Sip* is provided by the learning objectives that the game aims to address. Having clear learning objectives is considered critical for gamification design (Redhead and Saunders, 2019). The

learning objectives used for *Sustainable Sip* are teaching tertiary-level students about core concepts of systems thinking, and about the social, ecological and economic dimensions of business sustainability.

2.2 Theoretical Framework

Self-determination theory (SDT) and the intrinsic factors of motivation (Ryan and Deci, 2020) is used as the theoretical framework. SDT has been one of the most applied theoretical frameworks to serious games (Krath et al., 2021), especially with focus on the intrinsic factors that influence end-user motivation to play these 'games'. These intrinsic factors (autonomy, relatedness, and competence) are valued as having the greatest outcomes for learning (Ryan and Deci, 2020).

2.3 Design Framework

The design framework for *Sustainable Sip* is based on user-centred (Caroux et al 2015) and hybrid game (Kankainen and Paavilainen 2019) design. The user-centred approach is focused on constructs of engagement, enjoyment and perception, and has overlap with intrinsic motivation (Caroux et al. 2015).

2.3.1 Hybrid Game Framework

A hybrid game framework comprising of an analogue boardgame and digital application (app) is used to harness the tactile feel of a boardgame whilst enabling complex algorithms to be integrated quickly and accurately by the digital component. The analogue component inherently facilitates a multiplayer game environment, linking it to intrinsic motivation and user-centred design (e.g. Song et al., 2013). Analogue boardgames, also known as "tabletop" games (Kosa and Spronck, 2018), provide physical interaction that has been shown to help with communication (Illingworth and Wake, 2019), motivation (Kosa and Spronck, 2018), and provide an engaging experience to users (Lean et al., 2018). The ability of players to interact with tactile objects was seen as an important component for the game framed around learning in the classroom. Augmenting this physical component with technology, such as using computer simulations, can increase their ease of use by automating mundane repetitive tasks (Kosa and Spronck, 2018; Kankainen and Paavilainen, 2019). More importantly for *Sustainable Sip*, augmenting a tabletop game with a digital app provides three key attributes: (1) it provides a reliable and rapid means of quantifying the potentially complex interactions between social, ecological and economic dimensions, (2) data can be presented back to players (e.g. on a large screen) in real-time via a dashboard, and (3) data generated from the gameplay can be stored and retrieved for later analysis.

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2.4 Design Methods

Systems thinking (Sterman, 2000) is used for conceptualising the game engine for *Sustainable Sip* as it provides a formal framework for constructing and quantifying the components of a complex transdisciplinary system. It is especially salient for *Sustainable Sip*, which bridges social (customer loyalty), economic (supply-demand-price dynamics), and environmental (waste) dimensions whilst systems thinking is aligned with one of the learning objectives.

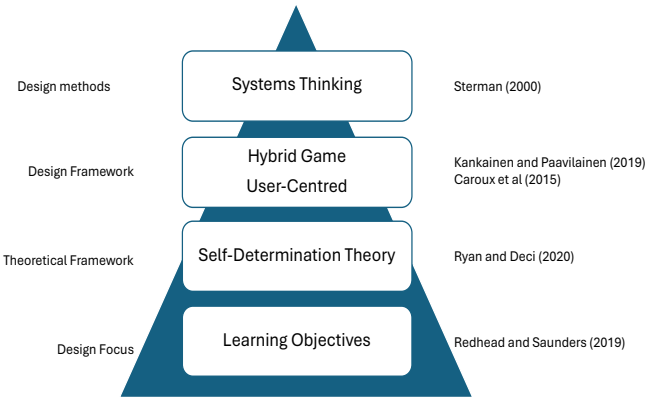


Figure 1: The design framework used to develop Sustainable Sip

3. Design Features

To provide scope for the design process, we developed the following design principles. These were established by the authors through an iterative approach, framed around the four levels of the design framework.

3.1 Principle 1 - Simplified Gameplay

An early decision in the design process was that the gameplay had to be as simple and unambiguous as possible. The rationale was that this approach would help to keep instructions simple to minimise time spent learning rules (Møller and Hansen, 2016), an important cognitive consideration when using the game in the classroom (Catalano et al., 2014).

Sustainable Sip has been purposefully designed to have only a small number of player decisions so that the game should be easy to learn and play, and not be inhibited by a large number of rules around decision-making. The required decisions for all players are:

1. *Decision 1 - How many coffee tokens to purchase from wholesaler?*
2. *Decision 2 - What price to sell the coffee?*

To help simplify these two decisions further, the number of coffee tokens that a player can purchase is restricted to the range 1 – 20 (Decision 1) and the price they can sell is restricted to either $1, $2, $3, $4, $5, $6, $7, $8, or $9 (Decision 2).

Sustainable Sip also includes a moderating role (Game Master) who leads the players through the gameplay whilst also managing the transactions associated with the two decisions. The rationale is this role minimises the transactional costs of players learning the rules upfront i.e. the Game Master teaches the players as the game unfolds, situating the learning as a facilitated workshop approach (Catalano et al., 2014).

The app assists with players understanding of the game by providing a roadmap for gameplay, using a bulletin board that periodically provides instructions to the players and through guidance provided by the Game Master (Figure 2). By default, these bulletin board instructions are only shown during the first round (round 1) of gameplay (but this can be toggled to show every round).

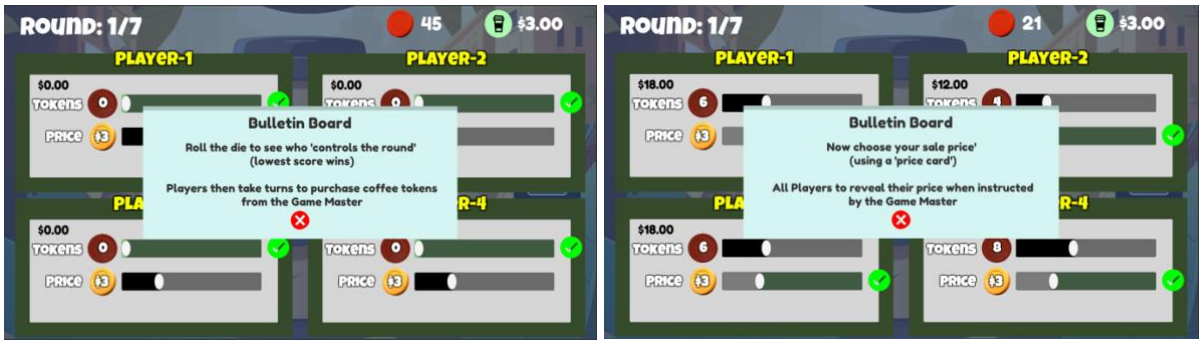


Figure 2: Bulletin board messages are used in *Sustainable Sip* to direct gameplay

The user interface (UI) of the app has been designed to help simplify the game play. The Game Master enters the player decisions into the app through 'sliders' (Figure 3). At the start of a round, the token sliders are first activated and the price sliders are deactivated. Once all the token data has been entered, the token sliders become deactivated and the price sliders are activated. This process helps ensure that all data for Decision 1 has been entered before Decision 2 is made. All activated sliders are colour coded to indicated whether the data has been locked in (black sliders) or not. For the token sliders, these will be green if they are not locked in. For the price sliders, the colour depends on whether the slider is above (green), equal (grey) or below (red) the wholesale price. The numerical values of each slider is shown to the left of the slider, providing additional feedback to the Game Master and the players.

Finally, the app manages complex calculations that account for the dynamics of supply-demand-price elasticity, along with the calculation of customer loyalty (see Principle 6). A 'black box' approach was taken so that the precise nature of these is not known to the players (Principle 4 – uncertainty) but also enables the game to include complex dynamics without burdening the players with these details.

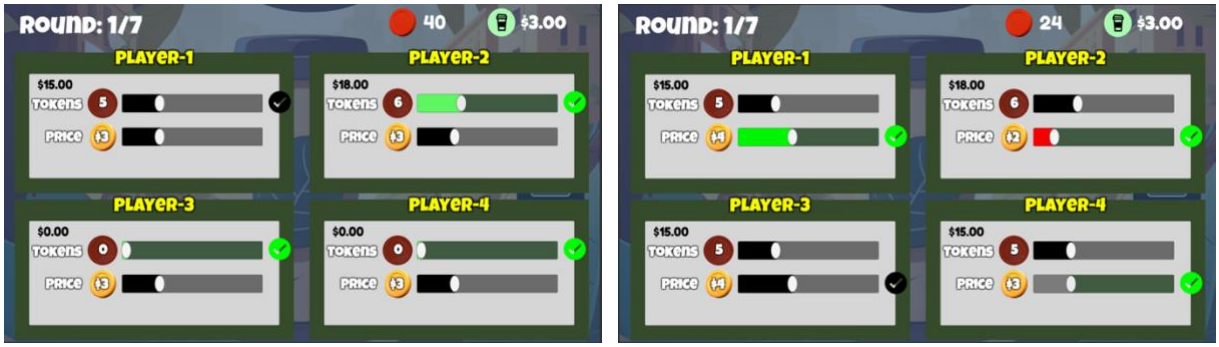


Figure 3: Sliders used to enter data in the app. Left panel – shows tokens purchased by each of the four players being entered. Right panel – shows price setting for each player

3.2 Principle 2 - Story Telling

It was important that the game had a strong story telling element. The compelling nature of a good story has been linked to motivation (Alexiou et al. 2022) and user experience (Caroux et al. 2015), and is an important component of systems science (Sterman, 2000). The story telling is presented within the app, through the use of disruption cards (Principle 4), and via the Game Master's interaction with the players. Beyond managing the business exchanges with players (selling tokens) and entering the 'decision' data into the app, the Game Master is responsible for 'setting the scene'. At the start, the Game Master introduces *Sustainable Sip* to the players by displaying a story that encapsulates the context ("*Welcome to Sustainable Sip, a game that provides a dynamic and experiential way to learn about the core concepts of business sustainability*"), instructions ("*Each round you will need to decide how many cups of coffee you pre-purchase…*"), and game objective ("*The Player that best balances profit and waste will be declared 'The Sustainable Sipper'*"). This story is presented across 11 'pages' in the app (e.g. Figure 4), with each page containing a short statement about an aspect of the game (context, instruction, or objective) along with an associated graphic. We purposively use short statements and clear graphics so that the narrative is introduced in bite-sized chunks.

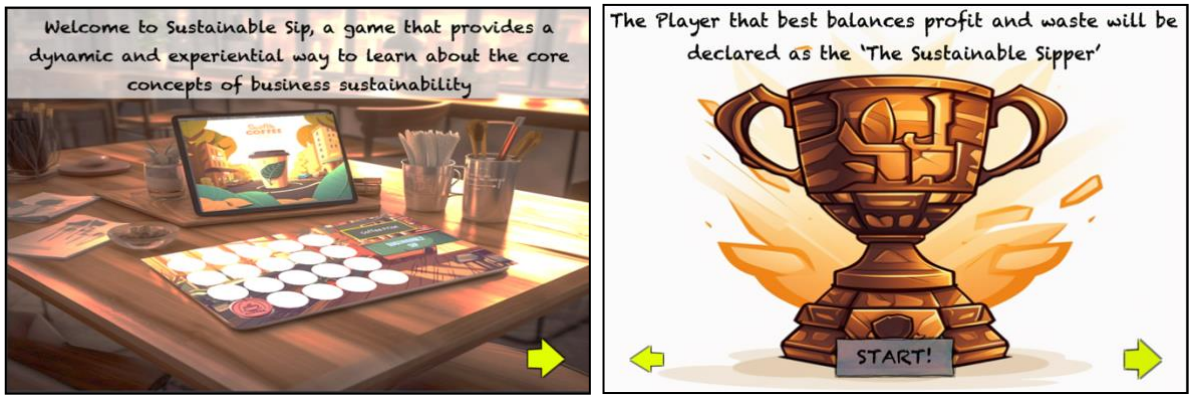


Figure 4: Left panel - The first page of *Sustainable Sip*'s story that appears after pressing the start button on the menu page. Right panel – page of the story that highlights the Sustainable Sipper prize.

3.3 Principle 3 – Prize Focus

Sustainable Sip was designed with the intention of providing a clear objective for 'winning the game' using the "Sustainable Sipper" prize (Figure 4 – right panel). Including such prizes have been shown to contribute to knowledge acquisition (Whittaker et al., 2021) and impact on motivation (Johnson et al., 2018). However, prizes may diminish feelings of autonomy (Deci et al., 1999) e.g. through presenting a controlling factor. It was desired that players be rewarded for their cumulative performance, which aligns with the sustainability theme of this game (and the second learning objectives), which by definition is centred on long-term performance. Information on progress towards this prize is presented in an information panel at the end of each round (Figure 5 – left panel). Detail about the loyalty factors can also be shown (Figure 5 – right panel) to highlight how waste, supply, and price are influencing customer loyalty ratings. This aligns with the first learning objective in terms of enabling the players a more systemic insight into their performance.

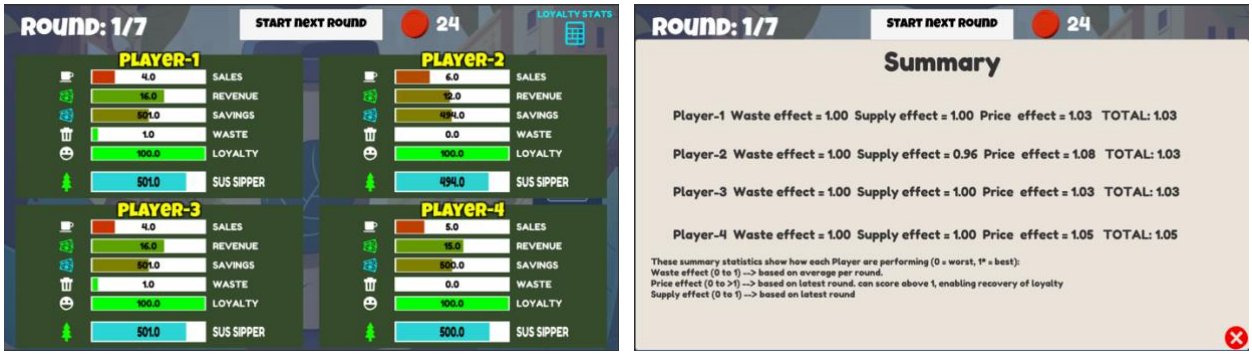


Figure 5: Left panel - 'Leaderboard' styled information presented to players at the end of each round. Right panel – additional information on the loyalty statistics that can be used for more in-depth discussion of player performance.

3.4 Principle 4 - Uncertainty in Decision-making

This design principle was motivated by the desire that any decision-making in the game involve uncertainty.

3.4.1 Multiplayer Game

Uncertainty in player decision-making is inherently incorporated in *Sustainable Sip* because it is a multiplayer game. *Sustainable Sip* accommodates four players (or four teams of players), each in control of a coffee shop. Each player (or team of players) aims to balance the dimensions of economic performance, environmental sustainability, and customer loyalty; the player that best achieves this wins the 'Sustainable Sipper' award (Principle 3 – prize focus). Information on how each player is progressing is summarised in a leaderboard styled dashboard in the app (Figure 5) that shows the key economic (sales, revenue, savings), environmental (waste) and social (loyalty) indicators as health bars. Using a multiplayer game can help players can engage in social learning (Ross and Weaver, 2012), and introduce "social competition" that can facilitate enjoyment (Vorder et al., 2003) and increase intrinsic motivation (Song et al. 2013).

A player's strategy has been shown to be affected by the uncertainty of an opponent's strategy (Calford, 2020). Players are competing against each other, and strategies are being based in the absence of *a priori* knowledge of what the other players will do. This is especially the case for price setting (Decision 2), where players reveal their prices simultaneously (see Principle 5). Conversely, the purchase of coffee tokens (Decision 1) is turn-based as determined by the player that controls the round (see Principle 5), and therefore the player that goes last has the benefit of knowing the purchases made by the other players.

3.4.2 Dynamic Uncertainty

Uncertainty is also integrated in the game through the hidden (black box) calculations of supply-demand-price-waste-loyalty dynamics that are calculated in the app. The underlying algorithms used to calculate the customer choice for a player's coffee shop (i.e. customer share) is not known by the players. Rather, a player's knowledge of these dynamics is articulated through the 'story' delivered at the start of the game, by the status of a player's 'health bars' indicating their performance so far (Figure 4), and the disruption cards that provide an indication of how the 'mood' of customers has changed around waste and price. Therefore, the purchase of tokens (Decision 1) is undertaken without precisely knowing the customer demand – buying too much coffee will cause a problem due to waste (unsold coffee tokens) but buying too little runs the risk of undersupplying demand. Both risks have implications for customer 'loyalty', but these are not weighted equally e.g. undersupply might have bigger effect than waste on reducing loyalty, but waste might have bigger effect than supply-demand on recovering loyalty.

3.4.3 Disruption Cards

Disruption cards are an additional source of uncertainty in *Sustainable Sip*. The aim of disruption cards is to introduce a change to the game dynamics through the following:

- Wholesale Price: adjusts the cost of purchasing coffee tokens from the Game Master
- Price Factor: changes the influence of price on Customer loyalty

- Waste Factor: changes the influence of waste on Customer loyalty

A single disruption card only affects wholesale price, price factor or waste factor. Waste factor can only increase, a constraint motivated by the desire for a game arc where customer sentiment will only increase towards better waste management practices. Conversely, wholesale price and price factor can both increase or decrease, based on the assumption that these can have a synergistic (price decreases) or antagonistic (price increases) relationship with the waste factor. Disruption cards are managed by the app, appearing irregularly as a spinning newspaper at the start of a round (Figure 6). This animation reveals a disruption panel that has three sub-panels (Waste Factor; Price Factor; Wholesale Price). A physical disruption card is selected by the game master, which will change one of these three categories.

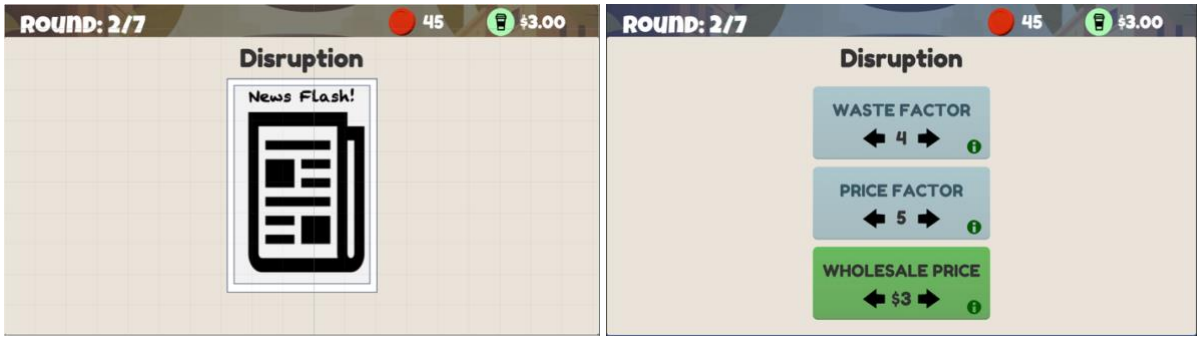


Figure 6: Disruption UI panel as displayed in the app. The occurrence of a disruption is indicated by the appearance of the disruption UI panel along with a spinning newspaper (top-left). This spinning newspaper is then replaced by three UI categories for waste, price and wholesale price (top-right).

3.5 Principle 5 - Round-based Gameplay

Sustainable Sip was specifically designed to be a round-based game based on the desire to provide players with the opportunity to revise their strategies routinely throughout the gameplay. As the app presents feedback information at the end of each round (Figure 4), the players can use this updated knowledge to inform the next round of decision-making.

3.5.1 Simultaneous Versus Turn-based Decision-making

A challenge of using a round-based approach is deciding whether players should make their decisions simultaneously or turn-based. A conceived advantage of simultaneous decisions is that this introduces a 'prisoner's dilemma' (Amadae, 2016) type of uncertainty into the decision process (incorporating an opponent's potential action into your own decision). A conceived disadvantage is the difficulty in integrating this process into a hybrid game. This is especially pertinent for Decision 1 (*How many coffee tokens to purchase from wholesaler*), where purchasing tokens requires a physical transaction between each player and the Game Master.

3.5.2 Controlling the Round

A turn-based approach overcomes the integration problem but presents the challenge that a player going first has less information about the 'system' than following players, providing an advantage to the latter. To address this issue, we introduced the concept of 'controlling the round'. This works by having one player determine the sequence that players purchase their tokens from the Game Master (Decision 1) for a given round. The 'round controller' is determined at the start of a round by each player rolling a die and applying a 'lowest roll wins' approach. If more than one player rolls the same lowest number (e.g. two players roll a '1') then a tie-breaker is used until there is a clear winner. Once the round controller is established, they announce the sequence that the players will purchase their tokens from the Game Master. Under these conditions, the round controller should select themselves to go last in this sequence so that they will know the decisions of all the other players before they make theirs. To provide a counter point, the pool of tokens is limited so that a player purchasing their tokens last risks missing out on tokens.

3.5.3 Simultaneous Price Setting

For Decision 2 (*What price to sell the coffee*), this integration process was less challenging because there is no physical transaction between players and the game master. To facilitate this, the price options were limited to a small set of price cards: $1, $2, $3, $4, $5, $6, $7, $8, and $9.

Table 1: Tabulated design principles for hybrid game drawn from intrinsic factors of motivation, self-determination theory (Ryan et al., 2006; Farrell & Moffat, 2014).

Factor	Query	Game Features and Rationale
Autonomy *Sense of willingness to play (volition)*	Does the game present a player with choices?	At the start of a game, each player can choose their 'playing' name to enter into the App. The use of a 'round controller', who selects the sequence of players (Decision 1).
	Does the game provide rewards for players?	Sustainable Sipper prize for the overall winner.
	Does the game include non-controlling instructions?	There is minimal scope for non-controlling instructions as the gameplay is moderated by the Game Master. This is a trade-off for simplified game play and the use of a prize as the key focus.
Relatedness *Role within a social community*	How does the game foster feelings of being connected to others?	The game helps present player-specific imperfect information about the game state. The role of 'round controller' fosters connections.
Competence *Need for a challenge and feeling of effectance*	How does the game provide opportunities to learn new skills?	Players are required to make decisions under uncertainty. The game provides student-centred learning around market dynamics by placing players as a manager of a business. Disruption cards provide indicators to the players about shift in market conditions and incrementally change game dynamics.
	How does the game provide positive feedback (including readily mastering tasks of the game) to players?	The game has six core measures of competence that provide feedback (savings, revenue, sales, loyalty, waste, sustainable sipper score).
	How does the game help players to master controls / combinations (perceived competence)?	The game is intentionally designed with simple gameplay that can be easily mastered (positive feedback) rather than being a barrier (negative feedback).
	Are there Opportunities in the game to unlock new abilities?	The game does not include opportunities to unlock new abilities.
Presence	Does the game make use of intuitive controls that make sense, are easily mastered, and do not interfere with sense of being in the game?	The number of decisions that a player has to make is intentionally small (2) and constrained to a small number of options. The app hides complicated calculations to make game easier to play and less likely for mistakes to occur.
	Does the game create a compelling storyline for the user?	The game comes with a story (narrative) that is provided for the game. The use of Disruption cards is aimed at changing the narrative during gameplay.

3.6 Principle 6 – Use of Simulation Modelling

A simulation modelling approach, grounded in systems thinking (Sterman, 2000) was used to guide the mechanics utilised by the app i.e. calculation of supply-demand, player costs and revenue, and customer loyalty. The motivation was to have these factors as deterministic rather than probabilistic events (economic outcomes heavily influenced by the roll of a die e.g. 'monopoly'). This principle has overlap with Principles 1 (simplified gameplay) and 4 (uncertainty). The specific technical details of this modelling is beyond the scope of this paper. Briefly, simulation modelling occurs each time the player decisions have been entered into the app. Customer share for each player is first calculated based on the player retail prices (Decision 2). This is then modified based on the carry-over loyalty rating from the previous round and modified further for a price-demand effect. The loyalty rating is then updated for the effects of price, waste, and supply. Both the price effect and waste effect on loyalty are calculated using a threshold that demarcates when customers are happy, or unhappy, with the price/waste. Whilst the price effect is calculated on the current round, 'average' waste (over all rounds played thus far) is used. The effect of supply is calculated using a sigmoid function so that it is bounded at upper and lower levels.

4. Game Design Summary

Table 1 summarises the design features used in *Sustainable Sip* that align with the intrinsic factors of motivation (Table 1). Most focus has been on aligning the intrinsic factors with gameplay simplicity (Principle 1) and reward (Principle 3), although the latter potentially comes at the cost of autonomy. *Sustainable Sip* does present a player with choices (Decision 1, 2) and rewards, which are lines of query for autonomy (Table 1). However, there is an absence of non-controlling instructions, which can diminish sense of autonomy (Deci et al., 1999). This is a result of the greater priority placed by the authors on the simplicity of game play and the prominence placed on the Sustainable Sipper prize.

4.1 Game Testing

4.1.1 Educator

The overarching role of the educator (teacher, lecturer, tutor) is to introduce *Sustainable Sip*, providing general context for the game (business sustainability), providing a broad outline of gameplay ("you will be managing a coffee shop") and objective ("to balance revenue with sustainability"), communicated through a presentation slides. An educator may take on the role of the Game Master, leading the players through the gameplay and managing any transactions. At the end of the game, the educator leads a class discussion about how the game went, what strategies were used, and what learnings were made. Any questionnaires are then provided to each participant to provide individual-level information.

4.1.2 Beta Testing

Sustainable Sip has undergone preliminary testing with academics and professional staff at the University of Queensland, Australia. This testing was undertaken to provide early feedback on the game's design and gameplay. Testing of the game occurred in March, 2024 in a class at the University of Queensland. The class (n=77) was separated into eight tables, with each table playing *Sustainable Sip.* Each table was provided with a game kit consisting of a six-sided die, four playing boards, 45 coffee tokens, a 1 A4 page set of game instructions, and a USB containing the app (PC and Mac OS versions). One person was selected by the players at each table to be the Game Master and installed the app onto a laptop computer. A short presentation was given by the educator at the start to outline the game's rules, aim and process. This presentation also included a short demonstration of the game using the app. The 8 games were overseen by three educators. At the end of the game (approx. 60 minutes), there was a class-level discussion reflecting on the game. An anonymous questionnaire was provided to students (n=39 responses) asking (1) what aspects of the game did they enjoy? and (2) what could be done to improve the game?

Overall, feedback highlighted that the gameplay is simple, intuitive and interactive, aspects that are attributable in part to the game design and the hybrid approach. The use of a Game Master, an app, and the use of simple gameplay rules, appears to help players quickly learn how to play the game. In addition, the app provided a focus and discussion point for the players at the end of each round when the results were shown (i.e. Figure 4), especially if these were shown on a large screen (common in teaching rooms at the University of Queensland). Suggested changes by the testers included reducing some of the physical components (adopted – initial version used physical money to represent player savings, which did not add to the game experience), refining the story (adopted), and adding music (not adopted). It was also suggested that the number of awards be changed; early design of *Sustainable Sip* featured four awards to reward different dimensions of the game (economic, environmental). However, feedback highlighted that better gameplay (and narrative) was achieved by just using the Sustainable Sipper prize. In addition to feedback on the game, the authors have picked up on how players have used the game in their strategies. For example, this highlighted that Decision 1 can give (but not always) an insight into each player's strategy for pricing. For example, players who purchased a low number of tokens (< 4) might implement a 'high-price, low-volume' strategy, whilst those that purchased a high number of tokens might implement a 'low-price, high-volume' strategy. However, with regards to purchasing a high number of tokens, this was also linked to the strategy of restricting the availability of supply to rival players.

5. Conclusion

We have presented *Sustainable Sip*, a hybrid (gameboard + app), turn-based, multiplayer game that has been designed as fit-for-purpose for students to learn about sustainability from two perspectives: systems thinking and business sustainability. We have explicitly structured our design on a framework that helps to tie the

learning objectives, theoretical and design frameworks, and design method, together. Six design principles were used - whilst all principles were valued by the authors as important, there were instances of trade-offs, especially when viewed through the lens of the intrinsic factors of SDT. Specifically, the desire for simplified gameplay (Principle 1) potentially works against a player feeling that they have freedom of choice within the game (autonomy).

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Mastering the Game: How Level Structure and Game Elements Shape Competency Acquisition

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Abstract: Understanding the dynamics of level structure and game elements in digital educational games is paramount to fostering competency acquisition. How levels are organized within a game, along with the use of various game elements, has a significant impact on the learning outcomes and skill development of individuals. Through the strategic design and implementation of these components, educational games can effectively engage learners and facilitate the acquisition of competencies in multiple domains. In addition to structure, the integration of gamification elements can have a profound impact on learner engagement and sustainable skill acquisition. Therefore, a key element for the success of a serious game is to create appropriate personalization and a balanced relationship between learning and gaming experience. As a result, a mini-game called "Basketball Physics Challenge" has been designed to be integrated into an intelligent, adaptive physical learning game centered around force and motion as part of an ongoing research project. By playing the game "Basketball Physics Challenge", players will apply their understanding of basic physics principles in a realistic, interactive, and virtual setting. An experimental design was used to test the mini-game, in which a gamified and a non-gamified version were used and compared. 20 participants completed the experiment, and their learning progress was meticulously tracked. Using competency-based knowledge space theory, the mini-game facilitated in-game competency assessment, enabled monitoring of learning progress, tailored learning experiences, and provided individualized formative feedback. The pilot was used to develop and implement a competency model that will be the subject of future in-depth studies. The results indicated that the gamified version of the game led to slightly higher engagement and performance levels compared to the non-gamified version, although the difference in learning outcomes between the two versions was not statistically significant. The analysis also showed that an optimal number of levels and a balanced integration of game elements are crucial for maintaining engagement without causing cognitive overload. Furthermore, the order in which the game versions were presented affected player performance, with initial exposure to gamification leading to better outcomes. These findings provide valuable information for the design of educational games and their effectiveness in skill acquisition. This research supports the development of powerful educational technologies that enhance learning through a coherent level structure and meaningful use of game elements that effectively promote learner engagement.

Keywords: Serious Games, Level Structure, Game Elements, Competency-based Knowledge Space Theory, Physics

1. Theoretical Background

1.1 Introduction to Serious Games and Gamification.

Serious games, also known as game-based learning, have gained significant attention in various fields such as education, healthcare, and behavioral change interventions. They are designed to provide specific learning content and assess the learning progress of players. Above all, the aim of serious games is to maintain and promote the motivation and engagement of players in the learning process (Haruna et al., 2023). Spieler and Slany (2018) divide the game design elements into three main categories: (1) game world, (2) game structure, and (3) gameplay. These game elements represent the core aspects of a serious game. They must be present in order to enable interactive and entertaining learning. Gamification, on the other hand, uses game mechanics or elements in non-game contexts to improve teaching and learning (Deterding et al., 2011). In contrast to serious games, gamification is not a stand-alone product, but builds on existing learning objects or tools. Game mechanics such as points, badges, leaderboards, and levels are crucial aspects in developing gamification for education to make learning interactive and fun.

1.2 Effect of Serious Games

Serious games have been shown to be effective in improving learning outcomes and learner motivation. Incorporating game elements into educational environments tends to increase students' enjoyment of learning, which often goes hand in hand with intrinsic motivation, as serious games inherently provide stimulating elements such as interest and fun (Wouters et al., 2013). Because of the intrinsic motivation factor, games, with their informal, free-choice functions, provide an ideal platform for children to explore and learn about the properties of materials and objects in the learning environment on their own (Boyle, Connolly & Hainey, 2012).

In addition to intrinsic motivational factors, serious games also include extrinsic motivational factors by incorporating external rewards such as points or ratings (Brown, 2007; Gray et al., 2019; Zhang & Yu, 2022). Self-determination theory (SDT) plays an important role in understanding intrinsic and extrinsic motivation in serious games. SDT emphasizes the importance of autonomy, competence, and relatedness for intrinsic motivation, which is consistent with the idea that serious games provide an ideal platform for independent exploration and learning (DeSmet et al., 2014). Serious games not only leverage intrinsic motivation, but also incorporate extrinsic motivational factors such as rewards to further enhance engagement and retention of learning content (Roozeboom et al., 2015). In addition, serious games have been found to promote attitude change (Chow et al., 2020), further emphasizing the impact of these games on learner engagement and outcomes (Zairi et al., 2022). In summary, serious games and gamification strategies can effectively increase learner motivation and promote higher levels of learning by aligning with frameworks such as self-determination theory. By incorporating elements that address intrinsic and extrinsic motivations, serious games provide a dynamic and engaging learning environment that supports modern approaches to education.

2. Present Study

2.1 A Basketball Challenge

The primary goal of the Basketball Physics Challenge project was to improve players' understanding of basic physics concepts through an interactive educational game. The project aimed to go beyond traditional teaching methods and deliver physics education in an engaging and contextualized way. Given the increasing importance of digital educational technologies in the learning environment of modern classrooms, the game provided an innovative platform to explore theoretical concepts such as initial velocity, motion and trajectory, throwing angle, gravity, friction and air resistance in a realistic simulation. In addition to the main goal of improving physics understanding, another important concern of the project was to investigate the impact of gamification elements on the learning process. Gamification, or the integration of game elements into non-game contexts, has been shown to be an effective means of increasing learner motivation and engagement (Looyestyn et al., 2017; Sailer et al., 2020). The hypotheses (H1 to H5) outlined in the study are directly derived from these project goals.

For instance, H1 focuses on assessing whether participants using the gamified version of the "Basketball Physics Challenge" exhibit higher engagement levels and motivation compared to those using the non-gamified version, aligning with the project's aim to enhance learner engagement. H2 examines whether the gamified version leads to greater improvement in learning outcomes related to force and motion, which is essential for achieving the project's goal of enhancing physics understanding. H3 investigates the optimal number of game levels that maximizes the acquisition of competencies in force and motion without causing disengagement or cognitive overload, contributing to the project's objective of promoting effective learning experiences. Furthermore, H4 and H5 explore the differential impact of specific game elements and their sequencing on learning outcomes and engagement, directly addressing the project's interest in understanding the effectiveness of gamification elements in the learning process.

In the implementation phase, the hypotheses will serve as a guide to refine the Basketball Physics Challenge mini-game. This ensures the incorporation of various levels and gamification elements to effectively achieve the project's objectives. Through a pilot study and subsequent main study, the hypotheses will be empirically tested to provide valuable insights into the effectiveness of gamification in achieving the project's overarching goals of enhancing physics education through interactive and engaging learning experiences.

3. Methods

3.1 Participants

The participants of the study were 20 students recruited from a secondary school in Liechtenstein. The students attended an optional 10th grade, an additional year of education after completing the standard curriculum. The age range was 15-18 years *(M = 16.25, SD = .76)*, 10 students were female, 10 male, 65% of students had German as their mother tongue. Overall, the physics grades in the sample were at the lower end; The students were randomly divided into two groups.

3.2 Study Design

The project study used a crossover design to investigate the effects of gamification on performance and skill acquisition in an educational game. The goal was to compare the effectiveness of two versions of the game: a version with gamification elements and a version without gamification elements. Participants were randomly divided into two groups. One group started with one version and then switched to the other. This method made it possible to consider the individual differences of the participants as a control variable and at the same time reduce the total number of participants required.

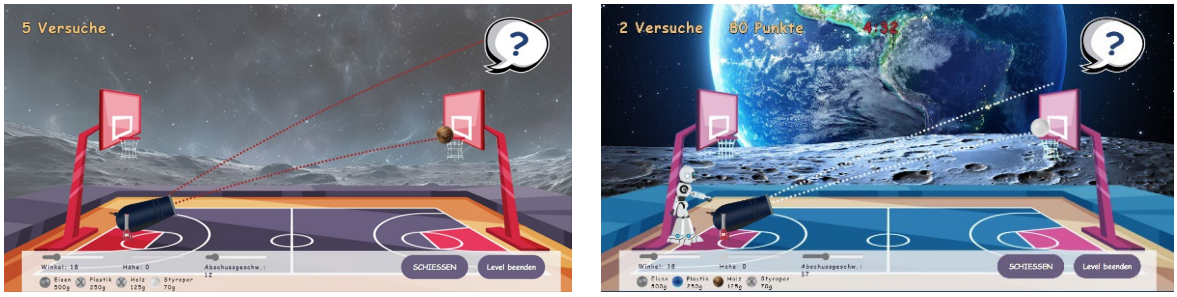


Figure 1: Screenshots of the "Basketball Physics Challenge". The left picture shows the "Non-Gamification" version; the right picture shows the "Gamification" version).

The gamification version (version A) of the game included game elements such as scoring systems, time limits and competitions to increase motivation and engagement. The non-gamification version (version B) focused solely on the educational content without any additional game elements. The challenges and physical concepts were identical to those of the gamification version, but without the game incentives and competitive elements. The game behavior was recorded to capture data such as the changes in game mechanic settings, as well as temporal progression, scoring, and attempts, which were necessary for further analyses of skill acquisition.

3.3 Learning Task: Content of the Learning Task

The central learning task of the game was to enable players to understand and apply basic physics concepts in a simulated interactive environment. Players were encouraged not only to learn principles such as initial velocity, motion, and trajectory, throwing angle, gravity, friction, and air resistance, but also to actively apply them in the game environment. This took the form of a basketball game in which players had to throw the ball into a basket with a cannon by adjusting these variables. This encouraged experimental learning by allowing players to test hypotheses about physical effects and learn through direct feedback in the game.

3.4 Level Structure

To comprehensively cover the above educational objectives, a level system was developed that offers increasingly complex physical challenges. The structure of the game levels is designed to provide increasing complexity and challenge in terms of physical concepts. For this structuring, a competency model was developed based on international curricula with a focus on Switzerland (e.g. https://www.lehrplan21.ch). The first levels focused on simple concepts such as initial velocity and throwing angle to teach players basic handling and understanding of trajectory. As the game progressed, the tasks became more complex, and players had to consider advanced principles such as gravitational effects on different planets and the influence of environmental factors such as wind or vacuum. Each level aimed to illustrate a specific physics concept and deepen understanding through practical application. The gradual increase in difficulty served to continuously challenge the players without overwhelming them, thus promoting effective and sustainable knowledge acquisition.

3.5 Learning Outcome Measures: Performance Measures

Various performance measures were used to quantify learning progress. These included scores based on the accuracy of throws, success rates representing the ratio between successful throws and the total number of throws, and the number of throws required to complete a level. These metrics provided an objective assessment of players' skill and understanding of the physical concepts.

4. Results

Conducting data cleaning and preprocessing for the Basketball Physics Challenge provided important insights into player engagement and learning effects. First, a sample was removed due to incomplete data and atypical game behavior - a player who did not attempt a shot. Analysis of the data distribution using histograms and the Shapiro-Wilk test for normal distribution revealed a significantly asymmetric distribution of scores for both versions (A and B), indicating non-normally distributed data, with highly significant p-values below 0.001. The data also showed multimodal peaks and a wide spread in the histograms, suggesting that there are different types of players or that certain levels are differently difficult. This could also mean that some players have not fully understood the game mechanics, or that they regularly fail at certain points in the game. To enable a more detailed analysis and to further optimize the game, it was decided not to use data transformation for normalization and instead to use non-parametric methods for further analysis. This decision allows a more detailed investigation of the actual game interactions and learning progress, unaffected by the assumptions of normal distribution.

4.1 Scoring Progression, Insights Into Player Skill Development, and Effectiveness of Game Structure

This study aimed to analyze the score progression of the two different game versions and to identify possible differences in game performance between the different levels, as well as to obtain indications for a suitable level structure in the game. In both game versions, the average scores show a general increase from the beginning to the end of the level, with version A increasing from 139 points in level 1 to 2358 points in level 9, and version B increasing from 170 to 2293 points in level 8, only to decrease slightly to 2271 points in level 9 (Figure 2). This trend indicates an improvement in player skill. However, the drop at level 9 in version B could indicate decreasing motivation or increased difficulty, which may require an adjustment to the game design.

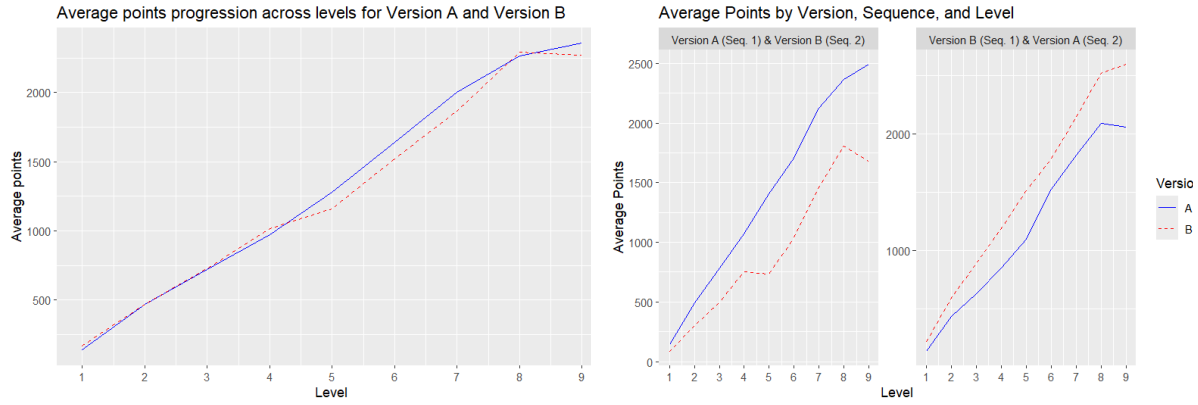


Figure 2 The average points progression by Version A and B across levels and the average points progression by Version A and B, sequence (1 = first game, 2 = second game), and level.

The Mann-Whitney U-test shows *(U = 796541, p = 0.64)* that there is no statistically significant difference between the scores of versions A (gamification) and B (non-gamification). This means that regardless of the gamification elements, both versions produce similar performance data from the participants. However, it was found that the mean score in version A *(M = 1275.22; SD = 850.60)* is slightly higher than in version B *(M = 1256.57; SD = 832.60)*, which could indicate that players generally perform better in version A or that the gamification elements have a positive effect on players' performance.

4.2 Sequence Influence

Examining the game versions in different sequences provides deeper insights into the differences in performance between versions A (gamification) and B (non-gamification) and their effects on the game outcome depending on the order in which the game versions are presented. Sequence 1 shows that both gamification (A) *(M = 1389.95; SD = 857.57)* and non-gamification (B) *(M = 1491.38; SD = 845.30)* reach high mean scores, with non-gamification reaching slightly higher scores. Sequence 2 shows a clear decrease in mean scores for both versions *(version A: M = 1098.33; SD = 809.24)*, especially for the non-gamification version *(M = 883.40; SD = 658.37)*. In the second sequence, the results are more consistent, possibly due to familiarity with the game. The

Kruskal-Wallis test for the combined variable (version & sequence) shows a highly significant difference between the different combinations of version and sequence *(Chi-square(3) = 182.68, p = . 2.2e-16)*. This result indicates that not only the sequence alone, but also the specific combination of gamification and non-gamification elements in different sequences has a significant influence on the game results. The Kruskal-Wallis post-hoc analysis using Dunn's method with Bonferroni correction confirms that both the specific game version (gamification vs. non-gamification) and the order of its presentation have a significant influence on the scores. The effect size between version A.1 (gamification played first) and version B.2 (non-gamification played in the second game run) *(r = 0.64)* shows that the probability that a randomly selected player from group A.1 achieves a higher score than a randomly selected player from group B.2. This effect is classified as "large", which indicates that gamification presented first tends to lead to better results. The effect size *(r = -0.47)* between version B.1 (non-gamification played first) and version A.2 (gamification played in the second game run) shows that the probability of a higher score in group A.2 is about *37%* compared to group B.1. This indicates a small effect, with player performance being significantly worse when gamification is presented after non-gamification. According to Cohen (1988), r ≥ 0.1 describes a small effect, r ≥ 0.3 a medium effect and r ≥ 0.5 a large effect. These findings are critical for planning and designing future games or learning tools, especially in terms of how to present different content and methods to maximize engagement and performance.

4.3 Success Rate, how Effectively Players Overcome Certain Challenges

Success rate is a measure of how successful a particular event or action is, measured by the number of successful outcomes relative to the total number of attempts or events. For example, in terms of the average number of attempts across all levels and versions of a game, the success rate shows how often players complete a particular level relative to the total number of attempts for that level. The success rate per version shows that the success rate for version A *(51.45%)* is slightly higher than for version B (*48.55%*). This indicates that version A tends to have a slightly higher success rate than version B, but the difference is small. To see which version has a greater influence on the second course of the game, the success rate was calculated for each version and sequence. It turns out that both versions have a very similar success rate at the beginning. In both versions, Sequence 1 tends to have higher success rates than Sequence 2, which could indicate that the order in which the elements are presented has an influence on success. It is possible that participants are more motivated or better prepared in the first sequence. Interestingly, however, players who first played version B (*33.17%*) and then switched to version A (*19.39%*) had a better second success rate than players who first played version A (*32.32%*) and then switched to version B (*15.12%*). The positive difference between the success rates in both cases indicates that the order in which the versions were played influenced the players' success rate. Players who played the non-gamification version first and then the gamification version tended to achieve a higher success rate compared to those who played the gamification version first and then the non-gamification version. This suggests that the introduction of gamification after the non-gamification version positively influences the game experience and possibly leads to a higher success rate, as the integration of gamification elements in later phases of the learning process provides an additional incentive and can increase players' motivation and skill acquisition. To get information about the level structure, the success rate per version and sequence per level was also analyzed.

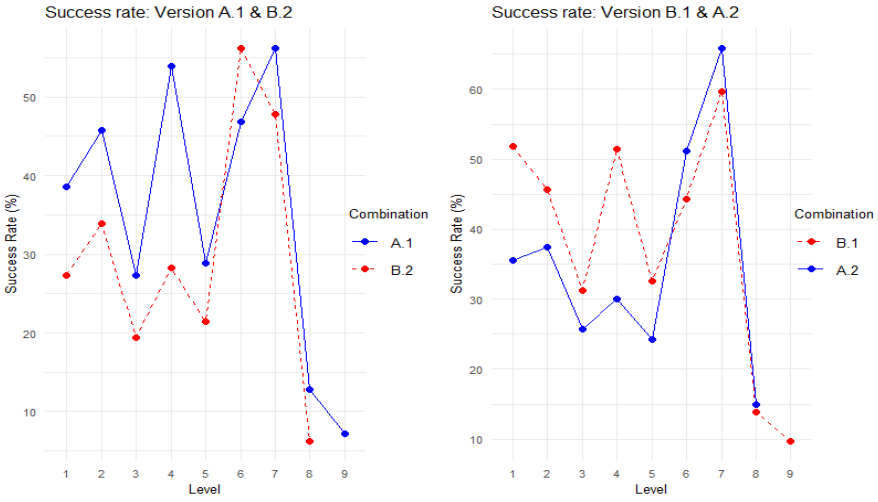


Figure 3: Comparison of success rates between different versions and sequences (left: students who played version A and then version B; right: students who played version B and then version A).

The success rates vary for both versions and sequences, with some levels having higher success rates than others (Figure 3). However, there does not appear to be a clear trend indicating that one particular version or sequence has a consistently higher or lower success rate than the other. It is important to note, however, that based on the previous findings, players at the higher levels have a better success rate on the second playthrough. This could indicate that players improve their skills and strategies throughout the game, regardless of version or sequence. However, the improvement could also be because players are more familiar with the game mechanics in the second playthrough and therefore have a higher success rate.

Overall, these results suggest that both the level structure and the order in which the versions are played are important factors in players' success rates. However, there is no clear evidence that any particular version or sequence generally leads to a higher success rate.

4.4 Attempts

Analyzing the average number of attempts across the different levels and versions provides insight into participants' behavior in relation to gamification and non-gamification approaches, as well as the influence of skill acquisition. There is some variation in the average number of attempts between versions A (gamification) and B (non-gamification) across the different levels. However, there is no clear trend as to whether gamification or non-gamification leads to fewer attempts. The results show that the average number of attempts generally increases as the level increases, regardless of whether gamification or non-gamification sequences are involved. However, it can be observed that the average number of attempts decreases in the middle of the game, especially in levels 6 and 7 (Figure 4, on the left). This indicates that the players gained experience over the course of the game and were able to cope well with the increasing difficulty of the levels. Only in levels 8 and 9 did the average number of attempts increase as the difficulty of the level environment increased. In terms of skill acquisition, this could mean that players understood the physical skills well up to level 7 but showed skill deficits from level 8 onwards. This suggests that factors other than game mechanics could influence the number of attempts. The analysis by version, sequence and level grouping showed that the average number of attempts in the gamified sequences was generally lower than in the non-gamified sequences *(Version A, Sequence 1: M = 4.91, Sequence 2: M = 5.15; Version B, Sequence 1: M = 4.83, Sequence 2: M = 5.10)* (Figure 4, on the right).

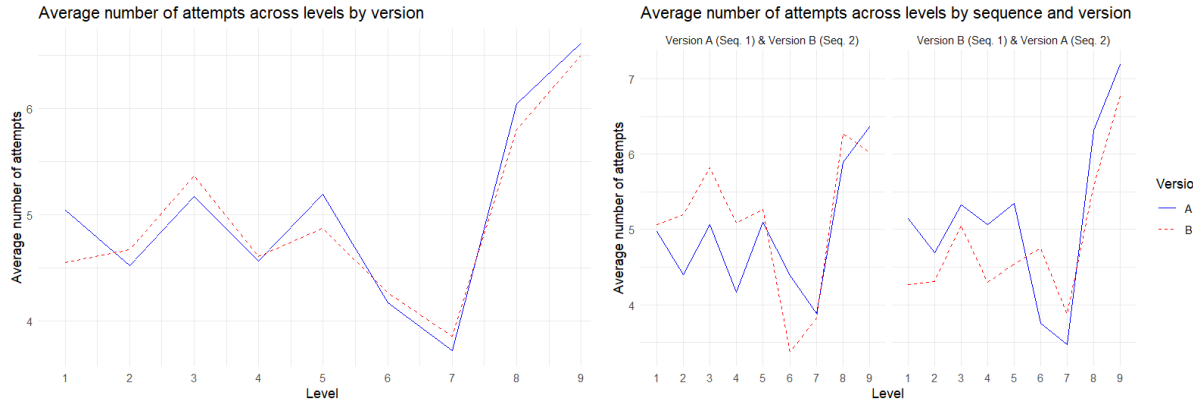


Figure 4: Average number of attempts by Version A and B, sorted by sequence and level (left: students who first played Version A then Version B; right: students who first played Version B then Version A).

This indicates that the integration of gamification elements can help to increase user engagement and motivate them to focus more on the tasks. However, the Wilcoxon-Mann-Whitney test showed no significant difference in the average number of trials between the two versions *(z = 808061, p = 0.267)*, indicating that there was no clear preference for one version over the other. The Kruskal-Wallis test for sequences within each version also revealed no significant differences *(Version A: Chi-square(1) = 0.318, p = .0.573; Version B: Chi-square(1) = 0.70 p = 0.402)*, suggesting that the order in which participants experienced the gamified and non-gamified approaches did not have a significant impact on the number of attempts. Overall, the results suggest that the integration of gamification elements can help increase user engagement, while the number of attempts over the course of the game increases as the difficulty of the levels increases.

5. Discussion

The results of our study provide important insights into the dynamics between gamification elements, level structure, and skill acquisition, particularly in the context of physics learning through interactive gameplay. The integration of elements such as scoring systems and competitions influences player engagement and can increase their motivation, which in turn influences learning success (Smiderle et al., 2020). Our hypotheses, centered around the impact of gamification on engagement, learning outcomes, and the optimal design of game structures, are supported and nuanced by the observed data. H1 posited that participants using the gamified version of the "Basketball Physics Challenge" would exhibit higher engagement levels and motivation compared to those using the non-gamified version. In summary, our hypothesis (H1) was largely supported. Our analysis showed that integrating gamification elements into the learning context proved to be an effective way to increase learner interest and engagement, which ultimately led to better learning outcomes. These results, though, are in line with previous literature suggesting that gamification elements can increase user motivation (Song & Yao, 2022). However, the difference in our results was not statistically significant. H2 aimed to assess whether the gamified version leads to a greater improvement in learning outcomes related to force and motion. Our results suggest that while both versions facilitated skill development over time, there was no substantial difference between them in terms of learning outcomes. This finding contrasts with some previous research suggesting that gamification can lead to improved learning performance (Buckley & Doyle (2014); (Chans & Castro, 2021). However, it highlights the importance of considering various factors, such as individual differences and game design, in determining the impact of gamification on learning. H3 explored the optimal number of game levels to maximize skill acquisition without causing disengagement or cognitive overload. Our analysis revealed that as the level difficulty increased, so did the average number of attempts, suggesting a potential threshold beyond which players may experience challenges in skill acquisition. While success rates improved at higher levels, indicating skill progression, it's important to balance level difficulty to keep players engaged without overwhelming them. This is consistent with previous studies emphasizing the importance of adaptive difficulty levels in maintaining player motivation (Hallifax et al., 2019). Regarding the optimal number of levels and game elements, we found that a good balance is crucial. Too many levels or game elements can overwhelm or disengage learners, while too few may not be enough to maintain engagement. An appropriate challenge that continually motivates the learner is critical to the success of the gamification strategy. H4 and H5 examined the differential impact of specific game elements and their sequencing on learning outcomes and engagement. The results of our research showed that the sequencing of specific gamification elements can have a significant impact on learning motivation. The order in which rewards, challenges, and progress indicators are presented can influence learner interest and engagement. Careful planning and coordination of these elements is therefore important to achieve the desired results. Notably, introducing gamification elements early in the sequence tended to lead to better results, highlighting the importance of strategic implementation of gamification in educational contexts.

Overall, the results show that level structure and the integration of gamification elements can have a significant impact on the game experience and skill acquisition in educational games. A well-designed level structure that provides increasing complexity of challenges can help deepen players' understanding of physics concepts. The integration of gamification elements can increase player engagement and motivation, which in turn can have a positive impact on learning success (Mekler et al., 2017). By embedding the learning content in an interactive game environment and the strategic use of gamification, the project aims to provide new insights into the effective design of educational games. These findings can help increase engagement and learning efficiency in educational contexts, which is particularly important when teaching complex scientific content. The results of the study should provide well-founded recommendations for the development and implementation of educational games that can be used in both school and non-school learning environments.

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Escaping the Bondage of Bullying: A Game-based Learning Approach

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Abstract: School bullying is a phenomenon of great concern worldwide, with profound implications for the emotional development of those involved. Leveraging the interactive nature of game-based learning provides a unique opportunity for active student engagement that goes beyond traditional pedagogical methods. This article aims to explore students' perceptions of bullying and present a digital game as an alternative educational approach to raising students' awareness, empathy, and empowerment. Furthermore, it will be demonstrated how an art-based virtual museum game engages students in exploring and understanding the phenomenon. A needs assessment on bullying was conducted on a student population sample during the school year 2023 - 2024. Subsequently, a digital 3D escape room type game (named "e-BOB") was used, which was redesigned and reconstructed by the students from an initial project within the Panhellenic Students Competition of Onassis Foundation "Hack the Art: Yiannoulis Halepas". The game was developed using Unity, Blender, and Krita platforms and is set in an art museum. Players interact with the sculptor's exhibits through micro-scenarios and quizzes drawn from the sculptor's life and artwork that tackle the issue of bullying. Key game features include goal achievement within a time limit and discovery of hidden elements. The analysis of the needs assessment data found that all students had been involved in bullying behaviors either as victims, perpetrators or observers. The majority of students focused mainly on direct forms of bullying and less on indirect forms, and most were unable to distinguish bullying from 'simple teasing', demeaning bullying behavior. Those at greater risk are the ones who show some element of differentiation in relation to the stereotypes of the social context in which they live. Several students indicated that the school environment needs to address the issue sufficiently. Finally, the game contributed to students' empathy about bullying, enhancing their self-reflection and managing strategies. Raising awareness, mental empowerment, and empathy for bullying requires dynamic and innovative approaches. With its potential for self-awareness and student activation, game-based learning should be incorporated into educational programs for bullying prevention and management within schools.

Keywords: Bullying, 3D Digital Game, Game-based Learning, Awareness, Empathy

1. Background

Bullying is a concerning phenomenon with a significant impact on the emotional development of all parties involved. The multidimensional structure of contemporary societies comprises a dynamic mosaic that makes bullying not just a matter of individual behaviour, but also a reflection of broader social issues such as inequality, discrimination, and social norms. Its prevalence is of concern to the global community (UNESCO, 2022) and local communities, raising questions about the regulatory responses of both governments and academics.

In the educational landscape of Greece there has been an increase in cases of bullying. Numerous incidents of school-related violence have been recorded throughout the country this year, some of which have been particularly serious and disturbing. Scientific research, as evidenced by a recent survey by the non-profit organization "To hamogelo tou paidiou" highlights that a significant proportion of school children have experienced incidents of bullying, thus indicating the educational system's shortcomings in addressing this issue (Leriu, 2023).

Efforts are being made to mitigate bullying in the primary place where it occurs, school settings. Bullying undermines the fundamental aims of education for educational achievement without intimidation, giving priority to intellectual progress along with unhindered social assimilation (Košir et al, 2023). Modern teachers are seeking to apply a wide range of methods and techniques tailored to appeal to students, enhancing engagement and effectiveness in promoting anti-bullying strategies. Using age-appropriate multimedia resources and experiential learning opportunities, teachers enhance students' understanding of empathy, diversity, and mutual respect. In addition, differentiated approaches such as learning through art, educators provide students with creative outlets for cultivating empathy, respect, empowerment among students and inclusivity (Yan et al, 2019).

Having these as input, we utilized our school's previous award-winning project: a digital escape room for the Panhellenic Student Competition "Hack the Art: Yiannoulis Halepas". Giannoulis Chalepas (1851-1938) was a distinguished Greek sculptor whose work had roots in marble sculpture. Chalepas was known for challenging social norms and for his endurance in mental health struggles. After the death of his mother and despite financial difficulties, he secretly took up sculpture, producing numerous contemporary and symbolically powerful artworks that established him as a prominent figure in contemporary Greek art (Goulaki-Voutyra et al, 2022). Through this project, students had the chance to learn about a resilient artist who persevered in his art despite the adversities he faced. The research group explored the parallels between the sculptor's experiences and life with bullying and leveraged them in a digital escape room game.

2. Pedagogical Context

Commencing with the initial project on the life and work of Halepa, we witnessed the transformative power of art. It serves as a potent tool for diagnosing difficulties, cultivating empathy, and healing emotional struggles. This is not the art that promotes toxic standards prevalent in contemporary youth culture, but rather the art of silence, concentration, and self-reflection that enriches the value system of young people: visual arts. This art form is harnessed as a means of education and expression in early school grades, primarily in kindergarten. However, in higher grades, starting from elementary school, students' creative expression is often curtailed, almost silenced by the onslaught of the curriculum. A dearth of art classes and infrequent museum visits hinder students' aesthetic education (Higgings, 2012).

The importance of art for children and people with emotional difficulties has been emphasized by prominent figures in psychoanalysis (Freud, 2005; Jung 1964; 2008). Art reveals the playful side of human nature and releases emotional tensions by symbolizing unconscious thoughts and desires within a controlled and healthy framework. Through constructive pedagogical approaches (Vygotsky, 1976), visual art is revitalized and catalyzes our study to attempt to change students' misconceptions and achieve a deeper understanding of the phenomenon.

Considering the therapeutic value of art (Malchiodi, 2009), we connected it with a real problem of school life, drawing on knowledge from psychological and sociological subjects and utilizing the playful use of digital technology as a means of exploratory learning and student engagement (Yosep, 2023).

Learning through play is an active technique that uses games to improve students' learning, inspiring them and encouraging them to learn. The unconscious or conscious motivation that drives people to play is that they learn.

Games, whether traditional or digital, are governed by rules, have goals, provide interaction and feedback, require problem-solving, promote self-correction, have a story/scenario, and are perceived as a means of entertainment (Vandercruysse et al, 2012).

The approach of teaching-learning through alternatives such as Game-Based Learning (GBL) empowers students to approach knowledge exploratively by playing, without a sense of external evaluation. They learn experientially at their own pace, mastering the art of managing the failure of their attempts, and persisting to solve a problem. The integration of GBL elements constitutes a modern educational approach (Landers, 2014; Papadakis, 2019) focusing on the practice of constructive pedagogy. Therefore, a digital game was developed as a cognitive tool, primarily aimed at students, but not excluding parents and teachers. Based on the teachings of socio-cultural pedagogical theories, after qualitative needs assessment research, scenarios were written, drawn from real school life, which prompt students to respond to real dilemmas in their own lives.

3. Methodology

3.1 Aim

This article aims to examine students' cognitive readiness towards bullying phenomena. It also aims to present a digital game as an alternative educational approach to raising students' awareness, empathy, and empowerment. Furthermore, it will be demonstrated how an art-based virtual museum game engages students in exploring and understanding the phenomenon.

3.2 Objectives

To investigate the level of understanding and awareness of the phenomenon of bullying

To explore the impact of educational programmes on cultivating students' awareness on bullying

To determine whether digital games can contribute to students' enhancement of empathy and empowerment on bullying

To investigate the impact of art-based interventions on attitudes towards bullying among students in a secondary school setting.

3.3 Method

An intervention study was used. The study was conducted in a public vocational high school in Athens. The student population comes from different areas of western Athens, from medium to low socio-economic backgrounds. It also includes various cultural groups such as immigrant children and Roma children. Initially, an educational needs assessment of the student population was carried out.

3.4 Students' Needs Assessment

The assessment was carried out in the period October - November 2023. A total of 58 high school students, aged 15-17 years, participated and a convenience sample (students who were readily available and accessible to the researchers) was used. Data collection was performed through semi-structured interviews – discussions in class, digital games which included both closed and open -ended questions, and collaborative group work. Participants were engaged in semi-structured, researcher-led discussions to explore awareness and understanding of bullying. Participants completed digital quizzes individually to assess their knowledge of bullying dynamics and finally through the collaborative group work, students were divided into groups and, prompted by a video (https://shorturl.at/vwxyN), depicting a girl's thoughts and feelings while being subjected to verbal, physical and emotional violence in her school, they were assigned different roles in groups (victim, perpetrator, observer, parent, teacher). Each group member recorded their feelings and perspectives based on their assigned role (Structured journal entries). Quantitative data from the digital quizzes were analyzed using descriptive statistics to determine students' overall levels of knowledge about bullying. Qualitative data from the group assignments were analysed thematically to identify common themes and patterns in students' perceptions, feelings and ways of handling similar situations.

3.5 Outline of Interventional Tool: Digital Escape room Construction

Following the analysis of the students' needs assessment, we developed a project consisting of 4 groups. Each team was assigned with a different assignment. The assignments have as follows:

- Study of the life and work of the greek artist, Yannoulis Halepas.
- Bullying experiences recording and scenario writing
- Constructing the Digital World, 3D Objects, and 2D Designs
- Game programming

The first team's primary responsibility was to connect the artists' life and work in order to identify artworks that could be linked to the emotions experienced by the perpetrator, the victim, the observer so as to be included in the museum. The second team and educators participated in discussions about bullying, particularly the definition, the reasons, and the consequences for all the parties held in sessions. After completing the study and data recording, the first and second team selected the exhibits and scenarios that were finally included in the game based on the objectives set by the involved persons during the project's development. Meanwhile, the construction and design teams were developing digital exhibits, and the programming team was modifying algorithms to meet the new educational goals of the game.

Problem Selection: The Phenomenon of Bullying Exploration of the Problem's Extent:

- Incidents of bullying in the reference school
- Incidents of bullying in Greece
- International recognition of the seriousness of the phenomenon

Research Questions:

- Do students recognise whether a situation of tension between students is classified as bullying?
- What characteristics do students attribute to the bully and the victim?
- Are students aware of the significant role of the bystander?

- How do they perceive the family and school attitudes towards the phenomenon?
- Are they aware of the consequences for all parties involved?
- Do they perceive their involvement in the phenomenon?
- Are they able to choose coping strategies?

Pedagogical Techniques:

- Scrum Methodology: Scrum is the chosen methodology for developing the game. It is a management framework teams use to self-organize and work towards a common goal. It describes a set of meetings, tools, and roles for efficient project delivery.
- Storytelling
- Game-Based Learning

Criteria for selecting the type of game:

- Escape Room 3D: The aim is to allow the player, whether victim, perpetrator or spectator, to "escape" from the Escape-Boundaries Of Bullying by freeing the game's hero.
- Maintenance of a simulated museum environment featuring artworks by a specific artist chosen for their relevance to the issue.
- Utilization of an existing award-winning game: The 3D digital game "Talk to Art" is built in a virtual museum, a replica of a real museum on the island of Tinos.

Game Pedagogical Objectives:

- To explore students' understanding of the phenomenon.
- To allow students to explore the concept of bullying and understand the involved roles (bully, victim, bystander, school, family).
- To discover possible causes and coping methods.
- To connect art with the phenomenon as a means of expression.
- To encourage empathy, reflection and critical thinking while playing.
- To experience role reversal.

Development Objectives for the Game:

- To create a game that is familiar and appealing to students/players and follows the rules of an escape room, such as limited completion time, searching for and collecting clues, and escaping.
- To include essential functions of digital games, such as pause, continue, restart, and game termination.
- To incorporate quizzes related to bullying types and maximise the connection between exhibits and

Scenario content

Scenario content and possible answers should reflect the emotions of all those involved in bullying, describe possible causes and consequences, and suggest coping strategies—narrating scenarios to increase player interaction/dialogue with the game. Players should be able to express their position by choosing among four possible answers, covering all possible emotions and attitudes per scenario. The game should help students realise the therapeutic aspect of art. Students should be introduced to museum environments to become future-conscious museum visitors.

Data collection from sources - Evaluation of data - Development tools

For writing scenarios about bullying:

- Documentary "Bullying Diaries" filmed in Greece and the United Kingdom, created within the framework of the European project "European Antibullying Network," funded by the Daphne III program of the European Commission, and implemented by "The Smile of the Child" in collaboration with 16 organisations working in the field of bullying from 12 EU countries.
- Seminars, "Art Therapy Activities" for educators (Open Educational Institute), by Dr. Maria Athanasekou.
- Conference Attendance
- Discussion and documentation of students' viewpoints regarding scenario development.
- Assessment of scenarios with the school psychologist

For the construction content of the game:

- For the museum's construction *(Figure1*), Google Earth images of the building (Tinos— Museum of Marble Crafts of Piraeus Group Bank Cultural Foundation) were utilised to analyse its external architecture, followed by its creation through the Unity platform.
- Virtual tours of the Telloglou Foundation of the Aristotle University of Thessaloniki were utilised to create 3D sculptures.
- Illustrations from books about the artist's life and work were studied to construct 2D copies of works designed by the 2D design team.



Figure 1: Building

3.6 Game Development

The digital three-dimensional game "Hack the Art - Talk to Art" was redesigned and reconstructed by the school students, focusing on bullying and following the objectives set.

For the development of the game, the following platforms were used:

- Unity for building the digital world (**Figures 1, 3-6**)
- Blender for creating the 3D sculptures (**Figure 6a**)
- Krita for the creation of 2D drawings and GIFs (**Figures 2, 6b**)

Hardware Specifications:

- CPU: Intel i9 12900H 3.8 GHz
- RAM: 32GB DDR5
- GPU: Nvidia GeForce RTX 3070 Ti
- Storage: 1000GB SSD
- Operating System: Windows 11 64-bit

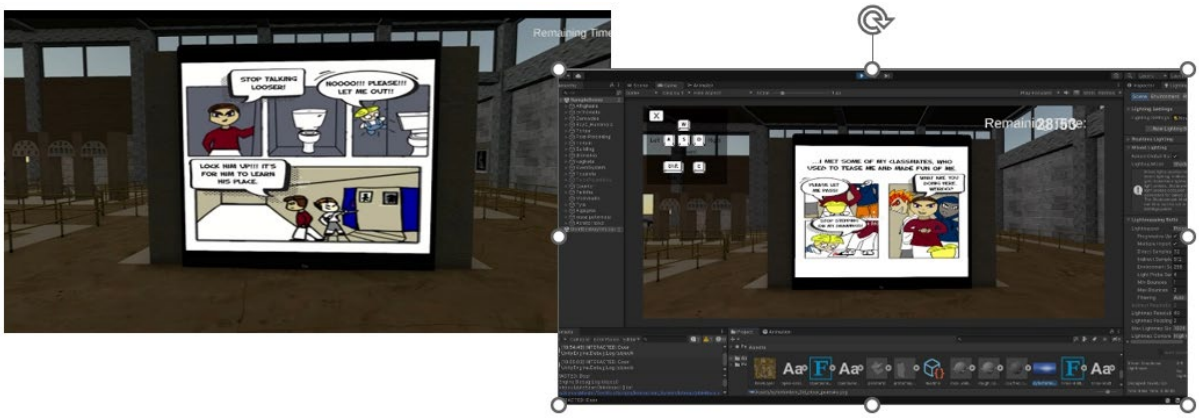


Figure 2: Comic

3.7 Game Description

Upon entering the museum, the player finds themselves in front of a video wall where a comic is displayed to narrate the game's main scenario and set the objectives for the player (**Figure2**). The main scenario revolves around a student who visits the museum director to appreciate the copies of drawings of sculptures by a painter. However, in the museum, he encounters his classmates who bully him and, this time, lock him in the museum's toilets. The player's objectives are to answer the questions posed for each exhibit and collect clues to free the student (**Figure 3**). The player navigates through the museum, seeking out each exhibit that illuminates for interaction.

The game progresses through three difficulty levels.

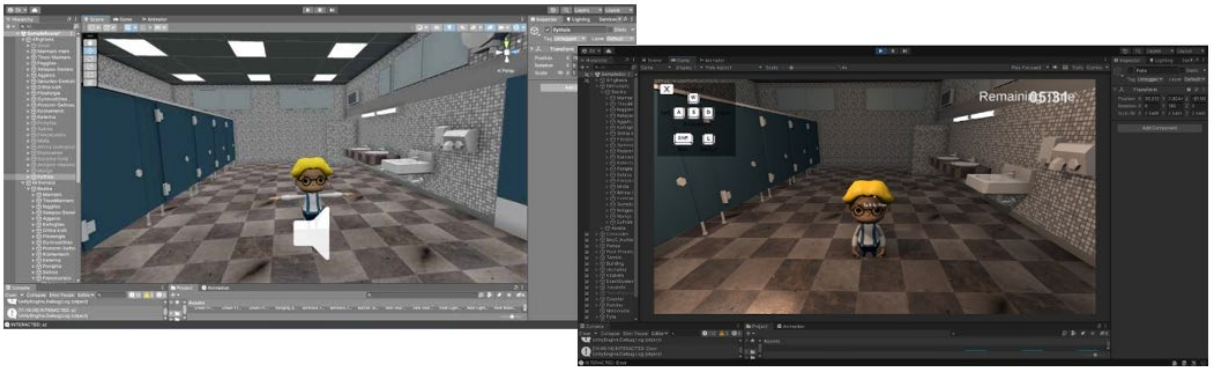
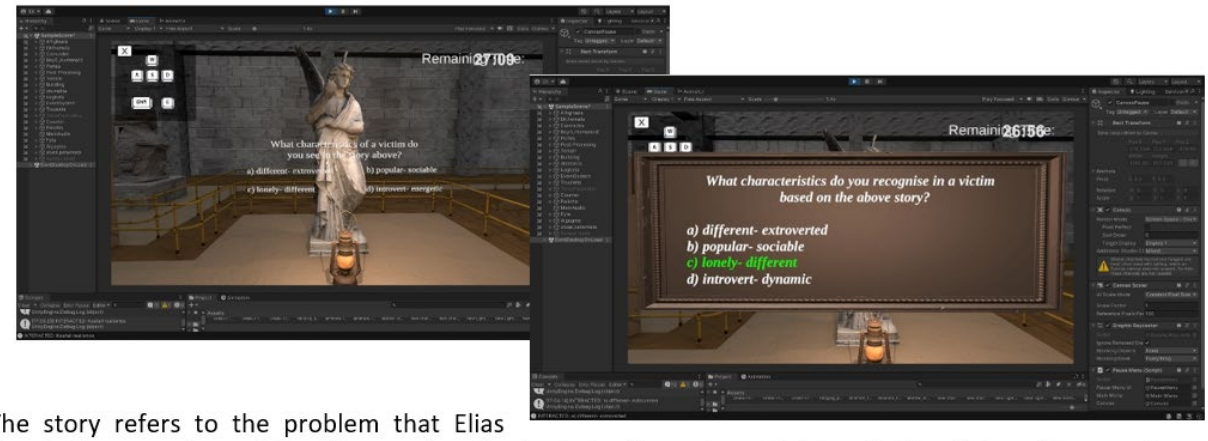


Figure 3: The Victim

1st Level - Definitions, Roles

At this level, through 5 questions, the aim is to present and define the phenomenon. The exhibits are placed linearly, and regardless of whether the player answers correctly or incorrectly, a pop-up canvas appears with the correct answer or definition (**Figure 4**). This specific technique was chosen to allow the player to recognize by themselves whether they answered incorrectly or to enhance their self-esteem and confidence if they answered correctly. To find the next question, the light of the current exhibit goes out, and the next one turns on.

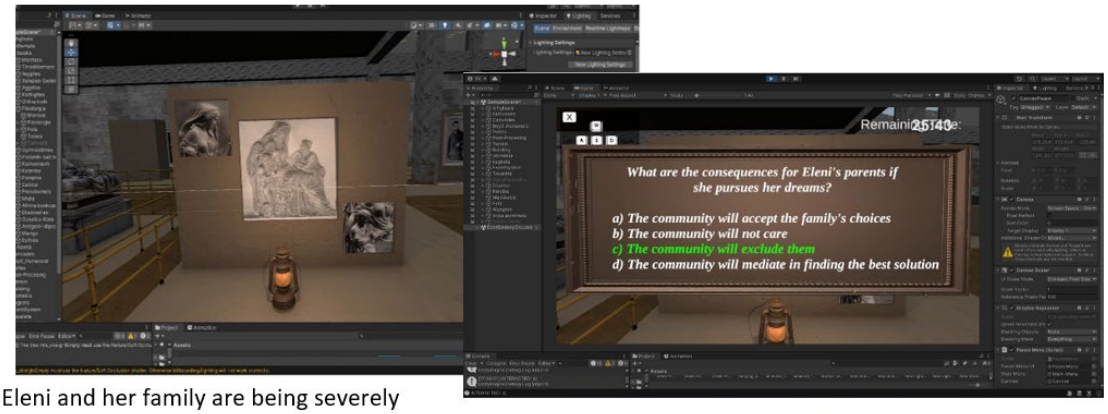


The story refers to the problem that Elias faced when a student of his videotaped and uploaded a discussion with his only friend about his sexuality

Figure 4: Level 1

2nd Level - Consequences

The difficulty level increases as more exhibits are placed in different random positions within the museum. Once again, the illumination of the exhibit is the guiding light for the player. The goal of the questions and scenarios at this level is for the player to discover the consequences of the phenomenon on the bully, the victim, the observer, the family, and society (**Figure 5**). Like the first level, the player progresses through the museum regardless of whether they have answered correctly.



Eleni and her family are being severely criticized by the Roma society, in which they belong, since Eleni does not conform to its standards.

Figure 5: Level 2 - Consequences

3rd Level - Coping Strategies / Put Yourself in My Shoes (**Figure 6**)

This level is the most challenging level, where the player has to answer ten questions contrary to the previous levels, collect clues hidden in some exhibits, and correctly answer all the questions based on the knowledge gained from the previous two levels. At this level, the players are required to find the correct answer by themselves. Every time they answer correctly, the light of the exhibit goes out along with the question, and if there is a clue in the exhibit, it appears for the player to collect. The question disappears if the player answers incorrectly, but the light remains on for the player to return and answer correctly. Collecting a clue from an exhibit is only possible if the player has answered correctly.

Completing the game requires answering all questions correctly in the 3rd level and collecting all hidden clues before the time limit expires. If the player fails, they become trapped in the museum.

4. Results

The following results were derived from recording the responses observed. At the same time, students played the game on the computer of the school, which was capable of running it, with a small student sample. Further investigation into the results with a larger sample is pending.

The tools employed to assess the students' attitudes towards the bullying phenomenon are:

- A multiple-choice question game with one correct answer (closed-ended) relevant to bullying scenarios (Table 1)



Figure 6a. Ekatoxiras, a sculpture of Halepas broke, and another hidden clay head was revealed from inside. People who are bullied, hide and close themselves up like Halepas did with the clay head in Ekatoxiras.



Figure 6b. The story features professor Kostas's attempt to combine the art of Halepas with bullying and creative learning.

Figure 6a-6b: Level 3 – Coping Strategies / Put Yourself in My Shoes

Table 1: Multiple-choice question game

Q	Players correct (%)
What forms can school bullying take?	73,68%
What is the key feature of bullying behaviour?	84,21%
"Boys are more violent than girls"	10,53%
The person who practices bullying behaviour often feels popular and derives pleasure from the act.	78, 95%
How might a child who is being bullied feel?	84,21%
School violence can cause significant consequences for the child	73,68%
Children who are commonly bullied have low self-confidence	52,63%
Your classmate while you are playing football accidentally hits you in the leg. Is this bullying behaviour?	78, 95%
The children-observers reinforce the behaviour of the abuser by their silent attitude	78, 95%
What should you do if a child spreads bad rumours about you at school and on social media?	73,68%
Which of the following is considered cyberbullying?	63,16%
After an argument at school, a group of kids send you threatening messages on a social network. What do you do?	42,11%
One of your friends tells you an embarrassing piece of information about another classmate. What do you do?	34,63%
What should you do if someone is harassing you via chat?	47,37%
What can I do if someone creates a fake profile using my name to send harassing messages?	57,89%
What is it called if an adult contacts a child via the internet to meet and exploit the child?	21,05%
What are some dangerous things you can post about yourself online?	57,89%

- Printed forms for collecting students' responses and reactions

According to the observations, the following results were recorded:

For the initial level focusing on definitions and roles of those involved:
Regarding the question "What is bullying?", the most common responses were:

"Intentionally repeated aggressive behaviour" and "The use of violence against someone weaker."
In a question concerning the differentiation of roles of those involved in a bullying incident based on a given scenario involving a girl from a low socioeconomic background who receives daily sarcastic comments from her classmates but does not react, students selected the answer "There are no roles since it is not a bullying phenomenon."

Regarding the question "What characteristics do you recognize in a victim based on the above story?" based on a story involving a video-recorded conversation among friends about one of their sexual identities and the unwitting public sharing of the video resulting in the protagonist leaving school, students attributed the following characteristics to the victim: "Lonely" and "Different."

In the second level concerning the consequences that the involved parties may face:

In the question "What are the consequences for Eleni's parents if she pursues her dreams?" based on the story of a young Roma girl from a supportive family who wants to study and differentiate herself from the traditions of her community, students stated that the community would be indifferent.

In the question "What are the main feelings of Anna's classmate after he chooses to defame her?" based on a scenario of online defamation with fabricated visual material due to romantic rejection, students chose the answer that the bully would feel "confidence, satisfaction, and uniqueness."

In the question "What are the possible impacts that Jason will have?" based on a scenario involving a young man who lost his mother and turned to alcohol, displaying violent and inappropriate behaviour towards classmates and teachers, students believed he would suffer from health problems, both physical and mental.

In the question "How will this incident affect Mary's parents?" which was based on a story of repeated sexual harassment within the school leading to suicide attempts, students expressed that they would feel frustration and anger.

In the question "What are the negative consequences for the school?" based on the previous scenario of sexual harassment, students responded that there would be a breakdown of trust and communication within the school between students, students and teachers, and between the school and families.

In the third and final level concerning coping strategies and role reversal:

In the question "You would be a bullying victim if: ", students answered, "Your classmates make fun of you every day in the schoolyard, and you don't like it."

In the question "Why did Mr. Costas select this activity?" which was based on a scenario describing an art teacher assigning an activity related to the works of sculptor Chalepas and asking his students to paint their emotions, students selected the answer "to help his students identify the feelings of the abuser and the victim."

In the question "If you were Thomas' older sister, would you do the same?" which was based on a scenario describing the role an older sister takes when learning that her brother is being abused, students answered, "Yes because they deserve it and I would want to protect my little brother."

In the question "Do you think this is the right approach?", which paralleled the action of Yiannoulis Halepas hiding a clay model within another work, with the choice of an individual experiencing bullying and concealing their true feelings, students responded, "No, the person who is being bullied should not behave in the same way as the perpetrator."

In the question "What do you think should be done?", which was based on a scenario describing students' inappropriate behaviour towards a new teacher, students answered, "The students involved should be punished with expulsion or a reduction in disciplinary privileges."

The question "How would you handle the situation if you were Mark?" was based on a scenario describing the profile of a student coming from a violent family environment, engaging in violence towards classmates, and feeling strong at school while feeling weak at home, students answered, "I would find another way to express my feelings and ask for help."

5. Discussion

According to the outcomes of the investigation of the educational needs of the student population and the intervention through the digital game, the following points emerged:

In terms of the level of understanding and awareness regarding the topic of bullying, the students' need assessment revealed varying levels of awareness and understanding. Our study highlighted different levels of awareness and understanding of bullying among students. This is in line with previous studies (Hellström & Lundberg, 2020; Yosep, I. et al, 2023). In particular, while some participants demonstrated clear knowledge, others showed misunderstandings or gaps in understanding. This diversity highlights the importance of tailored interventions to address the different needs of students.

As far as the role of educational intervention programs is concerned, our findings support the effectiveness of educational programs in raising students' awareness of bullying dynamics, in line with previous studies (Jones & Brown, 2020; Gaffney et al, 2021; Hamdani et al, 2024). Collaborative group work, which was enriched by digital quizzes, provided a platform for students to engage and reflect on the different perspectives of bullying scenarios. These interventions not only increased students' knowledge but also promoted empathy and critical thinking skills, in line with the objectives of bullying prevention programs.

Regarding the impact of game-based learning, the findings of this study underscore the potential of game-based learning as an effective tool for promoting students' learning, awareness, and handling of bullying. Colliver and Veraksa (2019) highlight that game-based learning is a useful way to understand young children's perspectives on their learning through play. Similar to our research findings (Smith et al, 2021; Jones and Brown, 2022), investigating the use of a digital escape room activity on bullying, revealed that participants demonstrated high levels of engagement and enthusiasm throughout the game as they actively collaborated to solve puzzles and navigate bullying scenarios. The immersive and interactive nature of the escape room not only captured the students' interest, but also allowed them to take ownership of their learning experience. Nevertheless, Bezençon et al. (2023) point out that such an activity can have heterogeneous effects.

Despite engaging in a virtual museum space, students primarily focused on the challenge of the escape room rather than the museum's content. Their interest was piqued by the 2D and 3D artworks created by members of the development team, with less enthusiasm shown for other sculptures. Upon encountering the artist's works in a physical space again, they will establish correlations and demonstrate greater interest.

In addition to the above mentioned, digital escape rooms, through simulated scenarios and decision making in real-time, provides students with the opportunity to develop critical thinking skills, empathic understanding and skills to manage bullying behaviour. Through interactive play, students are encouraged to explore the underlying dynamics of bullying, discern its root causes, and devise strategies for appropriate responses (Wang et al,2024).

6. Limitations

The study team acknowledges that students' responses may be influenced by contextual factors, including (a) the positioning of the question choices, (b) the length of the response text, and (c) time constraints leading to the expression of initial, rather than deeper, thoughts. Moreover, it is recognised that repetition and time for reflection are necessary to facilitate changes in attitudes, perceptions, and opinions. Additionally, it should be noted that three of the students engaged in the project development were concurrently preparing for university admission, which may have affected their availability and level of engagement.

7. Conclusion

Raising awareness, mental empowerment, and empathy for bullying requires dynamic and innovative approaches. With its potential for self-awareness and student activation, game-based learning should be incorporated into educational programs for bullying prevention and management within schools. Moreover, learning through art can help students explore complex emotions and interpersonal dynamics related to bullying in non-confrontational ways, fostering deeper understanding and empathy.

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An Idea Generation Game Design Tool for Health Behavior Change Games

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Abstract: Serious games (SGs) must engage, be entertaining and have a serious purpose to be effective. A health behavior change game (HBCG) can help change poor health behaviors but are difficult to design. One problem is there are few design tools to support developers of these types of games. This paper describes a card-based design tool for use during the idea generation phase of game design. The research question is: To what extent does an idea generation card tool have perceived value for SG designers generating ideas for behavior change games? This paper reports on the deployment of the tool for an HBCG to help individuals improve their diet and levels of physical activity. An evaluation was undertaken using qualitative data gathered through interviews with serious game developers and a focus group conducted with student game designers. Emergent common themes across both data sets were that the tool had practical and emotional value. Practical value in using the cards was found in the card structure, card content and sorting process. Emotional value included the positive feelings of having physical cards in front of them to use, the presentation of ideas and support provided on a topic they knew little about which brought some relief, increasing confidence and allowing for a more creative environment by freeing up their imagination. Negative feelings were also experienced and included participants remaining anxious about the range, complexity and interrelatedness of the concepts they needed to consider.

Keywords: Idea Generation, Health Behavior Change Games, Serious Game Design Tool, Behavior Change Techniques, Card Sorting Design Tool.

1. Introduction

Serious Games (SGs) have become a popular mechanism to encourage healthy behavior change. If they are designed well, they can satisfy effectively both education and entertainment requirements. They should aim to motivate through engagement and fun but also meet a specific, serious purpose. Engagement refers to the concentration immersion a player may experience while playing games. Fun refers to enjoyment. Purpose is normally expressed as a set of learning objectives. A significant challenge for SG designers is to ideate the foundations of a game that meets these three criteria. This paper describes a card sorting tool for use during the Idea Generation phase of the design of SGs that set out to change health behaviors. A Health Behavior Change Game (HBCG) seeks to change attitudes or behaviors by making desired health outcomes easier to achieve. One challenge of creating effective HBCGs is realizing complicated psychological theories and frameworks using game design elements. Even if an expert on these theories is part of a development team; a game designer requires their own understanding of them to properly weave them into a game's design.

In Shanks et al, (2020) we described Version 1 of a card-based idea-generation design tool to support idea generation for a HBCG SG designer/developer. Behavior change techniques (BCTs) and Self-Determination Theory (SDT) in combination with game principles informed the design of the cards. Final year University game design participants followed instructions and used the cards as if they were designing an HBCG. They were interviewed after this to gather insights. Subsequent qualitative data was analyzed using thematic analysis and as a result, the number of cards were reduced from 34 to 29. Some changes were made to some card content and to the instructions for the card sorting process. In Shanks et al (2021) we presented the results of deploying Version 2 of the design tool to participants in the academic SG field. We discovered that the cards had some value for idea generation but often had too much information thereby stifling creativity. The cards were reduced from 29 to 12 as a result.

In this paper, we present Version 3. This has changes to the card structure, content and guidance of the sorting process made as a result of the analysis of the previous data. Version 3 was subsequently tested with SG developers and a focus group of final-year University game design students. Both groups were given a tutorial using the design tool, SG developers had an online tutorial and the focus group had an in-person tutorial. In this paper, Section 2 offers an overview of SG design. Section 3 presents a brief description of SGs and Behavior

Change. Section 4 describes Version 3 of the Idea Generation Game Design Tool. Section 5 provides an overview of the study method and a discussion of the results. Section 6 touches on threats to validation, Section 7 states future work and Section 8 offers some conclusions.

2. Serious Game Design

The lifecycle of an SG typically starts with an initial research period to understand and develop the game context after which initial user requirements are gathered. The Planning and Design Solution stages include idea generation and the development of an increasingly refined product. Each version of the product is evaluated until a decision is made that it is ready for the market and a product launch. These stages are normally an iterative process. Figure 1 below shows a typical development lifecycle of an SG.

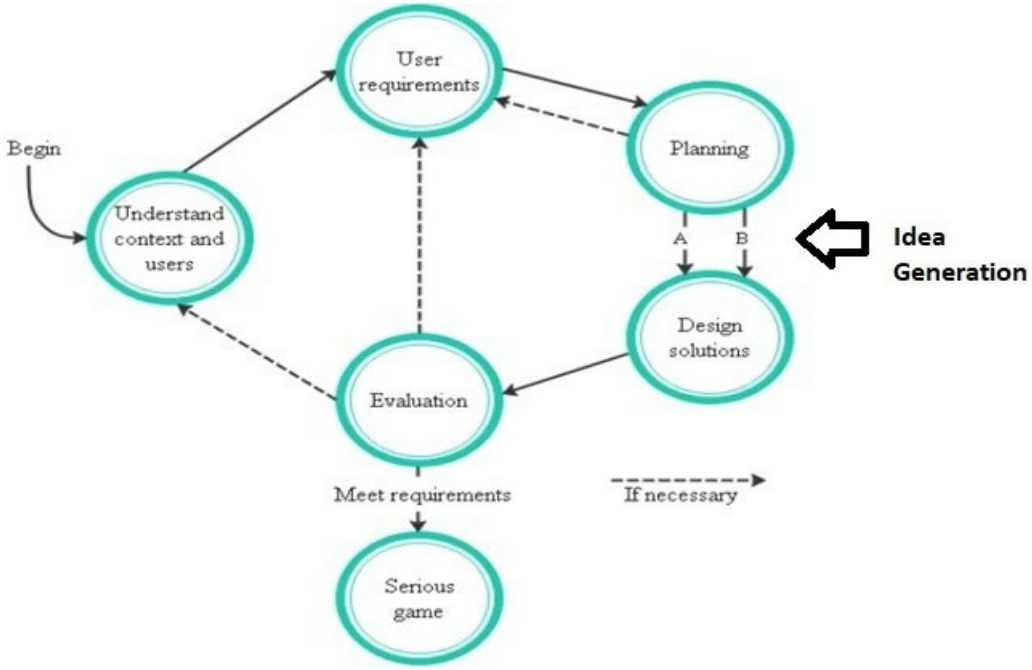


Figure 1: Serious game development lifecycle (Beristain-Colorado et al, 2021).

Idea generation draws upon many influences. There are many different techniques for generating ideas e.g. card-sorting, mind maps, role-playing, drawing a picture, attribute listing, storytelling, and brainstorming. Our interest is card sorting. Card-sorting has often been used to support idea generation for educational games e.g. (Pelser-Carstens, Matthew and Za, 2023). Tahir and Wang (2020) produced an ideation card-based toolkit to support the development of game-based learning concepts. Game design tools such as the Deck of Lenses (Schell, 2008) and the Playful Experience Cards (Lucero and Arrasvouri, 2013) provide concepts to follow during various design stages including ideation. However, there are few idea-generation card-sorting tools to support the development of HBCGs.

3. Serious Game (SG) Behavior Change

Behavior change through games often relies on the use of psychological Behavior Change Techniques (BCT) and the components of self-determination theory (SDT). A BCT is an active element of an intervention designed to change behavior (Michie et al, 2011). Self-determination theory (SDT) is a theory of human motivation. It identifies three basic psychological needs (autonomy, relatedness and competence) that drive an individual's behavior (Deci and Ryan, 1985). There are a wide variety of BCTs including goal setting, giving feedback, and providing information about the consequences of behavioral actions. There are many challenges when deploying BCTs to address a specific behavioral problem e.g. selecting an appropriate set of BCTs that fit the problem context, designing a consistent application of the BCTs, and developing a non-expert's complete understanding of behavior change. For example, the BCTs needed for an intervention to support the adherence to drug use in a patient may not all apply to an intervention for improving diet in adolescents.

Michie et al (2011) describe a taxonomy of 93 distinct BCTs. Duff et al (2017), Limone, Messina and Toto (2022) and Martin-Martin et al (2021) build on this taxonomy by setting out BCTs that can be assigned to an HBCG. These include feedback, prompts/cues, self-monitoring, goal setting, action planning, rewards, knowledge, motivation and tailoring. If a player is not engaged in the HBCG or does not find it fun, it is unlikely that the learning objectives will be achieved. Games tend to include enabling mapping to game design components that support behavior changes, so deploying SDT in games can increase engagement and enjoyment. Research suggests that games that satisfy the need for competence through optimal challenges are the most important contributor to the enjoyment of games (Rigby and Ryan, 2011; Tamborini et al, 2010). Autonomy and competence are positively associated with enjoyment, engagement and well-being (Ryan, Rigby and Przybyski, 2006).

Hornecker (2010) argues that often frameworks and tools designed to support the creation of games in general tend to be too constraining and burdensome to use in a creative process. The challenge is how to combine the freedom of an SG design exploration process within the structure of an orientating framework that integrates BCTs and SDT. Consider the design of an HBCG, *Escape from Diab* created by a large, multidisciplinary design team. It is a behavior change intervention designed to lower the risk of type 2 diabetes in 10-12-year olds through improving diet. Several different parts of SDT and BCTs were deployed such as intrinsic motivation from SDT and several BCTs e.g. goal setting and tailoring. Yet much of the in-game narrative is displayed through passive gameplay (cutscenes) where a player is sitting watching a scene take place without any input from them. Passive gameplay may not encourage players feelings of being in control or feelings of competence, both of which are required to inspire intrinsic motivation. This can impact players' feelings of being in control and undermine the application of SDT.

Two-thirds into the *Escape from Diab* project, close to half of the participants did not initiate any gameplay, indicating a real lack of sustained engagement. This might indicate that there was an insufficient balance of fun and entertainment present in the game to keep players engaged and motivated to play. Also, between the pilot of the game and the actual trials, 10 years passed and players now gravitate towards different types of games like mobile games with less passive cutscenes. The results of a subsequent study (Baranowski et al, 2019) found that it had little impact because it may not have included the right combination of behavior change and game design elements. Employing a flexible card sorting tool using SDT and targeted BCTs for HBCGs could be a way to address these shortcomings.

4. An Idea Generation Card Tool

To provide support for the generation of ideas during the development of an HBCG, we developed Version 3 of a card-based sorting tool grounded in ideas from SDT and BCTs. Version 1 had 34 cards in the deck, Version 2 had 29 cards and Version 3 has 12 cards. The size of the cards was increased from playing card size (64mm x 89mm) in Version 1 and 2 to A5 size cards in Version 3 (148mm x 210mm). From analysis of participant feedback, reducing the number of cards but placing more information on the larger cards should make the card content easier to recall and reduce cognitive load while still providing enough support. Font size was also increased in Version 3. The research question was:

RQ: To what extent does an idea generation card tool have perceived practical and emotional value for SG designers generating ideas for health behavior change games?

Practical value is concerned with the perceived value of the card structure, card content and sorting process so that it enables the generation of ideas and game flow without stifling innate creative freedom. Emotional value is concerned with how the cards invoke positive feelings such as relief, confidence, and inspiration or negative feelings such as anxiety, skepticism, or feeling unimaginative.

In Version 3, the headings are Tailoring to Player Values, Goal Setting: the Basics, Goal Setting: Looking Closer, Goal Setting: Action Planning, Rewards, Consequences, Autonomy, Competence, Relatedness: the Social Element, Knowledge, Feedback and Self-Monitoring. Each card is color-coded and describes what the BCT is (yellow), prompts under the heading Ask Yourself to stimulate idea generation (red), How the BCT can be applied under the heading How To (green) and a Practical Prompt (Blue). Figure 2 below shows the Tailoring to Player Values card:

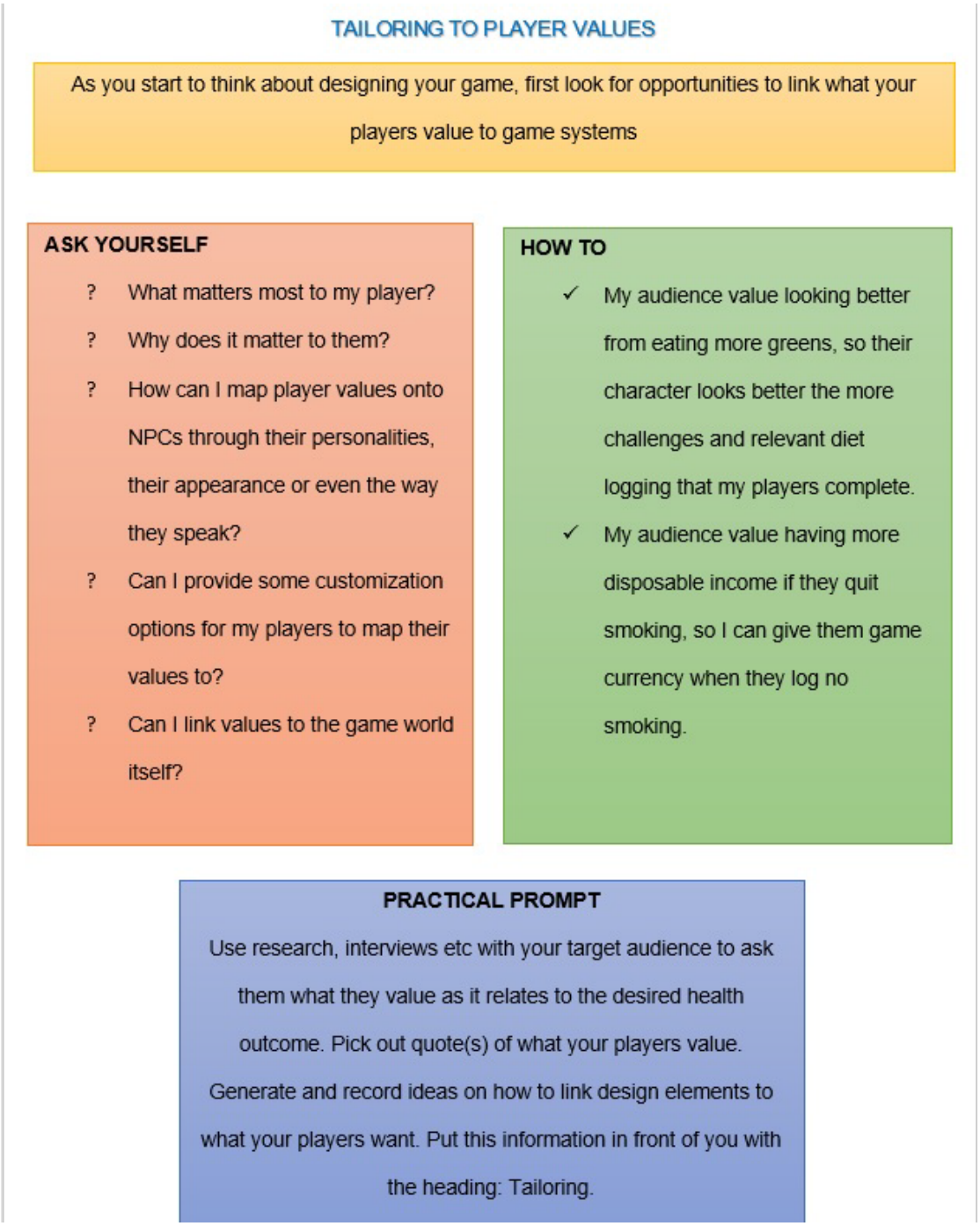


Figure 2: Tailoring to Player Values Card.

Tailoring to Player Values Card is the starting card, then users are free to draw another at random from the deck. Figure 3 below is an abstract overview demonstrating the role of all the other cards with two key takeaways of each card:

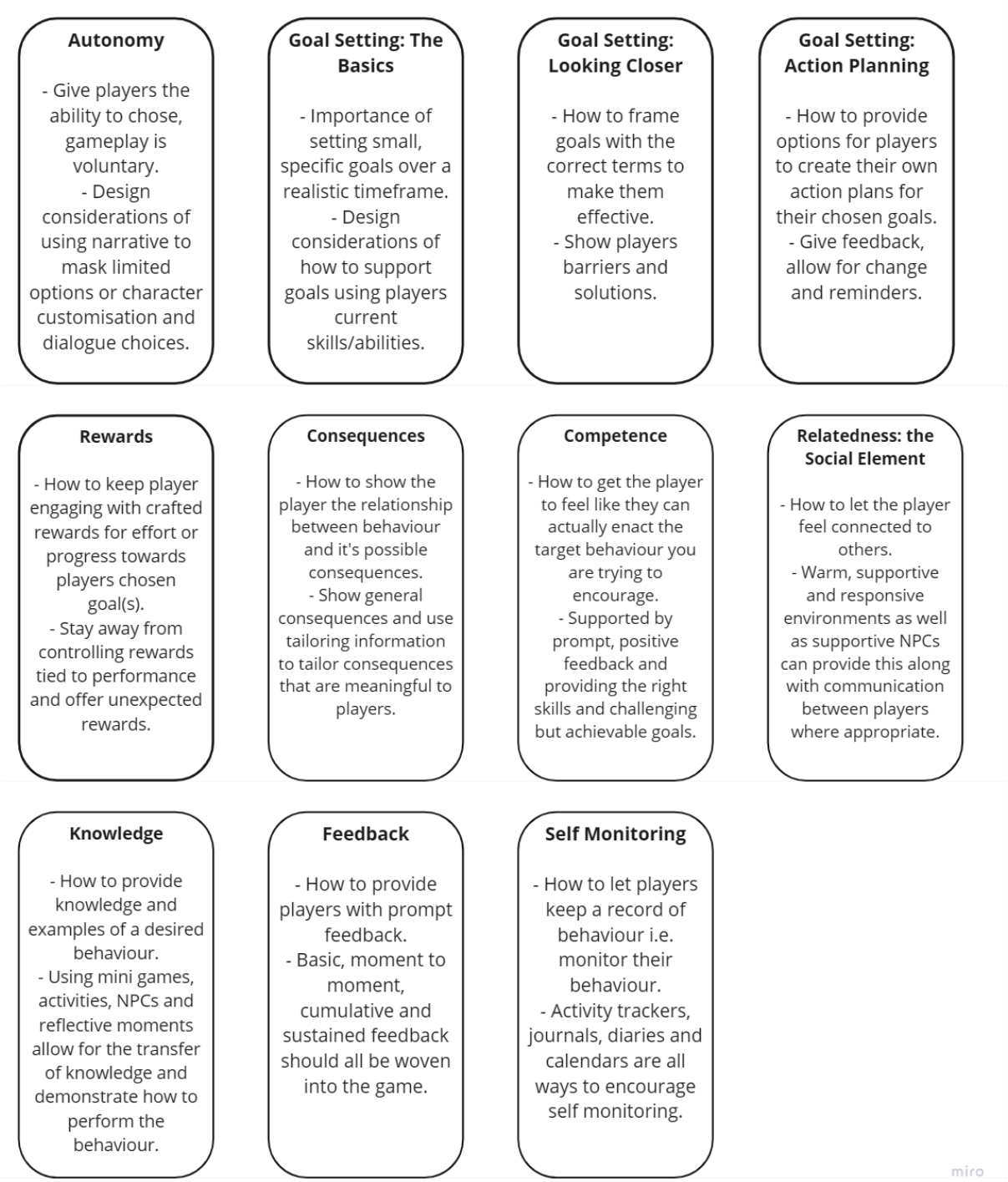


Figure 3: Overview of other cards and their key takeaways.

Relevant ethical considerations were applied including participant involvement, voluntary and informed consent, data handling and subsequent circulation of knowledge. Additional assurances were given to participants who were current students that grades received would not be influenced by their participation, withdrawal or statements. Data protection legislation was followed to ensure data was handled appropriately.

5. Idea Generation Card Tool Evaluation

To evaluate the card-sorting tool, two different data collection methods were used. Each stage of data collection influenced the design of the tool. In the first method, 2 male SG Developers were recruited through LinkedIn. Both had over 5 years of professional experience working on SGs. Each developer completed a separate online

tutorial where the cards were used in a digital tabletop. Each one was given a date and time that was convenient for them and they moved through the online tutorial and the use of the cards for one hour. Semi structured interviews (lasting 30 minutes) over Teams were conducted after the tutorial for each SG Developer. The questions focused on both practical and emotional value by asking how the SG Developers found the process of the cards as well as how they felt using them at different stages.

In the second method, 13 final year undergraduate students on the BSc(Hons) Game Development course were recruited (with one participant also working in the game industry) for an in-person ideation workshop and subsequent focus group, 11 males and 2 females. Student selection was achieved with non-probability, purposive sampling to select those who knew of or had worked within game design. Students were placed in groups of 3-4 and were given a copy of the card sorting tool and instructions. They were observed as they moved through the ideation workshop. This session lasted 1 hour and 40 minutes. There was a 10-minute break before the participants were randomly assigned into two focus groups. Focus group 1 consisted of 7 students, 6 males and 1 female and lasted for 30 minutes. Focus group 2 consisted of 6 students, 5 males and 1 female and lasted for 23 minutes. 7 questions were asked with probes included.

Critical realism and interpretivism were the ontological and epistemological approaches underpinning the project. Data was analyzed using reflexive thematic analysis i.e. a method for identifying themes, patterns and meanings across a dataset as they relate to the research question. The approach was inductive. Codes were extracted from the content of each data set and common themes developed from these codes. The data suggests that the design tool appeals to different audiences: beginners, experienced and highly experienced. Practical value was inferred by participant descriptions of how well the cards allowed them to apply BCTs and SDT without stifling creativity. Emotional value was determined by an analysis of qualitative data about how participants described how the cards made them feel.

5.1 Practical Value

Observations about the practical value of the cards have been arranged into subheadings on card content, card structure and the card sorting process. Key themes are presented in bullet points at the start of these sections.

5.1.1 SG Developers Card Content Themes

- Theme: Valuable for beginners.
- Theme: Ambiguous value for experts.

SG Developers found value in the information on the cards provided though it was slightly different for each one. For those with little or no experience with health behavior concepts, the information on the cards was regarded as striking a reasonable balance between knowledge acquisition and usability. For experienced SG Designers the information on the cards was regarded as of some but less value e.g. "*They were good for brushing up on my knowledge on behavior change, some of them I didn't know about. I felt like they were more for beginner devs, just from the wording. I would have liked to see some way to customize them a bit for more advanced projects*". It seemed to serve largely as a reminder of general BCTs, which was helpful, but more value came from additions to their specialist knowledge base. The BCTs provided seemed to be sufficient depending on the audience. For example, the SG developers noted that they felt more would be needed for more experienced designers of HBCGs: *"Like I said before maybe something for a developer who has perhaps made a few games like this and wants to improve them or see if they're applying useful things rather than going on instinct. An expertise deck almost?".*

5.1.2 Students Card Content Themes

- Themes: Tailoring as a filter.
- Theme: Restrictive questions.

The Tailoring to Player Values card emerged as the most beneficial aspect of the design tool as ideas were filtered through this card for both the SG developers and The Students. This card was popular as an anchor to ensure that ideas were on track enabling user-centered design. They used the Tailoring to Player Values card as a filter for ideas and to keep focus on ideas e.g. when they felt like they were going off track, they used this card to refocus on what was important. It was frequently mentioned by The Students especially that the cards helped to shape the start of the game e.g. "*We found that it was really good to generate ideas. So we had some ideas of what we can do as a project and then going through these questions like oh we could do this as well."* It was

noted by one Student that they did not find all of the card content useful e.g. *"I felt like generally a lot of the cards I was only looking at the left side with the ask yourself questions. It was only every now and again I'd be like, Okay, I'm not exactly sure what's with this one I'd look over to the other side."* Another Student mentioned that this may be because the content was too restrictive e.g. "*.. I think, possibly the questions and the first box was possibly a bit too restrictive. I think that's why people were possibly focusing on them so much."* This suggests that the questions on the cards may be too focused and not open ended enough to support creativity.

5.1.3 SG Developer and Student Card Structure Themes

- Theme: Flexible structure.
- Theme: Valuable information.

Emerging SG Developer and Student themes on the card structure were very similar. All the participants liked how the information was displayed on the cards, appreciating that there was flexibility about what part to read and the examples used. One SG developer did note that there *was "a ton of writing on them",* but the layout of *"short bullet points for each does help".* The SG developers noted the practical value of the layout and the color-coding of the advice and guidance. One did mention that the blue box on the cards containing the practical prompt didn't seem to add any value compared to the other color-coded boxes on the card. The Students mentioned that the separate color boxes drew the eye's attention and helped to provide a familiarity and comfort with the navigation process.

5.1.4 SG Developer and Student Card Sorting Process Themes

- Theme: Supportive design tool.
- Theme: Systematic but not stifling.
- Theme: Flexible process.

SG Developer and Student themes on the card sorting process were similar. Although the SG Developers and Students acknowledged that a rigorous systematic approach would be too formal and too inhibiting, most of them liked the step-by-step approach that the cards offered, because they provided sufficient guidance which was helpful but the flexibility to consider each card in any order they preferred (beyond the first card) which allowed them freedom to support their approaches to problem-solving. The SG Developers also explained that the process supplemented their approaches to ideation. Most Students felt the process helped them focus on ideas and enabled the linking between ideas and information during the ideation process.

5.2 Emotional Value

Participants noted positive and negative feelings within themselves as they engaged with the card-sorting tool although these feelings manifested themselves in different participants in different ways. The positive feelings emerged from (i) the comfort of having physical cards in front of them to use if they got stuck for ideas and (ii) the presentation of ideas and support provided on a topic they knew little about which reduced anxiety and brought some relief (iii) having some form of structure to guide their thinking which increased confidence and allowed imaginations to be freed up from anxiety. Negative feelings arose in some participants who remained anxious about the range and the complexity and the interrelatedness of the concepts they needed to consider. As a result, they lacked a degree of confidence that sometimes bordered on skepticism that the card-sorting tool would provide much help. Observations on the emotional value of the cards are organized into Students and SG Developers. Key emerging themes are noted in bullet points. Thematic analysis of the emotional value is still on going.

5.2.1 SG Developers

- Theme: Inspired.
- Theme: Confident.
- Theme: Reluctant.
- Theme: Skeptical.

For the SG Developers, at the start of the process, using the cards encouraged positive feelings of inspiration and support. Having the Tailoring to Player Values card as the first card they used and having it available later in the process as a focusing point to filter the project, encouraged them to use the other cards and reassurance that they could come back and check their ideas against this card during the entire process. On the other hand,

the SG Developers expressed a reluctance to embrace the ideas on many of the other cards because they were not sure that using the cards would lead to a "better" HBCG compared to their usual practices of idea generation. This is consistent with other work in that there remains a general degree of skepticism amongst SG Developers about the value of design tools during the design process (Neil, 2012). There seems to be some interaction here between practical and emotional value. When the SG Developers assigned a more negative emotional value through feelings of skepticism, they consequently assigned less practical value to the associated elements of the cards. When they felt positive feelings of inspiration through the use of the Tailoring to Player Values card, they expressed that the information was very useful.

5.2.2 Students

- Theme: Supported.
- Theme: Confident.
- Theme: Distrustful.

For the Students, the Tailoring to Player Values card also emerged as a key point of practical and emotional support, particularly at the start of the process. This card seemed to allow for a filter of ideas as well as an evaluation tool as they moved through the process. Participants felt they could generate creative ideas and have the Tailoring to Player Values card to provide a fallback to evaluate their ideas. This addresses an observation from the requirement survey that any design tool should allow for player insights to have value. The Tailoring to Player Values card may provide this by getting users to find what their target audience values, and use this as a filter for the entire development lifecycle. There was also less skepticism from the students, especially at the end of the process, compared to the SG Developers.

Students mentioned that the cards allowed them to visualize a better end product enhancing their confidence in using the concepts on the cards. There was a stronger feeling of confidence in this group compared to the SG developers. There is still an element of emotional distrust assigned to the information, a concern being that the commonplace use of the same tool by different SG developers may result in several games that appear similar to each other not necessarily in content but in structure. It is difficult to evaluate the efficacy of any design tool, but their anxiety on this point may be because participants were all given the same information on what their players value for the workshop.

6. Threats to Validation

The principal threats to validation are (i) that the sample populations of both the SG Developers and the Students are small and (ii) that the card tool has only been used for one type of HBCG. A follow up study could address these issues by recruiting a wider sample size to use the card tool. Additionally, the cards should be tested between groups by comparing participant usual ideation methods to a group using the card tool. The card tool has also only been tested with prompts for improving diet and physical activity. A follow up study should also investigate if it still has value when using a prompt for designing a SG for other health behavior concerns e.g. stopping smoking. Quantitative data could be collected in the follow up study, alongside additional qualitative, to allow for further validation.

7. Future Work

In addition to a follow up study, future work should also aim at evaluating the quality and long-term impact of the design outcome of the games developed as a result of using the cards during ideation. This could be done using the Consensual Assessment Technique (Amabile, 1982). This involves using a panel of experts to appraise ideas against a set of predefined criteria.

8. Conclusions

The efficacy of existing HBCGs remains an outstanding challenge and this may be a result of the lack of design tools to aid in this process. This paper describes a card-sorting design tool to support idea generation for HBCGs. The cards provide information about different aspects of behavior change theory and offer an iterative framework for game designers to lay over some fundamental principles of good game design including the design of a captivating game story, an appropriate set of game mechanics, and a constructive gameplay environment that allows learning. We report on a deployment of the tool to support idea generation during the design of a HBCG. A user recruitment survey, interviews and a focus group were conducted to explore the

experiences of users of the design tool at different stages of iteration. The main findings are that the tool may have perceived practical and emotional value for game designers by providing structure without stifling the brainstorming process and they envisioned a more effective end product by using the cards. This value was assigned to different elements depending on participants and the stage of iteration. Further work is required to expose the tool to more SG developers and for its use on a wider range of HBCGs.

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Renewing Systems Analysis: The Impact of Game-Based Learning on Repeating Students

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Abstract: Systems Analysis and Design, a second-year subject offered over two semesters, is experienced as challenging. The subject is offered at a South African university and form part of several baccalaureus courses, of which the BSc. Information Technology course is the most prominent. Several reasons contribute to the situation where a substantial percentage of students struggle to pass the first of two modules; the extensive theoretical concepts covered, the necessity to understand their implementation, and the ability to apply the theory in real-life scenarios simulated in a learning context. To address this issue, the class was split, to afford repeating students inverted learning with a gaming focus. The selection of games was aiming to suit the type of learning that was expected to take place. In support, students competed in their project groups. Students new to the module were taught as per the status quo. The mixed method enquiry of this changed setting focused on the group of repeating students. Quantitative data extracted focused on the success of students as repeaters, and their evaluation of the module compared to newcomer students. Qualitative data was gathered using interviews with purposively selected participants who passed the first semester as a repeating student and improved much based on the difference in participation marks, before and after the intervention. Qualitative data analysis focused on identifying codes to allow the categorization of responses into categories to elucidate the value of this endeavour. The participants on which reporting of this paper focuses, formed part of a larger study with a wider perspective. In this paper the focus is on the impressions of the individual regarding this experience. The intervention reported on occurred over a four-year period and was concluded six years ago. This allowed participants to complete their studies and start a career. Results show that the intervention did have a substantial impact on the progress of these students' studies and helped them to overcome study and work-related obstacles. The approach to this game-based may guide future lecturers experiencing similar challenges.

Keywords: Game-based learning, Systems Analysis and Design, Inverted Class

1. Introduction

In a context where many students come from disadvantaged communities, students who fail a module is oftentimes neglected, because the focus is on successful students. In addition, to motivate students who failed a subject seems like a difficult endeavour. In this paper the focus is on students enrolled for Systems Analysis, the first semester of a subject offered over a year, where a substantial number of theoretical concepts are covered, and students are expected to apply the theory in a practical group setting. A substantial percentage of students fail the module, which causes several challenges, such as a ballooning class, repeated fails, and repeating students influencing students new to the class.

When the opportunity arose to split the class due to limitations in practical venues, it was decided to do so logically, allowing a special focus on both new students and those repeating the module. The lecturer continued to prepare the new students in the conventional way, with the option available for the repeating students to also attend the theory class. Practical classes were split, and new students continued with the conventional class work and assignment sessions, while a class with a gaming focus was designed. The class was inverted to allow students to build new knowledge on exiting knowledge acquired before entering the class (Talbert, 2012). A second practical session for repeaters were spent in groups taking turns to present their projects. Project groups could only be formed within each class group, which only allowed repeating students to form a project group with other repeating students, and the same in the newcomer group. The lecturer focused on relieving the pressure associated with theoretical work, to focus on practical activities, and doing it in a fun way. Material applicable to each group were made available to all students. Games were selected to accommodate the underlying focus of the material included in a particular study unit, and therefore the learning to take place, namely (1) focused on facts, (2) facts and the application thereof, and (3) implementations where the interpretation of scenarios were the focus.

This case is the focus of this paper, while the success of the intervention is interrogated form the perspective of repeating students. Mixed methods are utilised, including quantitative and qualitative data to learn about the challenges students face, and how the intervention helped them to overcome them.

Subsequent sections discuss the theoretical foundation of the study (Section 2), namely game-based learning, Systems Analysis and Design, and the inverted class. Next, the problem is explained (Section 3), and in Section

4 the design of the research is discussed in terms of the case followed and its mixed method nature. Findings are relayed in Section 0, and the paper is concluded in Section 6.

2. Theoretical Foundation

The theoretical underpinning includes the subject matter covered in the first semester, namely Systems Analysis (SA&D-I), the first module of the subject Systems Analysis and Design (SA&D), game-based learning (GBL), and the essence of inverted classes as underlying assumption to the approach followed in the class of repeaters.

2.1 Systems Analysis

The book, Systems Analysis and Design for the Global Enterprise, compiled by Bentley and Whitten (2007) was prescribed as text book. In SA&D-I, the focus of the first semester on systems analysis, includes background information, project management, and the activities addressed by the phases of systems analysis, including requirements gathering, use-case modelling, data modelling and the analysis of the data, process modelling, and feasibility analysis. To place this semester in context; the second semester focuses on systems design, namely application modelling, database design, output design, input design, and user interface design. Although one could argue that system construction and implementation, and systems operations and support, are strictly not SA&D phases, they are addressed to allow students to experience the effects of analysis and design on the resulting system.

2.2 Game-based Learning

In earlier studies on SA&D and the closely related field of Software Engineering, to improve teaching and learning of material, a card game (Baker et al., 2005), game design (Claypool and Claypool, 2005, Cagiltay, 2007), and a real-life project (Gnatz et al., 2003) was used. These studies focused techniques to improve student involvement not only to improve learning of knowledge, but also skills and attitudes of students. Saleem et al. (2022) posit that gamification, although it may not resonate with all students, does motivate students, promote student interaction, and has a social impact. Work done by Nyahuye and Steyn (2022) found that gamification fosters teamwork, which links with the promotion of interaction. In addition to these benefits, Venter and Swart (2019) indicate that gamification can be used to strengthen the sense of community among students and supply immediate feedback on learning taking place. Game-based learning has links with gamification since it may include the allocation of points and stars for the completion of activities, but it would also involve redesigning activities to introduce rules of play to stimulate conflict – to make learning more interesting and engaging (Plass et al., 2015).

2.3 The Inverted Class

Akçayır and Akçayır (2018) claim that teacher-centred teaching is treating students as empty vessels that passively absorb information, while an inverted approach focuses on students. Therefore, student-centred learning theories, such as active learning, peer-assisted learning, and collaborative learning matches inverted settings well. Pashler et al. (2008) claim that optimal teaching methods would vary from one discipline to another. Willingham et al. (2015) came to a similar conclusion – that there are discipline-specific ways in which to teach its concepts. On a micro level this assumption was applied to different study units of the same subject, by using different games to promote learning of differentiated material.

3. The Problem

The SA&D-I class grew substantially, partly because of a yearly group of repeating students – because of the challenging nature of the module, but also because the campus numbers ballooned. In addition, the largest practical venue at the time, was a venue with ninety-nine seats, and at the start of 2015 the class grew to 114 students. The obvious solution was to split the class, in two equal parts, but the lecturer did not find the idea appealing. Conversations with management opened an opportunity to split the class in a logical way, instead of forming two equal sized classes; a class for students new to the module, the newcomers (class N), and another class for those repeating the module, the repeaters (class R). This option was considered since the lecturer perceived the repeating students to have negative influence on students new to the module – "*this is a very difficult module; expect to struggle!*", and in the groups that formed, the inclusion of repeating students did not allow new students to be confronted with the wow factor of analysing, designing and coding a system.

From an opposing perspective, the repeating students had a fair knowledge and understanding of the material but lacked the impetus to pass the module.

It is now ten years after this intervention was started and six years after it was discontinued, a substantial period, which allowed these groups of repeating students to complete their studies, find a suitable job, and establish themselves as computing specialists. As point of departure quantitative data is presented from the course results to facilitate understanding regarding how the progress of repeating student compared to students passing the module on their first enrolment. The questions arising, namely "How successful was this intervention from the students' perspective?" and "Did this intervention have a long-term impact on these students' lives?", was asked in interviews to obtain qualitative data. The content analysis technique was used to make sense of the data; immersion in the data allowed the researcher to identify codes, and form categories, which was grouped into themes (Kleinheksel et al., 2020).

4. Research Design

A larger study found that game playing motivated students, but here the focus is on drilling down in terms of whether game playing had an impact on the individuals' future studies and career. This study is treated as a case study as it explores a single phenomenon by obtaining knowledge by using multiple methods (Collis and Hussey, 2013). Being an explanatory case study, it explains how the intervention was experienced by participants, and why it is viewed as successful in the real-life situation (Myers, 2019). The mixed method approach was followed in this study to present a rich depiction of the environment by gathering quantitative and qualitative data sequentially, with the purpose to integrate it (Tashakkori and Teddlie, 2003). This results in triangulation of data, with two points known – to determine the position of a third unknown point. In this study triangulation is obtained through the following data sources: comparing the pass rate and average of repeating students to when they were newcomers and how repeaters evaluated the lecturer compared to the newcomers (quantitative focus), and interviews with five purposively selected young working adults who was part of one of the repeating classes (qualitative focus). Therefore multi-facets of research is leveraged to enhance the design to improve capacity to interpret findings (Denzin, 2017).

4.1 The Context of Students Repeating Systems Analysis

The period this study reflects on, includes the years 2015 to 2018. The focus of this paper is on an aspect of a bigger study where action research cycles were implemented to identify problems associated with the teaching of SA&D – to allow the emancipation of the participating students. The lecturer wanted to support individual students, by making multiple focused resources available. Support was planned to manifest in encouraging active student participation, and eventually stimulating growth of everyone to his/her full potential. This intent was amplified by splitting the class.

The newly created situation opened an opportunity for redesign, while retaining the underlying material, which was already considered pre-knowledge of the students repeating SA&D-I, anticipated to support the scaffolding of new knowledge. In support the group of repeaters were small, which facilitated this intensified approach. It also supported the underlying critical perspective that, per definition, these students have been negatively affected and is therefore in need of additional attention. Repeating students did not pass the module due to any of several reasons including financial difficulties, personal problems, low motivation, or other obstacles. At the time the focus was not on the pass rate of the group per se, but rather on a broader perspective, as promoted by Bunce and Bennett (2019), as well as Nixon et al. (2018), where the class design intended the creation of a positive and rich learning environment.

The prominent formative assessment opportunities such as the semester tests and group project were required by all students, while the smaller weekly assessments were focused on each class, and new instruments had to be designed in accordance with the repeating students' needs. The instruments that were contributing to the participation mark of the group of repeating students, is shown in Table 1.

Table 1: Instruments contributing to the participation mark.

Semester 1 Group: repeating students	Number	Weight
Quiz	4	
Happy hour	2	10
Expert witness	4	
Big assignment	1	10
Semester tests	2	50
Group project:		
1. Weekly presentation	1-3	
2. Consultation	1	30
3. Final presentation & demonstration	1	

The three points of differentiation, namely the games (10%), one assignment (10%) which asked these students to reflect on their own learning, and the weekly presentations (5%, not identified) was not substantially contributing to participation marks, yet the impact on students were large, as is evident from the results.

4.2 Games Included to Suit the Learning Material

Systems Analysis study units were grouped into three distinct categories which were matched to three different games. It should be accented that these repeaters were students of technology, and the use of electronic gaming would have been an option, but a decision was made that games should be far removed from technology. The intention with this approach was to strengthen the bonds between members of each project group, which were also game groups, to get students involved actively, to require their attendance in class, and to pull them into learning about subject matter without realising it. The three games associated with the grouped chapters are *quizzes*, *the happy hour*, and *expert witnesses in a court of law*. The implementation of each is discussed and illustrated below.

Figure 1Figure 1 shows how *quizzes* were conducted to cover theoretical concepts with little potential for practical application; the value of SA&D, the components of Information Systems (IS), developing ISs, and Systems Analysis (Bentley and Whitten, 2007).

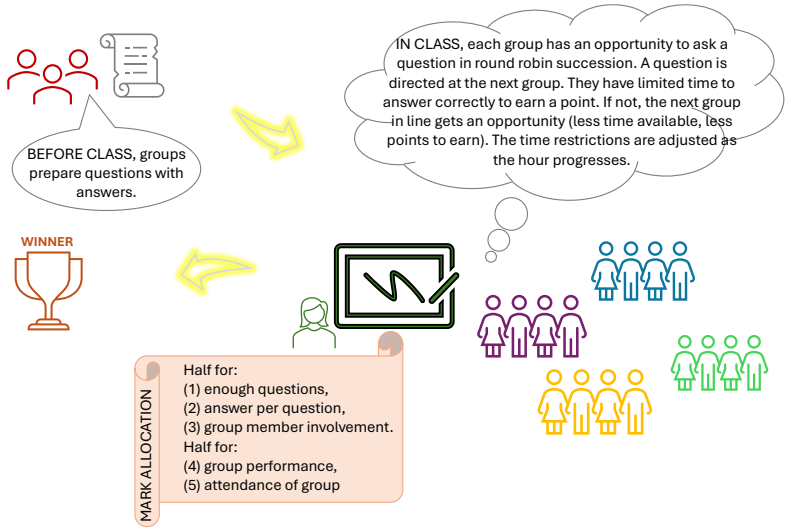


Figure 1: Format and assessment of quizzes.

With the help of the lecturer, the students managed each quiz, and they decided on mark allocations. In many cases it meant arguments regarding the facts as answers. The goal of each game was to announce the winning group. To allow this to be done at the end of a class, the lecturer allocated marks to preparatory work before

the start of the class and did the allocation of quiz marks as the questions were answered. The announcement of the winner was accompanied by a show of we-are-the-best, lots of applause, each winning member receiving a lollipop from the lecturer, and photographing the group members in attendance – in front of the evidence of their win. An example is shown in Figure 2. Photographs were shared on the WhatsApp group formed to serve the purposes of class R.

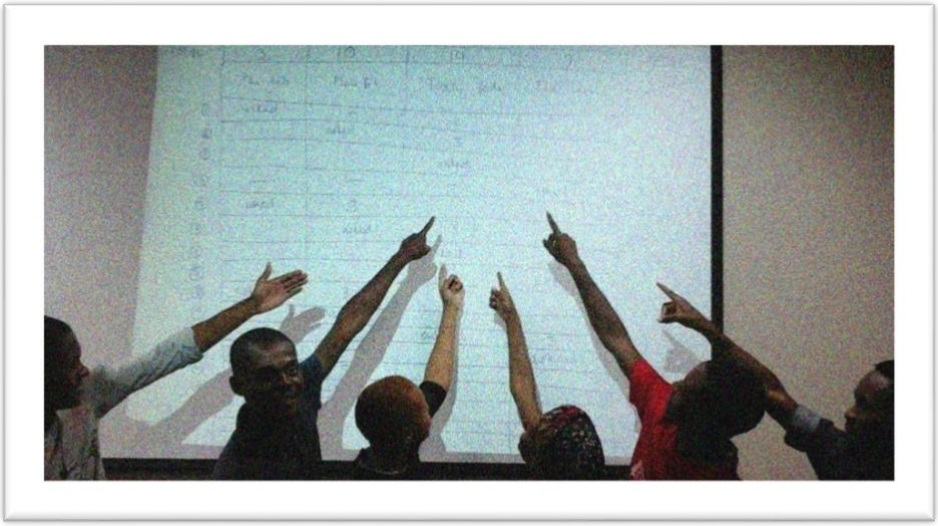


Figure 2: Quiz winners, Team Toxic Code (study unit 2 of 2016).

Subject matter that emphasizes theory and its implementation equally, includes the project management cycle and the implementation of its tasks, and the techniques pertaining to data gathering for the discovery of requirements (Bentley and Whitten, 2007). Each *happy hour* was directed by a set of Microsoft PowerPoint slides, with the slide shown in Figure 3, a reminder of the rules of the game. In preparation, the compilation of (1) a succession of questions slightly more involved than a typical quiz-question, and (2) its accompanying answers prepared by a student assistant and checked by the lecturer.

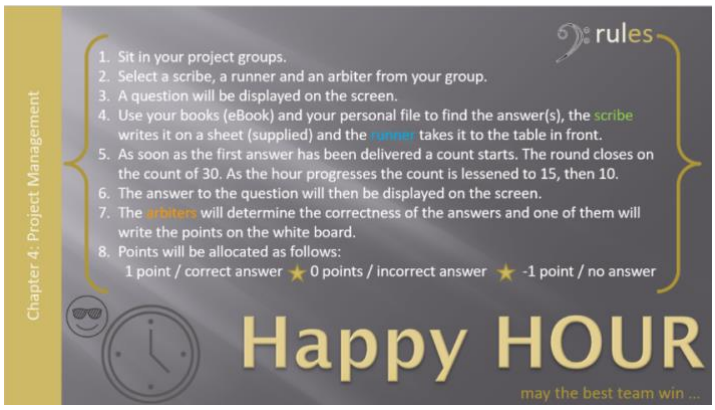


Figure 3: Happy hour game rules, as shared with students (study unit 4 of 2017).

This game created many fun moments because it required members acting as runners to physically move from where their group were sitting in the class to a table in front of the class where arbiters from each group sat. In this game the arbiters collectively decided on the mark allocation earned by each group for each question. The end goal was the same as for the quizzes, finding the winning group for each happy hour.

Regarding the physical setting; facilities were not ideal for the happy hour game, because the venue was a practical class with fixed desks that made movement difficult. Figure 4 shows a suggested setup that will work well for this game; each group should have a sitting area removed from other groups, which allow them to use their prepared material, talk, and to write out their answer. All groups should be removed from the arbiter table the same distance, and there should be no obstacles along the way.

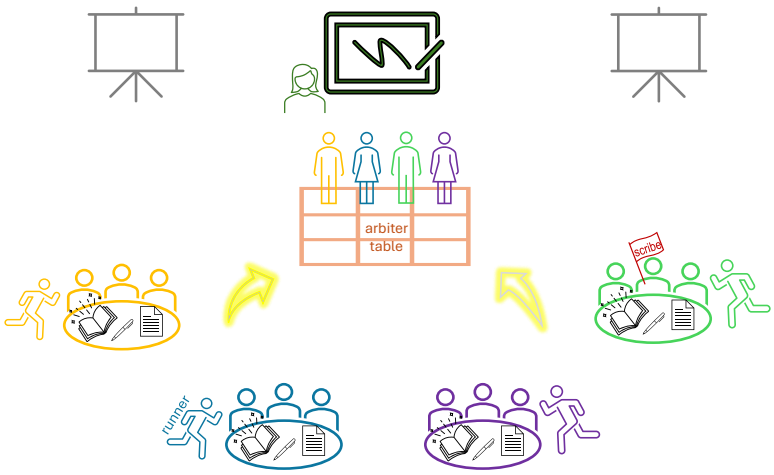


Figure 4: Suggested venue layout for happy hour game.

Practical implementations with little theoretical knowledge associated with it include: the development of use-cases, data modelling and data analysis (split in two sessions, because of the work load associated with it, process modelling, and feasibility analysis (Bentley and Whitten, 2007). Each *expert witness court session* was also directed by a set of Microsoft PowerPoint slides, with the slide shown in
Figure 5, reminding students of the rules of the game. In preparation for these games, (1) a scenario, typically from a previous year's test or examination was presented in the context of the material under discussion, with one or two practical analysis questions listed, and (2) its accompanying model answers were prepared by the student assistant and checked by the lecturer.

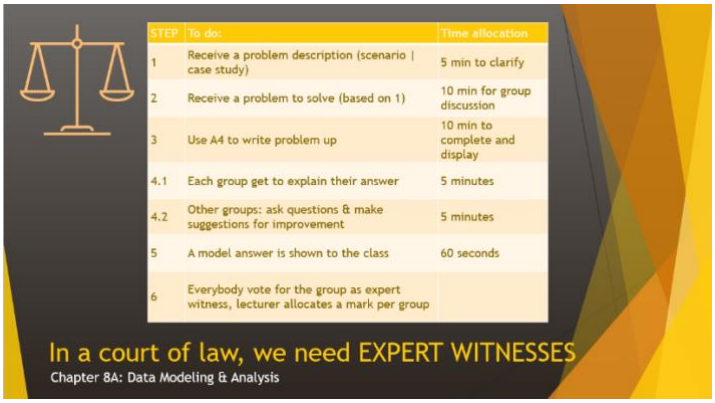


Figure 5: Expert witness game rules, as shared with students (study unit 8A of 2016).

According to the rules stated above, the slides were shown to the class in a pre-determined succession, with time allowed after each display for students to work on their answers. As soon as the allocated time has passed, prepared answers were displayed on the wall at the back of the class, and each group had an opportunity to present their answer, explain it, and the assumptions they made to get to their answer. Other groups could ask questions. Voting was used to determine the winning group. The class situation mimicked a court of law, where an expert may be called to state an expert opinion, be questioned, with a verdict as result. After the class, the lecturer allocated marks to each group's answer. In many cases the highest marks were not allocated to the winning group, since the lecturer did not interfere with the voting, as it was driven by the success of the presentation of each answer, while the marks were determined by how well the question was answered.

4.3 Quantitative Data Collection

The story the data tells from quantitative data on the performance of the students in the year preceding their inclusion in class R – as part of class N – compared to the year in which they participated in class R, the number of students who passed, and how repeaters evaluated the module compared to the newcomers.

4.3.1 Compare the Average of Repeating Students to When They Were Newcomers

Since students are allowed to move from one campus to another, and some students took breaks between academic years, not all students were in a preceding year's class. In a small number of cases, students moved from one class R to a next, in which case they were not distinguished from class N students when it came to the previous year's data. Therefore, the average of the students who were part of the previous year's class N were calculated using the sum of their marks, divided by the number of students. Note that only the students who earned a participation mark and qualified to write examination were included in the calculation, since only the final mark was used in the comparison. This comparison is relayed in Figure 6 which shows that the performance of these groups of students improved close to 10%, represented by the following respective percentages; 9.3% (2015), 7.7% (2016), 11.6% (2017), and 11.3% (2018).

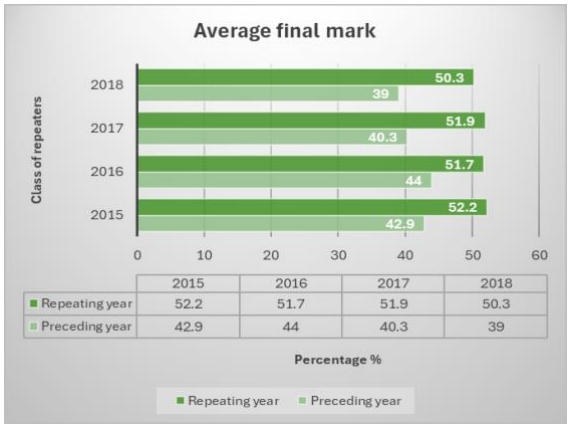


Figure 6: Comparing the average final mark of the repeating class with the previous year 2015-2018.

The next section allows us to drill deeper, in terms of the students' success in class R.

4.3.2 The Success of Repeating Students in Class R

Since a student's inclusion in class R meant that the candidate failed SA&D-I in the preceding year, the focus moves to how well the pass rate was in each year's class R. The figures relayed in Figure 7 shows the growth of class R, reflecting the increased student intake at the university, 26 in 2015, 31 in 2016, 32 in 2017, and 41 in 2018. It is clear from the graph that a substantial percentage of each class passed the module. This is supported by the percentiles of; 76.9% in 2015, 74.2% in 2016, 68.8% in 2017, and 65.9% in 2018. These figures are higher than that of the larger class (classes N and R combined) of; 66.7% in 2015, 62.3% in 2016, 65.8% in 2017, and 55.8% in 2018.

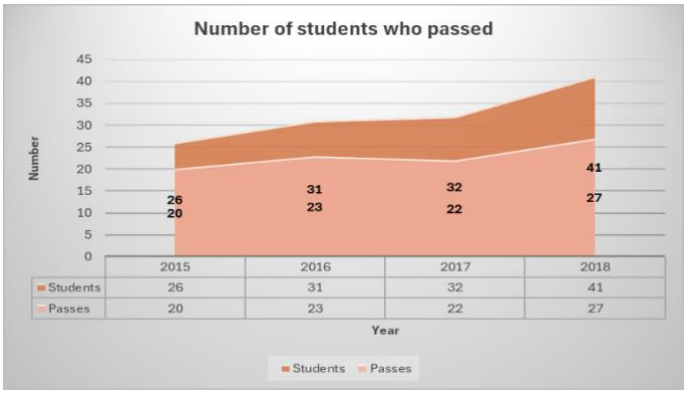


Figure 7: Performance of class R in terms of pass rate.

In addition to the data showing that students performed better in class R, their evaluation of the module is higher as seen in the next section.

4.3.3 How Class R Evaluated the Module Compared to Class N

The two years in which students could evaluate the SA&D-I module, class R shows a higher rate of satisfaction. Figure 8 shows a rate of 89.5% for class R compared to 78.3% for class N in 2015, and 84.8% and 75% respectively for 2016.

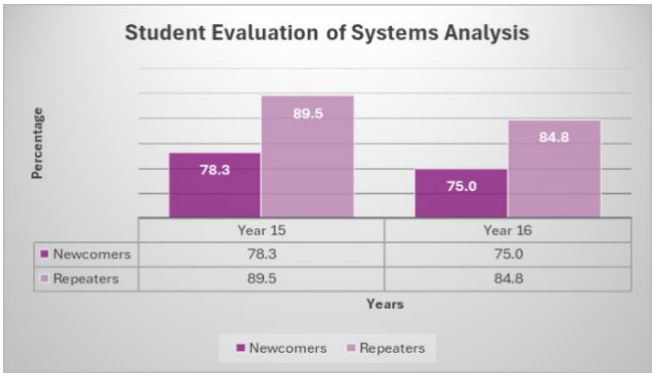


Figure 8: Students' evaluation of their SA&D-I class experience.

From the quantitative data it may be deducted that the setting created in class R was well suited to support the repeating students, with improved performance, a better pass rate compared to class N, and their indication that they were more satisfied with their class compared to class N.

4.4 Qualitative Data Collection

Interviews were scheduled for online sessions on the Zoom platform. Three groups of questions allowed participants to reminisce on their gaming experience and the influence it had on success in the module and beyond. With the computing technology environment known for being constantly changing at a rapid pace, it is expected that people working in this industry are placing a high priority on the constantly renewing of their knowledge. Along with this, one associates gaming with technology, and many students relating to this application field, either to become a game developer, or being an avid gamer. The list of open-ended questions used as instrument are shown in Table 2.

Table 2: Open-ended questions asked in interviews.

Category	Question
A. The games we played	
	In your view, was the games we played suitable?
	As a student in technology, are you critical of the fact that we did not use gaming computing technology?
B. Your experience regarding playing games in SA&D	
	Why did you struggle in SA&D?
	Did gaming facilitate your learning?
	Was gaming instrumental in your success as a repeater?
C. Effects of gaming beyond SA&D-I as module	
	Was the success you experienced as a repeater facilitating success in your studies as a senior?
	Are you using SA&D in your job?
	Were the success as repeater facilitating success in your career?

With interviews conducted online, the Zoom platform allowed its recoding and the compilation of transcriptions afterwards – with the intention to formalize the recordings – in support of the researcher familiarizing herself with the data. Codes were formed as a first step, then categories were formed, and lastly these were grouped into themes.

4.4.1 Participants

Eight young working adults were invited, with two being selected from each repeating class offered over the four-year period the arrangement was active; namely 2015, 2016, 2017, and 2018. The invite reached five, who responded and were interviewed. Interviews were built around the needs of the participants, with some as short as 30 minutes, and others as long as 90 minutes. The selection of participants approached to participate in an interview was done purposively based on their participation mark improvement from being a newcomer, to being accommodated in one of the repeating groups.

To create context, biographical information was gathered, and Table 3 shows the participants' biographic information. Participants were listed according to the order of their interviews, and were named P_1 to P_n, to protect their identities.

Table 3: SA&D repeating students as participants.

Participant	Gender	Active year	Level of education	Current age	Current job focus	Years working
P_1	F	2015	BSc in Information Technology	32	Robotics Process Automation (RPA)	7th year
P_2	M	2017	BSc Hons in Computer Science & Information Technology	29	Automation Engineering	5th year
P_3	F	2015	BSc in Information Technology	32	Business Analysis	8th year
P_4	M	2016	BSc in Information Technology	29	Software Engineering (with Software as a Service focus)	7th year
P_5	F	2017	BSc in Information Technology	29	Business Intelligence Development	5th year

When evaluating this group of participants beyond the formal reporting; only one has a qualification beyond degree level, with the remaining four indicating that they are thinking of continuing their studies soon. All participants started out at a company other than the one they are currently working at. All the participants are working at a prominent and established consulting company, software house, or company with an in-house computing department. They all indicate that they are in positions where they are challenged. All of them recognise the need for amending their knowledge continuously, and they are being aware of their need to stay abreast of changes to be relevant in their environment. Learning includes formal training. Interestingly, except for a limited time per week spent at the office for some of them, they are all working remotely. Appreciation for the flexibility their situation offers is evident, but all of them acknowledge that their job environments are stressful and require them to work long hours. Therefore, they recognise the need to actively manage their work-life balance. Participant P_3 excels at being a business analyst with a solid technical underpinning, but she expresses the wish to work in a software development environment soon. Participant P_4 uses his free time to develop Software as a Service applications to prepare himself for a future business which would provide opportunities for application development as well as a passive income.

4.4.2 Data Analysis

The aim of the data acquisition was to triangulate the quantitative data, as is evident from the open-ended questions asked. The codes and categories were guided by the open-ended questions (Table 4). All participants indicated that the semester spent as repeater in the SA&D-I class had them fully emersed in the hands-on approach of the games we played <GAME_GOOD – GAME_SUIT, GAME_FRMT>.

Table 4: Code table from category X questions – X.

Category	Code	Description	Occurrences
GAME_GOOD	GAME_SUIT	Games were suitable	5
	GAME_FRMT	The game format not important	5
JOB_USE_SAD	SAD_JOB	Use SA&D in my job	4

Category	Code	Description	Occurrences
	XSAD_JOB	Do not use SA&D in my job	1
STRUGGLE	WORK_STD	Paid my own way, alternated years of study and work	5
	MRE_WORK	Increased workload caught me by surprise	
	FIN_LATE	Financial constraints caused late start to semester	
	TECH_FCS	Could not find technology focus	
	FACT_MCH	Facts to learn were overwhelming	
OVERCOME	LOST_FEAR	Lost my fear of failure	5
	ACT_LRN	Active learning helped me	
	PRP_NTS	Prepared well and taking notes	
	LOST_SHY	Managed shyness	
	CRIT_WORK	Be critical of my work	
SUC_BEYOND_SAD	SUC_REP	Enhanced learning, success as a repeater	5
	SUC_SEN	Success as senior student	5
	SUC_CAR	Success in my career	5

Only P5 is not using the concepts addressed in SA&D directly in her job, but all participants relate the learning that took place in this class and in particular the games we played – about subject matter, skills and attitude – with their success in the class under discussion, the subsequent year, and their progress in their career <JOB_USE_SAD – SAD_JOB, XSAD_JOB>.

Beyond support of literature (Huizenga et al., 2017, Liu et al., 2020, Loderer et al., 2020), participants indicate being involved in the material, preparing for class, changing the way they prepared for assessments and events in their job environment, changing the way they learn effectively, building bonds among group members in such a way that these peers are now part of their career network, building confidence in presenting their case, speaking their mind, and making presentations, and being mindful of keeping up with technology changes – as lifelong learners <codes associated with OVERCOME>. They claim that they are confident young workers who is comfortable among the users they serve, they are not fearful of having a difference of opinion with users and are intent on working towards a mutual understanding resulting in a product serving the user excellently <OVERCOME>. Making mistakes are not the end of the world, but an opportunity to learn, and doing the job better because of learning <OVERCOME>.

Success beyond class R is evident, and participants indicated that the class stands out among other classes in their memory, and they linked successes in their senior year(s), and job environments to what they learned here <SUC_BEYOND_SAD – SUC_REP, SUC_SEN, SUC_CAR>.

5. Findings

Two related themes could be extrapolated from two categories, namely the major challenge experienced by each participant, and how the games we played helped each participant to overcome these obstacles. Figure 9 shows the failure identified by each participant, and it being turned into success.

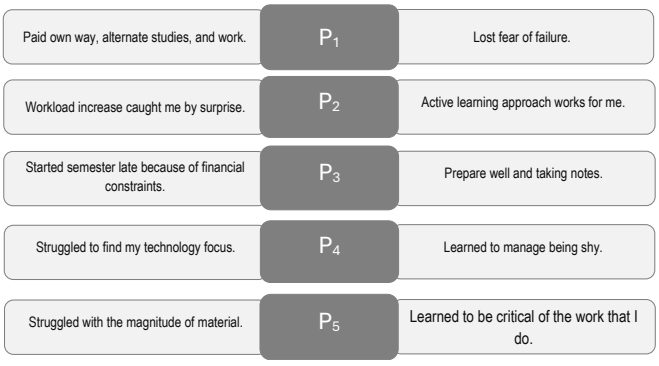


Figure 9: Participants' failures turned into successes.

The reason each participant listed for failing SA&D-I as first attempts differs for each participant: P_1 indicated that she paid her own way in her studies and alternated years of study and work <WORK_STD>, which distracted her focus, P_2 had a background in computing and comfortably passed his first year, but the increased workload of the second year of study caught him by surprise <MRE_WORK>, and by the time he realised his mistake it was too late to remedy the situation, financial constraints caused P_3 to start her semester late <FIN_LATE>, with too little time to build a participation mark, P_4 were struggling to find his technology focus <TECH_FCS>, which distracted him from his studies, and P_5 found the facts to learn in SA&D to be overwhelming <FACT_MCH>. Each participant could list one prominent positive feature that they took from playing games: P_1 lost her fear of failure <LOST_FEAR>, and learned that one should turn failures into opportunities to improve oneself – also in the workplace, P_2 found that active learning helped him more than reading through the material <ACT_LRN> and he changed his approach to learning to this day, P_3 learned that taking notes is her superpower <PRP_NTS> and she still uses notebooks in stand-up meetings and to plan her day, P_4 managed his shyness and learned to project himself <LOST_SHY> in his job environment and in presenting material to users, and P_5 acquired the skill of being critical of her work <CRIT_WORK> in order to determine problems before they occur. These experiences are aligned with the findings of Mao et al. (2022) who found that "*GBL had a large, significant positive effect on students' critical thinking*". It explains the ability of participants in the study to identify core challenges in their learning journey, and then address these with innovative solutions that ensured success in the years of study beyond the gaming intervention, as well as their work life.

6. In Conclusion

This study reflected on a scenario where the lecturer saw an opportunity to turn a bug into a feature – to use computing terminology. It was a situation to be opportunistic in taking an opportunity when a problem presented itself – in the form of the physical practical class not large enough to accommodate all the students of a growing class. In the subsequent class of repeating students that was formed, the inverted offering was made possible by the pre-knowledge of these students, and individuals could build on their knowledge in a non-conventional way. The paper-based games were only possible because of the small number of students in the class. Most of the students who participated in this class benefited from the more focused approach afforded by a small class.

After the four-year period of offering SA&D as two classes, circumstances changed sufficiently to allow the two classes to be merged once again. From the experience, computerised game-based learning was incorporated in this class, in the form of the Quizizz application.

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Gamified Networked Learning Environments in Higher Education: A Study on Student Engagement and Value Creation in Computer Science

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Abstract: In the rapidly evolving domain of computer science education, fostering deep engagement and sustained motivation among students remains a challenge. This study introduces the Answers platform, a pioneering online learning environment developed at TU Delft. This research aims to reimagine the learning experience for Bachelor and Master of Science Students in computer science by integrating gamification elements grounded in Wenger's value creation framework. Our paper explores two critical research questions: the perception of learners towards gamified learning experiences and the impact of the Answers' system on value creation and motivation. We incorporated points, badges, and leaderboards in a semester-long intervention to enrich the learning landscape. The Value Creation Questionnaire (VCQ) results indicated that the platform effectively created potential and applied value, significantly enhancing students' learning practices and motivation. However, its impact on fostering social connections could have been more pronounced. The platform also moderately influenced students' ability to impact their world and shift perspectives. The Intrinsic Motivation Inventory (IMI) revealed that students generally enjoyed using the platform but felt it did not significantly enhance feelings of connectedness. This paper contributes to the body of knowledge by demonstrating the efficacy of gamification in computer science education and offering insights into the design of engaging online learning platforms. By bridging theoretical frameworks with practical application, the Answers platform exemplifies the potential of gamified environments to revolutionize educational practices in the digital age.

Keywords: Networked Learning, Gamification, Value Creation, Computer Science Education, Online

1. Introduction

1.1 Background and Context

The digital revolution has profoundly transformed educational paradigms, particularly within computer science education, where the rapid evolution of technologies demands innovative pedagogical approaches. Amidst this transformation, gamification is a potent strategy to enhance learning experiences by incorporating game design elements into non-game contexts. This study introduces "Answers," a novel online learning platform developed at TU Delft, aimed at redefining the educational landscape for computer science students. Answers integrate gamification elements within a framework inspired by Wenger's theory of value creation (Wenger et al., 2011). This integration seeks to engage students and deepen their learning and professional development through a networked learning environment.

1.2 Literature Review

Gamification can significantly enhance student motivation and engagement in online education environments. Recent research has consistently shown that incorporating gamification elements into online learning systems positively affects students' participation and learning outcomes. Gamified learning environments effectively engage students using intrinsic and extrinsic motivators, leading to higher motivation levels and improved academic performance (Buckley & Doyle, 2016; Schöbel et al., 2019). Furthermore, empirical evidence supports the notion that gamification strategies can lead to a more stimulating and engaging learning experience, fostering both engagement and problem-solving capabilities among students (García-López et al., 2023; Çağlar et al., 2020).

In computer science education, gamification has shown promise in enhancing student engagement and learning outcomes. Studies have demonstrated that gamified CS courses can increase student motivation, higher retention rates, and improved assessment performance (Dichev & Dicheva, 2017; Barata et al., 2013).

Gamification elements such as leaderboards, badges, and point systems have been found to create a competitive yet collaborative environment that encourages students to actively participate and engage with the course material (Faghihi et al., 2014; López-Fernández et al., 2023). Recent reviews highlight that specific game elements, such as leaderboards and badges, are particularly effective in increasing participation and enhancing the learning experience. However, the impact varies depending on the curriculum's design and integration of gamification elements (Zhan et al., 2022). In line with these findings, Videnovik et al. (2023) review also finds that game-based learning in computer science education can enhance understanding and retention of material, particularly when aligned with curricular goals. The effectiveness is mediated by factors such as game design, integration into the curriculum, and student demographics.

Moreover, the application of gamification in higher education, in general, has highlighted its potential to transform traditional learning environments. By integrating game mechanics into university courses, educators can create more interactive and immersive learning experiences that cater to diverse learning styles and preferences (Huang & Soman, 2013). However, challenges such as ensuring the relevance of gamification elements, impact on learning outcomes, and maintaining student motivation throughout the course remain areas for further exploration (de-Marcos et al., 2014; Zahedi et al., 2019).

In sum, gamification is not merely a trend; it is a robust educational strategy that can significantly enhance the academic experience, especially for the computer science student, by increasing their motivation and engagement in online learning settings.

We utilize the Value Creation Framework introduced by Wenger, Trayner, and De Laat (2011) to assess and articulate the value generated through learning activities in communities of practice. This framework categorizes value creation into five cycles—immediate, potential, applied, realized, and transformative value—each illustrating a different impact that community participation can have on an individual or group (Dingyloudi & Strijbos, 2015). This approach is particularly effective in educational settings where learning outcomes are measured through traditional academic performance and the broader development of skills and capabilities vital in today's interconnected world.

In networked learning, gamification is increasingly recognized as a powerful tool for enhancing professional development. Educators and trainers can significantly boost engagement and motivation among learners by incorporating game-like elements into networked learning environments. This approach has been particularly effective in teacher professional development, where gamification strategies increase participation and encourage applying new knowledge and skills in educators' daily practices (Pozzi et al., 2016). Furthermore, studies have shown that gamification can enrich the learning experience by fostering a student-centered environment, which is crucial for effective professional development in various educational settings (Tsay et al., 2018). The strategic integration of social networks with gamification elements further enhances this impact, creating a more connected learning experience and promoting continuous professional growth.

1.3 Research Gap

The motivation behind this research stems from the observed need for more engaging and effective educational tools that can address the unique challenges of computer science education. Traditional learning platforms often need to improve in fostering motivation and deep engagement, which are critical components for mastering the complex concepts inherent in computer science. In response, our study explores the potential of gamification to fill this gap, hypothesizing that a learning environment enriched with gamification elements can significantly enhance students' learning experience, outcomes, and value creation.

1.4 Research Questions and Objectives

Two pivotal research questions guide our investigation: How do learners perceive the gamified learning experience in computer science Bachelor and Master of Science courses? Does using the Answers system impact the value created and motivation for a course topic? Moreover, how do gamification elements within the platform enhance motivation?

1.5 Significance of the Study

By delving into these questions, this paper aims to contribute to the growing knowledge of gamification in education, offering insights into its application within computer science learning environments. The subsequent sections will detail the methodology adopted for this study, present our findings, and discuss the implications of

integrating gamification with Wenger's value-creation framework in educational settings. Through this exploration, the Answers platform is posited as an innovative model for enhancing engagement, motivation, and learning outcomes in computer science education.

2. Methodology

2.1 Participants

This study engaged 372 participants, including Bachelor and Master of Computer Science students and course instructors actively involved with the Answers-EWI platform throughout the period under analysis.

2.2 Data Collection Methods

To comprehensively assess the impact of the "Answers" platform on learning outcomes and motivation, our study utilized a combination of automatic log data and questionnaires, each tailored to capture different dimensions of the learning experience and value creation.

Log Data: The platform automatically generates log data capturing detailed information on user interactions. This included data on the frequency and type of activities such as question posting, answering, and commenting. Log data provided quantitative metrics on engagement levels, enabling an analysis of how actively and in what ways students and instructors used the platform.

Questionnaires: Two types of questionnaires were administered to participants to gather data on perceived value creation and intrinsic motivation:

Value Creation Questionnaire: Based on Wenger's (2011) five cycles of value creation, this questionnaire was designed to measure the different layers of value participants perceived as being created through their interaction with the platform. The questionnaire items corresponded to the immediate, potential, applied, realized, and reframing value.

Intrinsic Motivation Inventory (IMI) - 29-item Version: This comprehensive tool assessed participants' levels of intrinsic motivation concerning their platform use. It includes five subscales: relatedness, interest/enjoyment, perceived choice, pressure/tension, and effort. The IMI helped us to understand the motivational dynamics influenced by gamified elements of the platform.

Each data collection method was chosen to complement the others, providing a rich, multi-faceted view of the educational impact of the "Answers" platform. Together, these methods enabled a robust analysis of both the measurable outcomes of gamification and the qualitative experiences of those engaged with the platform.

2.3 Research Design

This study employed a mixed-methods research design to evaluate the impact of gamification elements on value creation and student motivation within the Answers platform, a newly developed educational tool for computer science students at TU Delft. The primary objective was to assess how integrating gamification elements such as points, badges, and leaderboards influences students' engagement, learning practices, and intrinsic motivation.

Quantitative data were collected using two key instruments: the Value Creation Questionnaire (VCQ) and the Intrinsic Motivation Inventory (IMI). The VCQ, based on Wenger's (2011) five cycles of value creation, was designed to measure the different layers of value that participants perceived as being created through their interaction with the platform. The IMI assessed participants' levels of intrinsic motivation, focusing on five subscales: relatedness, interest/enjoyment, perceived choice, pressure/tension, and effort.

In addition to the quantitative measures, the VCQ included five open-ended questions to gather qualitative data on participants' experiences. These open-ended responses provided more profound insights into how students perceived the value created by the platform, allowing for a more comprehensive understanding of their experiences.

By combining quantitative and qualitative data, this mixed-methods approach enabled a robust analysis of gamification's impact on computer science students' educational experience. Quantitative data from the questionnaires were analyzed using statistical methods to identify significant trends and correlations. Concurrently, qualitative data from the open-ended questions were analyzed using thematic analysis to identify recurring themes and patterns in students' perceptions and experiences. This dual approach facilitated a holistic

understanding of how gamification influences educational outcomes, supporting the validation of results through multiple data sources and offering rich, contextual insights into the effectiveness of the gamification elements integrated into the Answers platform.

2.4 Description of the Intervention

The "Answers" platform is a novel educational technology tool developed specifically for the computer science department at TU Delft. Designed to enhance learning, networking, and engagement through gamification, "Answers" is an alternative to traditional Q&A forums by incorporating elements that motivate and engage students and instructors in a more interactive learning process.

2.4.1 Technical Features

The Answers platform uses Ruby on Rails with MySQL as the primary database. It is a modification of the open-source platform Qpixel by the Codidact organization (https://github.com/codidact/qpixel). User data is protected through end-to-end encryption and secure data storage practices. The platform complies with GDPR, ensuring that user privacy is maintained. User authentication is handled via the TU Delft single sign-on (SSO) mechanism. The source code is available at https://gitlab.ewi.tudelft.nl/eip/answers/qpixel.

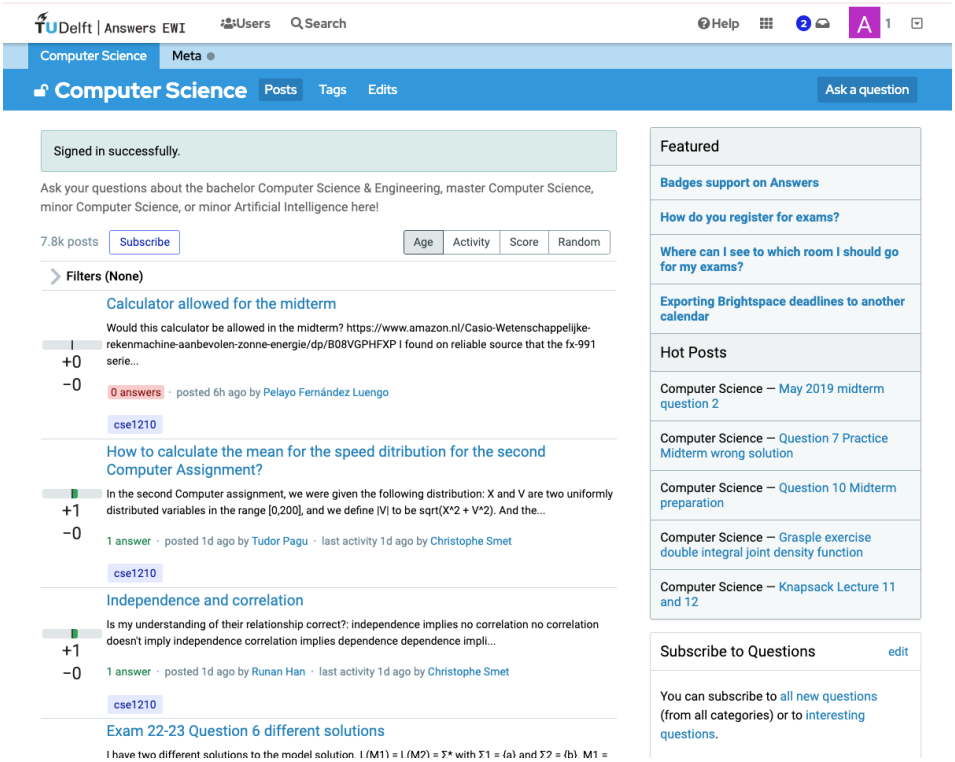


Figure 1: A Snapshot of Answers Platform

2.4.2 Design Principles

The platform features a user-friendly interface that allows participants to post questions, answer peers' inquiries, and engage in discussions. Each interaction on the platform is designed to foster a deeper understanding of computer science topics and to facilitate community building among students and faculty.

Key gamification features integrated into "Answers" include points, badges, and leaderboards. These elements were chosen based on their proven effectiveness in educational contexts (Deterding et al., 2011; Ibáñez et al., 2014). Points are awarded for participation activities, such as providing helpful answers and contributing to discussions. Badges are earned for reaching milestones and demonstrating proficiency in specific areas. The leaderboard showcases the most active and helpful participants, fostering a healthy competitive environment.

For the project's development, we started with an idea for a system where students could exchange information, building up a knowledge base for future years. We derived initial requirements for question and answer posting and searchability of previously answered questions. We looked for existing solutions and settled on

Codidact/Qpixel as a starting point for our application, which is available as open-source. From there, we made requirements for features that would improve the platform for use in education, involving various stakeholders like faculty and students to understand their needs and expectations. We had two Computer Science students work on implementing and integrating these features, following an Agile development methodology to ensure flexibility and responsiveness to user feedback. Finally, user testing sessions were conducted throughout development to identify and address usability issues. Both quantitative and qualitative data were collected to inform design decisions. Features that are generally useful are contributed back to Codidact.

After the initial deployment of the Answers platform, additional functionalities were added over time. Users were notified of new functionalities and instructed how they worked through the platform. Technical support was offered to address any emerging issues. Regular updates and feature enhancements were deployed based on user feedback. The platform's performance was continuously monitored through analytics, and feedback sessions were conducted with users to identify areas for improvement.

2.4.3 Engagement and Interaction Evaluation

We expanded the platform's analytics capabilities to evaluate user engagement and interaction patterns. We track various metrics, such as:

1. Number of Visits: Tracks the frequency students visit the platform. Higher visit frequency can indicate higher engagement.
2. Activity Frequency: Counts the number of activities performed by the users, such as posting questions, answering questions, and commenting. A higher frequency of activities can reflect active participation.
3. Achievement and Badges: Monitors the badges users earn and their progress towards achieving specific milestones. This data can reflect the effectiveness of gamification elements in motivating users.

The platform's design is based on the principles of Wenger's value creation framework, aiming to create immediate, potential, applied, and realized value for participants.

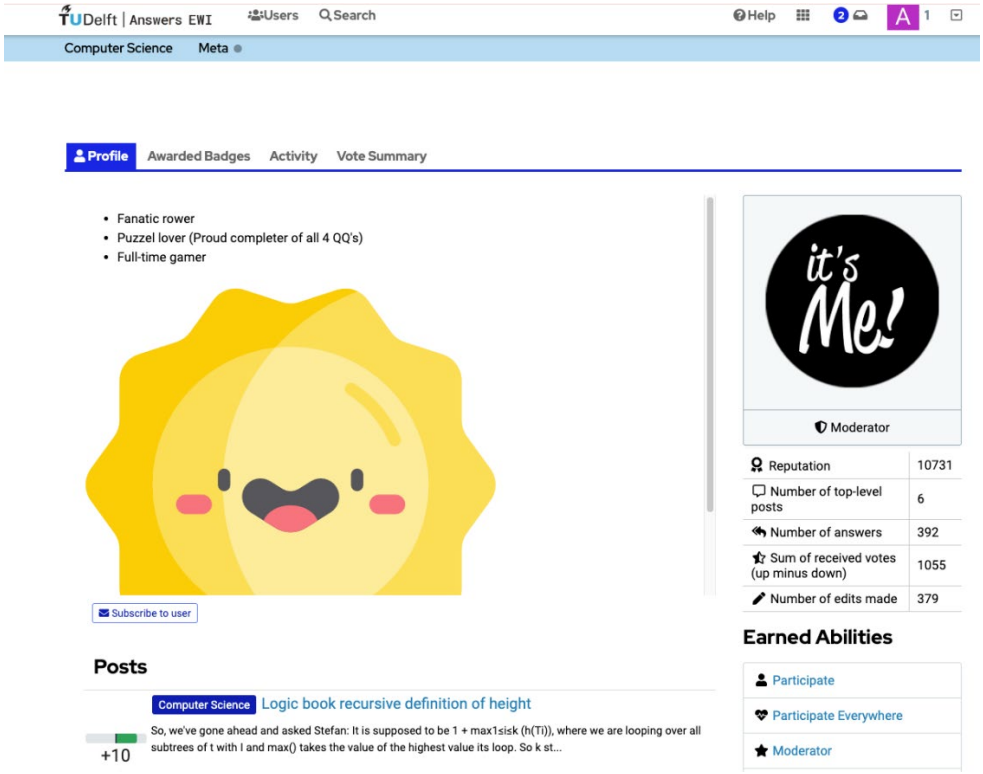


Figure 2: An example of Budges and Recognitions

This intervention was introduced at the beginning of the academic year. It was available to all computer science students and faculty, providing a real-time, dynamic environment for enhancing educational experiences through gamified learning.

2.5 Data Analysis

The analysis of the collected data from the "Answers" platform involved a comprehensive approach, utilizing both quantitative and qualitative techniques to ensure a thorough understanding of the effects of gamification on learning outcomes and motivation.

The qualitative data collected from the Value Creation Questionnaire were transcribed and analyzed using thematic analysis to identify recurring themes and patterns related to participants' perceptions of the gamification experience. Qualitative data analysis software (Atlas ti) facilitated the coding of the data, which helped organize the data into meaningful categories based on the value creation framework. This method allowed for the in-depth exploration of how the gamification elements influenced learners' motivation, perceived value from the platform, and overall learning experience.

A mixed-methods data integration technique was used to integrate the quantitative and qualitative findings. This approach involved comparing and contrasting results from both data sets to draw comprehensive conclusions about the study's hypotheses. By triangulating the data, we aimed to validate the findings across different methods, enhancing the reliability and validity of the results.

3. Results

3.1 Descriptive Analysis

3.1.1 Descriptive Analysis of Value Creation Questionnaire

Table 1: Descriptive results of VCQ

VCQ Components	Positive Value	Average	Std Dev
Immediate Value	38/60	3.7	1.36
Potential Value	9/60	2.08	1.18
Applied Value	53/60	4.51	1.17
Realized Value	24/60	2.88	1.30
Reframing Value	19/60	2.71	1.40

Table 1 provides a descriptive analysis of our Value Creation Questionnaire. This Questionnaire explores five cycles of value based on the value creation framework (Wenger et al., 2011). 38 Participants out of 60 indicated that the Answers platform created positive immediate value for them. In the open-ended question, they noted that, for example, Answers helped them Learn new materials and explore other students' questions. They described their experience as "Nice," "Useful," and "helpful." The other 22 participants who did not find the positive immediate value mentioned that they did not actively use the platform (7 out of 22) or did not find the platform helpful. For example, one of the participants mentioned:" I found the platform not to be so useful in general. Many of the questions were either very basic or debug/error related."

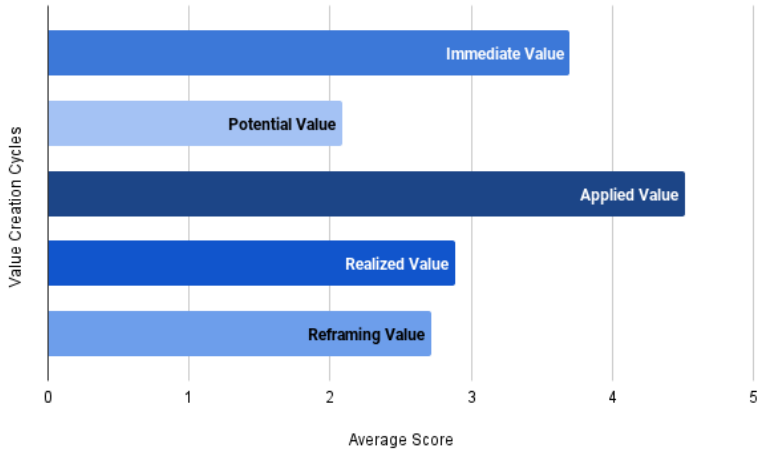


Figure 3: Average Score of Value Creation Cycles

The second part of VCQ explores relationships with peers and other students. Interestingly, only 9 out of 60 participants answered the second question (Participation affected my social connections (change in the number, quality, frequency, emotions, etc.)) positively, and the average score was 2.08. To elaborate on their experience, they mentioned, "I mainly use answers about the material rather than socializing per se."

The third part of this questionnaire explores the applied value that this platform can create for the participants. 53 participants out of 60 answered positively to the following question: “Participation helped my practices as a student (get new ideas, insights, materials, procedures, etc.),” and the average score was 4.51.

Our Fourth part investigates the influence of the Answers platform on participants' ability to influence the world as students (e.g., enhance my voice, contribution, status, recognition, etc.). 24 participants answered this question positively, and the average score was 2.88.

The last part investigates reframing value. Nineteen participants responded positively to this question: “Participation made me see my world differently (change in perspective, new understandings of the situation, redefine success, etc.),” and the average score was 2.71.

3.1.2 Descriptive Analysis of IMI

Table 2: Descriptive Analysis of IMI Subtests

IMI Subscale	Average	Std Dev
Relatedness	-0.30	0.59
Interest/Enjoyment	2.64	0.87
Perceived choice	0.82	0.78
Pressure/Tension	0.22	0.90
Effort	2.09	071

Table 2 illustrates the results of the descriptive analysis of the IMI questionnaire. The Relatedness subscale had scores clustering around the lower end, indicating that participants did not feel significantly connected to others through the platform. This suggests a need to improve social interaction features. Scores for Interest/Enjoyment were generally high, demonstrating that participants found the platform engaging and enjoyable. This aligns with the positive feedback on the platform's gamified elements.

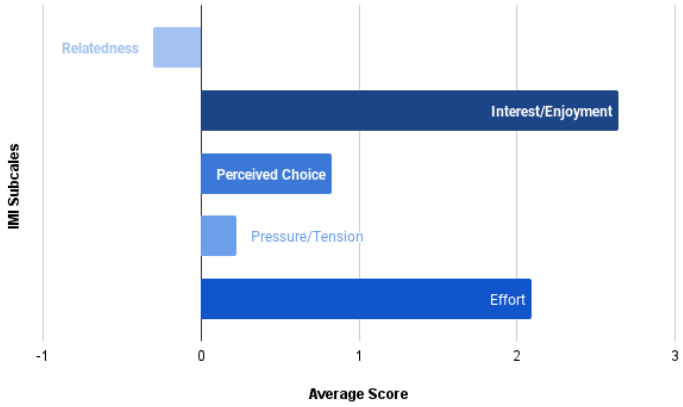


Figure 4: Average scores of IMI Subscales

3.1.3 Descriptive Analysis of Engagement and Interaction Analysis

The analytics module of the Answers platform provided detailed insights into user engagement and interaction. Key findings include:

Visit Frequency: The average number of weekly visits was 347, indicating regular engagement with the platform. As Figure 5 shows, participants constantly visit the Answers Platform, but we also see significant drops during holidays in weeks 8 and 14.

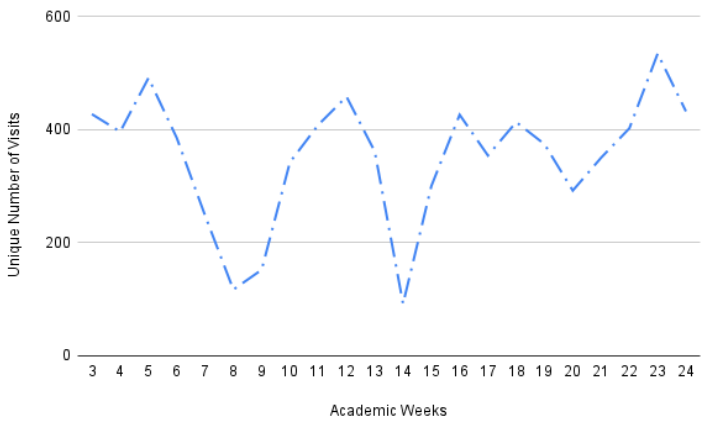


Figure 5: Visit Frequency

Activity Frequency: In total, our platform users raised 616 questions, answered 608 times, and left comments 395 times. Interaction Types: Most interactions were questions (38%), followed by direct answers (37%) and commenting (25%).

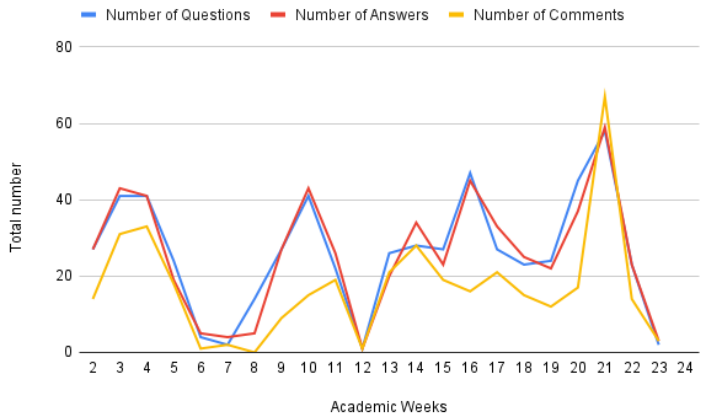


Figure 6: Activity Frequency of Answers Users

Badges Earned: Users earned a total of 428 badges during the study period, reflecting their achievements and milestones. The pattern shows the users' pick activity during exam periods.

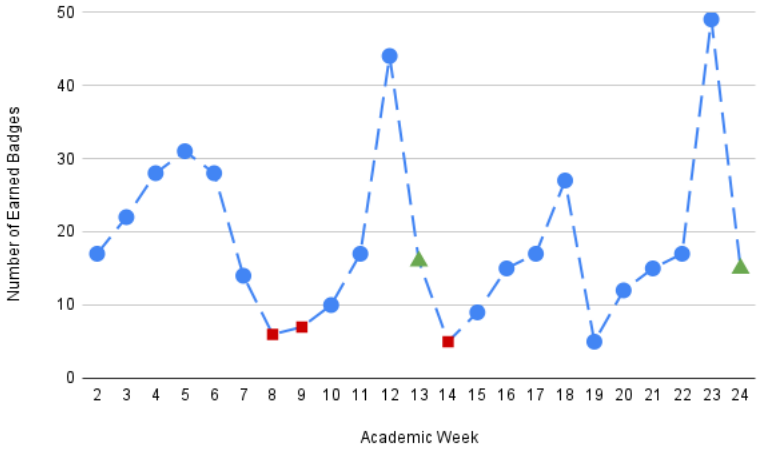


Figure 7: Total number of budges earned by Answers' users. Red squares indicate holiday weeks, and green triangles indicate exam weeks.

4. Discussion

This study aimed to investigate the impact of the Answers platform on student engagement and motivation using a combination of the Value Creation Questionnaire (VCQ) and the Intrinsic Motivation Inventory (IMI). The findings provide valuable insights into the efficacy of gamification in educational settings and its influence on various dimensions of the student learning experience.

4.1 Value Creation Framework Analysis

The VCQ results indicate a mixed but generally positive reception of the Answers platform among participants. Most students (38 out of 60) reported that the platform created positive potential value, with an average score of 3.18 out of 6. These students highlighted the platform's usefulness in learning new materials and exploring other students' questions, describing their experiences as "Nice," "Useful," and "helpful." This aligns with the first and second cycles of Wenger's value creation framework, where immediate and potential value is derived from the direct benefits and interactions within the platform.

However, 22 participants did not find immediate positive value, primarily due to their lack of active engagement (7 out of 22) or the perception that the platform's content needed to be sufficiently challenging and relevant. This suggests that while the platform has potential, its effectiveness is partly contingent on active participation and the quality of user contributions. Future iterations of the platform might benefit from strategies to enhance user engagement and ensure content relevance.

4.2 Social Connections

Interestingly, the platform's impact on social connections was less pronounced. Only 9 participants felt that their social interactions were positively affected, with an average score of 2.08. Many students indicated that they primarily used the platform for academics rather than socializing. This result suggests that while the platform is effective for academic support, it may not significantly enhance student social relationships. Enhancing features that promote social interaction and community building could be an area for future development.

4.3 Applied Value

The platform showed substantial success in creating applied value, with 53 participants affirming that it helped their practices as students, scoring an average of 4.51. This high level of applied value indicates that the platform effectively provides practical benefits, such as new ideas, insights, and materials, which students can integrate into their academic practices. This aligns with Wenger's notion of applied value, where the knowledge gained is utilized to improve practices.

4.4 Influence and Reframing

The platform's influence on students' ability to impact their world and perspectives was moderate. Twenty-four participants felt that their ability to influence their world as students improved (average score of 2.88), and 19 participants reported a change in their perspective (average score of 2.71). These findings suggest that while the platform does contribute to enhancing students' voices and altering their attitudes, there is still room for improvement in these areas. Encouraging more active and reflective participation could strengthen these aspects of value creation.

4.5 Intrinsic Motivation Inventory Analysis

The IMI results provide further insights into the motivational aspects influenced by the Answers platform. The relatedness subscale scored an opposing average of -0.30, indicating that the platform did not significantly enhance students' feelings of connectedness. Conversely, the interest/enjoyment subscale scored positively at 2.64, suggesting students enjoyed using the platform. Perceived choice scored moderately at 0.82, indicating some level of autonomy felt by students. Pressure/tension had a low positive score of 0.22, suggesting minimal stress associated with platform use, and effort scored 2.09, indicating that students were willing to invest effort into using the platform.

4.6 Engagement and Interaction

The descriptive analytics of engagement and interaction in the Answers platform highlight the platform's effectiveness in maintaining regular student involvement. The average number of weekly visits was 347, demonstrating consistent engagement with the platform throughout the academic term (Figure 5). This high visit frequency indicates that students frequently accessed the platform, likely finding it a valuable resource for their coursework. Additionally, the analysis of activity frequency showed that users actively participated by raising 616 questions, providing 608 answers, and leaving 395 comments (Figure 6). This distribution of interaction types, where questions constituted 38%, direct answers 37%, and comments 25%, highlights a balanced engagement across different forms of participation.

Moreover, users earned 428 badges during the study period, reflecting their achievements and milestones (Figure 7). The pattern of badge earning peaked during exam weeks, suggesting that gamification elements such as badges effectively motivated students to increase their activity during critical academic periods. These findings align with existing literature on the positive impact of gamification on student engagement and motivation (Deterding et al., 2011; Ibáñez et al., 2014), demonstrating that the Answers platform successfully fostered an interactive and supportive learning environment. Future iterations of the platform could explore additional features or incentives to enhance collaborative learning and student social engagement.

4.7 Implications and Future Directions

Overall, the Answers platform demonstrates the potential to enhance learning practices and provide enjoyable and valuable educational experiences. However, the mixed results regarding social connections and broader influences on student perspectives suggest that additional features to foster community engagement and more profound reflective practices could be beneficial. Future research could explore the impact of targeted interventions to increase active participation and platform content's relevance. Additionally, further studies could investigate the long-term effects of gamification on learning outcomes and motivation to build on the findings of this study.

By addressing these areas, the Answers platform could further its goal of creating a comprehensive and engaging learning environment that supports academic and social development for computer science students at TU Delft.

5. Conclusion

This study examined the impact of the Answers platform, a gamified learning tool, on computer science students at TU Delft. We explored the platform's influence on students' learning outcomes, motivation, and value creation through a mixed-methods approach. The findings indicate that while the platform successfully enhances learning practices and engagement, its impact on social connections and broader perspectives is less pronounced. The mixed results highlight the potential of gamified learning environments to improve educational experiences while pointing to areas for further enhancement. Future research should focus on strategies to increase active participation and foster a sense of community, ensuring the platform's content remains relevant and challenging. The Answers platform can further its mission of creating a dynamic and supportive learning ecosystem by addressing these aspects.

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Reaching Student Engagement by Balancing Gamification and Challenges in Minor Serious Gaming

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Abstract: This study originated from a Senior University Teaching Qualification on student engagement that withstanding many efforts on problem and challenge based education still is a concern. Within the minor Serious Gaming, third year students (n=35) where studied with mixed methods with the main question how to improve student engagement with challenges in serious gaming? First, a systematic literature study led to a new definition of student engagement: Student engagement is a multi-faceted concept that involves the interplay of various factors, including behavior, motivation, challenges, and autonomy. Then a pretest was done with last year's teaching team, a motivational survey and general evaluation survey was done and a focus group with group representatives was created. This led to two main interventions, a gamified business modelling workshop and direct feedback loops. From a gamification point of view, rewards are the best intervention but we could not implement them in this year's course. The value of this study is in understanding the complexity of student engagement. Improvement of engagement is possible with gamification, challenges and direct feedback. This study confirms that a high autonomy leads to a high engagement, future study has to be done with courses with low autonomy.

Keywords: Serious Gaming, Student Engagement, Gamification, Challenge-Based Learning, Higher Education

1. Introduction

Gamification is a new approach to learning that is not applied too often. Still, the underlying principles like feedback and rewards are long established teaching approaches (Yu, 2022). There is an international concern about student engagement among young adults (Petersen et al, 2021). Their results revealed a significantly higher user engagement with use of gamification. Hamari et al. (2016) conclude that engagement directly influences learning. Challenges in a game or gamification can positively influence the engagement. Aguilar-Cruz (2022) confirms this and also concludes that socio cultural aspects influence the learning. Yu et al (2020) also found gamification contributing to both student satisfaction and engagement, it can foster students engagement (Breiki & Yahaya, 2022). Engagement plays a key role in user's behavior and overall efficacy of goal or task-oriented behavior within computer-based environments (Psaltis et al, 2018). The main research *question* is:

How to improve student engagement with challenges in serious gaming?

2. Background

Table 1: Categories found in literature study

	Pedersen Et al, 2021	Dharwaman Et al, 2022	Khaldi Et al, 2023	Mohanaran And Srithiran 2022	Hamari Et al, 2016	Fitz Walter Et al, 2014	Psaltis et al, 2018	Yu Et al, 2020	Butler & Ahmed 2017	Rebelo Et al 2019	Zadeja And Bushati 2022	Hart Et al 2017
Challenges	X	X	X	X	X							
Behavior						X	X					
Motivation								X				
Gamification								X	X	X	X	
Autonomy				X								X

As educators navigate the complex landscape of education, they are confronted with multifaceted challenges that impact student motivation, behavior, and engagement. Through the strategic integration of gamification and the promotion of autonomy, educators can address these challenges by creating dynamic learning environments that inspire curiosity, foster collaboration, and empower students to become active participants in their education. In table 1 an overview is given of the systematic literature study.

2.1 Challenges

Challenges and gamification offer innovative approaches to enhance student engagement and motivation in the classroom, but they also present unique challenges for educators to navigate. The challenge is that engagement, also in the context of serious games, is a complex subject, as it encompasses various related concepts related to the user experience, including e.g. immersion, presence, flow, transportation, and absorption (Pedersen et al, 2021). The findings of Dharwaman et al (2022) indicate that an entrepreneurial simulation game, based on real challenges in a business environment, allows students to develop their self-efficacy, motivation, and engagement. Khaldi et al (2023) combine problem based learning elements with gamification and show that this is a powerful concept to increase learning. Mohanarajah and Sritharan (2022) show that programming is challenging in itself and that gamification is very helpful to create a flow. that the Computer Science students who played Shoot2Learn gained statistically significant improvements in learning conditional branching. Challenging components can be increased in an educational game since they can improve student engagement (Hamari et al., 2016)

2.2 Behavior

Behavior and student engagement are crucial components of a productive learning environment. Behavior refers to the actions and conduct of students, while engagement pertains to their involvement, interest, and active participation in the learning process. Fitz Walter et al (2012) study engagement on three levels, goals, sensing and game elements. Engagement is a multifaceted phenomenon with different dimensions, i.e., behavioral, cognitive, and affective (Psaltis et al, 2018). They conclude that the use of games with different degrees of challenge triggers different levels of engagement.

2.3 Motivation

Gamification offers a promising avenue for enhancing student motivation and engagement in the classroom. A student can be motivated by internal or external means. Intrinsic motivation is associated with learning something for personal pleasure or interest (e.g. playing games or creating games for fun), whereas extrinsic motivation is derived from external factors such as promised job opportunities and/or high salary scales (Ryan & Deci, 2000). Yu (et al, 2000) show that motivation is the most mentioned keyword within gamification and student engagement. In their literature study they conclude that most educational games could improve student motivation in game-based learning.

2.4 Gamification

Gamification has emerged as a powerful strategy for enhancing student engagement in the educational setting. Butler and Ahmed (2017) conclude that gamification is key in changing the learning experience for Computer Science students and will help them achieve their learning goals. Gamification is often depicted as a significant instrument to drive engagement, behavior change, and loyalty, which can be of great significance to online learning (Rebelo et al, 2019). This paper adopts one of the most popular definitions of gamification, which was proposed by Deterding, Khaled, et al. (2011, p. 1): gamification is the “use of game design elements in non-game contexts. Rebelo et al, 2019 mention the most commonly used gamification elements are:

Levels (73%);

Questions and challenges (67%);

Progress bars (67%).

On the contrary, the less used ones are leader boards (20%), badges (13%), and other tools (13%), including virtual currencies, virtual goods, and countdown clocks. Yu (et al, 2020) add feedback as a

gamification element. Gamification helps students gain motivation towards studying, and because of the positive feedback they get pushed forwards and become more stimulated to learn (Zadeja &Bushati 2022).

2.5 Autonomy (Self-efficacy)

Autonomy plays a crucial role in fostering student engagement by empowering learners to take ownership of their education and learning experiences. "Self-efficacy refers to an individual's belief in their own competence to carry out a specific task (Bandura, 1997). High self-efficacy increases the student's persistence at relevant tasks and helps them to be resilient and recover their motivation even after absolute failures. Research makes it clear that learning programming is challenging, and a learner needs high determination, dedication, and persistence. Students need to be intrinsically motivated to stay focused on learning. Self-efficacy plays a key role in keeping one's intrinsic motivation" (Mohanarajah & Sritharan, 2022). Hart et al (2017) show that situational relevance and authenticity are very important when using gamification to lever engagement.

2.6 Student Engagement

Student engagement is handled in all papers found in the systematic literature study. Therefore, we have not placed it in table 1 but see it a s an overall concept of the study. In all 12 papers found, the concept is not clearly defined. From this study we define it as: *Student engagement is a multi-faceted concept that involves the interplay of various factors, including behavior, motivation, challenges, and autonomy.* There has to be a balance between all these elements.

3. Method

This study followed a mixed method approach in which both qualitative and quantitative data were used to establish the effect of the interventions. For the literature study Wolfswinkel (et al, 2015) is used with the following search string: (serious gam*) AND (student engagement) AND (skills and challenges).

The empirical study was done from September 2023 until November 2023 for a period of 10 weeks. During the minor, the attendance on Tuesday morning 8.45 will be measured every week.

Before this period a short survey is send to last year's study to confirm the study gaps observed by the researcher. Two expert interviews were done with colleague that is also half responsible for the minor and a student assistant of 2022. They observed exactly the same gaps as the researcher observed.

During the period an intervention is done in week three, six and nine all students (n=35) are questioned on motivation of the task then at hand with the situational motivation scale (Guay et al, 2000). The questionnaire is derived from Deci and Ryan (2000). The Intrinsic Motivation is measured opposed to the Amotivation where the students have no sense of autonomy or control. The Identified Regulation (student control) is measured opposed to External Regulation (teacher guidance).

4. Results

In total 35 students enrolled in the Minor of the Business Information Technology that is accessible for every faculty and participated in this study. These students were divided over 7 project groups from 7 different programs. This course has many challenges for the student groups starting with a redesign of an existing serious game in the first three weeks. They have to apply new literature directly in creating a new operational version of an existing game. The main challenge starts in the fourth week when they start from scratch with the UN sustainability goals and create a new serious game within seven weeks. During the ten weeks many small interventions were done. The first intervention was directed at this study itself with the question how they would be motivated more? From the answers we decided to have a second intervention with a gamified workshop on business modeling, a subject they did not master yet.

Each week a headcount was done at the same moment on Tuesday morning 8.45 when a lecture was announced and performed (table 2). As expected from the peer preview the headcounts show a dip in week 3 and week 6 (shown in red). In week 4 we did an intervention with a gamified workshop which was a success (both in headcount and in evaluation. In week 7 we did not do an intervention but decided to start 45 minutes later with presentation without announcing it. We counted 16 students arriving "late"

and 12 students were on time (shown in red). In week 9 we did not do an intervention because the students needed time to finish their prototypes for the last test explaining the last low attendance in red.

Table 2: Headcount per week (n=35)

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
26	21	14	31	32	13	12	19	14	27
8.45AM	8.45AM	1st motivational survey	Intervention presentation	Thursday	2nd survey plus focus	8.45AM 28 at 9.20AM	25 at 9.20	Working session	Final presentation

The first survey was done in the third week with 20 students replying (n=20) and shown in table 3. The intrinsic motivation was higher (5.29 on a scale of 7) than anticipated from the headcounts and the peer reviews beforehand. The identified regulation was a bit lower than expected (4,94 on a scale of 7) but still positive. The external regulation was found quite high (4,07 out of 7) and the Amotivation was low (2,41 on a scale of 7). The Self-determination Index (SDI)(= 2 x IM + 1 x IR – 1 x ER – 2 x A) for the first survey was 6.63.

Table 3: First Survey in third week (n=20)

Intrinsic Motivation (IR)	5,29
Identified Regulation (ID)	4,94
External Regulation (ER)	4,07
Amotivation	2,41

In week six the survey was repeated while the students were busy with their second assignment (n=27). In general there is a negative tendency although the absolute figures are still quite high (table 4). The intrinsic Motivation (IR) dropped .64 to 4,65 out of 7. The Identified Regulation had a very minor drop (.14) but when question 6 is studied it shows an increase of "students that think the assignment is good for them" (.47). The External Regulation rises .38 but question 11 shows a big rise (1.03) which means that the have a higher feeling of obligation although nothing in the course is obliged except for the exam and the presentations. Finally Amotivation rose a little bit (. 31). The Self – Determination Index (SDI) = 4.22 (2.41 lower than the first survey)

Table 4: Second survey in sixth week (n=27)

Intrinsic Motivation (IR)	4,65
Identified Regulation (ID)	4,80
External Regulation (ER)	4,45
Amotivation	2,72

In week 6 we did two other interventions. First, we let student groups present gamification solutions to raise their own motivation. Secondly, we created a focus group of seven representatives from each group and organized an informal lunch evaluation.

Nearly all groups mentioned rewards as a possible gamification solution. The rewards came in many different way. Free, good coffee came second and cookies third. Fourth suggestion came from two groups to do quizzes to prepare for final trivial pursuit exam and combine that with rewards as extra time and bonus points.

The evaluation was rather positive and the main negative point was lack of structure but that was balanced out by the main positive point, the amount of freedom (autonomy). One group representative called the course "nearly perfect". Communication can still be improved and also the relationship between theory and practice can be improved.

The overall result of the official evaluation was very high with an average of 8.0 for the course (last year this was 7.5). The struggle between student autonomy (many students like the freedom that comes with the course) and teacher guidance (some students ask for more structure) becomes clear in this evaluation.

5. Analysis

The main challenge that we gave the students was to bring an idea for a game that arose from the group to a full implementation of a serious game. Dharwaman (2022) showed that this concept can deliver student autonomy, motivation and engagement but our measurements show more nuanced results. Although in general positive, the Extrinsic Regulation seems to lower the sense of autonomy. This means that balancing these factors becomes very important. Ideally, the students would create their own challenges.

Mohanarajah & Sritharan (2022) emphasize the importance of self-efficacy for the students within the course. Within the minor Serious Gaming that was studied we saw a high sense of autonomy but although we anticipated that the amount of freedom would rise in the second assignment because they could make their choices themselves it actually went down as mentioned in the first paragraph. Next to gamification we think that giving the students a role in designing the study and really listen to them helped in the first stage to get the sense of autonomy on such a high level.

Feedback, according to Zadeja & Bushati (2022), is a powerful (gamification) tool to engage students. Our last interventions were personal feedback loops with the groups and were received very positively. We took the students out of their normal accommodation and therefore literally out of their comfort zone to give very specific feedback on their serious game so far. It can explain the raise of External Regulation in the final survey as this feedback was announced in week 6, the week the survey was done. We confirm the work of Yu (2022) that feedback is an important part of gamification and of education in general and levers student engagement. It is strange that the intrinsic motivation drops a little bit in the second survey. Our explanation is that it is very high in the first survey, so absolutely it stays high and we had the expectation that without intervention it would drop much more.

Within the 2023 run of the course serious gaming we were not able to implement all gamification possibilities that were found. The gamified workshop we implemented proved to be a stimulus for attendance and from the general evaluation we derive a positive mention of several students. Although the feedback we gave is not necessarily a gamification instrument, the use of it was very positive toward student engagement. We feel it is the combination of gamification with other educational interventions that is the real challenge to this study.

6. Conclusions

Challenges are the most important engagement element considering gamification and serious games. Challenge Based Learning in combination with gamification can be very powerful to increase learning.

By actively listening to students and involving them in decision-making processes, educators can foster a sense of ownership and empowerment among students, ultimately leading to a more inclusive, supportive, and student-centered learning environment. Specifically in this course the lectures could start later, rewards in exam time could be given and rewards in grades can be applied.

Providing direct feedback is a powerful way to enhance student engagement in the learning process. When students receive immediate and specific feedback on their work, they gain valuable insights into their progress and performance, leading to a deeper sense of connection to their learning. Although the intrinsic motivation slightly drops in the second survey, we think that it still is on a higher level than expected.

Gamified workshops offer a dynamic and engaging learning experience that inspires curiosity, fosters collaboration, and empowers participants to apply new knowledge and skills in meaningful ways.

Previous conclusions on their own provide answers for the main question but we would like to address the question how to improve student engagement with challenges in serious gaming also as a whole. Improving student engagement with challenges in serious gaming involves finding a delicate balance between various elements: challenges, gamification, intrinsic and extrinsic motivation, as well as student

autonomy and teacher guidance and support. In the reflection and recommendations we elaborate on this.

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The Expert, The Novice, and The Skeptic: Game Literacy and Pedagogical Practice

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Abstract: This qualitative case study explores how teachers' video game literacy impacts their pedagogical use of the digital game *The Walking Dead* in an ethics education course at a Norwegian high school. The research question addressed is: how is teachers' pedagogical use of a digital game impacted by their levels of video game literacy? The study followed seven teachers, varying in teaching and gaming experience, over two semesters. Observations and semi-structured interviews were conducted to gather data on the teachers' experience and pedagogical practice using *The Walking Dead* in their classes. Three teachers were selected for deeper analysis based them showing differences in attitudes and practices, while having similar teaching experience. These teachers were labeled "the expert," "the novice," and "the skeptic" based on their gaming literacy and attitudes. The analysis was based on a two-dimensional approach to video game literacy, emphasizing operational and cultural literacy. The results show that operational literacy impacted how teachers perceived and used various game elements, especially how they identified and framed the game's dilemmas. The expert and novice saw the game's narrative as an important contextual resource for engaging with the dilemmas, while the skeptic saw it as merely a backdrop. The skeptic also had difficulties distinguishing between relevant and less relevant aspects of the game relative to the learning goal. Cultural literacy mainly impacted the teachers' ability to differentiate between students' perceptions and experiences of the game and different modes of playing. The expert had a more nuanced approach to how students perceived the game's motivational power, emphasizing the story's importance. The novice and expert explicitly instructed students to distinguish between playing for fun and playing to learn, while the skeptic made less of a distinction and saw playing the game more as a standalone learning activity. The findings suggest that teachers' video game literacy can significantly influence pedagogical use of digital games. Higher levels of operational and cultural literacy enable teachers to better navigate the game's elements, guide students' engagement, and facilitate connections between gameplay and learning objectives.

Keywords: Teachers, Video Game Literacy, Ethics, Game-based Teaching, The Walking Dead

1. Teachers, Gaming Literacy and Pedagogical Practice

Teachers have long been known to be important for games to become useful in the classroom (Molin, 2017). However, using digital games as educational tools has been shown to be a quite complex and difficult feat, and there are several factors which hinder teachers from incorporating games in their teaching. They include technical challenges related to hardware and software, pedagogical challenges related to connecting the game with educational content, institutional challenges such as lack of support from school administration, structural challenges like not having the time to prepare for or conduct game-based classes, and personal challenges like not having sufficient gaming experience, interest or literacy (Molin, 2017; Hayak and Avidov-Ungar, 2020).

Facilitating good use of educational games requires teachers to master a range of different roles and tasks. Berg Marklund and Taylor (2015) note the broad range of different tasks needed to be undertaken if games are to be successfully used in the classroom, such as designing the game based curriculum, preparing the necessary hardware and software and associated infrastructure, and administrative tasks during and in-between classes. They also list a number of different roles the teacher needs to take on: *gaming tutor*, instructing the students on how to play the game; *authority and enforcer of educational modes of play*, ensuring that students play the game with a subject-oriented mindset; and *subject matter anchor*, bridging the gap between the game and the subject matter it is intended to help students learn (Berg Marklund and Taylor, 2015, pp. 363–365). These roles partially overlap with the roles identified by Hanghøj and Brund (2011, p. 127), which include *playmaker* (explain the game, its goals and dynamics to the student), *guide* (help students link their gameplay with learning objectives), *instructor* (explaining how the learning goals relate to the game), and *evaluator* (understanding, exploring, and giving feedback based on players' experiences seen from an outside perspective).

However, the degree of video game literacy required by these tasks and roles remains unclear. Gaming literacy does not automatically result in confidence in teaching with games, but lack of gaming literacy does not

necessarily hinder teachers in using games (Bourgonjon and Hanghøj, 2011). Wargner and Wernbacher argue that "teachers who want to use digital games in the classroom do not need to be gamers" (2013, p. 2), stating that the main role of the teacher is to oversee the learning process offered by the game, making sure all students stay on track. However, this claim conflicts with the observations by Hanghøj and Brund (2011), who found that game literacy was critical for identifying disruptive game play and to scaffold the students' gaming experience in a curricular manner. In a later publication, Hanghøj argues that it is "crucial that teachers have developed *game literacy* based upon their experience with and understanding of different game designs" (2013, p. 6).

Further complicating the matter is the observation that different teachers can approach the same game in different ways. This can range from using them as a reward for students' work, merely showing video clips from the game, sitting and watching students play without much intervention, to facilitating deep connections between learning goals, game elements, and learning activities (Hanghøj and Brund, 2011; Berg Marklund and Taylor, 2015, 2016; Bacalja and Clark, 2021). Moreover, teachers' approach and perceptions can vary depending on professional experience (Hayak and Avidov-Ungar, 2020) or general attitude towards games related to their pedagogical beliefs (Prestridge, 2017).

Despite the crucial roles of teachers for successfully implementing digital games in education, teachers are still under-researched (Molin, 2017; Hayak and Avidov-Ungar, 2020). Studies have yet to explore the differences in how teachers use games in a thorough manner. Why do teachers approach games differently? Why do they struggle with using them in an educational manner? What is the relationship between teachers' gaming literacy, attitudes, and their pedagogical practices?

This study's approach to video game literacy is adapted from Bourgonjon (2014) and Hanghøj and Møller (2017). The study focuses on two aspects of video game literacy: *operational literacy* – being able to play the game, and having the necessary frame of reference required for interpreting what happens in the game, and *cultural literacy* –seeing the game in light of different cultural contexts and being aware of games as a diverse cultural medium, and making distinctions such as how a game is designed vs. how it is played or seeing the game as simulation vs. representation.

This goal of this paper is to provide an answer to these questions by reporting on the findings from a qualitative mixed-methods case study exploring how teachers at a Norwegian high school use *The Walking Dead* (Telltale Games 2012, 2016) in a course on ethics, aimed at helping students learn to use ethical theories. The research question this paper seeks to answer is: how is teachers' pedagogical use of a digital game affected by their levels of video game literacy?

The Walking Dead is an interactive narrative videogame not developed for educational use, but which nevertheless has a strong focus in ethics and moral decision-making. This makes it well suited for adaptation in the ethics education classroom. The paper investigates the use of a lesson plan created by two teachers at the school in 2012 (one of whom is the author of this paper) and has been in use ever since. The lesson plan focuses on the dilemmas found interspersed throughout the game's story. The class plays the game together in a classroom or auditorium, with students taking turns playing the game. The teachers pause at regular intervals to engage students in discussions of the game's dilemmas, using the ethical theories from the curriculum, including relational ethics, virtue ethics, ethics of duty (deontology) and consequential ethics (utilitarianism). The overall goal for the lesson is for students to appropriate these ethical theories as a basis for their own moral reasoning.

2. Method

This study follows a qualitative case study approach. Observations, class recordings, and semi-structured interviews were conducted with seven teachers over two semesters, all of whom varied in teaching and gaming experience. The teachers used *The Walking Dead* as an interactive thought experiment, where the game's dilemmas facilitated discussions based on ethical theories. All teachers received advice and instruction on using the game from more experienced colleagues at the school. The classes played a single copy of the game in the school auditorium or a classroom (see figure 1), with some students taking turns playing. The teachers instructed the game to be paused at critical points, engaging the class in group or whole-class discussions, after which students voted on the course of action.

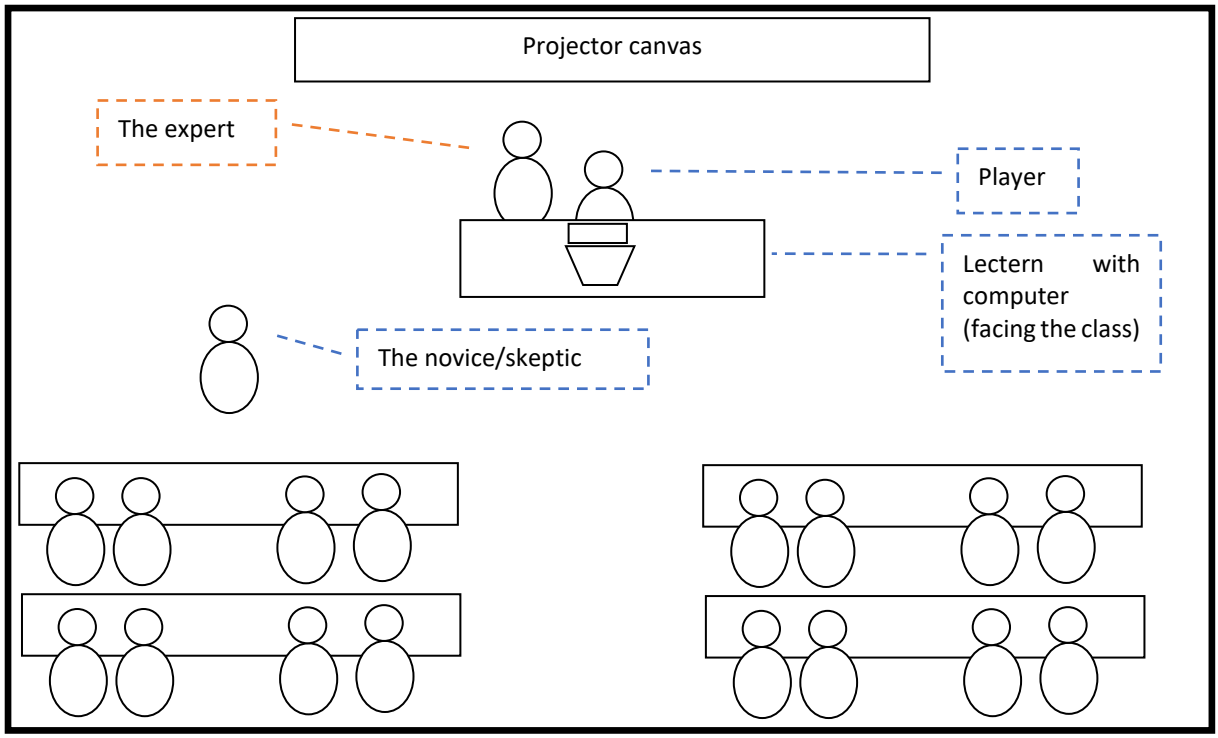


Figure 1: The classroom setup. Students took turns playing. The skeptic and novice positioned themselves to the side. The expert stood next to the player, providing guidance and support.

The data was collected during the spring and autumn semesters of 2019. Classes were observed and recorded for transcription, along with field notes written during observation. These notes sought to identify episodes for further exploration in the subsequent retrospective, semi-structured interviews. The interviews sought to investigate teachers' experiences of and perspectives on teaching with games in general, and *The Walking Dead* specifically. The interview guide contained both general questions pertaining to the teachers' gaming experiences both in and outside the classroom, and questions unique for each teacher, referring to specific episodes during the observed classes. These questions sought insight into how teachers experienced and reflected on these episodes, which could concern how they positioned themselves relative to the game and their students, where they stopped to engage in discussions, their motivations for doing so, and what episodes they themselves found positive or negative. In other words, the transcribed data from the classes focused on what the teachers were doing, while the interviews sought to uncover the underlying rationale for their practices and their subjective experiences.

The initial phase of analysis involved open coding of the transcribed data to identify preliminary themes related to teachers' practices and experiences. These themes were then refined and informed by relevant theories on video game literacy, creating a framework for thematic analysis. This framework was used to conduct a more focused and detailed analysis, operationalizing video game literacy concepts through interaction with the empirical material. Specifically, the framework distinguished between *operational* and *cultural* literacy (Bourgonjon, 2014; Hanghøj and Møller, 2017), with the former concerning how teachers approached the game as a pedagogical tool, and the latter pertaining to teachers' perceptions of their own and students' gaming experiences and dispositions.

3. Results

This section presents the impact of video game literacy on attitude pedagogical practice related to *The Walking Dead*. First follows a short presentation of the three teachers. Then follows an account of how operational and cultural literacy was found to impact the teachers' pedagogical practice with *The Walking Dead*.

3.1 The Expert, The Novice, and The Skeptic – a Presentation of the Teachers.

The three teachers studied for this paper have been given the aliases "the expert, "the novice" and "the skeptic". These labels have been created both for convenience's sake, as anonymity and research ethical concerns

demand identifiers such as gender be removed, and as descriptive categories summarizing the teachers' gaming experience and attitudes. They have each been teaching for eight years or more and have been using *The Walking Dead* for at least two.

"The expert" is a self-professed gamer and has used games several times across all their subjects and has been playing games since early childhood into their adult life. They report being very comfortable with games both in and out of classes and describe the use of games in their educational practice as something completely natural to them, treating games as just any other pedagogical tool in their repertoire.

The two other teachers, **"**the novice**"** and **"**the skeptic**",** have little experience or familiarity with games. The novice has used games in one other of their subjects, while the skeptic has only ever used *The Walking Dead*. While they both lack gaming experience and literacy, they display quite different attitudes both toward games in general, and the use of games in their classes.

The novice does not play digital games outside their professional life, and their attitude is best described as unenthusiastic rather than dismissive. They explicitly state that they would not have enjoyed playing *The Walking Dead* in their spare time, saying that they lack the patience for such games. However, they express much enthusiasm for the game used as an educational tool, saying that they found much joy, as well as utility, in it right from the start. While being unfamiliar with the game, the novice is familiar with the game's fictional setting, as they have enjoyed watching *The Walking Dead* TV-series.

The skeptic shares the novice's disinterest in recreational play of digital games and is even a bit dismissive of the concept. While having partly embraced the use of digital games in education, they repeatedly use the phrase "I'm still not convinced" regarding the pedagogical utility of games, and do not see the game as any more useful than other pedagogical tools.

It should be noted that all three teachers shared the same sentiment regarding the game's pedagogical utility on a general level. They all saw it as a useful way to vary their teaching methods, engage students, and provide dilemmas for discussion that were suitably removed from reality and everyday life that they did not risk offending students or making them feel uncomfortable. However, as the following sections will show, they displayed interesting differences when it came to using *The Walking Dead* in practice.

3.2 Impact of Teachers' Operational Literacy

Operational literacy was found to impact how the teachers perceived the game and its various elements, and consequently also affected how they used the game in their classroom. This largely concerned how teachers navigated challenging parts of the game not related to ethics, what parts of the game they thought of as most important for teaching and learning, and how they called (or did not call) attention to these aspects during class.

3.2.1 Gameplay Interventions

The three teachers differed in how they intervened during the gameplay sequences bookending the dilemmas, which often involve pressing buttons quickly in the correct order to defeat a zombie or navigating an enclosed space in search of an important item. The expert constantly stood by the side of the student currently playing the game, instructing them on where to go, what to do, and what buttons to press, assuming the role of "gaming tutor" or "guide" (Hanghøj and Brund, 2011; Berg Marklund and Taylor, 2015). The reason for this, the expert explained, is that they did not want "gameplay to steal attention from the story" and wanted to have as few interruptions or distractions as possible. In this statement, the expert demonstrates an understanding of "narrative" and "ludic" immersion (Bell et al., 2018) as different modes of play which can come into conflict with each other. The expert, in other words, is aware that there can be several, mutually exclusive ways of experiencing the game, and only some of which will be conducive to learning.

The novice also helped students navigate difficult parts of the game, but unlike the expert, did not position themselves right next to the student playing the game. They were also less consistent and explicit in their guidance. The skeptic, on the other hand, did not enter the role of guide or gaming tutor at all. However, both teachers explained that they saw students as a very valuable resource in their classes, often asking experienced students to handle playing the game.

3.2.2 Game Narrative

The teachers also displayed interesting differences when it came to how they saw the interactive narrative aspect of the game. The expert refrained from intervening for the first 30 minutes of gameplay, skipping two major dilemmas, as they wanted the students to become immersed in the story. This was to "make them better equipped to make informed decisions", the expert explained. In other words, the expert saw the story as an important contextual resource for engaging with the dilemmas. The novice shared this mindset, explaining that the game's story let them experience making difficult decisions as another person.

However, the skeptic did not consider the game an interactive narrative at all. When asked about that role the story unfolding between the game's protagonist and the other characters, the skeptic was somewhat taken aback, answering that "it would probably have played a bigger role if I had given it any thought". Thus, instead of seeing the game as a story where the player acts vicariously through the protagonist, the skeptic saw the game's dilemmas not as situated in the game's story but as representations of more general dilemmas "that we all encounter as some point in our lives". The skeptic contended that their lack of experience or interest in games made them not pay much attention to the game' story, seeing it more as a backdrop rather than an important context for the dilemmas.

3.2.3 Dilemmas

The final way the teachers were affected by their operational literacy was how they distinguished between elements of the game relevant to the overall learning goal, and how they frame these elements in their class. Operational literacy involves not only the ability to play games but being able to recognize the various elements constituting a game. In the unit studied for this paper, the dilemmas of the game play a very important role in this regard. Analysis revealed that while all three teachers talk about the dilemmas being important, the skeptic's perspective stood out from the other two teachers. In the interviews, the skeptic often complained that they felt the dilemmas were very similar. No other teacher, including the four not studied in depth in this paper, shared this sentiment. The skeptic also expressed frustration, noting how they "can't find examples of virtue ethics", and how it was mostly the same two ethical theories – consequentialism and deontology – that were repeated. Furthermore, during one of the interviews, when asked what pedagogical tool they would compare *The Walking Dead* to, the skeptic answered that it was akin to a PowerPoint presentation with assignments and tasks for the students to solve.



Figure 2: An example of an in-game dilemma. The protagonist, Lee Everett, former teacher and convicted felon, is questioned about his troublesome past, and must decide whether to lie or be honest.

This indicates that the skeptic had difficulties with distinguishing between the relevant and less relevant aspects of the game relative to the learning goal. While they did stop at certain proper dilemmas, the skeptic also paused the game during points other teachers did not stop, and which were not signaled as being important decision points by the game's design. These were points where a character (the protagonist or another person) had done something which could be considered morally questionable, like uncuffing themselves from handcuffs, entering strangers' homes or killing people who had turned into zombies. But these points were all part of actions required for the player to progress though the game, not interactive dilemmas. The skeptic also stopped after an act had already been committed, engaging the students in discussions over if this was right to do or not. Only on occasion did the skeptic stop the game before the player had taken an action. This resulted in the class mostly deliberating actions that had already been done, rather than discussing what to do next, and why. Finally, the skeptic framed the dilemmas and ensuing discussions in a manner which became more concerned with finding suitable theories for determining whether an act was good or bad, rather than exploring different alternatives

with teach of the four theories. For example, the skeptic asked students questions like “do you agree that this is consequential ethics?”. All this indicates that the skeptic, lacking operational literacy, had difficulties perceiving the interactive nature of *The Walking Dead,* and the dilemmas as important decision points facilitating player agency in the game’s story. Consequently, they perceived the dilemmas not as *dynamic, situated choices*, but rather as *tasks to be solved*.

3.3 Impact of Teachers’ Cultural Literacy

Cultural literacy mainly impacted the teachers’ ability to differentiate between how the game might be perceived and experienced by the students, and how teachers differentiated between different modes of playing the game.

3.3.1 Perceptions of Student’s Motivation and Engagement

Both the novice and the skeptic underline the game’s ability to motivate and engage their students. The skeptic believes that it especially appeals to students who regularly play games, and that this is a way to show them that the school thinks their cultural practices seriously, “meeting them where they are”, as the skeptic put it. The expert, however, did not reason about the games motivational power in this way. They had a more nuanced approach to how students perceived the game, arguing that students that played more competitively oriented games would likely find the game boring. They thus did not trust the game to be motivating or engaging for all students, nor that it would have such an effect simply by “being a game”. Rather, as noted in the previous section on game narrative, the expert felt that the game “presenting students with a good story” was the key component for engaging students. The expert emphasized this, as described earlier, by giving students ample time to immerse themselves in the story, and by ensuring that distractions form the game’s more challenging aspects were kept to a minimum.

3.3.2 Modes of Engagement – Playing vs. Learning

Before playing the game, both the novice and the expert made it clear to the students that they were not "gaming" or playing to have fun, but that they were going to use the game's dilemmas as a way of practicing using the ethical theories. In doing so, they both clearly instructed their students to distinguish between playing the game for fun and playing to learn. However, the novice was at one point during their class somewhat surprised by a group of students who were wanting to do the correct thing because they would lose the game otherwise. These students had succumbed to what Frank (2012) refers to as "gamer mode", where the learning goals are discarded in favor of reaching a more game-oriented outcome. This surprised the novice, and they expressed some frustration in the interview over not being aware of this way of thinking about the game.

The skeptic made less of an explicit distinction between different modes of engaging with the game. They noted that "stopping every other minute" caused frustration among some students. Another intervention which students found objectionable was when the skeptic paused the game after the protagonist had shot and killed a zombie who was a living human just a few moments ago. This happened during a quite intense actions sequence and was not framed as a moral decision by the game developers. However, the skeptic paused the game and asked the students if this was ok, but was met with an overwhelming "it's just a zombie!" from several students. Without the cultural frame of reference in which "zombies are ok to kill", as the novice remarked to their students, it became challenging for the skeptic to negotiate the moral status of zombies vs. humans. In the interview, the skeptic simply noted the students "just did not go along with it".

The skeptic also made less a distinction between playing for fun and playing to learn in remarking that the students were likely to reflect on the choices in the game without teacher intervention. This indicated that the skeptic saw playing the game as a standalone learning activity, instead of a way of facilitating learning though dialogue and discussion. They mentioned conducting most class discussions before and after the game was played, in contrast to the two other teachers. The skeptic believed that the students would likely have learned more if they played the game in pairs, as they would not have to deal with them interrupting the students' gameplay and discuss the game at their own leisure.

4. Discussion and Conclusion

This study highlights the significant role that teachers' video game literacy plays in shaping their pedagogical use of digital games in the classroom. By examining the experiences and practices of three teachers with varying

levels of gaming experience and attitudes, the study reveals how operational and cultural literacy impact the way teachers navigate game elements, guide students' engagement, and facilitate connections between gameplay and learning objectives.

The findings demonstrate that gaming literacy plays a crucial role for teachers' ability to fulfill important roles related to teaching with games (Berg Marklund and Taylor, 2015; Hanghøj and Møller, 2017). Higher levels of operational literacy are necessary for guiding students through challenging aspects of the game and ensuring that the focus remains on the narrative and learning goals. The expert's and novice's emphasis on the game's narrative as a contextual resource for engaging with dilemmas underscores the importance of situated learning and context in game-based education. In contrast, the skeptic's view of the narrative as merely a backdrop and their difficulty in distinguishing between relevant and less relevant game elements highlight the importance of operational literacy in effectively using games for teaching.

Cultural literacy also emerges as a crucial factor in shaping teachers' pedagogical practices. The expert's nuanced approach to students' motivation and engagement, compared to the novice and skeptic, suggests that cultural literacy plays a vital role in understanding students' gaming experiences and dispositions. Furthermore, the novice's and expert's explicit instruction to students to distinguish between playing for fun and playing to learn, in contrast to the skeptic's less distinct approach, emphasizes the need for teachers to guide students' engagement and prevent "gamer mode" from interfering with learning objectives.

This study demonstrates that teachers' video game literacy significantly influences their pedagogical use of digital games in the classroom. Operational literacy is crucial for navigating game elements, identifying relevant aspects for learning, and framing dilemmas effectively, while cultural literacy is essential for understanding students' experiences and guiding their engagement.

The findings have important implications for educational practice, suggesting that enhancing teachers' video game literacy should be a priority for the successful integration of games in education. Teacher education and professional development programs should address both operational and cultural aspects of game literacy to better prepare teachers for using games as educational tools.

However, the study's limitations, such as the small sample size and focus on a single game, should be acknowledged. It should also be pointed out that other aspects of teachers' knowledge, as well as other forms of media literacy, like the novice's familiarity with the The Walking Dead TV-series, and with the zombie trope in general, might also have impacted their pedagogical practice. Future research should explore the impact of video game literacy across different educational contexts and game genres to gain a more comprehensive understanding of its role in game-based learning.

In conclusion, this study underscores the importance of considering teachers' experiences and perspectives when exploring the educational use of digital games. By recognizing the diversity of teachers' gaming backgrounds and attitudes, and by promoting the development of their video game literacy, we can better support the effective integration of games in teaching and learning.

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Training for Board Game-based Learning: Evaluation Model and Preliminary Results From a National Program in Italy

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Abstract: Board Game-Based Learning (bGBL) is a dynamic pedagogical approach that leverages the immersive power and distinctive features of board games to promote active and meaningful learning. However, the use of board games in formal learning environments (such as schools, universities, etc.) is limited, and its use in informal learning contexts (such as cultural associations, after-school, fairs, summer camps, etc.) is often reduced to solely entertainment or engagement functions. The reasons include lack of competencies by teachers and educators and of pedagogical and instructional frameworks in scientific literature. In Italy, a joint effort by the National Sport association (CSI) and the Game Science Research Center has given birth to the first bGBL training course at the national level, based on a two-step structure: the first level (L1) is a short training aimed at all individuals willing to learn how to conduct board game activities in different settings; the second level (L2) is a more intensive course aimed at L1 trainees willing to learn how to design, implement, and evaluate bGBL activities. Evaluating the impact of such training is paramount to improve its quality, promoting new training opportunities nationwide, and better understand the competencies required for effective bGBL implementation in different settings. The present study focuses on two main aspects: first, presenting the model for evaluating the course, using Kirkpatrick's Four levels of evaluation as a reference framework, and the related tools that have been developed, including an *ex ante-ex post* questionnaire based on four dimensions of self-assessment (performance, process, attitudes, and idea of self); second, presenting preliminary results. We aim to identify the professional, motivational and competence profiles of individuals entering L1 courses, information that is instrumental to design the training to fit participants' needs and expectations. Taken together, this study might provide valuable information on the implementation of bGBL in various educational contexts and inform the design of learning curricula to enhance bGBL competencies.

Keywords: Educator Training, Game-based Learning, Impact Evaluation, Learner Profile, Board Games

1. Introduction

1.1 Board Game-Based Learning

Board Game-Based Learning (bGBL) is a dynamic pedagogical approach that leverages the immersive power and distinctive features of board games and role-playing games to promote active and meaningful learning. However, in Italy the use of board games in formal learning environments (such as schools, universities, etc.) is limited, and its use in informal learning contexts (such as cultural associations, after-school, fairs, summer camps, etc.) is often reduced to pure entertainment or engagement functions (Allsop and Jessel, 2015; Loperfido, Dipace and Scarinci, 2019). bGBL, also known in Italy as "Didattica Ludica" (Ligabue, 2020), involves the use of games, particularly board and role-playing games, as a privileged tool for the development of both "hard skills" (mnemonic study, acquisition of information and knowledge) and "soft skills" (cognitive, metacognitive, strategic, relational, emotional skills). The bGBL should not be understood as a substitute for existing teaching approaches, but in support of others traditionally used in the school system. bGBL requires the teacher, or facilitator, to play different roles in the design, development, and implementation of the activity, according to its context and scope, as well as personal style and pedagogical approach (Andreoletti and Tinterri, 2023).

1.2 The Training Courses

In Italy, the Centro Sportivo Italiano (CSI - a nationwide, nonprofit, volunteer-based association that promotes sports as a means for education, growth, commitment and social gathering) and the Game Science Research Center (an inter-universities research organisation that aims to promote, support and disseminate research in Game Science) has organised the first national bGBL training course, based on a two-level structure: the first

level (L1) is a short training (24h) aimed at all individuals willing to learn how to conduct board game activities in different settings; it is designed to train operators who could act in different educational contexts: formal (schools of all levels), non-formal (summer schools, community centres, etc.), and informal (fairs, public events, etc.). The target audience is very broad: it is enough to be of age to access it. The second level (L2) is a more intensive course aimed at L1-level operators willing to learn how to design, implement, and evaluate bGBL activities. In this study we will focus primarily on the L1 courses.

The overall aims of the present study are:

1. Develop a model for evaluating the effectiveness of L1 training courses.
2. Identify the initial profile of training participants. This includes:
    a. Demographic characteristics
    b. Previous experience with games, both personal and professional
    c. Perceptions concerning the educational use of games
    d. Expectations concerning the training

2. Model for Training Evaluation

Evaluating the impact of any training is a key step to understand its effectiveness and provide information to ameliorate it in further interactions. It is even more important in this context as there is not much evidence yet concerning professional training for bGBL. Thus, we developed a model with the aim of understanding:

1. the professional, motivational and competence profiles of individuals entering the training program, in particular L1 courses;
2. the learning achievements of the trainees;
3. the impact of the training on the trainees activity, including professional choices.

To this goal, the reference framework was Kirkpatrick's four levels of evaluation (Smidt et al., 2009). This has been chosen as it a) is a well-established methodology, with empirical support (for a critical perspective, see Reio et al., 2017) b) can be adapted to different kinds of training programs, including formal and informal contexts c) combines four kinds of evidence to provide a well-rounded picture of the training impact, both short- and long-term:

- *Reaction*, concerning the trainees' satisfaction for the training activity.
- *Learning,* the extent to which participants change attitudes, improve knowledge, and/or increase skill as a result of attending the program.
- *Behaviour,* the extent to which attending the training program determined changes in the trainees behaviour.
- *Results,* the final results that occurred because the participants attended the program.

In addition to the original levels, we added a diagnostic evaluation step, as one of the goals of the study was to understand the entering profile of the trainees (Table 1). The *learning* level used a self-assessment paradigm, motivated by the fact that the L1 course did not include any kind of product from trainees. According to Castoldi (2016) self-assessment can refer to four dimensions: tasks (*prestazioni*), process (processi), attitudes (*atteggiamenti*), idea of self (*idea di sé*).

- *Tasks* refer to the level of competence and ability that an individual shows in specific activities, including reaching goals and facing challenges.
- *Processes* refer to the procedures and methods through which tasks are addressed. This dimension focuses on"how" something has been done rather than "what".
- *Attitudes* refer to the mental disposition or approaches that a person assumes toward a task or a situation. Attitudes include motivation, enthusiasm, openness to change, resilience, teamwork, and stress management.
- *Idea of self* concerns the perception and awareness about oneself and includes evaluation of one's competencies, personal and professional identity, self-reflection, and personal growth.

The self-evaluation questionnaire was developed by crossing each dimension with the expected goals of the L1 training and identifying a question for each of the six learning goals of the training: game knowledge, ability to learn other games, ability to explain the rules, ability to modify and personalise the game experience, ability to relate to

players and teamwork. Each question was self-assessed through a 1-4 points Likert scale (Joshi *et al.*, 2015).

Table 1. The model for evaluating the impact of the L1 training.

3. Methods

The *ex ante* survey was structured in five parts (only four of them will be discussed in this study):

1. A demographic section, including questions concerning age, provenience, gender, current job, and professional experience.
2. Questions concerning the participant's expectations and playing habits, including the frequency of playing with different game types (board games, video games, role-playing games), perceived expertise with different game types, and past or current professional experiences with games.
3. An evaluation of the participants' knowledge of game mechanics. This part has not been included in this contribution due to text length limitations.
4. Questions concerning the participants' beliefs about the skills that can be developed through games, both in general and related to the aforementioned games.
5. A self-assessment of the respondent's competencies as ludic operator, as previously described.

Table 1

Level	Indicators	Evidence collection
Diagnostic evaluation	Participants' demographic profile bGBL perceived skills Attitudes towards bGBL as a teaching and learning approach	*ex ante* survey
Reaction	Satisfaction for the training Perceived relevance of the activity Engagement	*ex post* survey on perceived self-efficacy and bGBL skills.
Learning	Learning achievements in terms of knowledge, skills, and attitudes	*ex ante* and *ex post* self-evaluation
Behaviour (intended)	Future perspectives	*ex post* survey on future perspectives (including participation to L2 courses)
Behaviour (observed)	Active engagement in the training Enrollment in L2 course Professional or vocational activity (e.g. participation to associations, ludic events, as a ludic operator)	Learning analytics *post-hoc* questionnaire at 12-month distance
Results	Participation in initiatives involving bGBL changes in professional activity	Follow-up *via* email at 24-moth distance

The survey was administered in CAWI format, using Google Modules. Training participants were asked to fill the survey before the start of the training. Data was collected via Google Modules and analysed using R (R Core Team, 2023), an open-source and flexible language commonly employed in statistical analysis.

4. Results

4.1 Description of the Sample. 69 Participants Were Recruited for the Study (F = 44%, M = 49%, other = 7%) with Mean age of 41±11. Professions of the Participants are Reported in Table 2.

Table 2: Professions of the participants to the study

Profession	*N of participants*
Educator	15
Teacher	9
Employee	9
Creative and visual professional	7
Student	6
ITC professional	6
Unoccupied	6
Gaming industry professional	4
Care profession (nursing, speech therapy, psychology, medicine, etc...)	3
Other	4

Table 3 shows the education level of the participants.

Table 3: Educational level of the participants

Education	*N of participants*
Middle school diploma	3
High school diploma	32
Bachelor degree	15
Master degree	12
Postgraduate degree	6
N/A	3

The majority of the sample (N = 32) reported that they are not currently employed in education but express a desire to work in the field. Only eight respondents indicated no intention to pursue a career in education. Twenty-six participants are currently involved in at least one educational context and wish to continue, while only two education employees express a desire to leave the field.

Participants were queried about their experience in working or volunteering within educational settings. Twenty-three of them reported no prior experience, while the distribution of other responses is illustrated in Figure 1. Informal contexts emerged as areas where participants reported greater work experience, even if there are participants involved across all levels of education, from kindergarten to university.

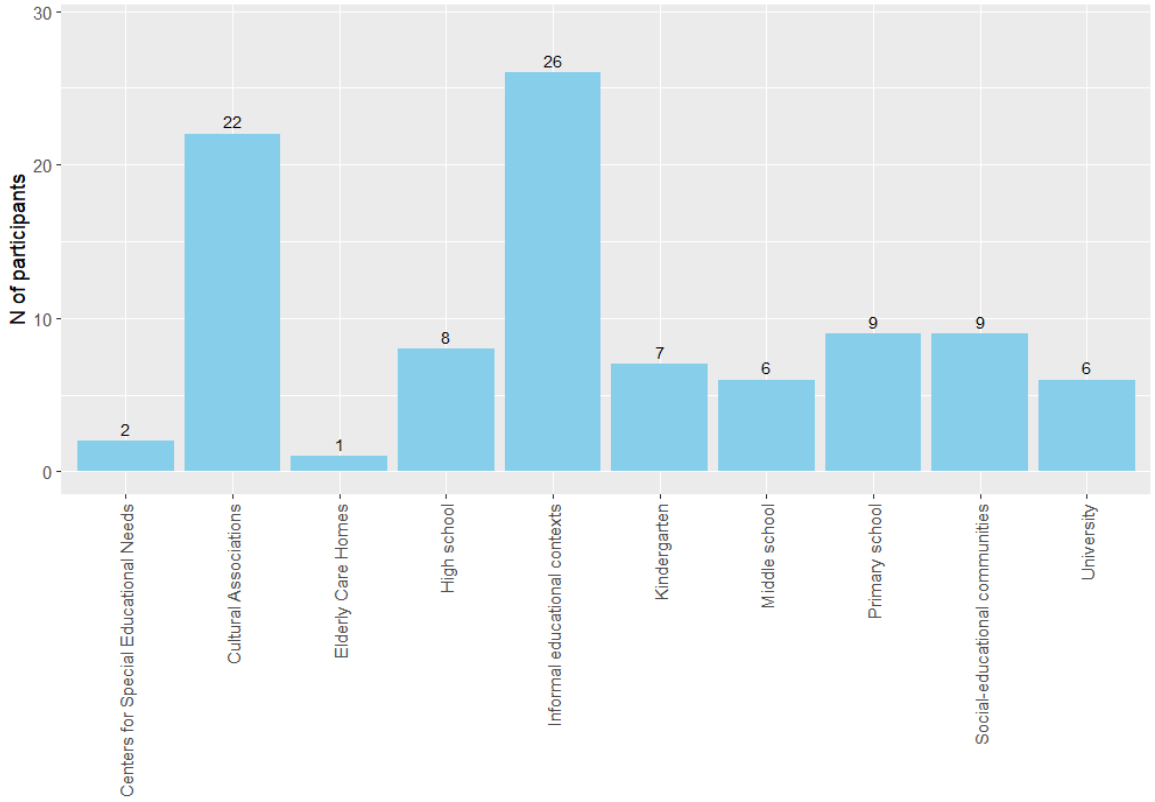


Figure 1: Educational contexts of work of the participants

Participants were asked regarding their use of games in their professional endeavours. Sixteen individuals (23%) stated they frequently and consistently incorporate games into their work, another sixteen reported occasional usage, and a further sixteen indicated sporadic use. Twenty participants confirmed they have never utilised games in their professional activities. Three participants did not provide a response; Most of the sample (N = 59, 83%) had not yet participated in a training course on games.

4.2 Participants' Expectations

Participants were asked regarding their expectations about the course. 54 responses were given. From the responses, 9 main themes emerged, as depicted in Table 4.

Table 4: Participants' expectations

Themes	*Description*	*N*
Educational skills	How to use board games as educational tools to foster learning and social development	19
Knowledge and understanding of boardgames	Deepen the knowledge of the world of boardgames, better understand their mechanics, and discover new ones	16
Application in professional contexts	Integrate the use of games into current professions	13
Dissemination	Make the world of board games better known to a wider audience	9
Psychological and social knowledge/theories	Explore the theoretical foundations of games, including psychological and social aspects	8

Themes	*Description*	*N*
Inclusion and diversity	Ways to make games accessible to various age groups and special needs, promoting inclusion	5
New professional career	Expand professional skills to open new possible career developments (new job)	3
Networking	Opportunities for networking and building collaborations	3
Formal recognition	Obtain a certification or formal recognition of acquired skills	2

Participants are primarily interested in expanding their educational skills. Additionally, they appear to be interested in the value of board games as tools for inclusion and for acquiring psychological and social skills. Given the introductory nature of this course, it is not surprising that many participants are interested in learning more about the world of board games in general. Expectations related to the workplace emerge, both in terms of acquiring new skills to be applied at the current workplace and in seeking and creating new work opportunities. For some participants, it is important to be able to improve their skills in spreading the culture and practice of board games. There is interest in formal recognition, but it is not very widespread, perhaps because the role of a game facilitator is not officially recognized at the moment and the certificate obtained from the course is only valid within the association that promotes it.

4.3 Participants' Playing Habits

The gaming habits of participants have been investigated. Table 5 shows how frequently the participants are involved in different types of gaming activities. The results indicate that the sample consists of individuals who are more accustomed to playing board games and card games. Video games are played quite frequently, with PC/console games being surprisingly more common than smartphone video games. Role-playing games are the least frequently played, particularly LARPs.

Table 5: Gaming habits of the participants

	Board Games and card games	Role playing games	PC/console Videogames	Smartphones videogames	Live action role playing games
Never	1	17	17	19	48
Once a year	2	14	9	6	16
Once a month	19	11	11	16	4
Once a week	20	16	10	6	1
Several times a week	21	10	17	6	0

Chi-square tests were conducted to examine whether there was an association between gaming habits and the use of games in professional activity. The results do not show any significant association (BG: ($\chi2 = 14.389$, df = 16, p = 0.570; RPG: $\chi2= 15.521$, df = 16, p = 0.487; VG: $\chi2= 13.294$, df = 16, p = 0.651; SVG: $\chi2= 17.711$, df = 16, p = 0.341; LARP: $\chi2= 10.296$, df = 12, p = 0.590).

Figure 2 illustrates responses to three questions regarding individuals' perceived expertise across three different types of games: board games, RPGs, and videogames. Each bar represents the frequency of responses indicating different levels of expertise, categorised as 'No', 'Small', 'Medium', 'Good', and 'Expert'. Overall, the graph provides insights into the distribution of self-perceived expertise levels within each gaming category, offering a glimpse into participants' confidence levels in their gaming abilities across varied gaming genres. From the data depicted in the graphs, it appears that participants feel more expert in board games compared to role-playing games, with videogames falling in between.

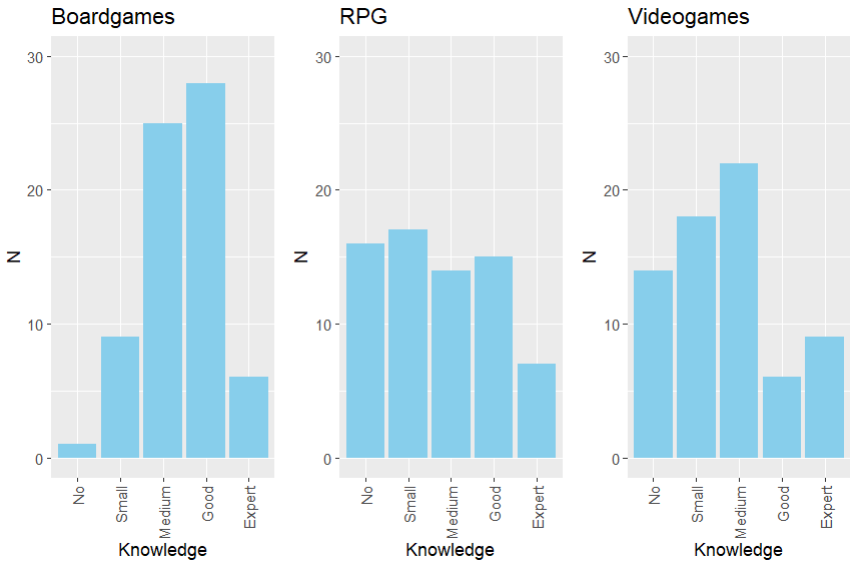


Figure 2: Participants' reported experience levels across three different types of games

Again, no significant correlations were found between perceived level of expertise and use of games in professional activities (BG: $\chi2=16.953$, df = 16, p = 0.389; RPG: $\chi2=12.024$, df = 16, p = 0.742; VG: $\chi2=22.97$, df = 16, p = 0.115).

4.4 Perception of Games as Educational Tools. Participants Were Asked to What Extent, in Their Opinion, Gaming Could Stimulate and Promote a Range of Skills and Abilities. Items Used a 5-Point Likert Response Scale Ranging From 'not at all' to 'Very Much' on a 5-Point Scale. The Results are Presented in Table 6.

Table 6: Perception of how games can promote abilities and skills

Item	*N*	*Mean*	*SD*	*Min*	*Max*
Disciplinary content	66	3.98	0.79	2	5
Cognitive skills	67	4.48	0.61	3	5
Metacognitive abilities	66	4.35	0.71	2	5
Emotional-motivational aspects	69	4.32	0.78	2	5
Visuomotor skills	67	3.99	0.75	3	5
Social, relational, and communicative skills	69	4.62	0.6	3	5
Logical-mathematical abilities	69	4.16	0.76	2	5
Inclusion strategies	67	4.45	0.70	2	5

4.5 Self-evaluation of bGBL Competencies

Finally, several other pieces of information have been asked to the participants regarding their competencies. Most of them usually teach games when they play with friends and families (33,3% do it “often” and 21,7% “always”). Five-point Likert scale questions, ranging from 'very little' to 'very much', were employed to examine participants' self-perception of their gaming skills and knowledge. Participants were asked to respond to the question 'To what extent do you feel capable of...' with each item exploring a specific aspect of their gaming

knowledge and competence. Table 7 shows descriptive statistics of each question. Most of these items have scores around the midpoint, except for 'have a collaborative attitude' (M = 4.09) and 'learn games' (M = 3.88). This initial assessment provides a snapshot of the sample at T0 and will be compared with the results of the same questionnaire administered at the end of the L1 training program to assess whether participants perceive an improvement in their gaming knowledge and skills after the training.

Table 7: Perceived knowledge and competences about gaming

Item	*N*	*Mean*	*SD*	*Min*	*Max*
Learn games	68	3.88	0.84	2	5
Assess suitability of games	67	3.30	0.90	1	5
Teach rules	67	3.48	0.84	1	5
Adapt games	68	3.34	0.97	1	5
Share management of games activities	68	3.53	0.97	1	5
Seek information about boardgames	67	3.58	1.12	1	5
Assess efficacy of a game activity	67	3.30	1.00	1	5
Study and teach rules	67	3.25	0.96	1	5
Change rules to adapt a game	67	3.09	1.16	1	5
Have a collaborative approach	68	4.06	0.73	2	5
Knowledge of boardgames	68	3.04	1.04	1	5
Feel comfortable ad playworker	68	3.59	0.87	1	5
Ensure all players know what to do	68	3.41	0.85	2	5
Adapt a game to the social context	68	3.41	0.97	1	5
Make people enjoy working with me	68	3.51	0.74	2	5

5. Discussion

In this work we propose a model for evaluating a board game training aimed at individuals operating in both formal and informal educational settings and geared toward the development of bGBL facilitator skills. We used Kirkpatrick's four levels of evaluation as a reference framework and integrated it with the self-assessment paradigm of Castoldi (2016). This model guides the evaluation of the course's effectiveness and its outcomes, considering the participants' initial level, their subsequent achievements, and intentions by integrating pre- and post-data, self-assessments, and performance evaluations. We developed two different questionnaires for the pre- and post-assessment. The response rate to the pre-intervention questionnaire (97% of participants answered almost all the questions) suggests that the tool was of a manageable complexity and length. This has made it possible to collect initial data useful for assessing the effectiveness of the intervention. The initial profiling of participants indicates that those who chose to enrol in the L1 course are not entirely new to the world of board games. Generally, they have a particular interest in the educational (28%) or inclusion (7%) aspects of board games and are interested in developing or maintaining a career in this field (85%). They have a good knowledge of board games but would like to deepen their understanding of them. A third of them have at least occasionally used games in their professional activities. They seem to already have a certain predisposition to facilitate others, being mostly those who explain the rules when playing games. Their interest in games is not limited to board games: more than half of the participants engage with video games or role-playing games at least once a month, preferring PC or console video games over smartphone video games. The level of initial competencies, as it emerges from self-assessment, is quite high: the lowest average score is above 3 (*Knowledge of board games,* 3.09), the highest exceeds 4 (*Have a collaborative approach,* 4.06). It will be interesting to see how this self-assessment may change at the end of the course, especially L2. Another preliminary observation concerns the lack of correlation between participants' gamer habits and professional use of games - this might suggest that the training is indeed able to appeal both "expert gamers" who aim to professionalise or disseminate their passion for games, as well as educators who wish to deepen their knowledge of games, considered a prerequisite for successful bGBL (Hsu *et al.*, 2013).

The current study is subject to several limitations: first, the nature of L1 training, which takes place throughout the year in different locations, requires constant upgrade of the dataset; each analysis is to be considered a freeze frame of a continuous process. The second, related limitation concerns the current lack of *ex post* data, which are required for the comprehensive evaluation of the training; self-assessment data are being collected and do not allow yet significant pre-post comparison. Lastly, due to format limitations we could not incorporate analysis of the participants' level of understanding of board game mechanics. This data significantly deepens our insights into educational strategies within game-based learning environments. Additionally, integrating the evaluation of L1 with that of L2 courses would provide a comprehensive assessment of the entire training path, particularly the use of facilitation methodology in L1 and instructional design in L2.

Taken together, this study provides a snapshot of the entering profile and expectations of individuals who have taken interest and enrolled in the first nationwide training course on bGBL. This ongoing research will help design future training to better fit participants' interests and help the initiative achieve a greater reach. Integration of current analysis with the other levels of the evaluation model will allow a comprehensive picture of how h the training can elicit changes in the participants' learning, attitudes, and individual and professional career paths. In conclusion, through the creation of a new model for evaluating the impact of bGBL training, the study provides precious evidence to support the improvement of training programs aimed at the development of professional bBGL competencies.

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Examining the Efficacy of a Physical Board Game for Geometric Transformations

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Abstract: A group of Hong Kong secondary school mathematics teachers collaborated on the creation of a physical board game, "War of Transformation", specifically designed to aid Hong Kong Secondary 1 students in applying transformation (i.e. translation, reflection, and rotation) of 2D figures, a topic in the local mathematics curriculum. The objective of the study was to delve into the game design and player experience from the viewpoint of the students as indicators of the effectiveness of the board game, comparing these elements across different abilities. A mixed-method design was adopted, from which data was gathered utilizing questionnaires and a focus group. The study involved a total of 102 junior form students secondary school students from three districts in Hong Kong, with a selected group of five students and three school teachers participating in interviews. The questions for the questionnaire and interviews were derived from the Model for the Evaluation of Educational Games. Quantitative data were used to provide an overview of student experiences, while qualitative data from the interviews provided further insights of the results. The findings revealed that students valued the game's design and had a positive gaming experience, comparing these elements across different abilities The design of the board and the use of online teaching aids were found to significantly enhance gameplay and learning. This study highlights the potential of thoughtfully designed game-based learning in fostering effective and engaging learning experiences.

Keywords: Game-based Learning, Board Game, Geometry, Student Motivation, MEEGA+

1. Introduction

Mathematics is an essential subject, providing the foundation for many professional fields such as artificial intelligence and business. It is also vital in solving everyday life problems. However, there is a concerning decrease in the proportion of students who are willing to pursue more advanced study in mathematics. According to the Hong Kong Examinations and Assessment Authority (2023) report, the proportion of candidates who took the optional extension part of mathematics examinations [1]decreased from 22% in 2012 to 15% in 2023. There is also an alarming mismatch between competence and interest in mathematics. Despite Hong Kong students demonstrating mathematical competence above the international average, their interest in mathematics is relatively low in the context of a high-stake examination-oriented culture in Hong Kong (李鎮揚 & 霍秉坤, 2022). These two observations highlight the need to look for ways to arouse students' interest in learning mathematics.

2. Literature Review

Geometric transformations are fundamental to the field of mathematics and involve mapping points on a plane in a one-to-one and onto manner (Junius, 2002). Each point on a plane undergoes a specific transformation (i.e. translation, reflection or rotation) mapping it to a new position from its original location. These transformations are not just mathematical operations, but they also connect various areas of mathematics. They are intertwined with other geometric concepts like similarity and congruence and extend to other areas of mathematics such as algebra, patterns, and functions. Moreover, they play a crucial role in mathematical reasoning (Uygun & Akyüz, 2019).

In secondary education, geometric transformations are also significant. They provide a practical way for students to begin grappling with abstract mathematical concepts. Geometric transformations can be represented

[1] The Hong Kong Diploma of Secondary Education Examination includes Mathematics as a compulsory subject for all candidates. The Extended Parts, which are separate subjects from the compulsory one, are optional for students who want to further study or work in related areas. The Extended Part offers two modules, namely Module 1 (M1): Calculus and Statistics, and Module 2 (M2): Algebra and Calculus.

algebraically, helping students make connections between geometry and algebra. They also deepen students' understanding of the concept of a function, considering transformations as functions that take points in the plane as inputs and generate other points as outputs. Geometric transformations can be represented algebraically. For example, a reflection over the y-axis can be represented as the transformation (x, y) -> (-x, y).

Traditional mathematics education often involves assigning exercises to help students review and apply mathematical concepts. However, such learning activities may unintentionally decrease students' motivation (Schukajlow et al., 2017), presenting a significant challenge in mathematics education. A positive correlation has been observed between learning motivation and academic achievement in Hong Kong (Cheung, 1988). Therefore, alternative pedagogical approaches that maintain student motivation while support student learning are desired.

Game-based learning (GBL) is a pedagogical approach that uses games to support student learning. Game-based learning can take many different forms, including board games, online games and Virtual Reality. Board games were widely used in mathematics education, such as in South Africa, Greek, and Indonesia. GBL has also widely contributed to mathematics in different aspects such as geometry, arithmetic, mathematical reasoning, and statistics. Trajkovik et al. (2018) stated that their outdoor game, a form of game-based learning, enhanced Macedonian primary students' motivation and academic results compared to traditional teaching methods. Besides knowledge and motivation, Garris et al. (2002) found that GBL enhances students' motor skills, strategic knowledge and attitude. As such, GBL remains a promising pedagogical approach in mathematics education to promote students' affect and academic success.

Solihatun et al. (2019)'s study highlights the challenges that students face in narrative tests in geometry, such as explaining and determining the circumference and area of squares, rectangles, and triangles. The use of board games in teaching geometry could provide an interactive and engaging method for students to develop their problem-solving skills and overcome these challenges through e.g. visualizing abstract concepts using real objects. Meanwhile, Achor et al. (2010) highlights the importance of the teaching method employed in academic achievement in geometry learning. Their finding supports the use of board games in teaching geometry as a promising alternative to traditional teaching methods. Moreover, Ketamo (2003)'s study demonstrates the effectiveness of developing a geometry learning game that adapts to the user's behavior, which produced good academic results among Finnish preschool students. This finding suggests that handheld devices and simple adaptation systems have the potential to enhance the learning experience for students. The existing body of research underscores the effectiveness of Game-Based Learning (GBL) as a powerful method for teaching geometry. However, a notable gap exists: most studies have predominantly focused on online games, leaving physical board games relatively unexplored. At the same time, GBL in either online or physical form should have similar outcomes (Debrenti, 2024). This study seeks to address this gap by providing valuable research data for educators and game developers alike. Specifically, it sheds light on the effectiveness of GBL from a user's perspective with both quantitative and qualitative data.

This study makes three key contributions. Firstly, it introduces a physical, hands-on board game that helps students apply geometric transformations. Secondly, the study examines the effectiveness of the board game across diverse student groups representing different mathematical abilities in three Hong Kong secondary schools. Finally, investigate students with different abilities respond to the use of GBL and the associated factors. The primary objective of the study is to investigate the effectiveness of the board game in terms of board game design and students' experience. This can verify the potential of board games as an educational tool.

3. Methods

The board game developed aimed at helping secondary junior form students and their families strengthen essential transformation concepts. This innovative board game underwent rigorous pilot within a Hong Kong secondary school. Building upon this pilot work, our study aimed to evaluate the effectiveness and quality of the game using the Model for the Evaluation of Educational Games (MEEGA+; Petri, 2018).

MEEGA+ is an adaptation of the original MEEGA model, specifically designed to evaluate computer-based educational games. Although its primary focus is digital education, two crucial quality factors, usability and player experience, remain highly relevant across different gaming contexts.

Player experience encompasses several dimensions, including attention, engaging challenges, social interaction, confidence-building, relevance, satisfaction, and perceived learning. These factors contribute to a holistic gaming experience. Usability evaluates the effectiveness and efficiency of the board game. Perceived learning

embodies the notion of transformation, which includes aspects like translation, reflection, and rotation in this study.

Our study extends the model's application beyond its original scope in mathematics education. We aim not only to gauge the perceived effectiveness of game-based learning but also to measure cognitive learning outcomes. Specifically, we assess students' perceived performance on transformations of 2D figures within a coordinate system involving translation, reflection, and rotation. Our investigation aligns with MEEGA+'s quality factors and is guided by two research questions:

RQ1: Is the board game designed to ensure usability learning experiences?

RQ2: Does the board game foster a positive player experience?

3.1 Game Design

The board game was co-developed by a group of local secondary school mathematics teachers in Hong Kong. The main purpose of "War of Transformations" is to promote geometric exploration. Designed for four players, this game unfolds on a 100 cm x 100 cm board (refer to Figure 1). Four hint cards about the movement of the piece are provided (Figure 2) for each player. Each player wields a set of numbered pieces, ranging from 1 to 9 (see Figure 1). Before the game commences, players strategically select six pieces, ensuring that the sum of their chosen numbers totals 23.



Figure 1: The Game Board

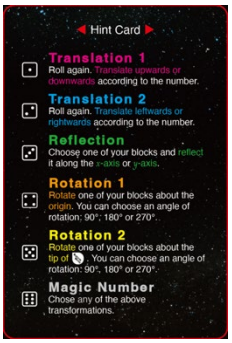


Figure 2: The Hint Card

Game Setup: Piece Placement: The dice roll determines the order in which players place their pieces. Sequentially, they take turns positioning their pieces on the board until all available spaces are filled. If no room remains, players can rearrange their already-placed pieces.

Movement Options: Once the game begins, players roll the dice to dictate their piece movements. The following options come into play:

- Translation (Up/Down): Roll the dice again to determine the number of squares to move.
- Reflection (Across the Reflection Axis): Reflect the piece along the specified axis on the board.

- Rotation (Around the Center of Rotation): Rotate the piece using the indicated centre point.
- Translation (Left/Right): Roll the dice again to determine the lateral movement.
- Reflection (Along Another Axis): Reflect the piece anew.
- Rotation (Centered at the Board's Center): Execute a rotation around the board's midpoint.

Figure 3 illustrates two examples of translation.

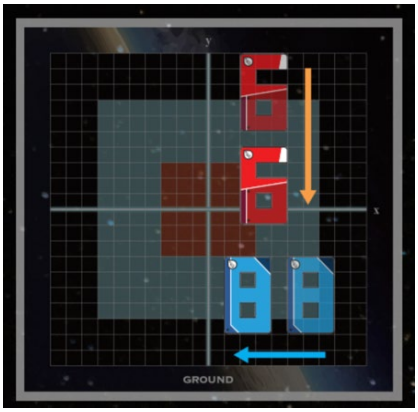


Figure 3: Examples of Valid Translations

Overlapping Pieces: When a player's piece overlaps with their opponent's, they can remove the opponent's overlapped piece.

Endgame Conditions: The game ends in one of two ways, whichever comes first: (1) Last Piece Standing: If only one piece remains on the board; and (2) Time Limit: The game has lasted for 10 minutes.

Scoring and Winning condition: When the game ends, players calculate their scores based on the pieces they removed. Each piece's score corresponds to the number it represents. The player with the highest score claims victory. Should multiple players tie for the highest score, they all win the game.

3.2 Other Game Resource

Some students may experience difficulty executing the movement of the pieces. To resolve this, the research team has developed a GeoGebra lesson activity (Figure 4) to assist students in verifying the correctness of their movements. This tool makes a significant contribution to the game, serving as a valuable aid for students to check their validity of the moves.

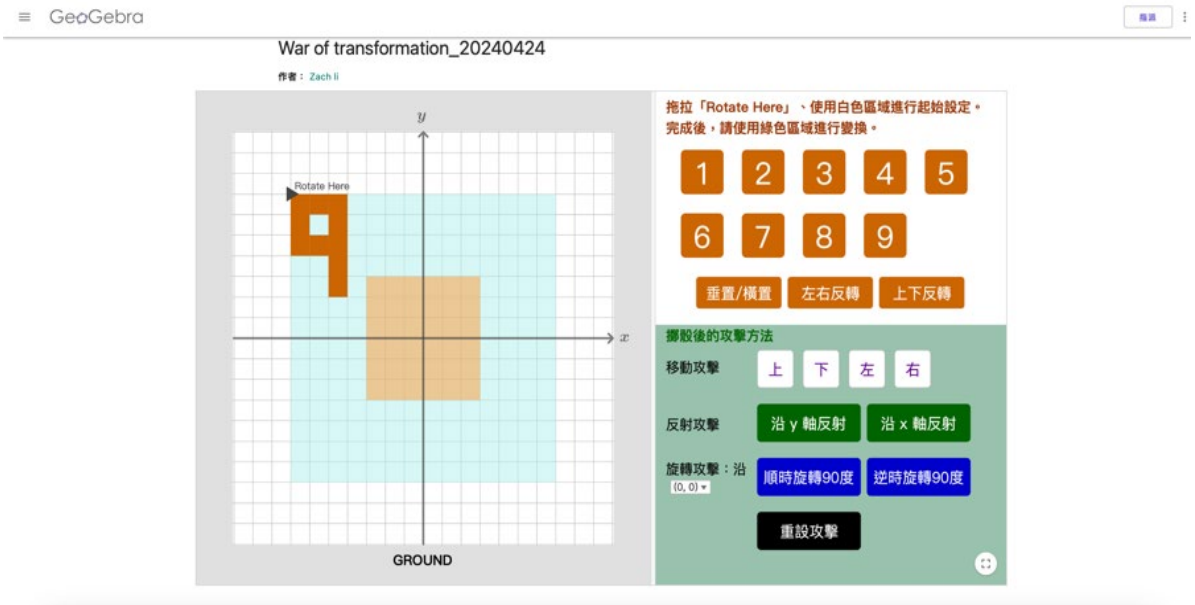


Figure 4: GeoGebra Lesson Activity

3.3 Research Design

The study was carried out in three Hong Kong public secondary schools, with 112 S1 and S3 student who are voluntary participants aged between 12 to 15. As part of the research procedures, these students engaged in the "War of Transformation" game at least thrice after school hours. After gameplay, they were asked to complete a questionnaire, and five students were randomly selected for an interview which prompted their perceptions of the board game. Schools A, B, and C are all mixed gender schools. According to public examination and intake results, School A excels in mathematics, School B shows average performance, and School C has lower mathematical abilities.

The study aimed to explore the effectiveness of the board game in terms of board game design and students' experience. The research methodology adopted is a mixed-method approach, encompassing questionnaires and interviews. The study aims to shed light on the students' perceived mathematical learning, motivation, and skills upon engaging with the board game.

The questionnaire is divided into three sections. The first section gathers demographic data, including school, age and gender. The second and third sections address RQ1 and RQ2 respectively (add RQ3 correspondingly), and utilizes the MEEGA+KIDs self-assessment questionnaire (Petri, 2018) to gauge student perceptions of the educational board game. Despite its development based on MEEGA+, targeting computer education, the questionnaire serves as a general framework for evaluating educational board games. The second section comprises a series of five-point Likert scale questions, ranging from strongly disagree to strongly agree, and includes 9 items and 23 items related to usability and player experience domains, respectively.

The focus group discussion questions were also developed from MEEGA+KIDs self-assessment questionnaire (Petri, 2018). It included 5 and 10 items related to usability and player experience domains, respectively. Five students were randomly selected.

3.4 Data Analysis

Inductive approach was adapted in this study. After the interview questions were designed, a codebook was created to facilitate the analysis of the interview transcripts. The coding process established a hierarchical structure of factors, including overarching themes and their corresponding subthemes. The initial set of subthemes was based on a review of relevant existing literature. For each code in the codebook, illustrative examples were provided from the interview transcripts to support the analysis.

The quantitative data derived from questionnaire served as supplementary information in support of the interview data. The mean scores of all items by each student within the same domain were computed. This mean score represented the students' attitudes towards that domain, with a range from 5 (Strongly Agree) to 1 (Strongly Disagree). As for the qualitative data obtained from the focus group, all data were transcribed. This transcribed data served as in-depth information for each domain.

4. Results and Discussion

Table 1 summarizes the demographic information drawn from the questionnaire.

Table 1: Demographic Information of Participants from the questionnaire

Demographics	School A (n = 32)		School B (n = 68)		School C (n = 12)	
	n	%	*n*	%	*n*	%
Age						
12 years old	12	37.5%	30	44.1%	0	0%
13 years old	20	62.5%	35	51.5%	1	8.3%
14 years old	0	0%	3	4.4%	9	75%
15 years old	0	0%	0	0%	2	16.7%
Gender						
Male	13	40.6%	41	60.2%	5	41.7%
Female	19	59.4%	27	39.8%	7	58.3%

4.1 RQ1: Is the Board Game Well-designed, Ensuring Usability Learning Experiences?

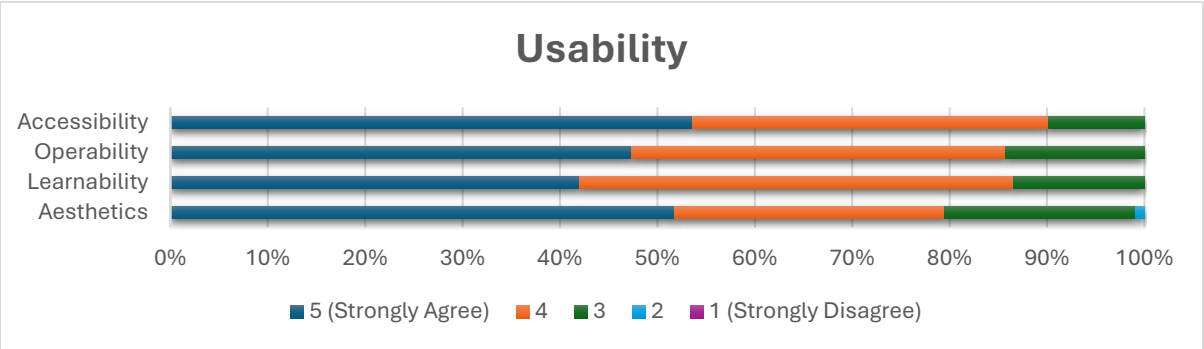


Figure 5: Perception towards the boardgame in the domain of Usability

The data generally indicates a positive perception among students towards the board game design. A large proportion of students strongly agree in the area of accessibility (90%), operability (86%), and learnability (87%). While the game is well-designed in these areas, there are also opportunities for improvement. For instance, in the area of aesthetics, one student disagreed with the aesthetic design, and several others remained neutral on this aspect when comparing it to other themes. All three schools are similar in their distribution of learning experiences across all domains.

4.1.1 Aesthetics

A majority of the students agreed that the game's design is appealing. This includes various elements such as the interface, graphics, cards, and boards. Furthermore, the students found the text font and colors to be harmoniously blended and consistent throughout the game.

4.1.2 Learnability

Most of the students concurred that they needed to acquire certain prior knowledge, specifically in the transformation of figures, to effectively engage with the game. The rotation aspect was particularly emphasized. The students agreed that the preparatory activities provided by the GeoGebra lesson activity were beneficial in this regard. Furthermore, the game's accessibility and learnability, which were positively noted by approximately 80% of the students, facilitated a quick understanding of the gameplay for most individuals. According to the School C teacher, the IT software initially assisted students with assessment, and used iPads to help them with their thinking. However, by the later stage, students no longer needed to use the iPad to assist with their thinking.

4.1.3 Operability

A significant proportion of students concurred that the game was easy to play, attributing this ease to the clarity and simplicity of the game rules. An accessory of the game, the "Hint Card", was noted to be particularly helpful. It served as a reminder to students about the correlation between the faces of the dice and the type of transformation that would occur.

4.1.4 Accessibility

A considerable percentage of students concurred that the game's typography, both in terms of size and style, was easy to read. Additionally, they found the color scheme used in the game to be meaningful. In particular, the color of the game board was noted to facilitate movement, especially in rotation. These findings suggest that the game's design not only meets accessibility expectations but also significantly contributes to the gameplay experience.

4.2 RQ2: Does the Board Game Foster a Positive Player Experience?

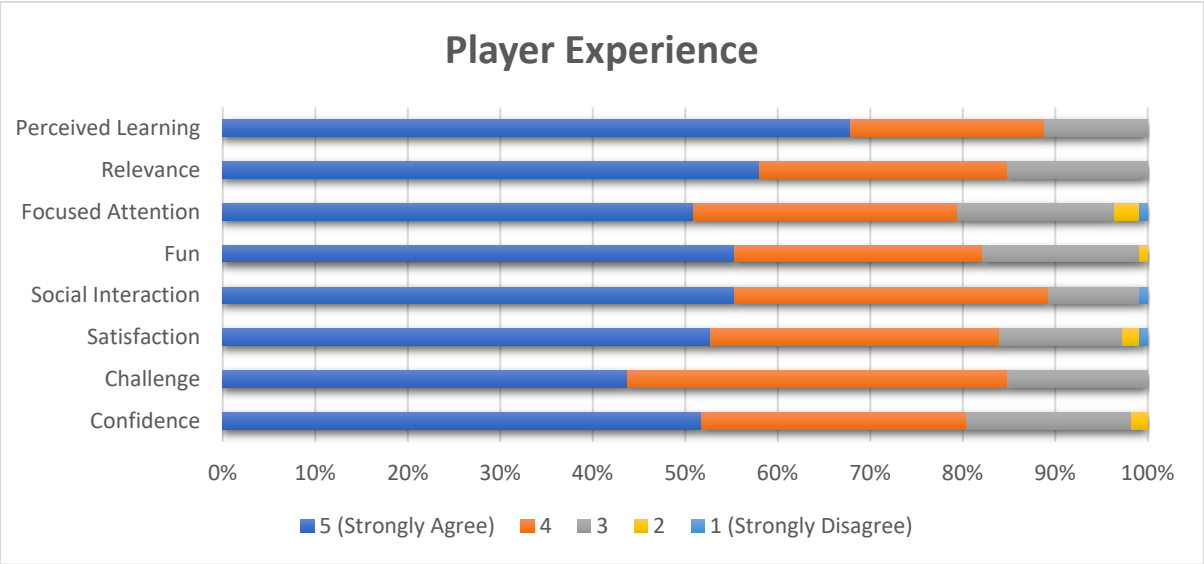


Figure 6: Perception towards the boardgame in the domain of Player Experience

The data generally indicates a positive perception among students towards the player experience of the board game. The game particularly excels in areas such as challenge, social interaction and relevance with a majority of students expressing strong agreement on these aspects. While the game is well-designed in these areas, there are also opportunities for improvement. For instance, in the areas of confidence, satisfaction, fun, and focused attention and Perceived Learning. Similar results are observed among all three schools in their distribution of learning experiences across all domains.

4.2.1 Confidence

Most students concurred that the game's content and structure enhanced their confidence in their learning capabilities. However, it was noted that a few students encountered difficulties in discerning the results, which subsequently impacted their confidence in playing the board game. Only 2 students from School A expressed low confidence in playing the board game. Triangulating from the teacher' interview, we speculate one possible reason is that School A provided less guidance for students compared to School B and School C.

4.2.2 Challenge

The majority of students concurred that the game posed an appropriate level of challenge for them. They appreciated that the game introduced new challenges and variations at a pace that was manageable and engaging. One educational institution implemented a scaffolding approach to gameplay, introducing students first to translations, followed by rotations, and finally reflections. Importantly, students also noted that the game did not become monotonous as it progressed, avoiding repetitive or boring tasks, which contributed to sustained interest and engagement.

4.2.3 Satisfaction

A significant majority expressed a high level of satisfaction derived from the completion of game tasks. This satisfaction was attributed to the sense of accomplishment experienced upon task completion. Furthermore, the students believed that their personal efforts were instrumental in their progression within the game. An additional aspect of the game that was highly valued by the students was its educational component. They expressed satisfaction with the knowledge and skills they acquired through gameplay. Based on these positive experiences, the students indicated a strong inclination to recommend this game to their peers. These findings suggest that the game effectively fosters a sense of achievement, encourages personal effort, and provides a satisfying learning experience, making it a valuable educational tool.

4.2.4 Social Interaction

A high percentage of students concurred on the positive impact of player interaction. They reported being able to engage with other players during the game, which significantly enhanced their gaming experience. The design of the game was found to foster both cooperation and competition among players, contributing to a dynamic and engaging social environment. Furthermore, students reported positive emotions associated with player interaction, indicating that the social aspect of the game was not only functional but also enjoyable. During the interview, the teachers communicated that the students were not actively moving their own game pieces; they were happy to provide suggestions and strategic recommendations to the players who were taking their turns. They were constantly thinking and discussing ways to persuade their opponents, in order to avoid having their own pieces captured. Regardless of whether they were actively participating or observing, the students maintained an engaged focus on strategizing and deliberating throughout the gameplay. One student commented how other players corrected the movement of the pieces; he learned from them. This aligns with Hwang et al. (2014)s' perception of peer assessment-based game development as an effective learning strategy. Moreover, when other players rectified the movement, they did not experience frustration; instead, they perceived it as part of the gaming process. This perception contributed to what is known as 'graceful failure.' Graceful failure refers to the ability of students to manage failures or errors in a manner that minimizes their impact on academic performance. This observation supports the notion that engaging in games that encourage risk-taking and exploration can mitigate the repercussions of failure (Hoffman & Nadelson, 2010). Such an attitude is crucial for students to achieve success in learning transformation.

4.2.5 Fun

A majority of students agreed that they had a positive and enjoyable experience with the game. The students expressed that they had fun while playing the game, indicating that the game was successful in creating an engaging and entertaining environment. According to the teacher interview, this student also made a lot of noise while playing and stood up to try and teach the other participants. Only one student from School B did not agree that the game was fun. Furthermore, the students noted specific instances during gameplay, such as certain game elements or competitive aspects, that elicited positive emotions, particularly happiness. However, a few students may still feel disengaged. One possible reason could be that the game requires prerequisite knowledge for transformation. If students lack this knowledge, they may not be able to fully enjoy the game.

4.2.6 Focused Attention

A significant proportion of students reported that the game successfully captured their attention right from the outset. They found elements of the game particularly interesting, which served as a strong hook for their engagement. Moreover, students reported a high degree of immersion in their gaming tasks, often to the point of losing track of time. This intense involvement suggests a profound engagement with the game. Many students also reported a sense of detachment from their immediate surroundings while engaged in the game. Only 3 students from School A and 1 student from School C agreed that they did not maintain focused attention during the game. According to Flow Theory, motivation peaks when individuals encounter challenges that are above average and perform at a skill level that is also above average. This phenomenon appears to resemble a state of flow. The state of flow has been positively correlated with academic performance (Chang et al., 2018). However, some students may easily lose their attention when playing the game. This could be attributed to the game's requirement for prerequisite knowledge in transformation. If students are deficient in this knowledge, their enjoyment of the game may be compromised.

4.2.7 Relevance

Most students concurred that the game's content was relevant to their interests. This relevance significantly contributed to their engagement and satisfaction with the game. Furthermore, students found a clear connection between the game's content and the transformation process, indicating that the game effectively communicated its intended learning outcomes. Moreover, students perceived the game as an adequate practice tool for the transformation process. This suggests that the game not only aligns with students' interests but also serves as an effective educational tool for facilitating understanding and practice of the transformation process.

4.2.8 Perceived Knowledge

In terms of knowledge acquisition, most students agreed that the board game contributes to their learning about various mathematical transformations, including translation, reflection and rotation. This finding aligns with the study by Moral-Sánchez et al. (2022), which suggests that game-based learning has a positive impact on learning geometry in secondary school. The content of the game was found to be well-aligned with the course objectives, thereby enhancing the relevance and applicability of the game in an educational context. Moreover, the teaching strategies employed within the game were reported to facilitate the understanding of the acquired knowledge. The practical opportunities provided by the game were also acknowledged for their role in enhancing learning outcomes.

Concerning skill development, the game was not only beneficial in terms of knowledge acquisition but also in the development of various skills. Students reported that the game helped them enhance their problem-solving abilities, a critical skill in many areas of life and study. The game's design and structure were found to promote communication skills, strategic thinking, and problem-solving abilities. These skills are not only valuable in the context of the game but also transferable to other areas of the students' academic and personal lives. Furthermore, the presage variable of academic motivation and the process variable of learning engagement positively affect the product variable of transferable skill development, respectively. This dual focus on knowledge and skill development underscores the game's potential as a comprehensive educational tool.

Overall, students with different prior knowledge level needed different preparation for the game and personalized feedback to successfully perform transformation of the pieces during the game. It is suggested that future research may further examine the types of preparation and personalized feedback to accommodate students' gaming and learning experience with varying backgrounds.

In short, this study emphasizes the value of physical board games in transformation and bridges the gap between theory and practice. Educators can leverage these findings to create engaging learning experiences that resonate with students from diverse backgrounds. Specifically, it sheds light on selecting diverse games for educational purposes and encourages the creation of new physical board games tailored to geometry learning.

The scope of this research was confined to a limited number of schools due to the resources available to the researchers. Consequently, the applicability of the findings to other school environments may be limited. Therefore, future studies should involve a larger number of schools to enhance the generalizability of the findings. As only perceived learning was investigated through a questionnaire, additional more objective quantitative methods should be incorporated to further explore the effectiveness of student learning, such as using an experimental pre-post test design.

5. Conclusion

In conclusion, this research has effectively verified a physical board game, "War of Transformation", as a novel method for learning, applying, and engaging in geometric transformation. The results align with the majority of GBL studies, which focus on online games. However, the physical game places importance on student face-to-face and immediate interaction, playing a pivotal role in facilitating peer feedback and enabling graceful failure. A significant number of students concurred that the game was well-structured and offered a positive player experience, particularly in learning transformation. The study further supported that the use of teaching aids and thoughtful board design can augment students' learning experiences. It is suggested that more educational institutions can adopt this strategy to contribute to the widespread adoption of this innovative learning approach. This study highlights the potential of meticulously designed educational games in fostering effective and engaging learning experiences.

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Do Video Games Enhance Competencies and Skills? A Study Case on Civil Engineering Students

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Abstract: The following article is a text that shows the relevance of including video games as part of an academic technique that promotes coexistence, communication, teamwork, develop some skills, competencies, and creativity among members of the university community -professors and students-. The objective of this research is to show the results obtained in a dynamic organized by the Civil Engineering department of a private university in Puebla, Mexico. The idea is to hold a private session and play "Call of Duty: Warzone II". It should be noted that with this activity the students can learn a specific content, in this case, the analysis of a hydraulic press, how it is built and how it works. In addition, the activity carried on, helped to create a better bond between teachers and students, but above all, showed the possibilities to generate greater interest in learning and to get the students actively involved in one topic. The theoretical framework on which this research lies in the following topics: Game-Based Learning -GBL-, innovative education focused on video games as community generators, and the importance of the development of certain skills among college students. The methodology that this study has, is quantitative. Particularly, a questionnaire -Likert scale-, is carried out to the students who participated in this dynamic. The main results show that the people who were in the virtual session are excited to interact under another type of scenarios that goes beyond the classroom, and that "breaking" the barrier between teacher and alumni becomes a differentiating and innovative element. In educational matters, they consider that the learning obtained from a video game is something that they had not contemplated; Added to this, the students ensure that working as a team, communicating their needs and doubts between peers, and getting involved in this kind of forums helps generate greater interest in engineering and acquire new knowledge. Finally, it can be concluded that video games nowadays are an indispensable tool not only to foster an online community but to take the teaching and learning process to another level.

Keywords: Game-Based Learning, Video Games, Higher Education, Educational Innovation, Students, Skills

1. Introduction

Educational contexts are characterized by being unpredictable and full of situations that help to reflect on the work of teachers. This leads to an increase in the challenges in the classroom and, therefore, teachers spend a little more time planning the sessions. In this sense, one of the pedagogical tools and techniques that has been incorporated is GBL; where games are used to promote certain learning. Huizinga (2019) describes that every playful experience has spatial limits, which separate the world of play from the outside world. Whoever decides to play must voluntarily enter this circle, where there are rules to comply with and that are very different from the conventional ones (Cornella, Estebanell & Brusi, 2020).

It is important to note that within the GBL there is a special category that focuses on video games, which, although they are not usually based on educational issues, present many problems that psychologists analyse when studying thinking and learning; These include active and critical learning, engagement, self-learning, and the principle of in-process learning (Gee, 2006).

As for their educational aspect, recent analyses show that the fact that these games present challenges with progressively increasing difficulty, challenges with solutions, the possibility of pausing or saving the game, etc., generates the possibility of being able to progress whenever you try and surpass yourself. For this reason, the game model works because it motivates students by helping them to develop greater commitment and encouraging the spirit of improvement. In addition to this, it should be mentioned that there is a clear link between games and emotions, this makes it an interesting way to promote learning, since memory works best when there is an emotional or experiential link with what you want to remember (Pacheco y Causado, 2018).

Considering the above, the objective of this article is to show the results of a methodology carried out with Civil Engineering students in which the GBL was used as a tool for the development of disciplinary and transversal

competencies. The idea of this dynamic is to play "Call of Duty: War Zone II" collaboratively so that students strengthen skills such as leadership or teamwork. Specifically, it was decided to use the video game because it encourages healthy competition, strategy, and group tactics to achieve certain goals. In addition to this, "Call of Dutty: War Zone II" has graphics, animations and usability of great technology and the latest generation; as well as a long tradition and acceptance over the years.

2. Theory Approach

The incorporation of technology based on video games or E-Learning as an educational resource is one of the many mechanisms that teachers can use with their students to develop skills, competencies, foster another style of teaching, generate community and exercise new roles; among them, that students can reason more effectively, be more autonomous and with a more open mind to the knowledge they are taught, where their ability to create and understand is better every day (Villacís, et al, 2022). In this way, and considering that there are various aspects that encompass the GBL, the following are the essential points at the theoretical level that serve as the basis for the realization of this project

2.1 Game-Based Learning

Although this concept has a few characteristics, for this analysis it refers to learning with video games to support and improve teaching and learning processes. It is considered as an effective style to motivate the student in active educational experiences. From this, habit changes can be promoted in both students and teachers. These actions make the student a more active actor in the academic process. Given this comment, the GBL is used when incorporating and applying games in the contents of the syllabi of each subject (Cornella, Estebanell y Brusi, 2020). Therefore, when used in higher education, playtime becomes a time for serious work; In this sense, there is a relationship between work inside or outside the classroom and the acquisition of knowledge through effort, performance and productivity (Trujillo, 2017).

Brull (2016), comments that Game-Based learning allows learners to participate and create a learning community, enjoy the freedom to experiment and make mistakes in a more enjoyable environment; in addition to the fact that students can interact with other types of sensations; In fact, there is evidence that students involved in this kind of pedagogical practices improve their learning.

It should be noted that this technique is still criticized, there is a myth that learning and playing cannot go hand in hand; However, one of the points in favour is that the dynamics adapt to the demands of new generations, which are in constant interaction with Information and Communication Technologies -ICT- (Hernández, Monroy y Jiménez, 2018).

Thus, the GBL becomes a tool to generate motivation in students and relate acquired knowledge; In addition, as mentioned above, by combining play with strategy, a motivating environment is created. It is worth mentioning that they normally generate physical or mental stimulation, help acquire practical skills, serve as exercise, have an educational role and can contribute to development and psychological balance (Jadán y Ramos, 2018).

It is necessary to recognize the advantages that video games can bring to training processes, since they invite the students to become an active part of the process. In addition, practicing in simulated situations helps them develop skills and gain self-confidence. Therefore, play as an educational strategy helps to solve many problems that are often mentioned in the classroom; Finally, we must add the capacity for engagement that makes the GBL technique even more relevant as a pedagogical tool.

2.2 Video Games in Education

Education has undergone important changes ranging from new methodologies to transformations in the way knowledge is constructed and transmitted; therefore, it can be said that education is an essential and permanent element in everyday life at both the individual and social levels (Ortiz & Cardona, 2020). In this sense, although video games have their origin in leisure, they have now become a tool for educational innovation, which responds to personalized and meaningful learning (Garbanzo, et al., 2017). The proliferation of these kind of games and the online multiplayer mode has generated communities among which experiences are shared, help is requested, and problems are sought or to invite matches between teams and stay informed of important news in the field (Marcano, 2012).

Likewise, video games have a socio-affective and an educational dimension; the first helps to dynamize group relationships, enhances participatory and collaborative work and induces reflection; the second because it helps the development of skills and abilities or the development of competencies. Specifically, war video games, are based on a sensory and psychosocial environment that generates emotional states that motivate different behaviors (Marcano, 2014). If this type of video game needs to be used as a playful technique, it must be accompanied by didactics in accordance with the objectives to be achieved; Therefore, the teaching methodology that fits best is problem-based learning and leadership development since its objective is to confront the student with fictitious problem situations. In addition to the above, these types of games promote the development of competencies (Mirama, 2019).

In conclusion, the use of video games in the classroom can be an innovative strategy, so its application will depend on everything from the teacher's attitude to renounce their traditional methodology, to the tools they have at their disposal to execute it. In this way, the essential elements by which video games can help create more active learning dynamics are covered; And although more can be written, for the purposes of this article, it is fair to talk about the skills or competencies that students can acquire during undergraduate education.

2.3 Development of College Skills

The competency-based education focuses on what a student is expected to know and be able to do by the end of the course; that is, when the student has demonstrated mastery of these skills, whether transversal or disciplinary. This type of teaching emphasizes the mastery of concepts, knowledge and skills, regardless of time (Díaz & Gallardo, 2019). In the same way, it proposes a series of changes and transformations in education, some of these are (Aria & Lombrillo, 2019):

- Analysis of conceptual and factual knowledge towards a focus on comprehensive performance in the face of activities and problems.
- Education must contextualize knowledge in the local, regional and international context; In addition, there must be a dynamic of search, selection, comprehension, systematization, critique, creation, application and transfer.
- It implies that learning is at the centre of education.

This means that it is now necessary to establish what learning students come with, what their expectations are, what they have learned and what they have not, what the learning styles are, and how they can actively engage in their own learning. From this, a change in teaching can be appreciated; which is not only to make knowledge more practical or to integrate theory with practice or to orient education towards employability; With this teaching, based on the development of competencies, it is intended to guide the training of human beings towards the ideal performance in the various cultural and social contexts (Aria y Lombrillo, 2019).

To have a more specific context, it should be mentioned that competencies are emergent characteristics of the person's encounter with their qualities, experiences and interests and with the demands of an activity to be carried out (Corral, 2021). They are also known as dynamic combinations of personal resources, complex systems of understanding and action that include "knowing how to think, how to do." It is constituted as an approach or proposal to train students because it aims to achieve a complex and ideal performance; In general, it looks for a relationship between what the student learns and the challenges of post-university life (Cuadra, Castro y Juliá, 2018).

3. Methodology

This study was conducted under a quantitative methodology. This approach is decided because it best suits the needs of the analysis presented, in addition, it helps to obtain the data more accurately for subsequent interpretation. It should be noted that the quantitative study corresponds to a constituent element of the statistical method to: collect, organize, summarize, present and analyse data required by the scientific method; and to obtain inferences from a volume of data when only a part of it is observed, thus being able to reduce uncertainty with respect to a research problem; In this way, valid conclusions can be drawn and reasonable decisions can be made based on this analysis (Zúñiga y Adame, 2020).

Specifically, a questionnaire with a Likert -Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree-, scale is carried out which included five dimensions to which certain characteristics were assigned: 1) Graphics/Gameplay: includes emotion, graphics, gameplay, and realism; 2) Social interaction/comprising: group work, supportive relationship, coordination of tasks to be carried out, friendly relationships and opportunity to

interact; 3) Learning: emotional learning and competency development; 4) Challenge/Overcoming: confluence of variables: motivations and learning and resolution of the challenge posed; 5) Activity/game: war games helps not only as playtime, but also as an educative tool; and, 6) Competency development: execution of the tasks to acquire and/or develop the necessary skills declared for this session.

These dimensions help to encompass the reagents so as not to have too extensive measuring instruments, and from this classification, it is possible to make the instrument to obtain the appropriate information. The instrument, which prior to its execution had a series of pilot tests as well as some modifications to improve its comprehensibility, was as follows:

1. This game has the ideal quality in images and sounds to be able to carry out an educational activity.
2. With this activity focused on the GBL method, I had more interaction between my classmates and teachers.
3. The sustained dynamic allowed me to obtain meaningful learning outside the classroom.
4. The challenge proposed by the dynamics of this video game fulfilled my expectations.
5. This educational dynamic is a fun tool to achieve several goals.
6. I was able to identify and develop the competencies declared for this activity.

It must be clarified that only the students answered this questionnaire. There was a universe of 30 people (20 men, 10 women); everyone was part of the course: "Hydraulic Works"; The number corresponds to the total of students enrolled in that course. The students were in the 9th semester, and on average they were 23 years old.

3.1 Activity Development

To get a clearer idea of how this activity was developed, a figure is presented with the steps that followed.

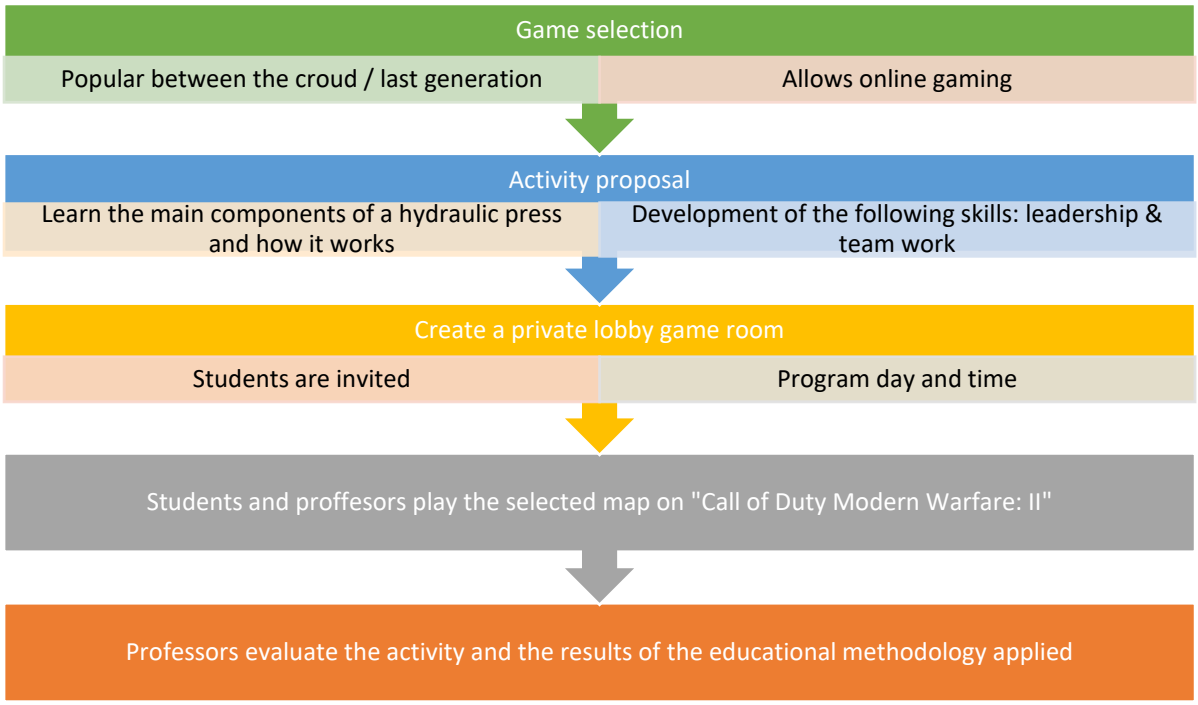


Figure 1: Step by step of the pedagogic activity

In this way, not only the methodological approach is established, but as can be seen in this image, the design process of the activity includes everything from the selection of the game to the evaluation of the pedagogical activity developed. To clarify the image presented, the process by which the activity is carried out is described below:

1. The teacher presents a topic in class
2. The professor asks who has the game "Call of Duty: Modern Warfare II"
3. In this case, all the students have played and own the game
4. The teacher tells them that he will open a private room in "Call of Duty: Modern Warfare II" and share the PIN to increase the knowledge about hydraulic Dams.

5. Time and day are shared, in this case, and according to the course length, teacher and students will be online in the game will be for 2 hours.
6. Students join the game created
7. First, a campaign is played between the participants, teams are assigned, and the game proceeds according to the rules, this means that the students enjoy the game, and literally play.
8. Once the palytime is over, the moment for the teaching and learning process is on, the teacher tells them where on the map they must go and everyone, arrives to the checkpoint mark.
9. Once in the agreed area, they talk about the construction of the hydraulic dam, how it works, main characteristics, and specific issues of this building
10. Doubts are resolved and the teacher makes a link between what is explained in class and the dam they just studied
11. The game closes.
12. The next class students answer the quiz

Once the experience was over, it was possible to verify that the dynamics used had a positive impact on the students, and this could be verified with the interaction that was had in the subsequent classes; In fact, students request that this type of experience be carried out again not only in this course; but in others to make the teaching-learning process more dynamic.

3.2 About the Video Game

The context of the game used in this activity is important, especially because one of the reasons why this video game is used is because it became the fastest-selling game in this franchise of all time. The game earned $800 million in physical sales in its first three days of release, surpassing the previous record for the series. In the UK, it became the best-selling in the week of release, in Japan, the PlayStation 4 version sold 24,371 physical copies in its first week of release. The PlayStation 5 version sold 17,710 physical copies in the same country.

Currently, "Call of Duty: Modern Warfare II" has surpassed $1 billion in sales worldwide, making it the first title in the saga to surpass this figure. As for the essential features, it is described as a first-person shooter video game developed by Infinity Ward and published by Activision. It can be played on PlayStation 4, PlayStation 5, Xbox -One, Series X/S-, and Microsoft Windows. It is the nineteenth instalment in the series of the same name. It was on sale since October 28, 2022. Finally, this game offers a set of gameplay and graphics innovations that elevate the saga to new heights, such as:

- An advanced and redesigned AI system
- Enhanced rendering and photogrammetry technology
- A new gunsmith system that allows for more customization than before.
- Pioneering innovations that set the trend in next-gen gameplay

Once the methodology, the activity applied in the session and the general principles of the game with which this practice is carried out are explained, it is possible to give rise to the results that were reached.

4. Results

The following lines present the interpretation of the questions that are asked in the measurement instrument; To make their understanding clearer, it is decided to create a graph for each of the questions and their subsequent interpretation. The findings are as follows:

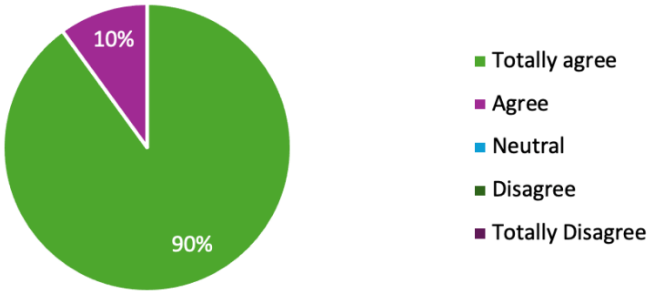


Figure 2: Question 1. With this activity focused on the GBL method, I had more interaction between my classmates and teachers.

This graph shows that 90% of respondents are in total agreement with the proposed reagent; They assure that "Call of Duty: Monder Warfare II" contains the necessary technical elements so that the educational activity carried out has the quality that is expected. In addition, they mention that when playing a state-of-the-art game, the sharpness of the graphics, the quality of the images and the realistic sound help to get even more involved with the environment. It should be noted that no one is unhappy with the visual features that the video game presents; an aspect that ensures its acceptance.

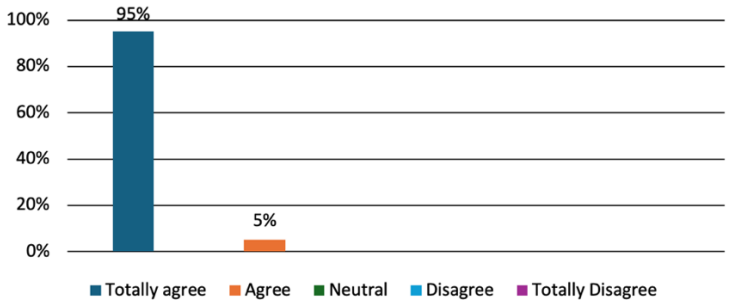


Figure 3: Question 2. With this activity focused on the GBL method, I had more interaction between my classmates and teachers.

The results of this graph show that the majority (95%) of the study subjects are in total agreement regarding the change in interaction between peers and with teachers as a result of this activity; They say that it is better, more dynamic and at times forgets the hierarchical aspect that can be presented in the room. Respondents agree that these kinds of forums are open and encourage feedback, exchange of ideas and even greater motivation to learn new things; It should be noted that 5% of respondents agree with this item.

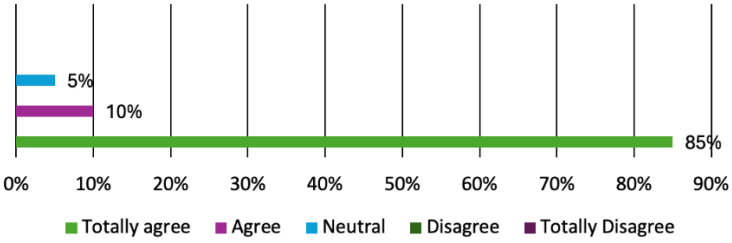


Figure 4: Question 3. The sustained dynamic allowed me to obtain meaningful learning outside the classroom.

The third question focuses on understanding how enriching learning outside the classroom was from the GBL, in this sense, 85% of those surveyed say they totally agree with this teaching style; They consider that there is a more informal forum but that it is also interesting, and they consider that the play space becomes a work environment where another type of knowledge is acquired under an innovative modality. 10% say they are totally disagreed, which also indicates that not all the group has the same skills and intention to carry out this type of activity.

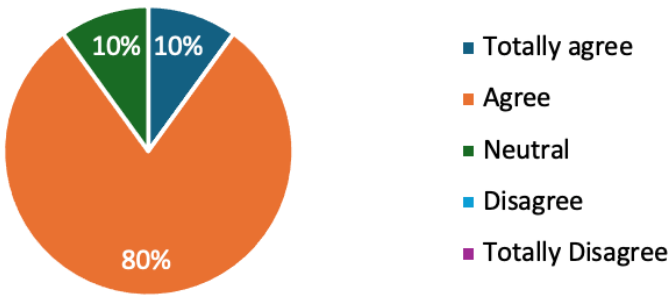


Figure 5: Question 4. The challenge proposed by the dynamics of this video game fulfilled my expectations.

For the fourth question, we seek to analyse if the challenge established when playing "Call of Duty Modern Warfare II" is adequate according to the characteristics of the game and the course taught. In this sense, 80% say they agree, while 10% are totally in agreement. It should be noted that 10% were neutral about the challenge

and the way to solve it under the GBL modality; This means that there are still people who have a percentage of resistance to this kind of educational innovations, which although they do not disagree, do not show the same level of interest as the others.

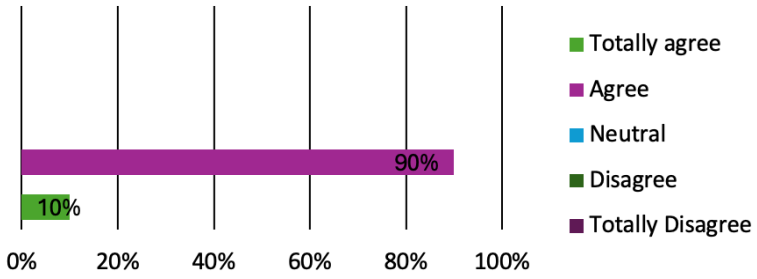


Figure 6: Question 5. This educational dynamic is a fun tool to achieve several goals.

The graph presented shows whether students find a correlation between play and academic activity. That is, if they find the link between fun and GBL. Faced with this, the answers are almost unanimous, on the one hand 90% agree and the remaining 10% are totally agree; This reflects that the pedagogical technique has the expected success, but above all, that the subjects of study -students-, understand that a video game can be used for didactic purposes and not only as a leisure space.

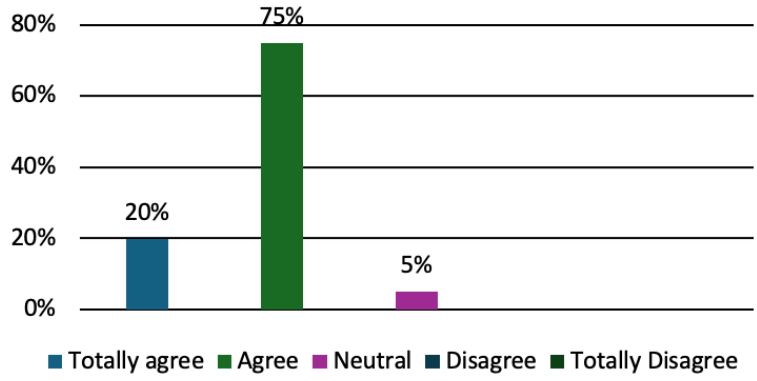


Figure 7: Question 6. I was able to identify and develop the competencies declared for this activity.

The last question refers to the way in which students develop or achieve competencies based on this pedagogical technique based on the GBL. Once again, the answers confirm the success of the dynamics carried out; This, because 75% say they agree, while 20% confirm that they are totally aggress, although 5% answered neutral in terms of the identification of competencies.

In this way, the results of this study are formed, which, as can be seen, show that the activity developed is configured as a successful technique and that it is well received by the students of the Civil Engineering career; In addition, it can be corroborated that playing "Call of Duty: Modern Warfare II" becomes a space in which learning, entrepreneurship, communication and other aspects converge thanks to the fact that this game is of the latest generation. This confirms that the GBL is an effective technique to encourage learning, teaching processes and emphasize the new role that both students and teachers have within higher education.

5. Conclusions

It is a fact that for some years now, the use of games in educational environments has become one of the didactic methodologies that has provoked the greatest interest among teachers and students, especially because it creates great expectations due to the ability to surprise and contrast with other types of more conventional techniques. As a learning alternative, it allows students to have more active learning processes, establish links with their peers and teachers, as well as signify the way they acquire new knowledge since games provide holistic, problem-based environments.

In this way, once the study is completed, it can be concluded that the objective of this activity is achieved; In this sense, the Civil Engineering students who participated in the dynamic developed some competencies such as

leadership, teamwork and problem solving. This could be verified with subsequent exercises where the way of addressing and seeking solutions to different academic problems could have better results.

In addition, it can be assured that "Call of Duty: War Zone II" is a game that not only entertains, but also helps both teachers and students to have a more active role in the teaching and learning process, relate under other types of schemes and in unusual forums and find points of interest; In addition to this, it can be seen that video games can have an educational purpose and not just entertainment. In this sense, it is here where the GBL finds a meeting point with educational innovation and the disruption that teachers must have when planning their sessions.

Finally, it should be mentioned that for these teaching proposals to have the impact that is required, it is important that, on the one hand, the teacher not only knows the games they intend to use, but also requires constant teacher updating. The idea of connecting with students and making educational processes more interesting not only requires technology, but also a sense of educational innovation that manages to go beyond the classroom, and if an educative institution wants to use GBL, it must have the necessary tools to be able to carry it out. Always, thinking that digital technology is a tool and not the objective, that is, the teaching staff must rely on it and not depend on it.

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Talking to Machado de Assis: Generative Artificial Intelligence to Simulate Dialogues with Prominent Figures

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Abstract: Generative artificial intelligence encompasses techniques for automatically generating content such as image, music, and text. A common application of these techniques, especially involving text generation, is the construction of conversational agents. In education, generative artificial intelligence has the potential to transform the learning process and enable new forms of teaching, such as the practical application of concepts studied in class and the acquisition of new knowledge through the interaction with computational tools. In Brazil, literature teachers often complain about students' resistance to the content and insufficient reading practice. To address these challenges, this work presents a serious game in which students can chat with Machado de Assis, an important writer of the Brazilian literature. The game was developed by integrating with ChatGPT. The validation was conducted with 15 high school students for them to interpret the book "Dom Casmurro". The MEEGA+ instrument was used to evaluate the usability and the experience with the game. The main findings were that students better understood the book, found the game easy to use, and felt immersed in the conversation with Machado de Assis, although they assessed the texts as long and tiring. In a world dominated by faster and visually stimulating forms of entertainment, such as video games and social networks, students may have different expectations regarding the reading experience. If they are not used to reading denser and more introspective texts, they may find it difficult to maintain interest when chatting with Machado de Assis. Finally, another implicit point in the game dynamics is observed: the (re)signification of the methodology to be adopted by the teacher, who will perceive the need to complement interactions with the writer in class according to what he can or should answer, tending to responses that stimulate students to study more about what is within the realm of knowledge about Machado de Assis.

Keywords: Literature, Serious Game, Educational Game, Generative Artificial Intelligence.

1. Introduction

Generative artificial intelligence (GAI) creates and interprets data, generating new information or artifacts based on learned patterns (Hu, 2022). In education, some reported benefits include the use of conversational agents, automated grading of essays, and personalized learning (Baídoo-Anu and Ansah, 2023). Overall, teachers believe that GAI can positively contribute to their pedagogical practices, especially those who have already experienced techniques of this nature (Kaplan-Rakowski *et al.*, 2023). Indeed, many research studies are focused on identifying the impacts of GAI in education and research, with a special emphasis on its contributions to learning (Cooper, 2023; Peres *et al.*, 2023).

Conversational agents built on generative AI models have made notable contributions in education by allowing personalized and interactive learning. These agents leverage natural language processing capabilities to engage learners in dialogues, offering real-time feedback, elucidations, and customized educational materials. By emulating human-like conversations, they promote active engagement and deeper understanding of concepts in fields of knowledge (Bozkurt, 2023). Examples of conversational agents for education include the simulation of medical patients (Anubharath *et al.*, 2019), writing assistants (Resch and Yankova, 2019), and language tutors (Pham *et al.*, 2018). Besides, there are several examples of GAI's contributions in different areas of education, including chemistry (Atmosukarto *et al.*, 2021), geography (Wilby and Esson, 2024), and languages (Pack and Maloney, 2023).

This article presents an experiment involving 15 high school students using a serious game that, through a conversational agent provided by ChatGPT, reproduces a famous Brazilian literature writer named Machado de Assis. Their performance was measured through a pre- and post-test protocol with 10 multiple-choice questions. The MEEGA+ instrument was used to measure how enjoyable the game was (Petri, Wangenheim and Borgatto, 2018). The objective of this work is to verify whether this conversation with the author can improve students' understanding of one of his works and relate students' impressions to this experience.

The following section describes some theories and related work that served as inspiration for some aspects of our work. Section 3 presents the game mechanics and its elements. Section 4 describes the research questions

and the methodology used in our research. Section 5 presents and discusses the results obtained. The paper concludes with a summary of the main findings and some ideas for future work.

2. The use of Games to Overcome Challenges in the Teaching of Literature

Almeida (2007) identified that there are difficulties in all disciplines but observes that Literature is one of the most problematic area. One of the reasons is that teachers insist on recommending readings that are not highlighted in the media (the bestsellers) (Zamariam, 2016), or that are difficult to interpret due to elaborate vocabulary. Additionally, the intensive use of social media distracts students, constituting aspects contrary to literary reading (Mbamalu and Onyido, 2019). The provision of short and disposable information has accustomed individuals to rapid and chaotic consumption, the opposite of the concentration and slowness required by the reading of literary texts.

It is worth noting that Almeida (2007) highlights issues in the content of Literature disciplines. The contents are focused on the history of Brazilian literary movements, rather than on reading literature, which further distances students from an interest in reading. Almeida (2007) suggests doing the opposite: starting from the interpretation of the works to identify characteristics that position them within a literary school. Thus, studying Brazilian literature from this perspective represents imprinting a memory in the language (Payer, 2007), which valorises it as Brazilian cultural heritage and strengthens literature in the country's identity formation.

Games have been used as motivators to get students interested in reading (Silva and Fernandes, 2015). Learning is stimulated by curiosity through the presentation of new challenges that arise as the game and the story progress (Gee, 2004). Learning should be subordinate to the plot, but fun should come first, with instruction following afterwards (Zyda, 2005). For a serious game to be effective, it is necessary to strike a balance between teaching without losing the significant aspect of fun (Breuer and Bente, 2010), meaning that learning should be embedded directly in the flow of the game. Games can be used as a complement to literature teaching in schools to empower students in understanding and perceiving the poetic language from the books (Silva and Fernandes, 2015).

Furtado, Vallerius and Barone (2013) and Record Jr *et al.* (2023) proposed digital games to reproduce the book "Vidas Secas" by Graciliano Ramos (Brazilian writer). The first game is a proposal in which the character embarks on exploring the scenarios to experience the plot of the book. The second is a game that presents a visual novel, with some decision points by the player. The 13 chapters of the book were developed, and the game was evaluated by Computer Science students and Literature teachers, highlighting that the game is like a graphic novel that easily promotes understanding of the work.

Zamariam (2016) presented a tabletop RPG proposal based on the book “A Cartomante” by Machado de Assis. After evaluating it with three groups of four students who claimed not to enjoy reading, the author observed the recovery of the students' affection for reading, enabling them to become more immersed in performing the roles of their characters. Furthermore, in Roiphe (2020), 34 physical games were organized with applications for literature, taking into account students' low interest in activities directed towards text reading and textual production. This work presents inspirations for memory games, question and answer games, card games, and many other types.

These studies highlight a gap in student engagement with reading habits, pointing to the need for innovative strategies that can arouse students' interest and curiosity. The lack of motivation for reading not only affects students' academic performance but also compromises the development of critical skills and the appreciation of the cultural richness present in literary works. Therefore, the analysis of these works reinforces the importance of alternative approaches, such as the use of educational games, to reverse this worrying trend and promote a more vibrant and participatory reading culture in classrooms.

3. The Game: Historical Chat[1]

Machado de Assis, son of poor mulatto parents and born in Rio de Janeiro in 1839, faced a difficult childhood and had limited access to formal education (Miguel-Pereira, 1938). However, his early intelligence and passion for reading led him to work as an apprentice typesetter, where he came into contact with various literary works. His works, which address themes such as society, human psychology, and the contradictions of urban life, are

[1] In portuguese the game is called “Chat histórico”.

known for their psychological depth and his ability to explore the complexity of the human condition. Machado de Assis passed away in 1908.

The application was developed for Windows 10 or upper using Unreal Engine 5.3.0. Unreal Engine is a game engine widely used for developing interactive digital games, creating immersive virtual reality experiences, and various other applications such as simulations and visualizations for medical and scientific visualizations (Epic Games, 2024).

To enable ChatGPT to mimic a personality, it is necessary to provide it with certain information when sending each sentence. For this experiment, the following text is transmitted with each interaction, to answer in the manner of Machado de Assis (translated from Portuguese).

> *Machado de Assis, one of the foremost figures in Brazilian literature, was born in Rio de Janeiro in 1839 and departed this mortal realm in 1908. A maestro of realism, his astute and perspicacious prose captivates readers worldwide. His mastery in delving into the human psyche and unveiling the intricacies of interpersonal relationships rendered him an iconic luminary of literature.*
>
> *His refined and elegant prose, coupled with a discerning critique of society, established him as a paragon of literary excellence. Among his most renowned works are "Memórias Póstumas de Brás Cubas" (The Posthumous Memoirs of Bras Cubas), "Dom Casmurro," and "Quincas Borba." Furthermore, he distinguished himself in the realm of short stories, as exemplified by the narrative "O Alienista" (The Psychiatrist).*
>
> *Please feel free to engage in dialogue, and I shall endeavor to respond in a manner reflective of Machado's distinguished style.*

When entering the application, the welcome screen is shown as illustrated in Figure 1. After the user clicks in any place, the application displays the main menu with three options: play, about and exit.



Figure 1: Application Home Screen



Figure 2: Main Screen

To start the interaction with the application, the user clicks Play, and he/she is transported down the stairs from a library to a Magical Book where the face of Machado de Assis is displayed.

From this moment the user can chat with Machado de Assis. Figure 2 demonstrates the corresponding graphical user interface. There is an input field where the user types his/her questions and sends them to Machado de Assis by clicking the button "Enviar"[2]. Next, the application answers through a text above the book (the answer area).

4. Methods and Materials

4.1 Research Purposes, Questions, and Hypothesis

Even in serious games where learning is the main purpose, the game design must also take the enjoyment into consideration. This is important to promote student motivation, which is one of the reasons to use games in learning contexts. Furthermore, as previously described, students have lost interest in extensive and complicated readings in favour of the immediacy of social media and mobile device apps. Therefore, a conversational agent that reproduces Machado de Assis could be a way to try to increase students' interest towards literature.

The main purpose of this study is to assess whether the use of a conversational agent can increase students' motivation and interest in learning literature. The hypothesis examined in this study is as follows:

H_0: There will be no difference in students' knowledge about the book "Dom Casmurro" of Machado de Assis after the intervention with the game.

Also, as research questions we considered:

1. Did the students enjoy the game?
2. Did the students find the intervention with the game interesting for fostering their motivation in reading?

4.2 Participants

This study was conducted in August 2023 in a second year of high school with 15 students aged 16, comprising 8 males (53%) and 7 females (47%).

4.3 Procedure

The validation protocol was determined as follows (Figure 3): the teacher led the students with activities and tasks to develop their knowledge about Brazilian literature. One of the researchers attended a class to present aspects of the software development profession, discussed this research, and provided a consent form for their parents to sign. Along with the teacher, students were suggested to read the book "Dom Casmurro". Another class was scheduled for them to return the form enabling them to carry out the experiment. Next, the students answered a pre-test (Figure 4) with ten multiple-choice questions. The researcher conducted the experiment initially by asking them to greet Machado de Assis to familiarise themselves with the application. Then, he asked the students to pose questions to Machado de Assis to comprehend the book "Dom Casmurro", e.g., where the story takes place, who the characters are, what a 'casmurro' is, and events that occurred in the plot (as illustrated in Figure 5). After this period of interaction with the application, the post-test (again Figure 4) was applied with the same questions as the pre-test, but with a different order for questions and alternatives of answer. Then the researcher asked the students to express their opinions about the game using the MEEGA+ assessment instrument. To conclude, the researcher conducted a semi-structured interview (Figure 6) to gather the students' suggestions and impressions regarding the experience.

[2] In English is Send

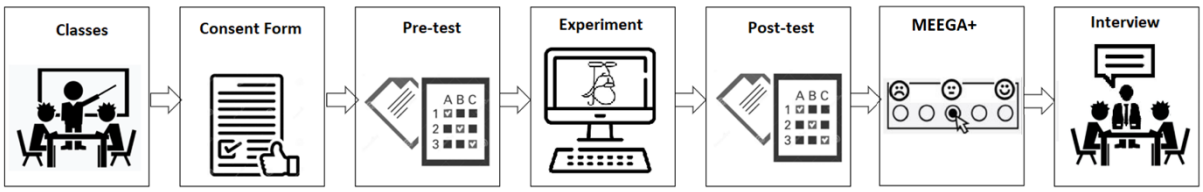


Figure 3: Validation protocol

1. What is the nickname that gives rise to the title of the book?
a) Capitu Casmurro b) Bento Casmurro c) Dom Casmurro d) Doutor Casmurro

2. What is the central event that triggers Bentinho's jealousy towards Capitu?
a) A wedding party b) Escobar's death c) Capitu's wedding d) A trip by Capitu

3. The narrator of the book is known by what nickname?
a) Santi b) Bentão c) Ben d) Bentinho

4. What is the name of the protagonist in "Dom Casmurro"?
a) José Dias b) Ezequiel c) Bento Santiago d) Capitu

5. In which city does most of the story take place?
a) Rio de Janeiro b) Minas Gerais c) São Paulo d) Salvador

6. What is Bentinho's ultimate fate at the end of the book?
a) He becomes a priest b) He marries Capitu and they live happily ever after c) He isolates himself from the world as a hermit d) He travels abroad

7. Who is Bento Santiago's best friend during his childhood?
a) José Dias b) Escobar c) Padre Cabral d) Capitu

8. Which of the following statements describes the reliability of the narrator in Machado de Assis's "Dom Casmurro"?
a) The narrator is completely reliable and reports events impartially.
b) The narrator is a fictional character and does not influence the story in any way.
c) The narrator is biased and tendentious, distorting events from his own perspective.
d) The narrator is reliable but occasionally forgets details of events.

9. What is Escobar's profession?
a) Lawyer b) Doctor c) Teacher d) Merchant

10. The book "Dom Casmurro" is an example of which literary style?
a) Romantic Novel b) Realistic Novel c) Epic Poetry d) Science Fiction

Figure 4: Knowledge test questions

1) Greet Machado de Assis and ask to discuss the book "Dom Casmurro."
2) Try to find out about the book: how the story is constructed, who the main characters are, where the main locations are situated, etc.
3) What is the central part of the story? Who is involved?
4) Why is the book called "Dom Casmurro"? What is a "casmurro"?
5) What happens at the end of the story?

Figure 5: Suggested script for the students

1. What did you learn from playing this game?
2. What did you enjoy about this experience?
3. What did you not like?
4. Any other comments?

Figure 6: Semi-structured interview questions

5. Validation and Discussion of Results

The study aimed to assess the knowledge acquired between the two validation moments, as per the statistical hypothesis below.

$H_0: \mu_{pre} = \mu_{post}$ There will be no difference in students' knowledge about the book "Dom Casmurro" of Machado de Assis after the intervention with the game.

In Figure 7 is illustrated the frequency at which of 15 students play digital games. We can observe that the majority of students play at least once a week.

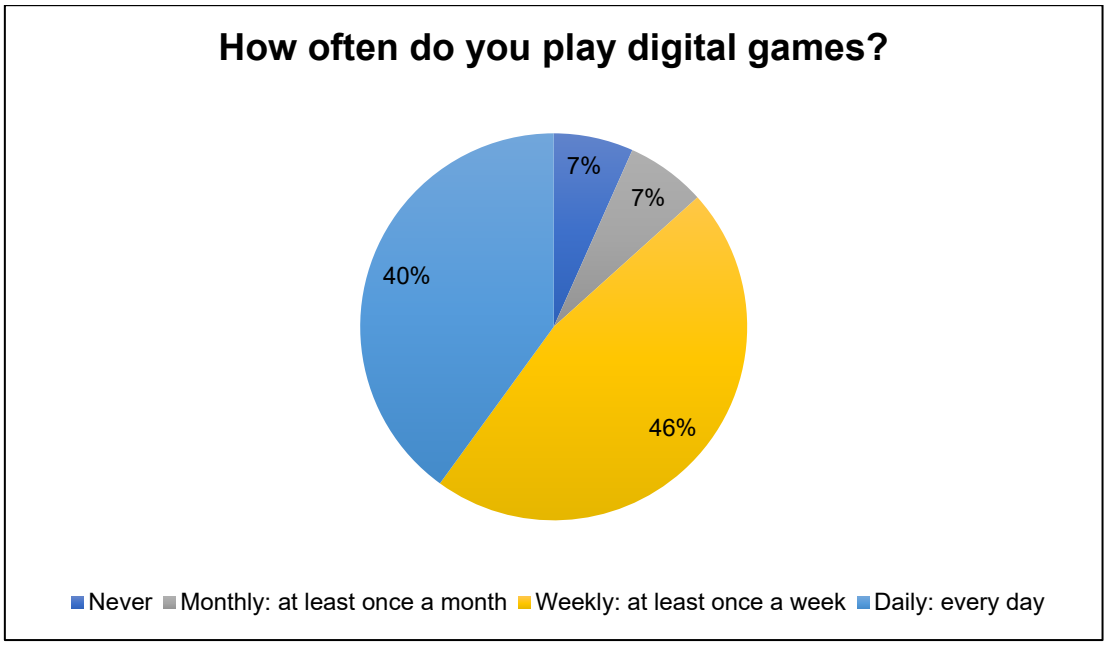


Figure 7: Frequency of students to play digital games

Table 1 presents the descriptive statistics of the tests. The questionnaire had 10 questions and 15 students participated, so total possible points are 10 x 15 = 150. It is evident that both the mean and median were higher in the second test compared to the first. Another interesting point is that the variation among students in each test remained similar. Additionally, Figure 8 displays the scores obtained by each of the 15 students in each test. Fourteen out of the 15 students improved their performance between the Pre-Test and Post-Test, while one student (number 2) maintained the same performance between the tests.

Table 1: Descriptive statistics of the knowledge tests

	Total possible points	Total points achieved	Mean	Median	Standard deviation	Variance
Pre-test	150	92	6.13	6	1.46	2.12
Post-test	150	131	8.73	9	1.53	2.35

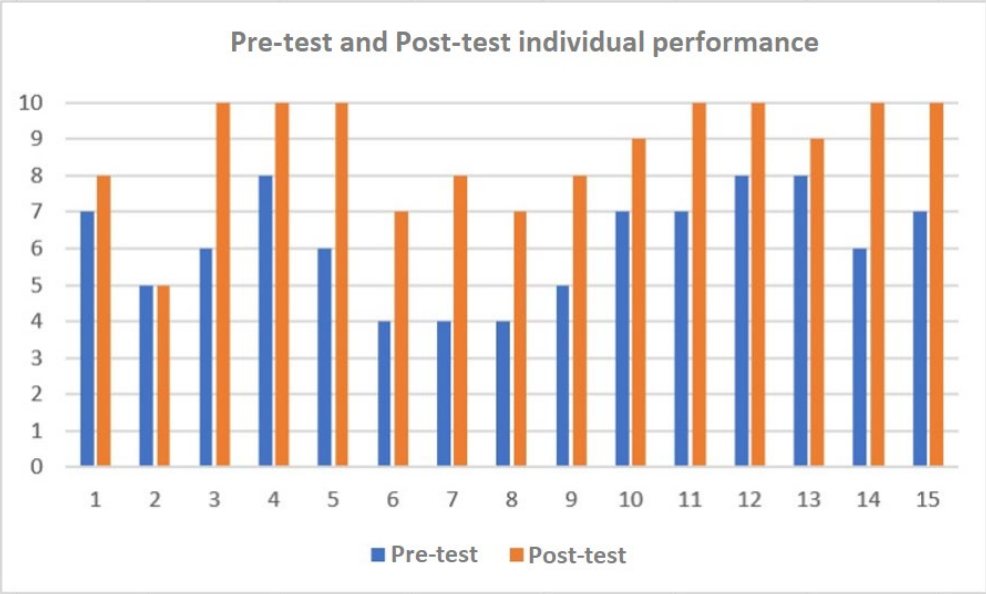


Figure 8: Individual performance on the tests

To verify whether the difference is statistically significant, the statistical hypothesis was evaluated using a paired t-test. The result of the *p-value* is 1.64 x 10^{-6}, so rejects the null hypothesis that the performance was the same between the two tests with over 99% confidence. Since the mean of the post-test was higher than the pre-test, it can be concluded that the performance improved after the application.

After the post-test, students answered the MEEGA+ instrument. It is composed by 27 items organized into 12 dimensions (aesthetics, learnability, operability, accessibility, confidence, challenge, satisfaction, social interaction, fun, focused attention, relevance and perceived learning) divided by two factors: usability and player experience. The graphs presented in Figures 9 and 10 show the distribution of each item among the five levels of agreement, from completely disagree (value=-2) to completely agree (value=2). The medians represent the most frequent level of agreement on that item. Almost all the medians show values of agree or strongly agree. Figure 9 show the items of usability factor. We can conclude that the lowest level of agreement was in the accessibility dimension, where students encountered some difficulty in reading due to the fonts size and styles. In Figure 10 are the items related to the player experience factor. Only the item describing the possibility of improvement in understanding the book did not reach the agreement of most students.

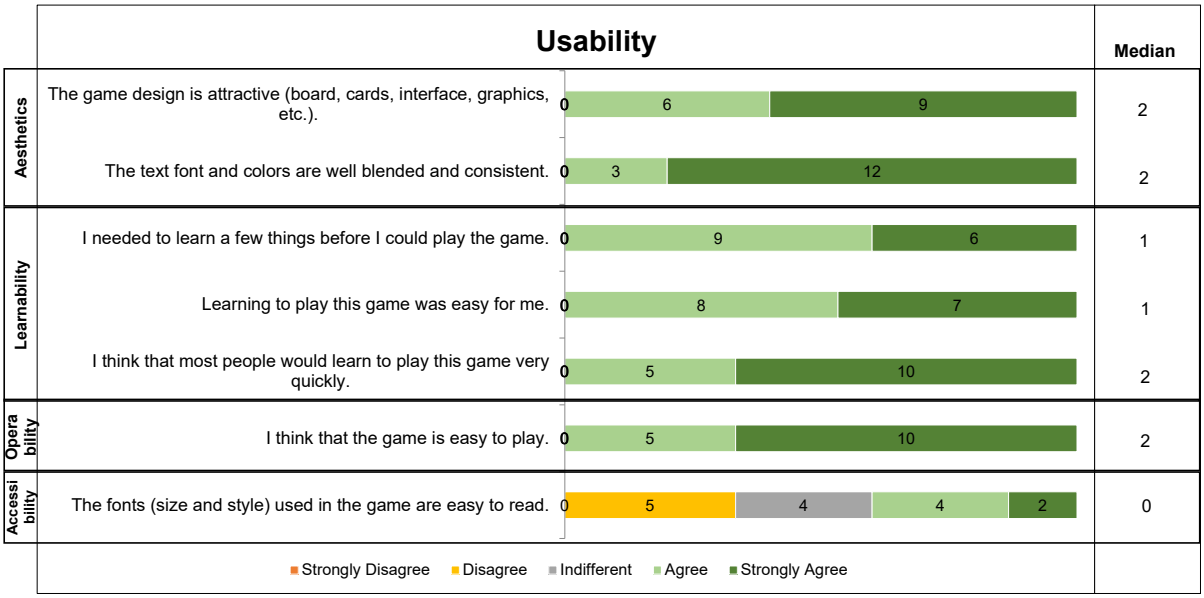


Figure 9: Usability evaluation

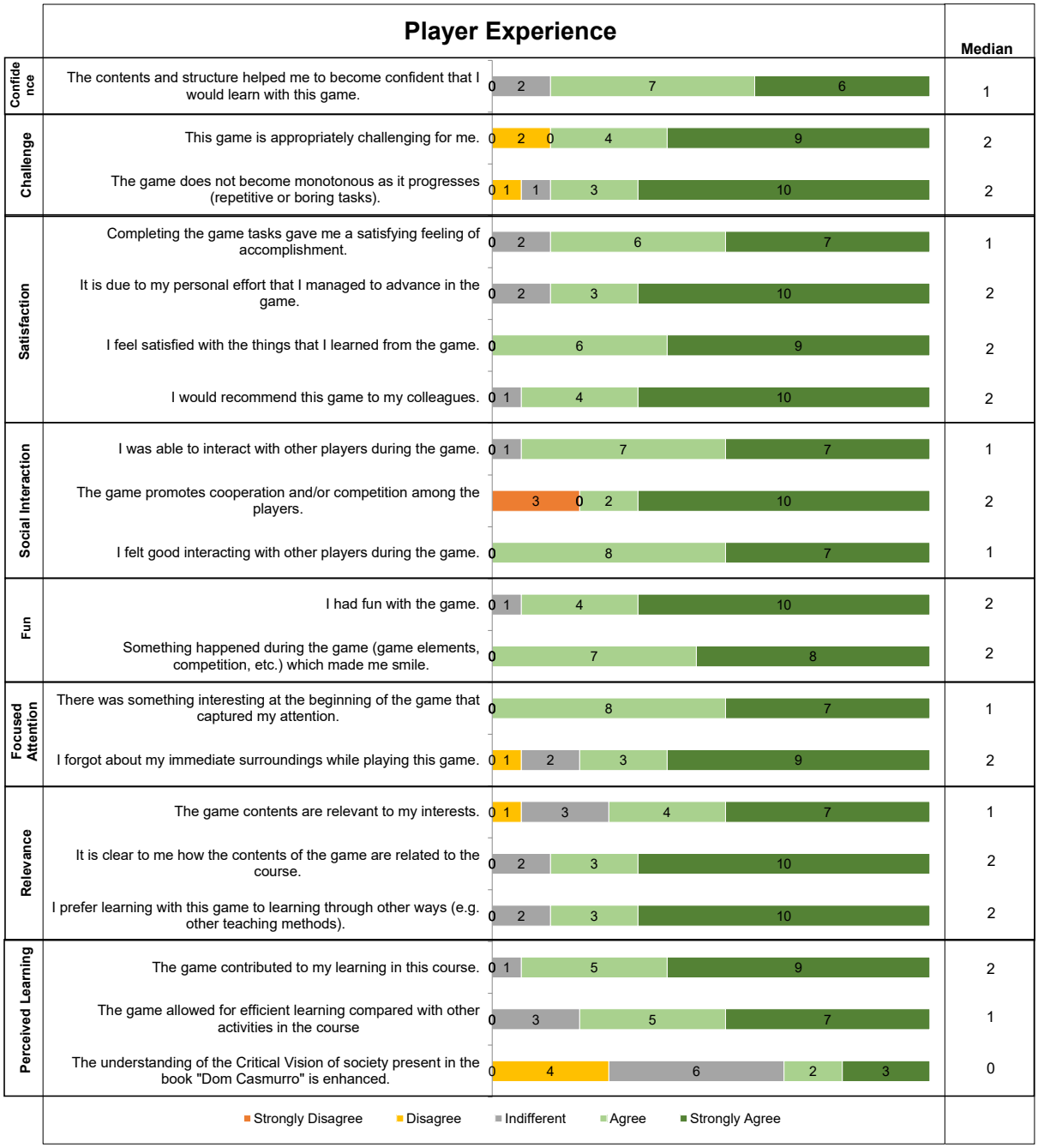


Figure 10: Player experience evaluation

To better understand these agreement values pointed out by the students, a semi-structured interview was conducted. The students commented that they enjoyed the activity of talking with Machado de Assis, as it allowed them to create a more intimate connection with him and the book, enabling them to explore other interpretations and aiding in the understanding of his messages and symbolism. However, the students highlighted the author's long and tiring responses, which required the use of a dictionary and a more accurate interpretation of what he was saying.

From a technical standpoint, the responses were coherent with the author's personality and the era he lived in. However, Machado de Assis' dialogues are structured in long narratives, and as reported by the students, they became tired very quickly with the stories presented. As an example of this, in the work "Dom Casmurro", the narrator-character, a 60-year-old man, recounts a love story with his neighbour, as well as a supposed betrayal. For a young person of the 21st century, in a context filled with technology, what interest is there in this plot? Presumably: none. Thus, literature is losing its value because the way it is brought into the classroom no longer

engages with the way contemporary youth construct knowledge. As a result, they do not read, cannot develop a habit because there is always something more interesting on the internet or in online games.

However, the students rated the game as easy to use and the gaming experience rewarding. Furthermore, as evidenced by the performance in the post-tests, interacting with Machado de Assis, even just within the context of reading one of his works, can be an educational and enriching experience that goes beyond simple literary analysis and extends to the personal and intellectual development of the students. The teacher's habit of engaging in this type of activity can modify the motivations and intentions of these young students.

6. Conclusions

The love for reading isn't "teachable", but young people can be guided on what to read if they find pleasure in reading. Differentiated and challenging activities can promote motivation in the pleasure of reading. The use of games, as presented in this paper, can be an effective alternative to awaken interest in reading. The interactive approach of games can make the reading experience more fun and stimulating.

Corroborating Gee (2004), learning does not simply occur through contact with technological tools, but rather through interaction. The game presented in this work demonstrates that. It was a fun interface with ChatGPT that mimicked Machado de Assis' responses, and its use showed that students achieved a better understanding of the book "Dom Casmurro". According to the results of the MEEGA+ instrument, the students enjoyed the game. However, as discussed at the end of the previous session, due to various factors, it is not possible to determine that the students found the intervention with the game interesting for fostering their motivation in reading.

The game configured as Machado de Assis can be used by the teacher to explore other books. Nevertheless, it demonstrated the potential for further research to investigate its effectiveness with other authors and, perhaps, the creation of more complex games involving different types of interactions with the author as an NPC (Non-Player Character), and even consequences based on the player's decisions according to the NPC's responses.

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Media at a Crossroad: Where Streaming, Games, Culture and Learning Meet

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Abstract: This article investigates instances of knowledge transference and construction in game-centred interactions. It combines computer science and linguistic research techniques to analyse instances of learning in streamed interactions. It identifies instances of knowledge transference and construction in chat interactions, streamer-chat interactions, and streamer-player interactions. The argument is presented that with a combined linguistic and game-based learning analysis technique instances of learning can be holistically explored and identified.

Keywords: Game-based Learning, Knowledge Transference, Knowledge Construction, Conversation Analysis, Cognitive Apprenticeship, Stream, Twitch.

1. Introduction

In the field of game-based learning (GBL), gaming holds as much potential for learning as educational gameplay. The range of genres within the field of gaming makes it difficult to explore instances of learning as understood through the transference and construction of knowledge. Nowadays, streaming platforms, like Twitch, play host to a significant portion of gameplay that occurs in massively multiplayer online (MMO) games as well as massively multiplayer online role-playing games (MMORPG). These streaming platforms, in turn, expand the potential for learning beyond in-game interactions and further complicate the identification of isolated instances of knowledge transference and construction.

This paper explores learning in the form of instances of knowledge transference and construction across three gaming genres during Twitch streams. It explores the scaling of knowledge within a domain, along the spectrum of “expert” and “novice” by leaning on previous research in these areas. Instances of knowledge transference are explored between streamers, players, and chat participants active in streamed sessions of Minecraft, PUBG, and Final Fantasy XIV. The author uses Computer-Mediated Conversation Analysis (CMCA) to investigate instances of knowledge transference and construction within the domain of serious games entertainment gaming. Through a combined analysis of player actions and dialogic interactions, the argument is presented that instances of knowledge transference and construction can be identified across gaming genres. The argument is also presented that not all instances of knowledge transference correlate to learning within the context of knowledge construction.

The data from this paper comes from an investigation of around 15 hours of Twitch streams, including a minimum of 90 minutes of game-play in three different gaming genres. The results are not groundbreaking but an accurate depiction of the complexity of identifying learning in gameplay of entertainment titles.

1.1 Learning in GBL

In the field of game-based learning (GBL), serious or entertainment games are seen as containing as much potential for learning as digital tools whose central aim is learning. To understand the use of entertainment games for learning, we must first understand learning.

Learning can be understood through an examination of knowledge construction and transference. Knowledge can be transferred between individuals who operate within the ascribed spectrum of “novice” and “expert” and interact within a domain. The knowledge that is transferred can also be scalable along the hierarchy of “rudimentary” and “complex” within said domain.

The range of genres within the field of GBL makes it difficult to explore instances of learning as understood through the transference and construction of knowledge. Furthermore, streaming platforms, like Twitch, play host to a significant portion of gameplay that occurs in massively multiplayer online (MMO) games as well as massively multiplayer online role-playing games (MMORPG). These streaming platforms, in turn, expand the potential for knowledge transference and construction beyond in-game interactions and further complicate the identification of isolated instances of knowledge transference and construction.

2. Knowledge Forms

In sociolinguistics knowledge transference and constructed throughout a conversation and within an interaction. Additionally, both occur on an individual or collective level and are tracked through the sequencing of linguistic markers in a conversation. These markers are then distinguished as indicators of either transference or construction. These instances are further influenced by social and collaborative interactions, speaker contexts, and speaker backgrounds (Heritage, 2013).

In GBL an analysis of linguistic actions and interactions is combined with an analysis of gameplay. Consequently, research has shown that knowledge transference and construction can occur between the game and the player or between players during gameplay (Gardner, 2010).

2.1 Domain Knowledge

Domain Knowledge is viewed differently in sociolinguistics and GBL. In sociolinguistics, knowledge is understood as common, mutual, or shared (Lee, 2001). In analysis knowledge of the world or environment is differentiated from linguistic knowledge (Kess et al, 1985). It follows that knowledge can be understood within a local or global context. Domain knowledge is then understood on a micro, meso, or macro level and is always understood in the context of a conversation. For example, domain knowledge can refer to the background of an individual or a shared context between individuals. On a micro level, domain knowledge could refer to a specific topic or a previous interaction within a conversation, i.e. what someone said two minutes ago. On a meso level, domain knowledge could refer to a topic or interaction across a set of conversations- i.e an individual's experience on a series of dates. On a macro level, domain knowledge could refer to a larger cultural trend or a knowledge category, i.e. discussions on politics in Western societies. In all instances, micro, meso and macro domain knowledge exists and functions within a larger social or cultural context.

In GBL, domain knowledge can be understood as the learning domain or the area in which learning takes place. Learning domains often refer to traditional school or learning subjects like Math, Science, or Literature (Bakan et al, 2018). In serious games, domain knowledge has traditionally been identified as knowledge of game mechanics, knowledge of a game, or gameplay within a game (Hanghøj et al, 2022).

2.1.1 A "Right" to Domain Knowledge

When knowledge is understood in a larger social, societal, and cultural context, an individual's right to participate in a knowledge domain, is always determined by others. These individuals could simply be participants in the conversation or outside individuals who are community members within the said domain. Individuals not only determine participation in a domain but also participation in knowledge construction. Moreover, an individual's status in a domain, ascribed by other individuals, is often based on their experience within that domain (Stevanovic, 2014). An individual's right to a knowledge domain and participation in knowledge construction is understood as epistemic authority.

Epistemic authority is understood as a right to or knowledgeability in a domain, which is often attained through experience in that domain. Epistemic authority is indexed in a conversation as high (K+) or low (K-), based on a speaker's expression of knowledge and the acceptance of a speaker's knowledge and authority by other participants in the conversation (Heritage 2013, Baynham, 2011). The transfer of knowledge occurs between participants with higher and lower epistemic authority. Thus an analysis of epistemic authority includes a distinction of knowledge transference and construction.

When combining these contexts, domain knowledge on a micro level would be understood as actions, events or affordances in a game, including previous conversations about the game. On a macro level, knowledge domain would be understood as the larger social and cultural field of gaming or the experience of an individual in gaming throughout their life. Finally, the status and role of an individual as "gamer" would be contingent on their epistemic authority, as well as knowledge transference and construction while interacting in a gaming community.

2.2 Knowledge Construction

Participants in a conversation create coherence, or shared meaning about identities, meanings, and events (Jacoby et al, 1995). As active participants in a conversation, Individuals process knowledge as the conversation progresses, and construct new knowledge based on the synthesis of transferred knowledge. Knowledge

construction is understood as the collection, refinement, and reflection of instances of knowledge transference (Hull et al, 2009).

Knowledge can also be constructed collectively and collaboratively- known as knowledge construction or co-construction (Zheng, 2012). Social constructivism and constructivist learning view (social) interaction as essential for learning. It follows that knowledge construction and co-construction is a paramount action in collective and collaborative learning theories. Moreover, the examination of the performance, negotiation, and attributions of roles and status during knowledge construction is equally valuable in the investigation of collaborative and collective learning (Baynham, 2011). In GBL, social constructivism and constructivist learning theories view expert (domain) knowledge and game progression as contingent on player interaction (Egenfeldt-Nielsen, 2006). Consequently, constructivism looks at competition and collaboration gameplay and game affordances that impact expert knowledge construction (Bakan et al, 2018).

2.3 Knowledge of Individuals

In a conversation, Knowledge construction includes constructing knowledge of individuals within a conversation. Individuals in a conversation express, perform or negotiate a status or role. Similarly, an individual can ascribe or be ascribed a status and role according to their epistemic authority. When it comes to domain knowledge, a common role and status is “expert” and novice”. (Thorne et al, 2012).

In GBL, the expression, performance, negotiation or attribution of the role and status of expert and novice is analyzed through collaborative and collective game-play. (Drosos et al, 2021). In these interactions, the game itself functions as a platform for collaboration between experienced (expert) and less experienced players (novice) (Rama, 2012). Moreover, gameplay and player interaction become a means by which players negotiate their roles as novices and experts (Steinkuehler, 2012). The role of expert, for example, is taken on when players give feedback on in-game action and gaming strategies. In contrast, the role of novice is performed and the status of expert is attributed when less experienced players seek advice on gaming strategies or in-game action from another player.

The performance of the expert role or status can also be then identified through the expression of expert knowledge. In some instances, the status and role of an expert is understood as a player possessing and executing expert knowledge of a game. A player with expert knowledge is seen as someone who can control game mechanisms or mechanics, comprehend multimodal texts, interact with and use game artifacts, and navigate, strategize, and problem-solve using game rules and affordances (Kiourti, 2022). The expression of expert knowledge can also be demonstrated through the refinement and reflection on past in-game actions (Richard, 2019) or the increase in speed or routine nature of in-game actions (Drosos et al, 2021).

3. Streams and Gaming

Streaming platforms provide a complex and rich setting for the investigation of knowledge construction (Tsovaltzi et al, 2019) and collaborative game-centered interactions (Faas et al,2018). Twitch is a streaming platform through which users from multiple languages, educational, and socio-economic backgrounds participate in gaming communities and collaborative gameplay known as live gaming. In streamed live gaming sessions gameplay can be in solo modes, player versus player, and collaborative modes of play with other streamers or in teams. Participants in streamed live gaming sessions can interact with streamers/players in chat and through the purchase of emotes and gifts that are channel specific. In GBL, an analysis of streamed gameplay can provide insight into collaborative interaction between players with varying game experiences, play levels, and gaming backgrounds. knowledge transference (Tsovaltzi, 2019) and collaborative learning (Faas, 2018) Our study focuses on gameplay in Twitch streams.

A stream based analysis was selected for this research packages based on the nature or previous research in streamed game-based interactions. Ideally, a stream-based analysis framework would yield uniform results across entertainment gaming title genres and gameplay interactions.

4. Data Collection

What follows is an examination of collaborative gaming interactions, across three games and genres in Twitch streams. The analysis of streams is done through the examination of knowledge transference and construction within the framework of Computer-Mediated Conversation Analysis (CMCA) (Herring, 2004).

4.1 Research Question

There are two questions we sought to answer through data collection about knowledge construction and transference. The first question is how knowledge transference and construction are present. This entails the identification of instances of knowledge transference and construction and an analysis of the content and nature of such knowledge. Does, for example, the nature or content of knowledge change? The second question is how knowledge transference and construction relate to the relationship between players and community members who are participating in the streams. Is, for example, knowledge more often transferred or constructed as the players move away from being novices to experts?

4.2 Game Selection

Three entertainment title genres were selected based on data on popular games among EU and US gaming populations (Newzoo, 2023). One game was selected for each category based on similar studies (Hanghøj et al, 2022, Albathi, 2022).

The three game categories selected were a.) open world-sandbox, b.) action adventure-atmospheric exploration, and c.) tactical first-person shooter. An open-world game is any virtual unstructured world where a player can freely, as opposed to linearly, move around and accomplish tasks in a game. A sandbox game is a creative element to a game that allows players more freedom in accomplishing goals in a game. Action-adventure games emphasize physical challenges that require players to use motor skills to accomplish goals, overcome obstacles, or collect items. Action-adventure games often surround a single theme, story, or setting that is explored as the game progresses. Shooter games involve the use of weapons to battle opponents, or complete challenges in the game. Finally, a tactical game involves strategic movement along a grid, often a map, and is played in a first-person format.

The games in this study are Minecraft, PUPG Battlegrounds, and Final Fantasy XIV. This selection of games also ensures the inclusion of Massively Multiplayer online (MMO) games as well as Massively multiplayer online role-playing games (MMORPG). From the selection of games, gaming modes were specified. In Minecraft gaming sessions survival mode was selected since it was a linear goal of defeating the Ender dragon. In PUBG Teams has a linear goal of surviving a Battle Royal, and Final Fantasy XIV has a player versus player (PvP) function in Crystalline Conflict and Frontline that has the linear goal of a team successfully pushing a crystal to the opposing team's side. All of these modes require collaborative gameplay and coordinated game action.

4.3 Stream Selection

Streamers who streamed consistently gameplay in each of these games were selected for our investigation. From here three sets of streamers were selected based on their experience and background in a single entertainment title or series. We selected streams that had beginner to advanced-level experience in one of the target games. This was easier for some games than others. Since player versus player (PvP) in Final Fantasy XIV is so niche, it was easy to find first an experienced player and isolate streams where they played with players who played in the Final Fantasy series but did not play PvP. Similarly, since Minecraft is often played by younger players, it was easy to find two adult streamers who were new to the game. Since PUBG has been around so long it was easier to isolate expert streamers, but because it is seen as a relaxed first-person shooter compared to other titles, it was difficult to find streams where the role of novice was distinct.

From the collection of these streamers' published streams, streams that involved collaborative play of two players (including the streamer) were selected. The decision for a two-player format was due to the issues of audio quality and transcription with teams of 3 or more players. In these streams, speech overlap made analysis too difficult. Initially, it was decided that three streaming sessions would be selected for each set of players. Since the streams varied drastically in length. This led to a distinction of rounds. Though a round varied in length, it was possible to isolate streams where a minimum of three rounds were played with a minimum of 90 minutes of playtime between the 2-players. Final Fantasy PvP rounds were understood as instances where players participated in a Team match in PvP in Frontlines or Crystalline Conflict which lasted anywhere between 15 and 20 minutes. A round in PUBG was understood as the players entering a battle royal game as a team which lasted anywhere from 10 to forty minutes. Minecraft rounds were understood as sessions where players collaborated in the collection of items or tried to defeat the final boss or Ender Dragon.

Table 1: Summary of Players selected

Streams			
Games	Final Fantasy XIV	PUBG Battlegrounds	Minecraft
Players	"D" and "K"	"B" and "J"	"I" and "M"
Experience level	Beginner, high beginner	Advanced, Intermediate (Beginner in PVP)	High Intermediate, Intermediate
Language of Play	English, Spanish	English, German, Swedish	English

Instances of knowledge transference and knowledge construction were isolated between chat participants, chat participants, and streamers in and around each round through an investigation of linguistic and in-game actions. What follows is a detailed summary of the results.

5. Results

These results are based on the transcription and analysis of roughly 405 minutes of streamed gameplay, which was completed over 6 months. Several patterns emerged from our analysis of game-centered interactions in Twitch streams related to domain knowledge. Knowledge complexity and knowledge construction.

5.1 Domain Knowledge

In our study instances of domain knowledge occurred largely on a micro level. The most common domain knowledge discussed on a micro level was game events while game world was the most common on a micro level.

Table 2: Domain knowledge on a macro and micro level.

Domain	
Mico	Macro
Player moves and actions	Player experience
Game Event	Game world or rules
Location	Stream or game technology
Game Item or token	
Game affordance or mechanics	

Table 3: Domain knowledge ratio across all games and all rounds.



On a micro level, domain knowledge involved player moves, game events, game items, and location. Player moves or actions were understood as any action a player took in the game. Some common moves were dying, attacking, killing, teleporting, collecting, running, jumping, regenerating, or healing. A game event was understood as a spawning of game characters, or changes in game setting or environment. In Final Fantasy and PUBG teams, game events were also understood as a team's status as losing or winning when it directly affected the gaming environment and setting. Location was understood as where a player or item was situated within the game. Game items and tokens could be weapons, supplies, game objects, or achievements. Game mechanics were understood as game affordances, settings, or actions that solely involve gameplay. Common topics across games were hot bar setup, actions on the controller or keyboard, inventory uses, and combo executions.

On a macro level, domain knowledge involves player experiences, game world, and technology. The player's experience was understood as any information about a player's experience The game world and rules were patterns of gameplay, items, affordances, or events. Stream or game Technology was understood as technical or mechanical knowledge. These three domain knowledge forms are related to participation in a larger gaming community or long-term experience playing a game or a series/update within or outside a gaming genre.

5.1.1 Domain Knowledge Complexity

Across all gaming genres, we found changes in domain knowledge complexity. As players played more rounds together the domain knowledge complexity shifted from game technology, affordances, and mechanics to game events and items. This change was more evident in players who took on the role or performed the status of novice.

5.2 Knowledge Construction

Knowledge construction was found across all games and occurred between players, players and chat members, and chat members. Indications of knowledge construction were identified through linguistic markers but could also be found solely in in-game action. However, every instance of knowledge transference did not correlate with knowledge construction. The correlation was highly dependent on the context and knowledge content being transferred (Heritage, 2013). Moreover, knowledge construction presented differently in each game.

In Final Fantasy, player "J" constructed knowledge about strategies of play in PvP, including how to execute combos, support teammates, survive and execute attacks, use character abilities, and how to win and lose a match. Players "B" and "J" co-constructed constructed knowledge of collaborative actions when playing on the same and different teams, including adapting to playing styles, and coordinating with each other's and other teammate's actions.

In PUBG, since "M" and "I" had extensive experience playing in teams, they relied on the co-constructed knowledge to prevent killing or shooting each other, coordinated killing or injuring other players, and coordinated avoidance of the ever-decreasing zone perimeter. Verbless sentences dominated knowledge construction in PUBG. However, it is unclear if this correlated to instances of high stress (Albathi, 2022) or the play style. In the following example "M" and "I" are constructing knowledge of opposing team members:

1	M:	Next to us (.)
2		Southwest,
3		(5.0)
4	M:	No south, (.)
5		Outside, (.)
6		Down

In this interaction "M" relies on verbless sentences (Lines 1-6) while "I" relies on coordinated in-game action to construct knowledge. Knowledge is transferred each time "I" and the opposing player change locations. After "M" indicates the opposing player's location (Lines 1-2) "I" turns left, then right, then left, heading to the southwest corner of the room, using the on-screen compass. After "M" expresses a change in player location using a recast (Line 4), "I" remains on the lower level of the room, not ascending the stairs directly ahead, walks into an offshoot of the main room, down an outer aisle, and shoots and kills the targeted opposing team player.

In PUBG, “I” and “M” also construct knowledge about their shared long-term gaming experience. They share experiences of player interaction, hacks, and bots in the game while playing and participating in the PUBG gaming community. In the following example “M” and “I” co-construct knowledge about a game hack:

1	I:	He just landed in the middle of open (.)
2		below us,
3		(1.0)
4	M:	What
5	I:	Yeah,
6		What the fuck you run into the wall?
7		What?
8		Dude (.)
9		That's not the first time I see that (.)
10	M:	[Okay]
11	I:	[He just ran through the wall on my
12		screen,]
13		He landed outside and just run through
14		the wall (.)
15	M:	Hm (.)
16	I:	Fuckin’ (.)
17		What?

When If this interaction was only isolated in the (micro) context of the immediate interaction, the response tokens “Yeah” “Okay” and “Hm” (Lines 5, 10, 15) and expletives (Line 16) would initially signal knowledge transference. However, within the larger (macro) context of “M” and “I”’s cumulative knowledge of hacking, this interaction can be interpreted as knowledge construction.

In Minecraft, “D” and “K”, as beginners, largely constructed and co-constructed knowledge about the use of game items, game mechanics, and game rules. Their knowledge construction through chat interactions changed in complexity. As “K” and “D” played more together, participated in the Minecraft community, and interacted with community members, they learned to scale the epistemic authority of chat participants. This resulted in not all instances of knowledge transference being accepted and used in knowledge construction of the game and gameplay. In the following example, “D” and “K” are learning to locate an in-game event and use a game item:

1	K:	Is it like under this mountain (.)
2		You think?
3	D:	Yeah (.)
4		we might be able to just dig
5		⌜guys,
6		Do you think we should just dig
7		down here? ⌝
8	K:	People are sayin’ “dig”
9	D:	Okay yeah (.)
10		Let’s dig down here

The use of tag questions (Line 2), model verbs “might” and “should” (Line 4, 6), the hedge “like” (Line 1), and response tokens “yeah” and “Okay” (Line 3, 8) indicate the co-construction of knowledge between the players and chat participants. In this interaction “D” and “K” the acceptance of the transference of knowledge and the epistemic authority of chat participants is shown in the in-game action of digging in the indicated spot.

5.3 Novice and Expert Status and Role

Across all gaming genres, the roles of expert and novice were identified. Similarly, expert status was attributed to players and chat participants. The status of expert was attributed to players who coordinated gameplay, demonstrated collaborative gameplay (Steinkuehler, 2012), demonstrated expert knowledge, or identified as members of the gaming community (Thorne et al, 2012). One common demonstration of expert knowledge was the use of items and affordances to defeat spawned characters or win a match against other players (Kiourti, 2022). Another demonstration of expert knowledge was increased speed or efficiency in the execution of in-game actions (Drosos et al, 2021).

5.3.1 Status and Role Demonstration and Attribution

The demonstration of expert status and role was found in each game. Although its demonstration varied slightly between games.

In Final Fantasy, the coordination and collaboration of in-game actions was attributed to the role and status of expert. During each round “B” took on the role of expert by using “callouts” or verbal cues to coordinate and direct in-game action. Though “J” took on the role of expert knowledge in his use of callouts in later game rounds, their reliance on requests indicated that “B” was attributed the status of expert. This was due to the fact that both “J” and “B” had played all Final Fantasy games, but only “B” had experience in PvP.

In PUBG, the role of expert was demonstrated through expert knowledge and coordinated game action. An example of expert knowledge expression was “I”’s number of kills, assists, or hits (Knocks) compared to “M”. An example of coordinated action was when “M” used requests to determine movement within or between locations. Similarly, even though “M” and “I” demonstrated expert knowledge of the game, “M” used compliments and apologies, regarding in-game action, to attribute the status of expert to “I”.

In Minecraft, the role and status of expert were connected to expert knowledge expression. One example is “K” completing in-game actions “D” indicated as non-expert knowledge and that led to his death. Consequently, the role of expert was attributed to “D” by “K” through compliments, requests, an suggestions, even though “D” had only begun playing Minecraft a few weeks before “K”.

5.3.2 Status and Role Negotiation

Across all games, the role and status of expert were also negotiated between players, chat participants, and players and chat participants. The negotiation of attributed roles was done by the individual upgrading, downgrading, or accepting the role.

In the following Final Fantasy PvP interaction, the negotiation of the role of expert and novice was negotiated between “J” and “B” through their coordination of actions, in this case, the order of attack on an opposing team member:

1	J:	Oh (.) this Ninja's gotta go:
2.	B:	He should be down here.
3		(1.0)
4	J:	Yeah (.)
5		I'm gonna ┌ I'm gonna get'e:m ┐
6		Maybe not maybe not (.)
7		He's healin', (.)
8	B:	[Finish hi::m,]
9		He's healin', (.)

10 I got one more ┌ one more┐

11 B: [I got'em]

12 J: You got'em?

13 B: Yeah

14 J: Yeah he's done (.)

15 Good Teamwork (.)

16 Look at that,

17 (1.0)

18 See (.)

19 I'm not complete ┌ completely useless

20 for that ┐

In this interaction, the model verbs “should” and “gotta” (Lines 1, 2) and imperative sentences (Line 8) indicate the expression of the role of expert. Even though “J” downgrades his through the adverb “maybe” (Line 6), he further negotiates his role through the adverb “completely” (Line 19). The response tokens, or “yeah” (lines 4, 13, 14) and compliments (Line 15) are also an indication of “J” negotiating and “B” accepting this role.

The negotiation of the role of expert and novice was also present in chat and player interactions. In the following interactions, the role of expert is negotiated by two chat participants Kaixer9 and kasbig.

1 kasbig: Hi! I just got back into FF14.

2 When I left, like 6 years ago,

3 i had a character with every job 4 at 60 and i had most of the

5 Endgame content downed.

6 Should I just start a new

7 character? its been a looooong

8 time.

9 (1.37)

10 Kaixer9: @kasbig no, you can always do

11 New game+

12 (1.22)

13 Kaixer9: and they gifted 1 free fantasia

14 for new players that ends ARR,

15 if you didnt get it in the past

16 maybe you have it now to redo

17 your character (not sure)

18 (0.50)

19 kasbig: alright cool. my inventory is

20 fulled with idk what. just gonna

21 put it all in storage and keep

22 playing lol

23 lol thanks [player “B”]

Through the response token “no” (Line 7) and the adverb “always” (Line 8) Keixer9 tries to perform the role of expert (Line 12). A lack of response from kasbig leads to a renegotiation of the role, evident through Kaixer9’s use of the adverb “maybe” (Line 11). This downgrade is accepted by kasbig in his response token “alright cool” (Line 14). Finally, kasbig’s response token “thanks” (Line 17) affirms the attribution of the status of expert to “B” instead of Kaixer9.

Another example of the downgrade of a role or status performance can be seen in the following exchange during Minecraft gameplay. In this interaction chat members express the role of expert by using suggestions, warnings, and requests, and “D” and “K” reject their role performance:

1	420weedtown:	da spawn
2	Ricegrt:	bed for respawn at the
3		portal !!
4	Ulovehd:	noo you need beds
5		[player “K”]!!
6	Snowy_chan:	SET SPAWN AT AT
7		STRIKING HOLD
8	hea111:	Bed fer spawning
9	gothbimbo_rat:	MO BED
10	[player “K”]	yall [player “D”]
11		has two beds /lh

The chat’s uses of the response token “no” (Line 3) and imperative sentences (Lines 2, 4, 5, 6), including the commands (Line 4, 6) and requests (Line 1, 5), indicate their negotiation of the role of expert. The players “K” and “D” not placing the requested item is a rejection of this role expression. The shift to capital letters (Lines 4, 6) demonstrates the chat’s attempt to upgrade their role and express their role of expert. This attempt is rejected and their role is downgraded through “K”’s clarification and use of the pronoun “Y’all” (Line 7).

6. Conclusion

The result of this investigation identified domain knowledge, knowledge construction, and role negotiation in streamed collaborative gaming scenarios. These elements were found in the CMC systems of Twitch in written (chat) and spoken interactions (audio/video) between players and stream participants. Though some argue that knowledge transference is synonymous with learning (Chen, 2015), this analysis cannot definitively prove that knowledge every instance of knowledge transference correlated to learning nor that the prevalence of knowledge transference guaranteed a correlation with knowledge construction.

Overall, these results demonstrate that an analysis of streamed interactions can provide a multifaceted and holistic view of knowledge construction and gaming community membership and participation.

Future research into streamed interactions would be beneficial to GBL in its investigation of the stages of cognitive apprenticeship.

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Unified Effort: Developing a Mixed Reality Serious Game for Collaborative Crisis Management Training

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Abstract: Crises and disasters include both predictable and unpredictable events. In a turbulent world that has recently experienced a pandemic and wars, and is increasingly affected by climate change, there is a growing need to develop effective public crisis management capabilities. Emergency preparedness is a critical foundation for crisis management. Training and exercises are essential components of preparedness and are becoming increasingly relevant for a wide range of organisations in society. To achieve a unified response to threatening events, a wide range of actors - with different backgrounds, objectives, competencies and organisational frameworks - must overcome the challenges of working together. To address this complex situation, forums for knowledge sharing and learning are required. Serious games in mixed reality can be used as a platform for collaborative training and serve as such a forum. Mixed reality systems connect virtual and physical reality, providing users with a sense of immersion, engagement and interaction in both environments. The aim of this paper is to design a short, serious game for collaboration training with two command levels in a mixed reality. Theories of crisis management, along with related research on serious games design, create the framework for the game. The game content was further developed in a co-design process with selected professionals. This paper describes the development of the "Unified Effort" game. The serious game is designed for basic training of municipalities and county offices in soft skills such as communication, situational awareness and group decision making. The game is not intended to replace hard skills such as procedural training and field drills, but can be used as a supplement to this type of training.

Keywords: Crisis Management, Societal Security, Training and Exercise, Serious Games, Mixed Reality, Games Based Learning

1. Introduction

In the wake of the global pandemic caused by the novel coronavirus (Covid-19), the constantly changing climate, and the general unrest in various regions of the world, there is a growing need for the development of effective public crisis management capabilities. Crises and disasters include both foreseeable and unpredicted events. Crisis management is about anticipating the former in order to minimise the latter (Di Loreto et al., 2012). Crises share several similarities with Horst and Webber's (1973) "wicked problem" (Booth et al., 2020; Criado & Guevara-Gomez, 2021; Crivellari, 2019). Problem understanding and problem resolution are concomitant to each other. An image of the problem and of the solution emerges gradually among the actors (Horst & Webber, 1973, pp. 161-162).

Crises present governments and leaders with decisions they do not face on an everyday basis. But crisis management involves more than just "big" decisions (Boin et al., 2017). Decisions also need to be implemented, often by a diffuse network of actors. Getting things done therefore requires horizontal and vertical coordination. It is of paramount importance to ensure effective coordination in order to prevent miscommunication, unnecessary overlap and conflicts between governments, agencies and actors involved in crisis operations (2017, p. 16). The wickedness of a crisis makes collaboration both necessary and challenging.

Lack of collaboration has been identified as a key failing in several major disasters and crises. A lack of coordination between federal, state and city governments was identified as a factor contributing to the failures observed after hurricane Katrina (Cole & Fellows, 2008). For the Norwegian government, the aftermath of the terrorist attack on 22 July 2011 has been characterised by a focus on the lack of communication and coordination between government departments (Gjørv, 2012).

Emergency preparedness is a crucial basis for crisis management, and training and exercises are essential components of preparedness. The experience of personnel involved in disasters and crises has demonstrated that those with a high level of relevant competence are better able to manage the situation during and after the crisis, than those with a low level of competence (Weisæth & Kjeserud, 2021). This includes collaborative training. It is a common misconception that collaborative training is synonymous with full-scale exercises, which are fully set up with personnel and material "in the field" (Sommer et al., 2020). Despite the high level of ambition for cooperation, these exercises frequently result in each organisation practising internally within its "silo", due to a lack of sufficient advance training (Løvik, 2010). This frequently occurs due to a lack of fundamental clarification regarding roles, responsibilities and authority. Consequently, significant

resources are expended on a task that should have been practised on a smaller scale. Based on this, there is a need for innovative ways to approach, design and implement collaboration training.

A unified response to a disaster involves a variety of stakeholders with different organisational structures and backgrounds, and sometimes competing agendas. *Forums* are needed where stakeholders can come together to improve understanding and reconcile differing views (Fleming et al., 2020). This article suggests that two-level collaboration training through serious games in a mixed reality can be such a forum. Mixed reality systems connect virtual and physical reality, providing users with a sense of immersion, engagement and interaction in both environments. Although mixed reality games have received increasing attention across multiple disciplines, their adoption in crisis management and disaster response training is limited (Alharthi et al., 2018).

The aim of this paper is to design a short, serious game for collaboration training with two command levels in a mixed reality environment. Crisis management theories, together with related research on serious games design, create the framework for the game. The game content is further developed in a co-design process with selected professionals. The paper describes the development of the game and includes a concept sketch of the game. The serious game will be empirically tested for various learning outcomes in a subsequent study.

2. Theoretical Foundations

2.1 Soft Skills for Crisis Management

Crisis management involves different kind of competencies, from very specific procedures ("hard skills") to more generic competencies ("soft skills"). The first section highlighted the importance of collaborative actions in crisis management. Inter-disciplinary collaboration is essential when working in multi-disciplinary teams (Amaratunga et al., 2018), and research emphasises the importance of soft skills such as team working, communication, situational awareness, leadership, decision making in the face of competing demands (Bakken et al., 2017; Di Loreto et al., 2013; Radianti et al., 2020), problem-solving with partial or contradictory information (Linehan et al., 2009), time management and stress management (Di Loreto et al., 2013). Although the term "soft skills" is not commonly used in the social psychology literature, these skills have been extensively researched and are considered to play an important role in the quality of group decision making (Linehan et al., 2009). Getha-Taylor (2007) notes that public crisis management teams are often staffed by people from non-disaster organisations, with different professional backgrounds, and members of disaster organisations. This can create cultural barriers. Her response to this challenge is to build relationships between actors at different levels before a disaster strikes. Therefore, training in soft skills to build relationships and equip managers and key personnel with the necessary flexibility, skills and confidence to deal with sudden and unexpected events (Di Loreto et al., 2013) is an important part of emergency preparedness.

2.2 Serious Games and Mixed Reality

One way to address soft skills training could be the use of serious games. A serious game provides participants with a fun and immersive experience from which they can learn at an individual and group level (Di Loreto et al., 2012). Kankaanranta & Neittaanmäki (2008) define serious games as "games which aim at providing an engaging and self-reinforcing context in which to motivate and educate the players". Serious games can be a forum for enhanced understanding, training and relation building (Fleming et al., 2020). Serious games can help crisis managers and actors to see things differently (and act differently) from the way they are used to (Di Loreto et al., 2012), and can be a useful tool to bring stakeholders from different backgrounds closer together in a simulated environment (Schueller et al., 2020). Solinska-Nowak et al. (2018) note the social dimensions of serious games: collective play contributes to relationship building, negotiation, conflict resolution, and experience and information sharing, all of which can be useful in disaster preparedness. The same authors also highlight another important aspect. Despite their many advantages, serious games cannot replace more standard approaches to disaster preparedness education. One of the main limitations of games is that they inevitably oversimplify the circumstances of disasters (2018, p. 1026). Therefore, serious games cannot be treated as stand-alone disaster management training tools. Crisis management competence is developed in a series of recurring exercises, rather than in a single exercise (van Laere & Lindblom, 2019). A serious game can provide an arena for social interaction that takes place in the natural context of practice, which can facilitate valuable collaborative skills that can be useful later in a comprehensive capability building process.

One of the key challenges in designing training simulations is how to make them relevant for actual practice (Alharthi et al., 2018). Previous simulators often attempted to replicate the environment as closely as possible,

to improve practicality and immersiveness. However, an exact reproduction of the environment is not always necessary (Jensen et al., 2013). This presents designers with the challenge of striking a balance between capturing the real experience and making the training practical, yet effective (Alharthi et al., 2018). By reducing fidelity, for example by using photos and local maps instead of a virtual reality, the game can be more easily focused on one aspect of training, such as coordination, making the training more suitable for evaluation (2018).

Mixed reality is an alternative way to balance between immersion and reality in training (Alharthi et al., 2018). Mixed reality games engage the surrounding environment through physical interaction with tangible objects, mental engagement with simulated elements, and social interaction with other participants engaged in the same exercise. These types of games can offer unique opportunities to design training simulations that capture the different aspects of crisis management (2018). Mixed reality combines virtual information with physical reality in physical environments. This use places the game in the natural context of practice and can add realism. A serious game consisting of a live, scenario-based mixed reality simulation will allow actors to coordinate with each other, both face-to-face and remotely, to mitigate a simulated disaster (Fischer et al., 2021). These types of serious games also help responders build advanced coordination skills by facilitating training opportunities for human-agent coordination and collaboration (Ramchurn et al., 2016).

2.3 Game Design

2.3.1 Command Post Exercises

One way of distinguishing between exercises is between discussion-based and operations-based exercises. In its doctrine, the U.S. Department of Homeland Security describes “games” as a discussion-based exercise. Games are designed to present an actual or hypothetical situation to ensure that actors make plausible decisions and take appropriate actions. Games can be used to improve operational and tactical skills, stimulate team building or reinforce training (Department of Homeland Security, 2020, pp. 18-19). The same doctrine describes functional exercises as operations-based exercises. Functional exercises are most often designed to evaluate and test functions and capabilities in a realistic, real-time environment, but with a simulated movement of resources (2020, p. 20). A specific type of functional exercise, often called “command post exercise”, deals only with management elements and is carried out by practising the management function within an organisation or in cooperation with other organisations, without using their crews, but by practising cooperation within or across organisations (Sommer et al., 2020).

2.3.2 Design Principles and Possible Pitfalls

Alharthi et al. developed a set of design principles for developing games that engage actors in crisis response style communication, planning and sense-making activities. These principles are listed in Table 1.

Table 1: Game design patterns (Alharthi et al., 2018)

Design Principle	Description
Mix communication	Teams should work in situations in which members spend some periods collocated and others remote, which enforces the need for learning and practising implicit coordination and overhearing.
Distribute information with uncertainty	Different members of the team should have different items of information, requiring team members to share and integrate information and enabling the formation of team cognition constructs.
Enhance situation awareness	Audible clues should supply information about the local situation that is made available to other team members through a shared audio system, engaging team members in processes of developing situation awareness.
Engage developing intelligence	Team members should make informed decisions about how to collect information and need to make judgments concerning its authenticity and value. to identify essential elements of information.
Create emergent objectives	Emergent objectives may be discovered and lost as a scenario of a disaster plays out, and team members may identify new objectives through gathering information.
Support collaborative planning	Team members need to consider converging and diverging lines of activity that take place in the field, in which they should learn how to collaboratively plan for contingencies when activities enter exceptional states.

Van Laere & Lindblom (2019) note that the choice of scenario is of minor importance. Rather, the training design should focus on accurately simulating basic crisis management processes that are relevant in any crisis scenario (e.g. interpreting early signals, alerting and informing the public, situation analysis, creating situational awareness, delegating tasks, and prioritising resources and problems, etc.) (2019, p. 43). They also provide some useful tips in their characteristisation of the training approach: (i) crisis management training is an environment to develop and learn, not an examination; (ii) first educate, than train; (iii) focus on "how the crisis management organisation operates," and not on resolving the scenario; (iv) active coaching during game execution speeds up the learning cycle; (v) encourage self-evaluation; and (vi) recurrent training is needed to master different skills and to refresh collective memory (2019, p. 45).

In an overview of collaborative serious games for crisis management, Di Loreto, Mora and Divitini (2012) comment on possible pitfalls in game design and content. These are: (i) there is limited linkage with an actual territory (i.e. the game takes place in an abstracted environment); (ii) there is virtually no possibility to play with roles (i.e. there is no room for cross-training to gain a deeper understanding of each other's roles); (iii) the importance of the debriefing phase is underestimated (i.e. there is too little focus on evaluation and knowledge transfer); and iv) there is no support for coaching during the game sessions (i.e. there are no natural breaks in the game to coach the participants) (2012, p. 5).

These theoretical foundations have guided the design process of the serious game for two-level, collaborative training in crisis management.

3. Method

3.1 Co-design Approach

An iterative co-design process took place, as shown in Figure 1. The literature review and interview session were conducted to adapt the game to *generally accepted principles and design*. The workshop focused more on developing the details of the game content by "brain-picking" people with several years of experience from dealing with different crises at the tactical level. This was all to increase the realism and credibility of the game and, ultimately, its face validity.

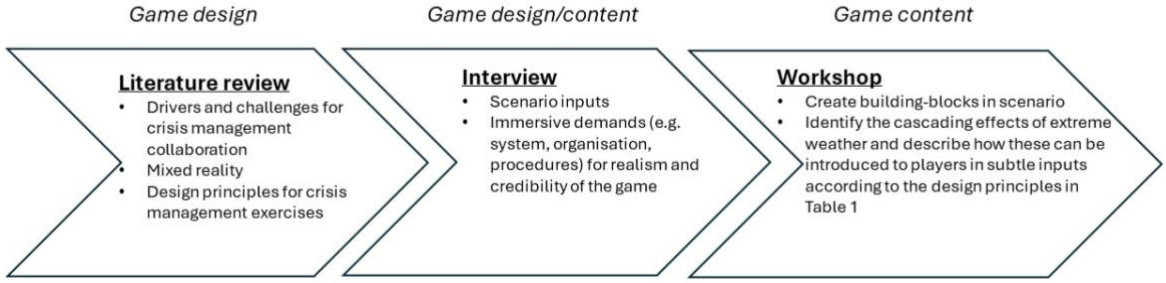


Figure 1: Design and development process

3.2 Interview

To validate the game design principles before developing the content, an expert evaluation was carried out with two experts. These were a high-ranking academic in the field of crisis management, and a person from the Norwegian Directorate for Civil Protection (DSB) with more than 10 years' experience with exercises at both municipal and county manager level. A semi-structured interview was conducted to increase the relevance of the serious game and to answer the following questions: (i) given the design principles, which scenario is the most useful to include in order to involve several communities and simultaneously challenge the county management level?; and (ii) which prerequisites should be included in order to make the mixed reality relevant and realistic?

3.3 Workshop

The workshop was attended by eight participants representing the emergency services, all with between 11 and 20 years' experience. The services represented were the police (2), fire brigade, ambulance service, Red Cross, Norwegian Public Roads Administration, army, and Home Guard. All workshop participants attended the BA course in "Emergency Training and Exercises" as part of the final semester of their bachelor's degree in Crisis

Management. All participants had experience with crisis management software and knowledge of basic exercise planning. The aim of the workshop was to detail the lead-in scenario and storyline, and to generate ideas for cross-sector playable scenario inputs and cascading effects of extreme weather that would trigger or include the elements from Table 1 (Alharthi et al., 2018). The workshop lasted just over two hours and was divided into 15-minute sessions, with each session focusing on a different element from Table 1. The group work was followed by a 30-minute summary session to refine the ideas.

4. Results and Discussion

4.1 Expert Interview

During the expert interview, a few scenarios which could give rise to "downstream consequences" were discussed. These included a failure in a nuclear reactor and a municipal data hack. However, both responders asserted that the most suitable scenario for this game's intention would be an extreme weather scenario. This scenario is highly relevant as it encompasses a multitude of potential cascading effects. Cascading effects in public crisis management occur when an incident triggers a series of interconnected events, such as floods, waterborne infections, loss of electricity, landslides, and so forth. These effects could unfold in a disparate manner across the municipalities, ultimately creating significant challenges for the county manager's office.

Mixed reality games engage the surrounding environment through physical interaction with tangible objects, mental engagement with simulated elements, and social interaction with other participants engaged in the same exercise (Alharthi et al., 2018). The experts identified a select number of universal, cross-sectorial objects that could be used in such a game, to facilitate a realistic mixed reality. The crisis management software, which is available to all municipalities and county managers' offices in Norway, facilitates crisis management at all levels by enabling the logging, reporting and sharing of analyses and information. The "Proactive Staff methodology" (Lunde, 2019) entails the establishment of a fixed meeting agenda and subsequent reporting for all levels of staff. The methodology facilitates crisis management in the initial phase, enabling the effective resolution of problems that may arise. The methodology indicates that a startup meeting is of paramount importance, during which a common situational picture is established, based on the facts at hand, and the consequence potential is assessed. This potential serves as a basis for decision and allows decisions to be taken now, based on an analytical assessment of the future. The utilisation of maps, map layers and "aerial photos" extracted from VR was recommended as a means of enhancing the scenario. This low-fidelity use of simulators does not detract from the focus on the task at hand. In terms of social interaction, the respondents proposed the convening of separate meetings in the municipalities and county offices, with a subsequent cooperation meeting with one representative (liaison officer) from each of the municipalities. This approach would facilitate the socialisation of both levels within and across crisis management levels. These inputs were instrumental in the further design of the game. At the end of the interview session, a game organisation was proposed, as shown in Figure 2.

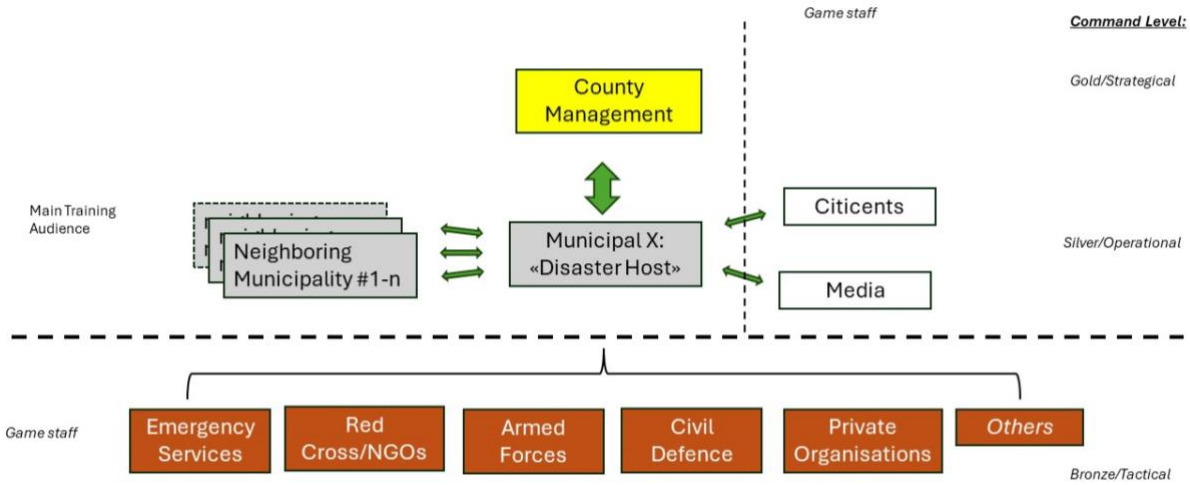


Figure 2: Game organisation

4.2 Workshop

The workshop focused on the creation of concrete game content, such as lead-in scenario and storyline details, ideas for cross-sector playable scenario inputs, and relevant cascading effects of extreme weather. The group work was framed by the results of the expert interview: focus on the challenges of collaboration at two levels of command, extreme weather scenario, use of crisis management software and a standardised staff methodology. With these assumptions in mind, workshop participants used the patterns from Table 1 as guidelines for the creative process of developing ideas for game content.

4.2.1 Mix Communication Modalities

There was a substantial degree of consensus regarding an approach to organising the players to achieve this objective. Firstly, all participants are gathered in one room to have a common briefing, where all common information is shared (step 1 in Figure 3). Then each municipality goes into separate "command posts" to prepare and execute their internal startup staff meeting (steps 2-3). After 45 minutes, they send a meeting report to the county manager's office (step 3a). Subsequently, they commence preparations for the forthcoming startup meeting, which is primarily based on the in-brief and the reports from the municipalities (steps 4-5). After the county manager's office has delivered their meeting report (to the game staff, step 5a), a physical cooperation meeting is held with a representative (liaison officer) from each municipality (step 6). This meeting is open to all game participants for educational purposes, although only those present at the meeting will actively participate. Here final warnings, actions and supports are planned to achieve a unified effort (step 6a).

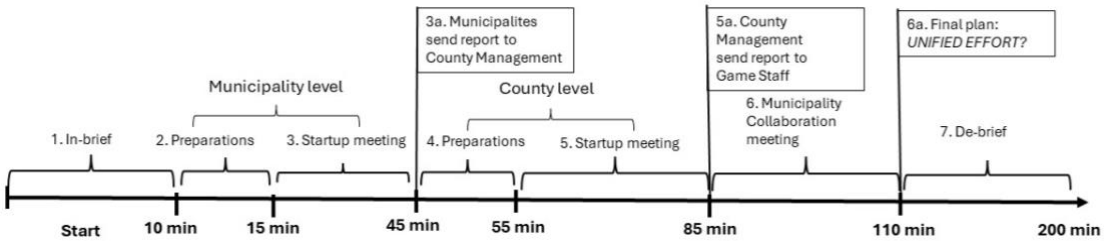


Figure 3: Game timeline

4.2.2 Distribute Information With Uncertainty

The workshop resulted in the formulation of a concrete scenario pertaining to extreme weather conditions. The lead-in scenario is set in an extreme hot and dry summer. A municipality experiences the outbreak of a forest fire near two neighbouring municipalities, yet there is no control of the fire. The weather forecast predicts two days of high temperatures, followed by heavy rainfall and thunderstorms. The wind will change direction, turning 180 degrees. The lead-in scenario itself entails the potential for several cascading effects of the heatwave, including the possibility of more wildfires, the evacuation of citizens, the closure of roads and railways, the loss of electricity, and torrential rain with potential landslides and thunderstorms. This information, along with regional maps and a brief overview of resources, is presented in a neutral manner. Following the introductory briefing, the various player groups proceed to their designated "command posts" to prepare for their initial meeting. It is up to the players to identify the potential consequences of incidents affecting their region, considering the specific characteristics of the municipality in question.

4.2.3 Enhance Situation Awareness/Engage Developing Intelligence

Crisis management software enables the sharing of images, including tailored "news articles" from both regional and national media sources. The workshop yielded several ideas, including articles on the impact of extreme weather events, alongside information on the indirect effects of such events. One example is an article on local actors who are looking forward to the implementation of a major public event (which geographically will be very exposed to the wildfire, if the wind turns). Furthermore, information shared via crisis management software may comprise a combination of data extracted from social media, which may include both useful information and irrelevant content. It is therefore necessary to verify the accuracy of this information.

4.2.4 Create Emergent Objectives

The relevance of different cascading effects to different municipalities may be contingent upon geographical, technical and demographic differences. The workshop focused on the identification of incidents that could potentially occur within a municipality, with the understanding that the consequences might extend beyond the immediate area. This included an examination of the potential impact of such incidents on neighbouring municipalities. To be able to handle these incidents, it is necessary to provide advance warning to the relevant region, so that it can take timely action. Examples of such incidents include the issuing of warnings concerning the imminent closure of roads and railways, the potential loss of electricity or drinking water, and the risk of waterborne infection.

4.2.5 Support Collaborative Planning

This part of the workshop focused on the identification of cross-municipal factors that could potentially have an adverse effect on regional critical infrastructure. One such factor was the potential impact on a regional hospital. The objective of converging and diverging lines of activity may also be incorporated into the lead-in scenario, in which different municipalities require assistance from one another in order to effectively address the potential cascading effects. At the individual startup meeting (steps 2-3 in Figure 3), the municipality *can* ascertain the necessity of notifying neighbours and identify its own need for support. This requires both skills and cleverness. Consequently, the period following the municipalities' start-up meetings (after step 3a) is deemed an opportune moment in the game for the delivery of coaching to the staff. Furthermore, the game offers a second opportunity to identify instances of convergence and divergence in activity. At the municipal collaboration meeting (step 6), participants are expected to consider the region as a unified entity and to identify actions that can be undertaken collectively. At this stage, all the players rally behind a plan, a *unified effort.*

4.2.6 Game Mechanics

The chosen methodology, software and meeting structure provide direct guidance for the mechanics of the game. The in-brief reveals some details of the scenario and sets the scene. This is a standard brief given to all players simultaneously, using a fictional narrative provided by pictures and maps. The purpose of this introduction is to answer the "who", "where", "when" and to some extent "what"- questions. After the joint briefing, all participants go to their individual locations, each of which is equipped with a monitor and the crisis management software. The crisis management software menus displayed on the monitor represent the user interface elements. Incoming messages are displayed in the log stream and outgoing communications are sent and displayed in the message distribution menu.

The Proactive Staff methodology dictates that you always begin with a startup meeting with a fixed agenda, which implies six questions: (i) what happened, what do we know?; (ii) what are the potential consequences?; (iii) what do we do?; (iv) what do we need?; (v) what are the consequences for daily operations?; and (vi) are there other issues working for or against us? After the various crisis teams have held their initial meeting, they distribute their meeting report in a standardised format to all participants using the crisis management software. The teams will receive updates and inputs, both fake and real news, through this channel during the game.

The meeting structure, with two common arenas (in-brief and coordination meeting) and one individual meeting, forces the crisis staff to make timely decisions and fill in the agenda items of the start-up meeting. The output of the individual staff meetings, received in the crisis management software, will provide important input to neighbouring municipalities and the county managers' office.

The entire game is outlined in Figure 4.

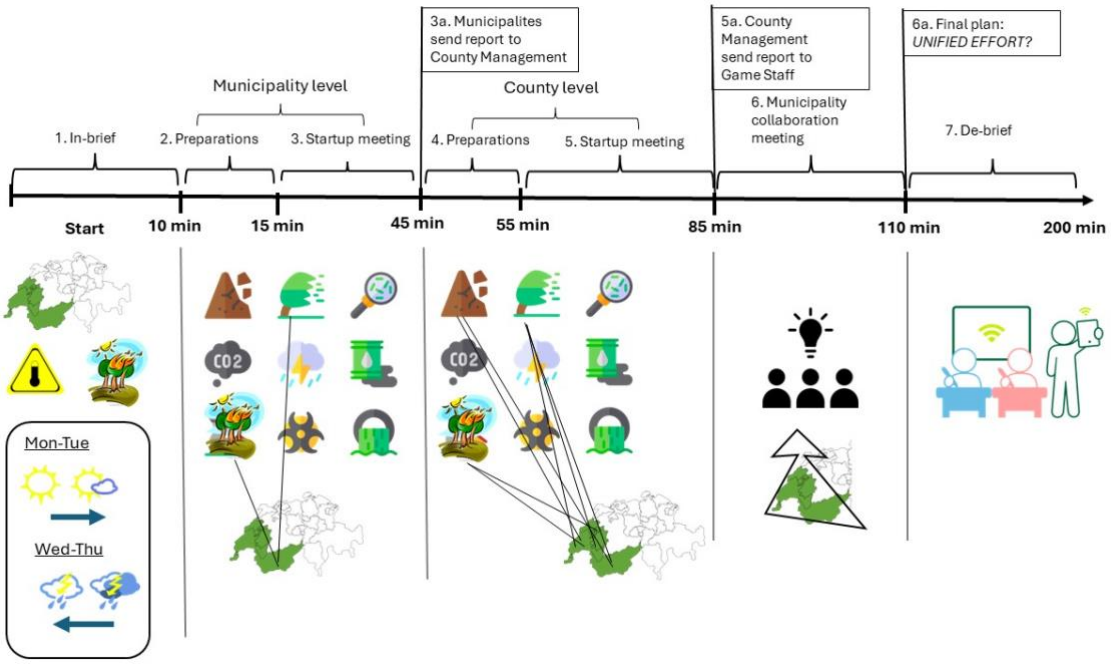


Figure 4: Principal sketch: ”United Effort“ (Images collected at www.seekpng.com)

4.2.7 Limitations and Further Research

A limitation of the game is that it requires a certain level of competence in staff organisation and decision making. It also requires some knowledge of communication and information sharing. Therefore, inexperienced staff will need some basic training in advance. It is recommended that participants attend a half-day seminar on the Proactive Staff methodology to familiar themselves with the meeting agenda and the expected outcome of the startup meeting. Some basic knowledge is also required to use the crisis management software. The supplier of the software will provide its own training, and it is important that at least one member of the staff is an experienced user. Alternatively, this role can be filled by a member of the game staff to ensure a smooth flow of information and log-keeping.

The next step is to pilot test the exercise in its entirety. This will be the subject of the next study. Effective staff work is the result of a complex mix of condition factors (personnel, organisation and context), process factors (team- and task-focused) and outcome criteria (Essens et al., 2005). After the pilot test, a qualitative study will determine the actual experience of the players in order to improve the *condition factors* and make the game more realistic. Through a semi-structured interview, pilot test participants will be asked to share their experiences of the game and suggest improvements. Topics of the interview will be perceived realism and the balance between size (duration of the game, number of participants) and complexity (how many factors are included and how realistic are they?).

The game will then be used in training sessions where different questionnaires will be used to quantitatively measure more specific learning objectives related to the different soft skills (*process* factors). Different metrics will be used to evaluate the impact of the game on participants' skills and ability to collaborate. Berlin & Carlström’s survey instrument will be used to measure collaboration, perceived learning and utility (2015, p. 23). Barton et al. (2015) has shown that “anomalizing” and “proactive leader sensemaking” play crucial roles in determining success for operational teams. They provide survey items for both factors (2015, p. 83). These measures will be supplied by more general psychological terms of collaborative importance, such as self-efficacy, social support and interaction (Herberg et al., 2018). The game itself provides measurable *outcome* criteria, such as group decision making (on time and content quality). (Shared) situational awareness will be measured (Endsley, 1995) and communication logged to capture whether, for example, cascading effects relevant to other participants are registered and communicated to the right actors.

The game is designed for Norwegian municipalities and county councils. This may limit its generalisability to other contexts. However, the game is designed to focus on training general soft skills and how the crisis management organisation works, communicates and cooperates - not on solving the scenario. The design

principles of this game can be applied to any scenario involving two levels of crisis responders. The cores are the meeting points, the dissemination of the decisions of the different participants to the other players and the correct use of this information to build a common situational awareness. Different versions of the United Effort game therefore have the potential to train any two-level crisis management, but with an adapted scenario and communication network.

5. Conclusion

This paper proposes a short serious game for collaborative training with two levels of command in a mixed reality. The game is designed for basic training of municipalities and county offices in soft skills. The "Unified Effort" game addresses the need for forums where different community safety stakeholders can learn from each other and provides a "missing link" in a sequence of exercises. Collaborative skills are usually learning objectives in full-scale exercises, but the "Unified Effort" game allows responders to train these skills on a smaller scale and early in the training process. Serious games are not intended to replace hard skills training such as procedural training and field exercises, but they can be used to complement this type of training. Both soft skills and hard skills exercises have their natural place in a progressive, comprehensive capability building process.

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Limes (the Roman Frontier): Developing a Video Game for History Learning

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Abstract: The use of gaming technologies in education holds great promise to provide engaging learning experiences. Whereas video games have been successfully used to foster learning in several school subjects, the current understanding of the potential of video games for history learning is still limited. This paper details the development of *Limes*, a 2D top-down educational game created in Unity and rendered in pixel art. The game targets 5th/6th grade secondary school students and is set in the third century AD in southern Germany, a period characterized by political and social instabilities. *Limes* digs into the complex relations between the Roman Empire and the Alemanni tribe, one of the most powerful Germanic tribes of this period. The player can experience this pixelated world through the eyes of an Alemanni child, who forms a friendship with a Roman centurion. The unfolding narrative places the young protagonist in the precarious balance of peace and conflict, and the player needs to navigate the diplomatic tensions of the era. The gameplay consists of five levels, including primary missions and optional secondary missions which unlock special features (e.g., puzzles, quizzes). *Limes* incorporates a variety of game mechanics, ranging from running and interacting with characters to stealth missions, throwing rocks, and horse racing. These dynamics are integrated into the historical narrative of the game, enriching the player's experience. The game development process combined insights and methods from multiple disciplines, including game-based learning, educational, social, and cultural psychology, education sciences and pedagogy, and history education. Moreover, the game capitalizes on Unity's wide array of development tools, which provide extensive customization possibilities, and employs pixel art, facilitating an engaging environment while maintaining a cost-conscious development process. Initial tests and expert feedback highlight the promise of *Limes* as a game that leverages historical accuracy and innovative educational tools to foster a deeper understanding of Roman history. Next steps include empirical studies with students to test the game's effectiveness (e.g., in improving interest in and knowledge of Roman history).

Keywords: Educational Gaming, History Education, Game-based Learning, Intercultural Understanding, Unity Development

1. Background

The application of digital technologies in education and cultural heritage has proven to be a promising avenue for engaging diverse audiences through immersive, dynamic, and personalized experiences (Arrigoni and Galani, 2019; Kelpšienė *et al.*, 2023). In particular, video games have emerged as innovative tools in these fields, as pilot projects within museum contexts have shown their potential to create novel engagement pathways and make historical knowledge accessible to broader audiences, including those without prior background knowledge (e.g., Ropeik, 2014; Johnson *et al.*, 2015; Viccari, 2016; Hiriart, 2019; Harrington, 2023). History education is an auspicious context for video game interventions, engaging learners in reflecting on the significance of the past and its impact on the present. For a long time, history has been regarded as a subject that only required memorizing facts and data from the past (Van Drie and Van Boxtel, 2008; Nachtigall *et al.*, 2022). However, in the last decades, it has been argued that history is not about accepting or rejecting facts uncritically but is viewed as an essential aspect of participation in a democratic society (Van Drie and Van Boxtel, 2008; Nachtigall *et al.*, 2022). For instance, Barton and Levstik (2004) argue that history should promote reasoned judgment about important human matters. The importance of history goes beyond the learning of historical facts and encompasses several processes that imply reflecting, judging and deliberating over a historical event (Van Drie and Van Boxtel, 2008; Nachtigall *et al.*, 2022). A number of terms have been adopted for describing these ideas, such as historical literacy (e.g., Lee, 2005, 2007; Perfetti et al., 1995), historical thinking (e.g., (VanSledright and Frankes, 2000; Wineburg, 2001; Schreiber *et al.*, 2006) historical consciousness (Van Drie and Van Boxtel, 2008) and historical reasoning (e.g., Kuhn et al., 1994; Leinhardt et al., 1994). Video games, with their capacity to create narrative learning environments, are particularly well-suited to enhancing history education (Akkerman, Admiraal and Huizenga, 2009). People tend to interpret historical events in different ways, based on social-economic or personal ideas (Carretero, López-Manjón and Jacott, 1997). Especially students often use modern

contexts and view the past through the lens of the present, which is an important source of misunderstandings of history (Akkerman, Admiraal and Huizenga, 2009). Situating a historical phenomenon in a historical context, which can be achieved by narratives, is a key activity in history education and can help overcome such misunderstanding. Narratives organize historical information in a coherent and contextualized way (Falk and Dierking, 2000; Sugiyama, 2001; Akkerman, Admiraal and Huizenga, 2009; Liu, 2022), and narratives can easily be integrated into video games (Akkerman, Admiraal and Huizenga, 2009). The use of history as a main theme for educational video games has been described as particularly promising by McCall (2016), who provided a guide for new and experienced educators who want to engage their students towards history by using existing historical commercial video games, such as Assassin Creed, Civilization and Total War. Nonetheless, the current understanding of the potential of video games for school students' history learning is still limited. Moreover, history video games that are designed to closely align with specific learning objectives outlined in the curriculum and that could thus easily be integrated into regular classroom teaching by history teachers are scarce.

In response to this gap, the present paper details the development of *Limes*, a 2D top-down history game created in Unity and rendered in pixel art, specifically designed for use in 5th/6th grade history classes. The following sections illustrate the steps taken to bring *Limes* to life and how the game integrates educational theories to foster a deeper understanding of Roman history among young learners.

2. Outline of the Project: How Limes has Come to Life

2.1 Concept

The incorporation of historical themes in educational video games has been identified as highly beneficial (e.g., McCall, 2016). Importantly, a balanced integration of narrative and gameplay is particularly crucial in educational video games where engagement and learning must coincide (Booker, 2006; Schell, 2014). In addition to consulting key video game design literature (e.g., Booker, 2006; Schell, 2014) an important first step of the development of *Limes* involved understanding what the main target group (German school students) needed to learn about Roman history. As the Roman Empire is an integral part of the 5^{th}/6^{th} grade curriculum in German secondary schools, it was decided to focus on these age groups and grade levels. By understanding the main topics covered in the curriculum, it was possible to pick a historical period that was well-suited for a video game. As the name suggests, one of the main topics in *Limes* is the limes itself, referring to the functions of the ancient Roman border in Germany and across the empire. Other important themes were the relationships between the Roman Empire and the Germanic folks and a focus on Germanic tribes' history, with particular attention to the Alemanni. The educational objectives of *Limes* are to foster students' motivation (e.g., interest in history), understanding of Roman-Germanic relations and knowledge about Roman history, historical empathy, critical thinking, and intercultural outcomes. These objectives guided the development of the narrative and gameplay, ensuring that each element contributes to meaningful learning outcomes. The narrative of *Limes* is set in third-century AD southwestern Germany and follows an Alemanni child, caught in a plot that could ignite a war. This storyline provides a lens for exploring historical themes, through the child's journey and interactions with a Roman centurion named Ariovist. This storyline is the result of balancing the aspects of game design, narrative and history education.

The next step was to figure out the best and most effective way to bring this historical period and its characters to life. The initial idea was to develop a 3D video game with a cartoony style; this choice was connected to two main reasons. Firstly, it is easier and less time-consuming to develop cartoon-like characters than real-person characters and 3D animations have been found to engage a wide audience (Bedrina, 2018; Matsangou, 2018). However, after developing a 3D character (see Figure 1), it was noticed that 3D development was not the right choice for the development of *Limes*, which is developed as part of the PhD project of the first author. Given the limited time frame of a PhD, the game was moved to 2D, allowing the creation of faster assets, such as building and natural features and game characters. The decision to switch to 2D was also corroborated by pretests conducted at the Technical University in Stuttgart (Hochschule der Medien); these tests were conducted with game design students and professors to obtain feedback about the game's story. To allow them to play something, the first author developed a very simple 2D video game using a software called RPG-Maker (see Figure 2). Some feedback suggested that a 3D historical video game may raise unrealistic expectations due to comparisons made with some of the current commercial historical video games, such as the well-known Assassin´s Creed series. In conclusion, the decision to make a 2D video game was influenced by project resources and timeframe, and also aimed to avoid creating a product that raises too high expectations from the outset. In the next sections, the game development and its features will be explained in more detail.



Figure 1: 3D model representing a Roman Centurion developed in ZBrush.

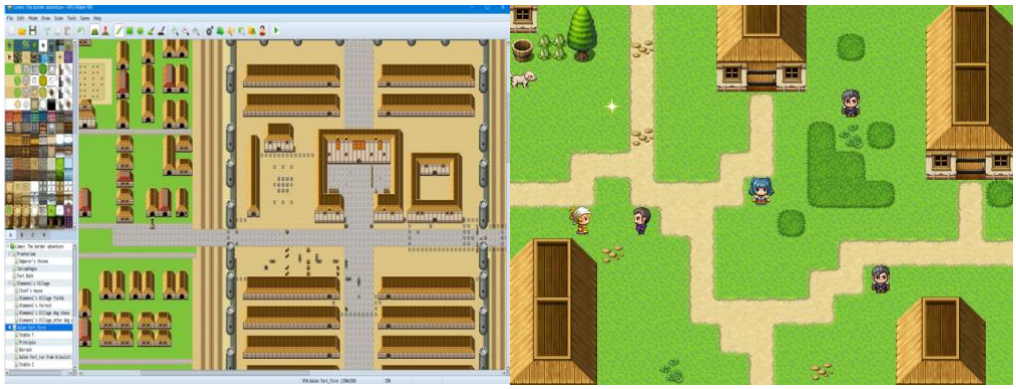


Figure 2: Screenshot of the software used to make a pretest of the video game (left side) and gameplay screenshot from RPG-Maker (right side).

2.2 Levels and Codex System

Limes consists of five levels that guide players through the narrative journey of the Alemanni child protagonist during Roman times. Each level—The Village, The Fort, The Limes, The Unknown, and The Return (see Figure 3)—incorporates distinct historical themes that provide insights into the Roman and Alemanni history (Fuchs, 1998; Garnsey and Saller, 2014). After completing each level, players receive a performance-based score ranging from 1 to 5 stars. This rating reflects how many additional tasks the player has completed within the level.



Figure 3: The five game levels of *Limes*, from left to right: Level 1 (The Village), Level 2 (The Fort), Level 3: The Limes, Level 4 (The Unknown), Level 5 (The Return).

Level 1: The Village introduces players to the story's protagonist, giving some initial insights about the Alemanni people and a brief introduction to the Roman Empire as a political entity. This sets the stage for the cultural contrasts that follow in the next levels. This level introduces other important characters, such as the child's father, a powerful and wise Alemanni chef, and his advisor, Lüger, who will play a more important role towards the end of the story. The real adventure starts at the end of the level when the child gets kidnapped by Roman soldiers.

Level 2: The Fort details the architectural and organizational structure of a Roman military outpost, highlighting the strategic importance of such locations, especially close to the empire's borders. This level introduces one of the most important characters in the video game, Ariovist. He is a stoic and proud Roman centurion tasked with bringing the child back to his village. Although this task may seem like an act of kindness, it is initially merely done to avoid an open conflict with the powerful Germanic tribe. His sentiments will be clear from the beginning, creating a confrontational relationship with the child and highlighting how much Romans and Germans despise each other. This relationship will become clearer as the game progresses, giving important insights into cultural differences and their complexities.

Level 3: The Limes explores the Roman Empire's border defences, giving players insights into its expansion and interaction with neighbouring tribes. During their journey, the duo unexpectedly falls into two traps set by adversaries seeking to capture the child for a ransom of gold and silver. In a turn of events, the child bravely rescues Ariovist from a dangerous situation. Similarly, Ariovist demonstrates his loyalty by risking his life to protect the child. These acts of courage and sacrifice significantly deepen their relationship, highlighting themes of friendship and trust despite their cultural differences and memberships to different groups.

Level 4: The Unknown takes place in a remote Germanic village, reached after the protagonist and Ariovist unintentionally stray from the limes into a dense forest. Lost and isolated, they stumble upon this village, a setting that challenges Ariovist's preconceived notions and exposes him to the culture of the Germans. This level serves not only as a geographical detour but as an important point for character development and narrative depth. During their time in the village, they encounter Lüger, who happens to be the architect behind the earlier kidnapping attempts of the child. After capturing the child and the centurion, Lüger reveals that his deepest ambition is to ignite a war against the Romans, driven by his belief that such a conflict would elevate the glory of the Alemanni and cement his legacy as a formidable leader. These revelations will bring the child and Ariovist even closer, laying a solid foundation for a friendship that transcends their initial differences. At the end of the level, the duo manages to escape from Lüger's control and sets off to warn the child's father about his treacherous advisor.

Level 5: The Return marks the dramatic conclusion of the story. Ariovist makes a noble sacrifice to protect the child from capture, and the child is reunited with the father. Despite Ariovist's selfless gesture, the father remains unwilling to reciprocate by intervening to rescue Ariovist. However, the child decides to confront the danger alone, risking everything to rescue his Roman friend. In a climactic showdown, the child confronts and ultimately overcomes Lüger, putting an end to his malevolent plans. This courageous act not only saves Ariovist but also cements their friendship, which has been forged and strengthened through challenges and mutual sacrifice. The level concludes with a reflection on how the protagonist and Ariovist have grown and how their perspectives on each other and the Roman and Germanic cultures, respectively, have evolved, shaped by the experiences they have shared during their journey.

Each level has a mandatory main mission and a non-mandatory secondary mission. The secondary missions are meant to give players a chance to experience extra missions with different game dynamics and gather more historical information. Secondary missions provide players with opportunities to explore diverse game dynamics, such as stealth operations, battling enemies and solving puzzles. Additionally, players can experience unique activities not available in primary missions, such as participating in horse races. As the player's performance is assessed based on the number of extra tasks completed during a level, completing secondary missions rewards players with higher scores at the end of each level.

A central feature of *Limes* educational architecture is the *codex system*, an innovative feature that allows players to unlock historical information through interactions with game characters. This system enriches the narrative and serves as a dynamic educational tool, enabling players to access detailed explanations of historical figures and events at any point in the game. This information is accompanied by images and customized historical maps designed specifically for this game (see Figure 4). The engagement with the codex can be tracked to analyse its impact on learning outcomes (e.g., testing whether players who spend more time reading codex entries learn more).



Figure 4: Gameplay screenshot of the codex system of *Limes* (left side) and historical map developed for the Limes codex system using a software called QGIS (right side).

2.3 Game Development in Unity

The development of *Limes* was facilitated primarily through Unity, a powerful cross-platform game engine renowned for its flexibility and wide usage in indie and professional game development. Although RPG Maker might seem like a simpler option Unity was chosen for its versatility and the greater control it offers over the game's development. In addition, Unity possesses a huge asset store, which can facilitate the use of numerous types of assets, accelerating the creation of low-budget video games, such as *Limes*. The work in Unity can be divided into three sections: asset creation, coding in C#, in-build Unity development and voice integration with ElevenLab.

1. Asset creation employed pixel art graphics, which was achieved by using a software called Aseprite. This pixel art tool is specifically designed to create animations and sprites, allowing for the portrayal of historical themes with artistic clarity (see Figure 5). Pixel art not only invokes the nostalgia of classic games but also serves as a visually simplistic yet effective medium to convey complex historical narratives, ensuring that the educational content is accessible and engaging to learners (Messaris and Humphreys, 2007; Squire, Gee and Jenkins, 2011; Egenfeldt-Nielsen, Smith and Tosca, 2016).



Figure 5: Examples of characters used in *Limes*.

2. Central to the development of the video game was the use of C#, Unity's primary programming language. The flexibility and object-oriented capabilities of C# enabled the creation of complex gameplay mechanics and interactive learning modules tailored to the historical content. Scripts written in C# facilitated the integration of a complex dialogue system with decision-making scenarios, which are vital for engaging students in active learning and critical thinking about historical events (Lin, Huang

and Yang, 2023). Scripting was essential in developing the different game dynamics included in the video game. The game dynamics of *Limes* are moving in the environment and interacting with game characters through dialogues. During a mission, the player will be allowed to throw rocks at targets, engage in horse races and be involved in stealth missions, where it will be important not to be seen by the enemy (see Figure 6). Moreover, C# was vital in creating essential game features such as the codex system and the game database.



Figure 6: Gameplay screenshot during a horserace mission (middle), gameplay screenshot during a throwing rock mission (right side), and gameplay screenshot during a stealth mission (left side).

3. The build process within Unity involved layering the pixel art assets with the coded functionalities to assemble the game's levels and interfaces. This phase optimised the interaction between graphical elements and script-driven behaviours, ensuring seamless gameplay and educational delivery. Unity's Scene Management and Prefab systems were extensively utilized to manage and reuse game objects across different levels efficiently, enhancing development time and runtime performance. Another important feature used during this phase was the Unity asset store, which contains many free and paid assets. The asset store provided important features used within the game, such as terrain tiles, dialogue system, environment noises and music. This helped create the five levels of *Limes* effectively, saving development time.

4. Integrating voice narration in *Limes* involved employing ElevenLabs, an advanced AI tool that converts text to audio. Incorporating voice acting was not merely an aesthetic choice but a strategic enhancement to the game's immersive quality. By giving the characters distinct voices, the game becomes more engaging and accessible, helping to bring the historical narratives and personalities to life. This auditory dimension significantly enriches the player's experience, making the educational content more enjoyable and memorable (Dewatri *et al.*, 2023).

Limes uses MongoDB, a flexible and scalable NoSQL database, to manage and store gameplay data effectively. This integration with Unity allows for seamless real-time data capture, which is crucial for the dynamic environment of the game. The database records a variety of metrics, such as levels completed, individual-level performance, total playtime, and specific interactions with hidden game features like quizzes and puzzles that are only accessible to players who perform very well in the game (a feature often used in commercial video games). Furthermore, it tracks interactions with the codex, including how many times and how long codex entries are accessed, providing insights into the educational engagement of players.

2.4 A Multi-disciplinary Approach to Game Development

The game development process combined insights and methods from multiple disciplines, including game-based learning, psychology, history education, and education sciences and pedagogy. The educational objectives of *Limes*—fostering students' motivation (e.g., interest in history and the Roman Empire), knowledge about Roman history, historical empathy, critical thinking, and intercultural outcomes (e.g., positive diversity beliefs)—guided the integration of these disciplines into the game's design. A strong adherence to game-based learning principles ensured a balance between the need to cover subject matter and engaging gameplay (Plass, Homer and Kinzer, 2015). In addition, insights from educational psychology, for example, on how to trigger and maintain students' situational interest as precursors of developing an enduring personal interest in history and the Roman Empire (Hidi and Renninger, 2006), influenced the design of tasks in the game. Also, based on cultural and social psychology research, the game emphasizes the value of cultural diversity and learning about different cultures (here: Romans and Alemanni) (Bardach *et al.*, 2024). Furthermore, principles of the well-established social psychological intergroup contact theory (Pettigrew and Tropp, 2006) were integrated. Specifically, intergroup

contact theory states that positive contact between members from different groups can reduce prejudice and foster tolerance (Pettigrew and Tropp, 2006). The friendship between the child protagonist and Ariovist is an excellent example of the potential for positive intergroup contact. From education science, generic principles of instructional quality (e.g., the importance of cognitively stimulating learning content) were adopted. Based on insights from history education and didactics, the narrative emphasizes historical empathy and perspective-taking, and helps players understand complex historical events. It combines engaging storytelling with careful history examination, improving player's history knowledge and critical-thinking skills (Wessell, 2017).

2.5 Initial Tests and Expert Feedback

Following the development of the initial version of *Limes*, the game was tested by a diverse group of participants, including academics with backgrounds in education, psychology, and history, as well as avid video gamers. This broad spectrum of testers was chosen to gather insights and ensure the game's educational and entertainment values were optimized across different user groups. Overall, players showed great interest in the game and evaluated it very positively. The feedback received was instrumental in refining the game's design and functionality. For example, participants highlighted the need for clearer instructions regarding the use of the codex system. In response, the game was updated to include more intuitive guidance on how to access the codex, accompanied by a notification system (see Figure 7) that alerts players when new information is available. This adjustment aimed to enhance the educational experience by ensuring players are fully aware of the learning resources at their disposal.

Another significant area of enhancement was the gameplay mechanics and dialogue accuracy. Testers identified several glitches that affected the game's flow and immersion. These issues were addressed, improving the overall smoothness and playability. Additionally, considering the game's bilingual nature—available in both English and German—special attention was given to the large volume of dialogues and their corresponding audio recordings. Translation and audio sync errors were corrected to ensure consistency, giving all players the same quality of content and storytelling. Overall, the insights gained from this phase have not only improved the game's educational efficacy but have also enhanced its engagement and usability, making it a more powerful tool for learning and enjoyment.

An important next step will involve in-depth pilot tests with secondary school students as the target group of *Limes.* After that, experiments in the lab will be conducted to test the usability of the game and effects of specific game elements. Then, it is planned to conduct a large-scale evaluation study in history school classes to gain insights into the effectiveness of the game in improving central outcomes (e.g., interest in history and the Roman empire, knowledge on the Roman Empire and history understanding, positive diversity beliefs).



Figure 7: Gameplay screenshot showing the implementation of a notification system to unlock codex entries.

3. Conclusions

To conclude, *Limes* leverages historical accuracy and innovative educational tools. *Limes* provides an engaging gameplay experience and a rich, interactive learning environment, effectively combining insights from multiple disciplines to achieve its educational objectives. Initial tests and expert feedback highlight the game's potential as a valuable resource in history education. Empirical studies with school students are now crucial to evaluate

the game's educational effectiveness and inform scaling strategies for its broader use in (German) secondary school history classes.

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Exploring Play as the Nexus of Games and Playfulness

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Abstract: In this paper we provide an original theoretical framework for conceptualising the relationship between play, games, and playfulness. This framework is intended to support in understanding the different potential benefits and drawbacks of the use of games and playful approaches in universities. To evidence its significance across the sector, we apply the framework to seven different forms of play pedagogy used in Higher Education. First, we define and differentiate between games as problem-solving systems and playfulness as an engagement philosophy. We highlight the advantages of games as experiential learning environments and as intrinsically engaging tools, and the benefits of playfulness for promoting lusory attitudes within ludic communities. We argue that play – encompassing both an activity form and state of mind – can be conceived as the nexus of games and playfulness, bringing the affordances of both as well as additional synergistic benefits relating to the normalisation of failure. Second, we present a taxonomy of seven forms of playful learning in higher education that emerged from a large-scale literature review of the use of play in higher education over the past fifty years. These are: roleplay, simulations, traditional play, play worlds, ludification, playmaking, and alternate realities. This taxonomy is then tested against the literature base to provide a suite of examples of different ways in which playful learning encompass games and playfulness. We conclude by discussing the limitations and potential uses of this approach when applied to the practice of play as a pedagogy.

Keywords: Playful Learning, Games, Play, Playfulness

1. Introduction

Researchers and educators have studied and applied games and play to adult learning from a variety of disciplinary perspectives – including education, sociology, and Philosophy – over many centuries, stretching back to the use of war games for leadership training in feudal China (Morgan, 2024). In more recent years, play theory, game studies, and computer sciences have added additional dimensions to the field. Different theoretical approaches to playful learning, applied in different learning contexts, and with different levels of rigour, mean that the published literature provides a colourful yet ultimately confusing picture of evidence for the contemporary researcher or educator.

In this article we build on a comprehensive literature analysis of the use of play and games in adult learning over a fifty year period (Whitton, 2023) and have also the results as the basis of a taxonomy of playful learning which we test for the first time in this article by applying it back to the range of playful learning pedagogies discovered in the literature. To underpin this, we consider the theoretical basis of – and the relationship between – games, play and playfulness, and we propose a theoretical framework where both games and playfulness can exist in isolation, but when combined they create the potential for play.

We present the basis of our theoretical model, and an initial application of that model to dominant playful learning pedagogies. In doing so we hope that future researchers will critically test the model themselves, and that education practitioners will be better able to select appropriate playful pedagogies for the context of their learners.

2. Games, Playfulness, and Play

There are many definitions in the literature of 'play', 'games' and 'playfulness'; the definitions overlap, clash and open up gaps. In our review of these terms in the academic literature we have been drawn to the definitional works of Suits (1978), Sicart (2014) and the scholarly analysis of Stenros (2015), which have helped us to focus in on defining criteria for each term.

For the definition of 'game', this led us to reject the commonly proposed *goals*, *rules* and *challenges* (as other activities such as a formal examination exhibit these same criteria, but are not games), and the notion of *enjoyment* or *fun* (as these are subjective – one activity may be fun for one person, but a trial for another). However, we found the idea that games operate in a separate world with different consequences from the real world (the ideas of *fantasy* and *safety*) to be a defining characteristic (running headlong into a door to try to

open it has very physical consequences in the real world, but in a game could be tried without any risk of physical harm).

Suits (1978) provided us with another, core, defining characteristics: a *prelusory goal*, *lusory means*, *constitutive rules*, and *lusory attitude*. This implies the introduction of goal with unnecessary obstacles, which would be ridiculous in real life, but make a game more challenging and fun. A lusory attitude is the willingness to abide by these unnecessary rules and enter a 'spirit of play'. For our definition of a game, the first three of Suits' characteristics are tangible and objective, but lusory attitude is subjective (it requires that players both adopt a lusory attitude, and also that they agree that the game is a game). We therefore think that lusory attitude cannot help us to define game but might help us to define playfulness (see below). We can therefore combine the above objective elements into a definition:

> A game is a **deeply interactive challenge** in an **unreal context**, with a **goal** and **lusory rules** (where the rules preclude the most straightforward means of achieving the goal).

In contrast to the objective nature of a game, playfulness is a subjective *attitude*, separated from play as an *activity* by Sicart, and this provides us with a useful separation of the two terms. We see playfulness as the capacity to *use play beyond the context of play*, allowing individuals to engage in any activity in a light-hearted and joyful manner. Playfulness is explored as a stable character trait from the perspective of personality psychology, with various definitions emphasizing different aspects such as physical, social and cognitive spontaneity, joy, sense of humour, and intellectuality-creativity. In summary, playfulness is an attitude of mind that embodies a willingness to engage in activities in a light-hearted, joyful, open, mischievous, and comedic manner – which suggests that playfulness is closely related to having a lusory attitude, allowing individuals to take risks, try new experiences, and accept failure in a spirit of adventure. Playfulness can be applied to any activity, making it a versatile mindset beyond just the context of games.

> Playfulness is an attitude of mind that embodies a willingness to engage in activities in a **light-hearted**, **joyful**, **open**, **mischievous**, and **comedic** manner.

From the literature, we have identified three elements common to **play**. First, it is voluntary – "whoever must play, cannot play" (Carse, 1986, p4). Play is approached voluntarily, with a lusory attitude, and with a willingness to accept and engage with artificial prelusory rules. Second, is a sense of freedom: away from the constraints or repercussions of the 'real world' and in a place of safety. And third is the autotelic nature of play: it is done in the moment, purely for the joy or delight of the experience itself. This has been interpreted by some as play having no actual value ("an occasion of pure waste" (Caillois, 2001)) but there are clear and evidenced evolutionary benefits that derive from play that extend through to adulthood (creativity, problem solving, well-being, socialisation), and there is also value in doing something enjoyable simply for its own sake.

When compared to our definitions of games and playfulness above, we define play as the point that the two meet: a voluntary and intrinsically motivated activity that involves engaging with a game playfully, adopting a lusory attitude, in a free context that is not constrained by the real world. Play is approached with a mindset that values joy and delight in the experience, seeking the freedom to be creative and innovative within the boundaries of the game's rules. This mindset allows us to play for the sake of playing, without extrinsic motivations, and to enjoy the activity purely for its inherent value:

> Play occurs when a person engages with a game playfully, adopting a **lusory attitude**, in a **free context** (where actions in the game are not constrained by the real world) purely for **enjoyment**.

While it is possible to engage with games without truly playing them if the intention lacks a playful mindset, the playful mindset is what turns game engagement into play. Playfulness can also be applied to activities outside of games, but without a lusory attitude and adherence to a set of game rules, this engagement would not – by our definition – constitute play. Playfulness and games intersect to create play possibilities (see Figure 1). We define the centre section as play potential, as even if there is a game plus a playful facilitator, it is up to the learner to accept the invitation to play, or maybe even to see it as play.

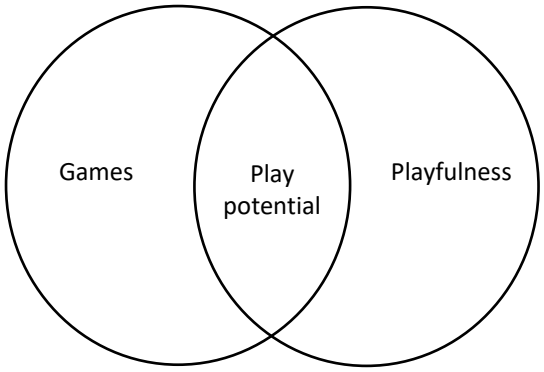


Figure 1: Play potential can happen only when educators use games and facilitate playfulness

Defining relationship between games, play and playfulness helps us to provide a solution to the paradox of educational gaming: is 'forced' educational play technically play? From our definitions, we can see that first an educational game is still a game, even if it is not engaged with voluntarily or is not fun, and second that an educational game that players engage with playfully can be play. Where the players are intrinsically motivated to play, do so freely and with enjoyment then they are not just engaging with a game but playing it.

We define playful learning as pedagogic approaches that use, incorporate or build on aspects of games or playfulness. From our literature review this incorporates two broad playful pedagogic types.

- **Using games** describes pedagogies that use game structures or mechanics within teaching or the wider curriculum, such as game-like goals, rules, competition, collaboration, problem solving, or feedback mechanisms. This might also include the use of off-the-shelf games, with the addition of playful contexts, narratives or challenges to connect them into the learning. Games in this sense are essentially experiential problem-based learning environment that are designed to use a suite of mechanics that make them intrinsically engaging.
- **Facilitating playfulness** describes pedagogies that encourage or support learner playfulness in non-game contexts, such as applying fun or creative narratives, characters or situations, or encouraging playful behaviour in classes or creative responses to assessments. By facilitating playfulness educators can emerge students in alternate worlds in which they can safely try new things and ideas without impacts in the 'real' world and explore possibilities in creative ways.

Both games and playfulness support learning through failure as an inevitable part of game play and by providing the safety net to make mistakes. In the sections that follow, we will build on this distinction to explore different ways in which types of playful learning can be used to achieve each of these ends.

3. Taxonomy of Playful Learning in Higher Education

In order to better understand the range and types of playful learning that are taking place in Higher Education globally, we undertook an in-depth literature analysis exploring the use of play in higher education over a fifty year period (Whitton, 2023). The review used the Scopus database, selected because of the scale of its coverage and included journal articles available in English that were published between 1973 and 2022 where the title of the article contains either "play*" or "gam*" and where the abstract contains the words "undergraduate", "postgraduate" or "higher education". Irrelevant articles were removed, including those that use a game pun in their titles, ones focusing on playing music, analysis of theatrical plays, studies into gambling behaviour and sports performance, analysis of leisure games, discussions of drinking games, economic game theory, and teaching about games in traditional ways. This left 1090 articles that were included in the analysis.

This analysis enabled us to develop an emerging taxonomy of playful learning in higher education by identifying seven different types of approach in the literature that use games, or playfulness, or a combination of both. At this stage, we are still playing with category names and testing our constructions of each of the categories to ensure that there is minimal (ideally no) overlap between them. However, as the field of playful learning continues to grow and evolve, we assume that this taxonomy will do the same; new forms of playful learning may emerge (as escape rooms and alternate reality games have done in recent years) that require the taxonomy to be expanded, other categories may decrease in relevance. We see this as a living analysis tool rather than a finished product. One important feature of the taxonomy is that we do not see any of these playful learning

pedagogies as being intrinsically digital or analogue in implementation and this taxonomy is purposefully technology agnostic. The literature analysis identified seven different types of playful learning in higher education:

- **Roleplay** describes a situation where participants are asked to take the role of another person or character in specific scenarios (Rao and Stupans, 2012). This enables students to learn experientially by understanding what it is like to 'be' a different person and why they might make the decisions they do, to imaging possibilities, and to practice skills in a safe environment without the consequences of taking that role in the real world. Roleplay has been commonly used across all areas of medical education, as well as in a range of other disciplines, most heavily in the social sciences.
- **Simulations** provide models of the real word, often in a highly simplified way, with which students can interact, and see the effects of their actions on the state of the system in a safe space where the outcomes do not matter in the real world. The most common type of simulations in the playful learning space are business simulation games, in which students take on business roles and make company decisions, which were the first games used in higher education (van Ments, 1995).
- **Traditional play** describes the use of traditional game formats such as board games and card games (Moseley and Whitton, 2013), with modified versions of traditional entertainment games being common throughout the literature, as well as formats such as quizzes (and modified quiz shows) and more recently there is a growing body of work into the use of toys, stemming perhaps from the growing popularity in the use of LEGO for 'serious play' (James, 2013).
- **Play worlds** describe the use of structured and differentiated places in which learners can experiment and solve problems in a delimited space that is separate from the real world. The most common form in the literature is digital games, and particularly 'serious games' which describe games where entertainment is not the primary purpose (Westera *et al.*, 2008). Play words provide learning environments that are intrinsically engaging, often with clear goals, narratives and an internal rule-set. While they are predominantly digital, examples do exist in the analogue world, such as theme parks.
- **Ludification** describes the use of game or play elements outside the context of the full structures of a game, the most common form of which is gamification (Deterding, 2012), which uses game mechanics such as points, badges, and leaderboards to provide extrinsic motivation to non-game contexts, and has been criticised for its focus on 'pointsification' (Huang *et al.*, 2020) with a call for more 'meaningful gamification' (Nicholson, 2015) that focuses in developing intrinsic motivation, participant freedom, and engagement with narratives.
- **Playmaking** is when students are supported to build games or other playful experiences themselves rather than playing existing games. This enables students to learn through a process of development, testing, failing, trying again, and eventually succeeding (Rawlinson and Whitton, 2024). The focus on creation of games or play immediately acts as a play signifier that differentiates playmaking from other creative development projects and identifies it as a form of playful learning.
- **Alternate realities** explicitly make use of narratives to create spaces in which the real world and imagined other worlds overlap and are relatively new in higher education. This includes alternate reality games in which players collaboratively solve puzzles over weeks or months, other pervasive games (Montola, Stenros and Waern, 2009) that blend real and fictional worlds including street games and treasure hunts, and escape rooms (Fotaris and Mastoras, 2019) in which learners must work in small groups to solve puzzles.

This taxonomy is useful for providing an overview of the types of playful learning approaches that have been used in higher education over the past fifty years. In the following section we will explore how each of these approaches might be used both to support the use of games and facilitate playfulness, drawing on examples from the corpus analysed in the review, and further afield where appropriate.

4. Application to Play Pedagogies

The analysis of literature described in the previous section provides a way of identifying and thinking about the different types of pedagogic approaches that fall under the broad umbrella of 'playful learning'. In this section we will apply our definitions of games, playfulness, and play, described earlier in this article, to the taxonomy, in order to differentiate between the ways in which each of the pedagogies in the taxonomy use games and facilitate playfulness. Examples of the applications of each pedagogic type in each context are shown in Table 1 below.

Table 1: Examples of the use of games and facilitation of playfulness in higher education

Pedagogy	Using Games	Facilitating Playfulness
Role play	Role-playing game	Medical role play
Simulations	Business simulation games	Building simulator
Traditional play	Educational board game	Lego serious play
Play worlds	Video game	Virtual world
Ludification	Gamified system	Use of play techniques
Playmaking	Game development	Playful design
Alternate realities	Alternate reality games	Pervasive learning environments

Role play is mainly used in the literature for facilitating playfulness by creating a safe environment in which students can practice and fail. There are many examples in the literature, particularly from the health field, such as students taking on the role of therapists and getting feedback from their interactions with clients (Bailey, Deardorff and Nay, 1977) or teaching medical ethics using role play to immerse students in the issues of euthanasia and consent (Noone *et al.*, 2013). The use of role-playing games in the literature is relatively uncommon but there are examples of using online role-playing games, for example to teach foreign language grammar and composition in World of Warcraft (Gellar-Goad, 2015).

Simulations most commonly take the form of business simulation games, from early paper-based games, such as an early simulation game used to teach healthcare finance (MacLeod and Smith, 1984), through a rapid evolution to digital, with the advantages that computers can simply and swiftly carry out calculations that would be time-consuming on paper, such as a game that simulates the global stock market (Torga *et al.*, 2018). There are few examples in the literature of simulations that are not games, but they include, for example, using the *SimCity* game, not as a game in itself, but as a way of simulating city-building for planning education (Minnery and Searle, 2014).

There are a wide range of examples of traditional play, both as games and as play facilitators. Games includes examples of board games for teaching archaeology (Huffer and Oxenham, 2015) and undertaking chemistry revision (Adair and McAfee, 2018), card games for teaching veterinary medicine (Ober, 2016), and dice games to teach probability (Stephenson *et al.*, 2009). There are also many examples of using toys (and particularly nostalgic childhood toys) to facilitate playfulness, such as using and adaptation of the 'serious play' approach to use Lego to teach cell biology (Garden, 2022).

Play worlds predominantly explores the use of digital games in higher education, and there is a large variety of game types including games specifically designed for education such as a games specifically developed to improve information literacy skills (Encheva, Tammaro and Kumanova, 2020), as well as studies that use existing games such as *Angry Birds* to teach artificial intelligence (Yoon and Kim, 2015). There are fewer studies that look at play words designed to facilitate playfulness but, in particular, there are several that look at the use of the *Second Life* virtual world (Childs, 2010).

Ludification is almost exclusively about gamification in the literature, such as the use of digital badges to motivate students (Delello *et al.*, 2018) or the use of leaderboards in engineering education (Ortiz-Rojas, Chiluiza and Valcke, 2019). However, there are also examples of more deep and 'meaningful gamification' that have more in common with play, such as embedding narrative in training (Armstrong and Landers, 2017). In addition there are approaches that more explicitly embed elements of playfulness into teaching such as the use of magic and drama as play signifiers (Hilas and Politis, 2014).

Playmaking is when students make games or playful experiences, and in the vast majority of cases this involves game-making. This can be students of game studies learning to make games as part of their game-design curriculum (Altanis and Retalis, 2019) or game-making as an activity to teach a different subject, such as students designing games and subsequently analysing the artefacts produced to surface assumptions about social class inequality (Sandoz, 2016). In contrast, there were almost no examples of students designing playful experiences, although there is research on developing metacognitive skills by designing playful solutions to complex problems (Marone, Staples and Greenberg, 2016).

Alternate realities are a relatively new form of playful learning and while many examples incorporate games, there are also examples that use playfulness outside of the context of play. For example, alternate reality games

have been used to support student induction (Piatt, 2009); in contrast, pervasive learning environments (Brookes and Moseley, 2012) harness the immersive qualities of alternate realities to create a playful environment without the explicit structures of a game.

Although, as the examples show, each of the approaches here can use games and facilitate playfulness, some approaches are more common in the literature. Role play tends to be most commonly used to facilitate playfulness in higher education; simulations, play worlds, ludification, and playmaking tend to be more focussed on games; while traditional play and alternate realities provide a mixture of the two.

5. Conclusions

We have provided an original contribution to the field through a set of clear and distinct definitions of games, playfulness, and play and a taxonomy of playful learning based emerging from, and tested against, a large literature base spanning fifty years. This analysis shows that games can be used effectively for adult learning and playfulness can be used to facilitate to support learning, but when added together, play combines the best of both of these and has potential for the greatest effect on learning.

This poses two challenges for education practitioners. First, those that are using games need to consider the possibilities of additionally facilitating playfulness, for example using 'play signifiers' or techniques to give students permission to play. Second, those already using approaches that facilitate playfulness need to consider whether it would be appropriate to use game mechanics to provide structures to create play.

It is important to note that some of the terminologies and claims in the articles reviewed do not match the terms used in our definition; terminology is used in different ways across different fields of study. For example, 'gamification' is used ambiguously in the articles with both its original meaning (using game mechanics in non-game contexts) and more broadly to simply mean using games. Several activities are called games in the literature but do not meet our definition of games and are in fact what we describe as facilitating playfulness. We do not aim to homogenise the language of play (and believe it would in fact be futile to try) but by offering definitions that highlight the juxtaposition of objective games and subjective playfulness we hope to highlight the differences between these two approaches to creating playful learning and the synergies that are created when both are in harmony.

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Design of a Serious Game to Teach Esports Concepts and Career Pathways

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Abstract: The popularity of esports has gained public interest over the past decade, leading to the industries evolution, providing further avenues for career prospects and educational outreach. Esports, abbreviated from electronic sports, is the nature of playing video games casually or professionally at a competitive capacity, either as an individual, or as a team. Previous research areas in esports have focused on education, psychological factors, health and nutrition, business management, performance review, and commercialisation, factoring in the relevance of esports in sports and supporting terms. The industry has different avenues and perspectives that are advantageous to develop innovative approaches, providing information about the industry, and improving the understanding for the wider general audience. Serious games and games-based learning provides the opportunity to educate and inform about the phenomenon of esports and the potential career industry pathways. This paper presents a conceptual design for an esports serious game to educate players about esports in relation to career pathways and genres. Investigation and adaption of serious game frameworks (e.g. Learning Mechanics-Game Mechanics, Activity Theory Model of Serious Games) will be adhered to through the research. This will lead to the development of a serious game for potential stakeholders to assist in their interests in studying or learning about esports and its multi-faceted career opportunities through simulated scenarios. A mixed methods approach will support the increased frequency of new esports programmes in secondary, further, and higher education, using a serious game to inform prospective students in relation to potential career avenues. The conceptual design idea presented in this paper will support the initial research steps of a serious game to teach about esports.

Keywords: Esports, Serious Games, Competitive Gaming, Career Pathways, Game Genres, Serious Game Frameworks.

This paper provides a conceptual design of a serious game to teach about esports and career pathway opportunities, leading to informing and educating prospective students of potential opportunities available in the industry.

1. Introduction

The gaming industry and the activity of playing video games has permeated into society as a mainstream activity. By 2024, the games industry is projected to reach $455.60 billion in the market revenue with a trajectory continuing to soar (Statista, 2024). The surge in video games coupled with content creation (i.e. streaming) has influenced the popularity of esports. Esports, shortened from electronic sports, is the competitive playing of video games (Werder, 2022; Rogers, 2019) and as of 2019, has become a successful billion-dollar industry (Newzoo, 2019). Competitive games have been around for centuries, originating with the ancient Greek Olympics in 776 BC (Zhou, 2023). Video games, and competitive playing originated in the early 1970s at Stanford University, with the first recorded official esports tournament of "Spacewar!" (Scholz, 2019). Over 50 years later and the industry is soaring as a mainstream activity, breaking off into various levels in education, ranging from high school education to higher education either as a "*social space in which gamers can build community*" (Byrne, 2020, p. 25) or as a taught subject, e.g. business and events management, content creation (Scott *et al.*, 2021).

Serious games present a potential approach to teach about the domain of esports, the history of esports, the genres and career pathways. The serious games industry as of 2024, holds a market size value of $11.67 billion, with figures expecting to increase over double by the next ten years (The Business Research Company, 2024). The purpose of a serious game is to educate and train whilst fulfilling a sense of achievement for the player at the same time (Silva, 2020). Serious games research exists in multiple areas such as health, military, and education and games that are customised implementations (e.g. Baxter *et al.*, 2023; Hainey, Baxter and Holder, 2023). There is also the use of commercial games such as Doom II (e.g. Loh, Sheng and Ifenthaler, 2015) and Minecraft Education Edition (e.g. AlJanah *et al.*, 2023). AlJanah *et al.* (2023) used Minecraft Educational Edition as a tool to enhance engagement in higher education and to demonstrate the effectiveness of modified gameplay to teach programming concepts. Baxter *et al.* (2023) designed and developed a serious game to focus educating stakeholders about career pathways in the games industry.

2. Research Design

2.1 Methodology

The investigation and selection of research methodologies in the research will be mixed methods, starting with an initial phase of conceptualisation, leading to future phases of design, development, and evaluation. There will be a continued systematic literature review approach in academic literature highlighting important approaches to serious game design principles, leading to an effective use of game genres in certain scenarios (e.g. puzzles in problem solving scenarios). Interviews and surveys will gather further insight, combined with a user requirements analysis to identify commonalities in esports titles and genres. These findings will allow identification of effective strategies and approaches, with a high-quality output on teaching stakeholders about the esports industry and connecting career pathways.

2.2 Data Collection Methods

Due to the contrast in subject areas, there will be a separation in the method of collecting empirical data for esports and serious games. With the lack of common literature between the topics, the projected outcome should be positive, ensuring the creation of a supporting, high standard, serious game reflecting these outcomes. The initial selection for academic literature in esports and serious games will lead to results from different databases, due to the popularity and difference in research accomplished in these areas. The data collection of empirical data will be subject to a Boolean logic search (Aliyu, 2017) outlining the keywords to align the best databases for empirical gathering (e.g. esports, serious games, competitive video games).

Furthermore, mixed methods data collection would be effective in the research, addressing the serious game purpose. These methods would include interviews and surveys, as well as focus groups and observations to gain concrete solutions in addressing effective approaches to effectively teach about esports to stakeholders and to ensure support of the research hypothesis. These conclusions will come from industry experts, both esports and serious games, with a focus from beginners to professionals.

3. Evolution of Esports

In recent decades, the surge and demand for esports has transformed, turning the industry into a global phenomenon, capturing the attention of countries across the globe. Starting as a side spectator sport to accompanying the ever-growing video games industry, esports has taken a monumental step to becoming its own standalone industry, reshaping entertainment. The industry evolution has called for a diverse advancement in areas such as career opportunities and potential growth for educational outreach joining in with content creation (Johnson and Woodcock, 2021). Esports, stemmed from electronic sports, is the competitive playing of video games, professionally or casually, competing individually or most commonly, as a team. Academic research in esports has explored dimensions ranging from education to psychology, and health and nutrition to business management. Researchers have saw these opportunities, gaining a broader understanding of esports, deriving from traditional sports providing a connection to relative terms and industries, and developing innovative approaches to disseminate information and provide a deeper understanding of the domain.

3.1 What is eSports?

Esports revolves around the competitive playing of video games with competitors partaking in organised tournaments across video game titles and game genres. The art of traditional sports relies heavily on the physical attributes of an individual, while esports relies on physical attributes, and a focus on the strength of meta skills (e.g. strategic thinking and teamwork) in a virtual environment. Early academic research found a focus on, and comparison, to the definition of traditional sports, extending the definition through the art of digitalised sports (e.g. Wagner, 2006). Wagner (2006) defined esports with the proposition of rewriting a definition by Tiedemann (2004) on traditional sports. This definition, although dated, still gives a broad and comprehensive definition dating back to early academic research.

"*'eSports' is an area of sport activities in which people develop and train mental or physical abilities in use of information and communication technologies.*" – Wagner (2006, p. 4).

3.2 Popular Esports Games And Genres

Within the games industry, game genres vary, with one or multiple per game. These genres all adapt different game mechanics and features, prevailing as being common occurrences in that genre. Examples include the skill-tree system, a common approach to support player advancement in role-playing games. A weapon management system, an approach in shooter genre games. Academic research to date presents studies focusing on a game specifically and not the genre. Mora-Cantallops and Sicilia (2018), as an example, focused on esports studies within the popular multiplayer online battle arena game, League of Legends. They investigated ranked (competitive) play, as opposed to casual, indicating the importance of the player experience to support the competency levels through 547 participants in the completion of an online survey. This research found that team collaboration was key to winning any game, no matter the skill level or role played in the game, revealing teamwork at the heart of esports. You have better chances of working as a team than on your own.

The popularity of game genres in the industry, will not always resonate with the popular game genres for esports, within reason. Due to the nature of competitive gaming, not all genres are applicable or popular by the wider population. As we saw in the previous example, Cantallops and Sicilia (2018) showed us the multiplayer online battle arena genre through the game, League of Legends. This is one popular genre within the industry, see Table 1 for an overview of leading genres within esports with examples of games from the esports industry. These games highlight an example of the top four genres in esports with a sample of popular, corresponding titles.

Table 1: Esports genres and games. Results and games adapted from Esports Charts (2024) data. Results extracted May 2024.

Genre	Example Games
Shooter	Counter-Strike 2 Fortnite Valorant Overwatch 2
Multiplayer Online Battle Arena (MOBA)	League of Legends Dota 2 Mobile Legends: Bang Bang
Sport	Rocket League EA Sports FC/ FIFA
Fighting	Street Fighter Tekken Mortal Kombat 1 Super Smash Bros. Ultimate

3.3 Esports Ecosystem

Since the first official recorded competitive video games tournament in the early 1970s, esports players competing against other players have evolved. This has been highlighted through online servers or connected via a local area network (LAN), individually or team-based, directing towards what the esports ecosystem is today (Scholz, 2020). The ecosystem has grown and become an intricate system, involving branches into the industry (e.g. content creation, the player, the game, tournaments) as highlighted by Johnson and Woodcock (2021). The core of the ecosystem in esports comprises of the teams, the game, the game publishers, the distribution to streaming platforms, the tournament organisers, and the biggest factor in esports, the sponsors (Reitman *et al.*, 2019).

3.4 Career Pathways in eSports

With the industry of esports taking a mass leap in the recent decade and the popularity of games continuing to be a staple in households worldwide, the appeal to younger generations wanting to achieve a dream job in the industry has increased (Salo, 2017). As suggested by Salo (2017), the younger generation are seeing these highly paid professional players achieve greatness through esports and are wanting the same for themselves. As addressed by Salo, the lifestyle surrounding a profession in esports can be difficult to control, straining your life habits or strenuous mental issues, highlighting resemblance to traditional sports. These difficulties can lead to early retirement from players, or difficulties in achieving a career beyond professional esports. With the idea of designing a serious game, this would assist in the areas of career and skill development early-on, gaining insight to stakeholders about the different career opportunities available within the esports industry. This may include going from a professional player in esports to becoming a caster. See below in Figure 1, an example of potential

career pathways in the esports industry and the retrospective career pathways beyond esports that are available to potential candidates. These are only a small example of popular areas in career pathway opportunities.

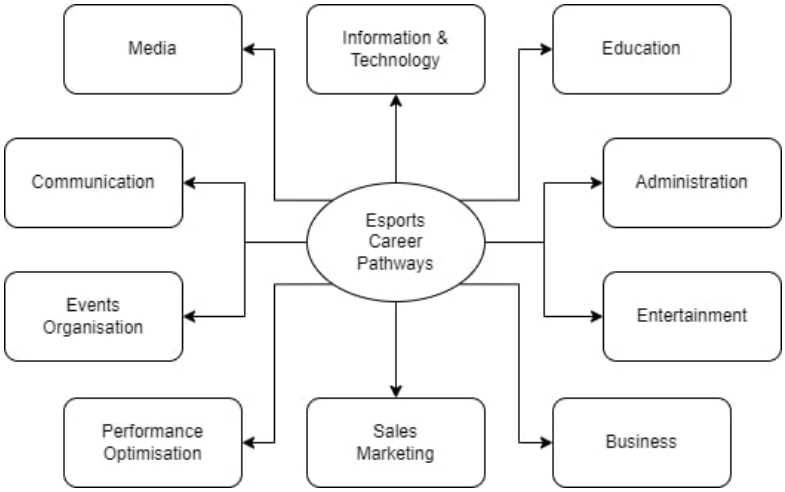


Figure 1: Esports career pathways. Adapted from Besombes (2020).

4. Serious Games

The academic research surrounding esports has explored a diverse range of disciplines, reflecting on the industries multifaceted dimensions. These areas have included the examination of psychological factors (e.g. motivation, performance, skills), health and nutrition (e.g. physical performance in players, dietary needs affecting cognitive influence (Johnson & Woodcock, 2021)), and business management (e.g. financial and legal standing (Hedlund, Fried and Smith III, 2020)), but rarely serious games. The use of a video game to teach potential stakeholders about the underlying concepts, historical events, games, genres, ecosystem, and career pathways would be important in demonstrating an innovative approach to teaching the subject area. Serious games and game-based learning provides an opportune research gap for the design, development and evaluation of a game providing a fun, yet, educating experience for players, focusing on beginner to experienced stakeholders in the industry.

4.1 Frameworks

Bellotti, Berta, and De Gloria (2010) suggest serious game frameworks and pedagogy as practical and constructive ways to learn about domains (e.g. health). The sole reason for a serious game is to create an educational experience offering information through gameplay (Silva, 2020) while conventionally using intrinsic motivations to entice the player in the game (i.e. learning). See Table 2 highlighting potential frameworks. Serious games shortened to SG and games design shortened to GD. These frameworks highlight potential frameworks that will be adhered to throughout the research and development.

Table 2: Serious game and game design frameworks examples

Framework	Type	Reference
Four-Dimensional Framework (4DF)	Development - SG	de Frietas and Oliver (2006)
Activity Theory Model of Serious Games (ATMSG)	Design – SG	Carvalho *et al.* (2015)
Student-centred Digital Game-Based Learning (SCDGBL)	Development – SG	Coleman and Money (2020)
Framework for interactive and iterative scenario generation for Serious Games	Development – SG	Luo *et al.* (2013)
Commercial-off-the-shelf (COTS)	Evaluation – SG	Ulrich and Helms (2017)
Mechanics-Dynamic-Aesthetics (MDA)	Design – GD	Hunicke, Leblanc and Zubek (2004)
Design Pattern Canvas (DPC)	Design – GD	Zavcar, Mayr and Petta (2014)
Game Object Model (GOM)	Development and Evaluation – GD	Amory (2007)

5. Teach eSports to Stakeholders: Development of a Serious Game

The development of a serious game will adopt a constructivist pedagogical approach, achieving the sole purpose of providing a learning platform, insight for potential stakeholders interested in the industry, and informing them about the concepts and career opportunities. These stakeholders will primarily focus on entry-level students and staff to support gaining further knowledge or revision. The design and development of a serious game gives opportunities to address a new learning and teaching approach for this domain, teaching the diverse fundamentals of the industry using the virtual environment of esports, games, and genres to create simulated experiences for the player to interact with.

Thus, presenting a game-based approach solution, this addresses a knowledge gap within both serious games and esports, addressing and giving justification to the development of a serious game in the domain of esports. Between serious games and esports, popular definitions exist in the academic literature. According to Werder (2022, p.394), esports is the "competitive or organized technologically enabled activities encompassing varying degrees of physicality, virtuality and technological immersion" adapting from Cranmer *et al.* (2021). In the domain of serious games, according to Laamarti, Eid and El Saddik (2014), serious games are "an application with three components: experience, entertainment, and multimedia" highlighting the different between serious games and terminology such as "training simulation, computer game, and sports". See figure 2 that gives a visual diagram expanding this, highlighting the possibilities that could are achievable with the development of a serious game.

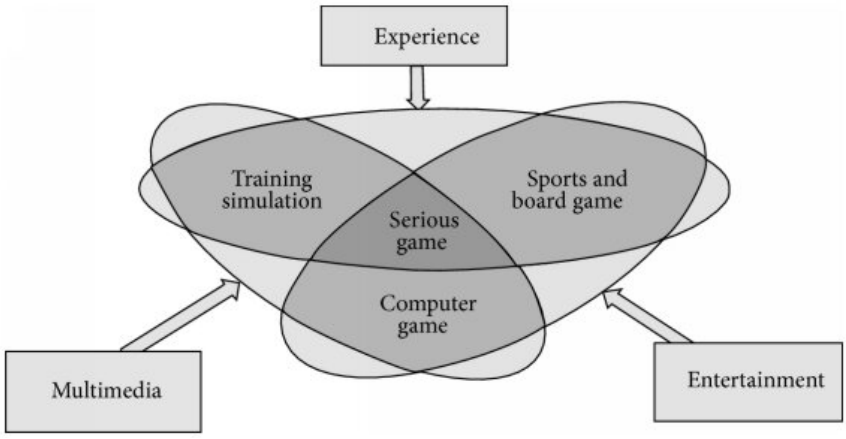


Figure 2: Definition of serious game (Laamarti, Eid and El Saddik, 2014).

Prior to any development, it is important to consider the learning and assessment outcomes and the content integration to the game. Initial stages of research will follow a user requirements analysis, aiming at the inclusion of gaining external knowledge from peers and representatives involved in or around the industry. From the serious game development side, it will be important to analyse already existing serious games such as Marine Doom (Loh, Sheng and Ifenthaler, 2015) and specifically their genres, giving insight to best practices to demonstrate an educating, yet entertaining experience for the player through simulated scenarios.

5.1 Research aim

The primary aim of this research is to develop a serious game to educate stakeholders, primarily teachers and students, about the esports concepts and career pathways. The additional purpose of the serious game will be to educate individuals about the esports industry, while exploring the history, games, genres, ecosystem, and the career development opportunities. This will explore the personal skill development in the industry, inform students of the widespread meta skills, and technical, with association to a potential career in esports.

5.2 Gameplay Aims

The proposed serious game will follow set gameplay aims to support a strong developed game. These gameplay aims are as follows:

- To develop a serious game fulfilling the educational needs through entertaining, engaging, and high satisfaction gameplay, embedding the theory of intrinsic motivation.

- Create simulated experiences as an esports player from the amateur to professional stage through gameplay mechanics and genre-based scenarios with an element of challenge and reward.

5.3 Learning Outcomes

The important outtake from a serious game is to provide an innovative approach to not only educate stakeholders about gaining knowledge in the esports industry, but also to provide these stakeholders the opportunity to retain this knowledge and establish it in real-life situations. It is important that with these virtual scenarios through gameplay, it will give a visualised pedagogical focus in the game to assist with the knowledge retention. Through this design and development, it will be important to adhere and adapt from the cognitive domain of Bloom's Taxonomy (Buchanan, Wolanczyk and Zinghini, 2011) through the gameplay and mechanics creating challenged based scenarios related to esports. Due to the widespread of genres, the serious game will take inspiration from educational and industry games where the gameplay will assist in informing this. The learning outcomes of the game are as follows:

- Educate and familiarise the player with the esports industry.
- Educate and inform the player about the concepts of esports, exploring the history, the popular games and genres, and the ecosystem.
- Educate and inform the player about the skill development in esports, exploring the career pathways and opportunities available.
- Reflection of the esports industry through game-based learning content integration approaches (i.e. quizzes or NPC dialogue interaction).

5.4 Initial Game Design Considerations

As the core development of the serious game has not commenced and the initial game design stages are underway, Table 3 below gives mention to brief ideas surrounding basic game development decisions. These design considerations are as follows:

Table 3: Initial game design considerations for the game.

Platform	Windows PC
Development Environment	Unity Game Engine or Unreal Engine
Assets	***3D Assets***: Unity Asset Store or Epic Games Marketplace. ***2D Assets/ User Interface Design***: Unity Asset Store or Epic Games Marketplace & Adobe Creative Cloud Suite (independent designs).
Visuals	Mixed-style dependant on the scenario. Main style will be a stylised art style.
Audio	Use of royalty-free music for diegetic and non-diegetic sounds sourced from online resources.
Controls	Keyboard and mouse (use of W, A, S, D for movement and additional keys for actions).
User Experience (UX)	Progressive, immersive esports player journey from amateur to professional through gameplay mechanics.
Difficulty	Challenges designed through esports specific-based scenarios adapting from genre and game-based learning techniques.
Level Design	A hub-and-spoke with further integration of linear, semi-linear and open layout.

6. Future Directions

As presented in this paper, the design and development of the serious game is in the initial planning stages, with further research to begin soon. The development of the game will start with a small prototype addressing a sample of the pedagogical aims to evaluate and assess the feasibility of the outcome. The prototype design will be determined through the utilisation of the user requirements analysis to explore initial views with assets used for development from the Unity Asset Store, Epic Games Marketplace or any online resources sourced as appropriate. The project will evolve through enhancement of gameplay mechanics and features by including game techniques from research to adhere to the increased user experience and immersion. The player will be in a centralised hub area represented by an esports environment (i.e. stadium or arena) where you must build up your professional career through social media interactions and challenges. There will be interactive experiences for the player such as an esports 'Hall of Fame' which will break off into an integrated learning environment teaching about the history, games, genres, and ecosystem within esports. As you progress through the game, you will have features to support the user experience but also challenge it, having opportunities to level up through a league while having help from your virtual coach who will provide feedback to the player on a regular basis. You will see a mix of interactive experiences for the player with NPCs assisting at times too.

The applied techniques used in the serious game will reflect on educating and informing stakeholders about the intricacies of the esports industry and the application of the multifaceted career pathways. This will be adhered to using visualised scenarios in the gameplay with a pedagogical focus assisting in obtaining and retaining knowledge for stakeholders in a challenged manner. This will highlight the importance of how the knowledge gained applies to an industry or educational scenario while the use of an innovative game-based tool sustains a base knowledge about the esports industry to stakeholders. The development of the game will support an iterative development practice. As this progresses, it will be important to evaluate the appropriate stages to ensure all gameplay mechanics, features, and learning outcomes are effective. The serious game will use a mixed methods approach, primarily using questionnaires and surveys. Further evaluation in the final stages through interviews or focus groups to give a wider scope and informative feedback to aid the outcome.

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Designing Games for GDPR: Negotiating Understandings of GDPR in EU Schools

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Abstract: In this study we combine a participatory design process with a citizen science framing, to foster a dialogue on GDPR in the school. We focus on the perspective of students, approaching them as co-researchers, in designing and evaluating a series of apps, aimed at spreading knowledge on GDPR. We have created a design space between secondary school students in Denmark and Italy, to gather insights across different countries. Results show that approaching students as designers and testers enabled them to provide honest and concrete insights on their experience with GDPR. We identified a detachment related to their posting activities, caused by how social media platforms (SoMe) challenge the boundaries between their personal and school-related ecologies.

Keywords: GDPR, Games-design Based Learning, Participatory Design, Technological Literacy.

1. Introduction

Students and teachers live in a complex world, constantly facing new challenges, such as technological change. From a citizen science perspective, design practice can provide room for students to reflect on their experience, speak their mind, and propose actual change.

This paper investigates how a game-design based learning approach can contribute to the integration of GDPR in the school, fostering a dialogue across schools in Europe. We have engaged students from a high school in Copenhagen, to develop an app to enable other students, their teachers, and friends to learn about GDPR. They created a series of prototypes for their Informatics class, conducting a user-centered design process within their schools, interviewing teachers and schoolmates. A total of five prototypes were created, conceived as gamified quizzes with colorful themes. The three most complete prototypes were tested through online workshops, with teachers and students from two Italian schools (a junior and a senior high school).

Our goal was to enable teachers, and both designer and evaluator students to express their perspectives, regarding emergent challenges on the integration of GDPR in the school, fostering a democratic dialogue. We look at schools as ecologies for learning and social interaction, whose boundaries have been challenged by the digitalization of teaching practice and increasing use of SoMe (Marchetti et al 2024). Our studies show that the involved students believe they know how to manage online, but are not aware of how their school ecology overlaps with their personal ecologies, generating unintended consequences. However, participating in the design process enabled students to engage in a playful dialogue, concretizing their doubts through their perception of the prototypes, without feeling judged for eventual misconduct. Both student groups felt as "experts" supporting other students from other countries, as the Danish students were approached as "designers" and the Italian as "testers".

Following a citizen science approach, students from different countries also acted as co-researchers providing insights on SoMe in the school, contributing to the GDPR sociopolitical debate, while developing playful solutions from their own perspective.

2. Theory – An Ecological Citizen Science Approach

The goal of our project is to explore how to promote awareness and an open dialogue in European schools, about GDPR laws and data protection, targeting teachers, teenagers, and young adults. Therefore, we created a design space to engage secondary education students in a game-design-based learning intervention, as part of a larger project named Spadatas: Security and Privacy in Academic Data management at Schools (Amo-Filvà et al 2023, https://spadatas.eu/), funded by the Erasmus+ program of the European Union. GDPR or General Data Protection Regulations refers to a body of laws promulgated by the EU, to provide commonly approved guidelines for the treatment of people's personal data, addressing private citizens, companies, and public institutions (Amo-Filvà et al 2023, 2022, Marchetti et al 2024).

GDPR has become a major concern for schools through the past 10 years, in correspondence to societal changes, such as the increasing integration of ICT systems in every aspect of our lives, including the school, with the agenda of fostering technological literacy among young people in our digitized society (Heywood 2021, di Sessa 2001). By technological literacy, we refer to a set of knowledge and skills enabling citizens to be aware of their rights in the use of digital platforms, not to feel controlled or misled by these platforms (Heywood 2021). Acting responsibly on SoMe platforms has been included in the list of desirable skills within technological literacy in schools, as the digitization of the school acted as a transformative force pushing teachers and school administration to educate themselves at multiple organizational levels, and to act as disseminators with respect to their students (Marchetti et al 2024).

Our approach leverages an ecological perspective on the digitization of the school following the consolidated perspectives of Raptis et al (2017) and Nardi and O'Day (2000). From an ecological perspective, the school appears as a network including a series or actors: students, teachers, school principals and other professionals working in the school, including the parents of the students (Raptis et al 2017). Within this network teachers and students constitute core actors, as schools are eulogies finalized towards learning and teaching practice (Nardi and O'Day, 1999). A series of tools is used daily to support these practices, which have increasingly become more digitized, imposing new requirements with respect to the teachers' competences. A main issue that has emerged through the Spadatas project is that teachers are forced to constantly educate themselves on GDPR and the use of digital platforms, while at the same time provide the same knowledge to their students (Marchetti et al 2024).

In our study we combined the notion of digital ecology with a citizen science approach, to address students dealing with GDPR as citizens and participants in their school ecology.

The citizen science approach aims at involving the public in scientific inquiries and data gathering (Dickinson et al 2010) as scientific co-researchers (Hidalgo et al 2021). The term citizen science was coined in the 90's and it has become a growing field of research for the scientific community, municipalities and policy making, and education. According to Vohland et al (2021), the notion of citizen science still needs to be understood in depth, in relation to its essence and legitimate use, for instance if it has been abused by institutions and researchers to gain more funds, or for exploiting citizens' workforce to gain new data for free. Areas of investigations can be identified in real world problems, ranging from ecological and environmental research as in Dickinson et al (2010), to urban planning and technology related topics, social sciences and humanities, all lacking a clear scientific framing and demanding open-ended approaches, that could address the individuals and communities involved in a sensible way (Hidalgo et al 2021).

The European Citizen Science Association has provided a 10-principles framework for conducting citizen science inquiries, summarized by Haklay et al (2020, p. 1) in five crucial areas, such as: 1. Core concepts, 2. Disciplinary aspects, 3. Leadership and participation, 4. Financial aspects, and 5. Data and knowledge. According to Haklay et al (2020) the citizen science framework includes a variety of activities and practices, actively involving volunteers in data collection or analysis for different scientific disciplines, such as natural, social sciences and the humanities. Roles and responsibilities of volunteers emerge as a main ethical aspect, as volunteers and researchers should act as equal, for instance roles and responsibilities of volunteers should be discussed transparently with researchers. However, it is the researchers who set the agenda for the inquiry and must provide clear guidelines for participation. Dickinson et al (2010) propose as an example of early citizen science the inquiry *Transit of Venus* project, which was funded by the British government in 1874 and engaged amateur astronomers all over the world to measure the distance between the Earth and the Sun.

In this respect, an interesting angle of investigation for our study is the relation between citizen science and participatory approaches applied to innovation, education, and policy making (Vohland et al 2021, Hidalgo et al 2021), underlining the importance of conducting co-creation workshops.

Our project is positioned at the intersection between citizen science and participatory design, as we are involving higher education students as co-researchers, in collecting data regarding how to support school and their fellow students in navigating GDPR norms across European borders.

According to Hidalgo et al (2021) co-creation approaches are being increasingly adopted in collective decision-making processes, however, the majority of citizen science projects rely on participation for data collection, sometimes for analysis, to allow for larger scale investigations, while forms of co-creation would allow for deeper involvement of citizens. Hidalgo et al (2021) proposes the *PAR* model (Participatory Action Research) for community-based research practices, in which citizens are invited to design and implement research processes as co-researchers. In these processes, citizens can be approached as "competent in-the-field experts" (Hidalgo et al 2021, p. 203) able to provide valuable insights, not differently from user-centered and participatory design approaches, in which individuals of different ages, including children (Druin and Kolko 2017, McNally et al 2017), are approached as experts of their own practice (Björgvinsson et al 2010).

We see as a common point of departure, for researchers engaging in participatory design and citizen science approaches, an assumption of humility of being aware of not knowing all about the situation under investigation, which lead them to include other people, who might be involved in the given situation as peer investigators, to gain new meaningful knowledge from the field. The role of the researcher becomes, therefore, that of a facilitator, creating room for shared discussion and providing a framework for the investigators to contribute to the inquiry. In our study, students and teachers are involved as co-researchers, where students are given the task to act as developers of learning resources addressed to fellow students or their younger siblings, and for their teachers, so that teachers might gain more awareness but also potentially use the students' applications in their class, to discuss GDPR-related issues with other students.

3. Method

Our study adopts a qualitative participatory design approach inspired by the works of Björgvinsson et al (2010), Druin and Kolko (2017), and McNally et al (2017), where students act as co-designers of playful-gamified applications about GDPR. The citizen science framework provided additional guidelines for fostering a democratic, constructive debate with the students, as actors in society and not only in the school, engaged in data gathering. We have initiated, therefore, a design space, in which students acted as experts (designers and testers) on their experience with GDPR, engaged in gathering data and deepening their knowledge of GDPR among their peers and their teachers. Following Druin (2002) and Druin and Kolko (2017), we have involved secondary education students from Denmark and Italy, providing a frame for the role of the students in two main groups:

1. Designers
    - Students from Oerestad gymnasium, technical highschool in Denmark, age group 17-19
2. Testers
    - Students from IIS Eugenio Bona, technical high school in Italy, age group 15-19
    - Students from An Italian middle school, age group 13-14

At Oerestad, our study leverages study activities related to the *privacy-app-project,* which was conducted in the auspices of the subject Informatics B (a 2-year course), addressed to 3. Grade high school students, who had chosen Informatics B as a non-mandatory subject. The students came from various study lines, but most had a focus on media science, a relevant subject to our study. Informatics is a very broad subject area covering issues like app-development, website design, game design, databases, it-security, SoMe and more. At Oerestad the chosen learning approach in ICT is inspired by Caspersen and Nowack (2013) and by the American tradition represented by Seymour Papert and Mitch Resnick (see for instance Resnick 2022). Hence, students from Oerestad were involved in gathering data while being already in the process of learning how to develop digital games and apps.

On the other hand, we involved the Italian students and their teachers as expert testers, evaluating how well the proposed apps could fit their needs regarding awareness of GDPR. The students from IIS Bona belong to the same age group as those from Oerestad, and are engaged in a technical education, while the students from Arborio school are enrolled in the final grades of their 3-years middle school, just before highschool, hence they could represent younger friends or siblings to the designer-students from Oerestad.

As previously mentioned, we combine participatory design with citizen science, which are generally presented as large-scale inquiries, potentially involving a municipality, or even all the citizens of a country or even people all over the world through web pages and online applications (Haklay et al 2020, Dickinson et al 2010, Hidalgo et al 2021).

A little discrepancy can be found between citizen science and participatory studies, which privilege co-design activities within small-scale inquiries. Our study represents a sub-inquiry involving three schools in Italy and Denmark and it is part of a large-scale study on GDPR in the school involving schools in several countries within the EU.



Figure 1: Observation setup for online workshops.

Our approach is to involve teachers and pupils from these schools in situated workshops, with the goal of gaining authentic data, specific to the different contexts, in contraposition with average abstract data, which might not represent truthfully what happens in European schools. Therefore, our study can be seen from a multidimensional perspective, as the researchers conduct participatory inquiries locally and across different countries, but the gathered data are shared and compared among the researchers, to gain a larger-scale

perspective on the similarities and differences among the experiences of teachers and students, and to facilitate sharing of strategies developed in the different countries. We collected data through ethnographic methods physically and online (Fig. 1), mostly note taking, but we are avoiding intensive video-recordings so as not to risk data leaks. However, we adopt sketching as a supportive practice (Causey 2017), to gather visual evidence of the students' engagement during the workshop.

Our study embodied ethical values as we approach students as adults with respect, not as kids to be educated or preached, as potentially guilty of sharing inappropriate content. In this way we hope to engage in an honest exchange, we do not expect them to admit any wrong doings regarding GDPR or need for guidance, which might lead them to feel patronized and ditch our collaboration. On the other hand, our focus is on the prototypes and the design process as room for negotiation and exchange, so we are not interested in gathering personal data from the students, and we can respect GDPR to the core, without exposing the participants to our studies in any ways, going beyond basic guidelines from our study boards.

4. Prototypes, the BASIC Model, and Testing

The design of the prototypes was supported by one of the authors and teacher, by means of the *BASIC model* for design and innovation, which builds on the Danish tradition of learning based on the spoken word, ideas of problem-based project-based learning Holm-Larsen (2004). This model was developed on top of the *DesignToImproveLifeEducation-model*[1], specifically for high schools, and it is a simpler version of well-known models like for instance the double diamond-model[2].

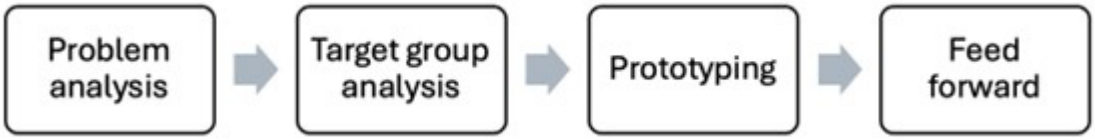


Figure 2: The BASIC model.

The BASIC model (Fig. 2) proposes a series of phases, first letting the students to investigate the problem area and defining the problem that they will address through divergent activities. Afterwards (phase 2) they will converge, focusing on a specific target group. In the 3rd phase, they will create mockups of solutions to the problems, and in the last phase (4), the students present their problems, target groups and prototypes and get feed-forward from other groups and the teachers on how to move on and elaborate more on the developed solutions. The process can then be repeated as many times as possible, in line with iterative design methodology (Preece et al 2017).

Through the BASIC model, students can work alone or in groups, taking a point of departure in a general subject area, like for instance privacy, and exploit design and game-based learning methods to create interesting solutions for their target group, which can constitute a motivating factor.

After the initial design-phase, the students developed high-fi prototypes in the *Code.org* environment, a very simple yet powerful app-development tool, where users can produce actually working, very nice-looking apps, with databases and more in a JavaScript-like programming language, using block-based as well as textual coding.

The students could choose their target group, most students chose to address their peers at high school, others opted for parents, younger students, or children in compulsory school, while a group addressed their former teachers from compulsory school in Denmark.

[1] https://blog.folkeskolen.dk/blog-hogd-handvaerk-og-design/design-to-improve-life/165249
[2] https://www.designpsykologi.dk/hvad-er-double-diamond

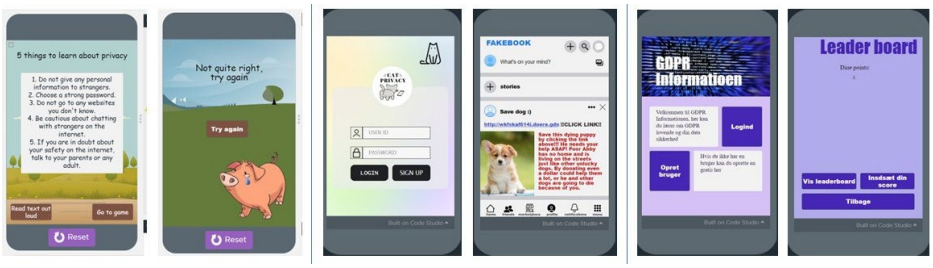


Figure 3: First and last pages of the apps tested with the Italian students.

The students were quite creative and leveraged game elements to make the subject area more interesting and graspable to the target group, including quizzes, simple games, sound effects, surprising and fun elements and more; they spent around 10 hours on this project. A total of five prototypes were created and three were selected for testing, as they were the most complete (Fig. 3).

These three apps were structured as self-evaluation quizzes, completed with guidelines and summaries of GDPR norms. One app targeted small children proposing a farm animal-inspired theme (Fig. 3 left), another one started with the image of a cat but similarly to the third prototype proposed a high-contrast graphic style with bold headlines (Fig. 3 center and right).

Links to the three apps were sent off to members of the target group by email, SoMe and more, together with questionnaires, so their target group could get back with feedback about the apps, their contents, and playability.

To test the prototypes in Italy, we edited a PowerPoint with an Italian translation of each page of the quizzes, that the teachers printed and distributed to the students to support them during the test. This test was conducted online in an ethnographic fashion, as one of the authors collaborated with local teachers, observing, and taking notes and sketches on the tester-students' responses and comments. At Arborio the test was framed within their citizenship-related teaching and was split in two sessions with three classes, during the first session the students got an introduction to GDPR, during the second session the students tried the prototypes and had to answer a short questionnaire. At IIS Bona we conducted one session with three classes, as the students were previously introduced to GDPR.

In conclusion the tester-students were learning about GDPR norms, in relation to social sciences-related subjects and were introduced to iterative testing methodology. The students from Oerestad learned about idea-generation and app-development, working with real world problems, databases, flow in games design and other relevant theories about computer games-design, making appealing interfaces to various user interfaces (the rule of thirds, various gestalt rules, color theory). We also covered databases and E/R-diagrams (so they could make a simple login system), agile systems development methods like scrum. Furthermore, the designer-students need to learn a lot about data privacy and how to make these very complicated issues available to a target group.

5. Analysis and Discussion - the Prototypes and GDPR

In general tests with Italian schools assumed an amusing tone, students and teachers were collaborative, they laughed, and seemed thrilled by the event (Fig. 4). The evaluator-students were generally impressed by the prototypes of the designer-students, their feedback could be grouped into two main categories: the *perception of the apps* and their *perception of GDPR in the school* as potential users of the apps. The prototypes were evaluated as "very good", "fun" and even "impressive" by both schools, a rating emerged in which the app with the cat in the starting page was rated as the best, as the students liked the idea of having a mascot while keeping a professional appearance. The animal-farm app, rated as second best, was found cute but a little "childish", suitable for younger users; interestingly the younger students from Arborio also agreed with this judgment. The third prototype was found to be well-developed and "serious", students from Bona said it would be more suitable for teachers or adults.

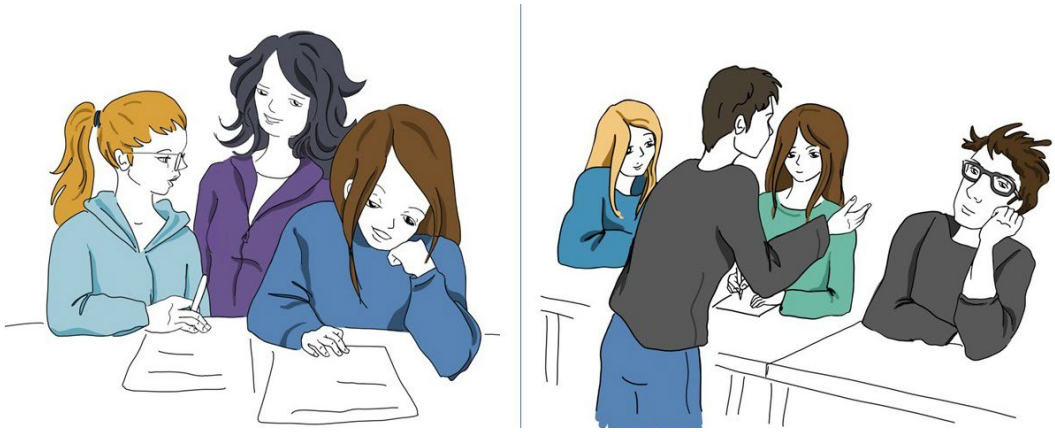


Figure 4: Sketches from online workshops. Left: Teacher and students from Arborio. Right: Teacher and students from Bona.

Emerging sub-themes related to the perception of the apps were that of *playability* and *inspiration sources*. The quiz concept was found relevant, however, several students desired a more playful experience, inspired by RPGs or platform games, such as *Fortnight* as according to a student from Arborio. A few girls from both schools said that they would prefer an app reproducing their experience with their favorite SoMe platforms - *TikTok* or *Instagram* - with reference to fashion or pop music, a girl from Arborio explicitly mentioned her Instagram stories as a model. Discussing the use of apps in Denmark and Italy with Arborio classes, Instagram and TikTok were equally popular, but The Italian students were then surprised to hear that Danish students do not use much Whatsapp, while it was said to be very popular in Italy. Other students from Arborio suggested reproducing "phishing" messages, suggesting clicking on a button to: send credit to a friend in need, or to get credit sent by a parent. Recalling these phishing messages, which were deemed as "fake" or "frauds", fostered laughs among the students.

A final live session was organized between the students from Arborio and Oerestad gymnasium, months after the creation of the prototypes. During this session there was a nice atmosphere and connection between the students, despite the session being mediated online by the teachers, the language barrier, and the age difference between the students (from 12 in Arborio up to 19 circa in Oerestad). The Italian students presented their country and local environment and what they have learned about data privacy, the Danes asked questions to the Italians as informers regarding their prototypes. In the end the students continued talking about their daily lives in the two countries. This session was successful as it showed potential benefits for both student groups, engaging youngsters in creating and exchanging game-based learning materials across different European countries about complex topics, like data privacy; however, it should have been closer to the apps development to be meaningful for our study, as the Italian tester-students could have been more precise about their feedback and the Danish designer-students had moved on to other projects, so they could not use the feedback anymore.

Regarding the second theme, *perception of GDPR in the school*, the students from Arborio said to have never heard of GDPR, but to be aware of the risks of posting online. The older students from Bona and Oerestad claimed to have had training, as a girl from Bona said: "We know!" another from Oerestad said: "At our age we are aware, maybe we could address younger kids!" Interestingly all students believe to be informed enough on data privacy, even those who were new to GDPR, hence they do not identify with the target group around this study, pointing at a "younger" age group.

However, two incidents reported by Italian teachers reveal a more complex landscape. A teacher from Bona said that once a student spilled cocoa on the floor and offered to clean up. During the cleaning, the student and a few classmates started teasing each other innocently, according to the teacher, one of them filmed the student cleaning and posted the video on Facebook. The student's mother found the video and complained with the teacher, thinking that her child was being bullied. A teacher from Arborio told us that a student shared negative comments about a teacher in a SoMe group, which were re-shared outside the group, reaching that teacher, hence a disciplinary meeting was arranged with the student's parents.

These cases reveal a form of detachment of the students regarding their posting activity, they claim not to "post about school" or to "only post about their personal life", such as: selfies or videos about holidays, nights out, or weekend activities, mostly on Instagram. However, the teachers mentioned having seen students posting about

class trips or content involving classmates, at times girls exposing themselves in revealing clothing, hence unconsciously posting inappropriate content about school.

From an ecological perspective, the students do not seem aware about how their personal and school ecologies intersect with each other through social media, and how adults (teachers and parents) participate in both even if they are not intended receivers of the shared content. We find this the most problematic result of our study, suggesting the need to visualize in a playful way, how apparently innocent posting activities might cross boundaries between the two ecologies, involuntarily infringing GDPR norms.

From an overall perspective, our contribution revolves around three main areas as in Table 1.

Table 1: Contribution areas from our study.

1. Participation	Blending citizen science and participatory design,
2. Concretization	The role of a design space in negotiating meaning of GDPR in schools,
3. Sense-making	Prototyping and testing as epistemic practices

Since the students believe to be aware of how to post correctly, in spite of emerging issues, our design space enabled us to avoid preaching and foster an honest dialogue, inviting the students as co-researchers following a citizen science approach (Hidalgo et al 2021) framed through a participatory design process (Björgvinsson et al 2010). Moreover, designing around GDPR, potentially an abstract topic, enabled us to concretize our dialogue with the students focusing on the prototypes. Finally, testing and prototyping emerged as epistemic practices, as the prototypes elicited concrete thinking on what is GDPR, the playability of the apps, and their learning value, across different countries.

6. Conclusion

Mixing citizen science and participatory design proved to be profitable strategy for involving students, it

enabled us to engage students from different secondary schools across Europe giving them a voice, about issues that might concern them directly. A main finding from this study deals with students' perception of GDPR and of the boundaries between personal and school ecologies, as something they think they know, but leading to unintended consequences. Moreover, the design intervention provided room for self-paced game-based learning for students (designers and testers), emerging as a promising practice, when engaging young learners across European borders, sharing small games and learning materials, in complicated topics like data privacy. However, more work needs to be done in this field regarding how to frame these interventions, overcoming cultural and linguistic boundaries.

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Rekindling Connections to Languages through Socio-Cultural Immersion Using Game-Based Learning and Virtual Reality: Cipher VR Case Study

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Abstract: Traditional language learning methods often fall short in engaging learners, especially in the context of indigenous languages like Irish. In this study we show how the language learning game Cipher VR combines digital game-based language learning with Virtual Reality (VR) to reconnect learners with indigenous languages, using the Irish language as a case study. Initially designed for English, Cipher has undergone several iterations to adapt to the Irish context, and is now completing its metamorphosis into a VR platform aimed at meeting the needs of less-resourced and endangered languages. This paper explores Cipher VR's development, emphasising the learner-centric design that merges educational aims, engaging gameplay and a culturally grounded approach to create an immersive and motivating learning experience.

Keywords: Game-based learning, Virtual reality, Indigenous language, Cultural heritage, second language acquisition

1. Introduction

Traditional language learning methods often fall short in engaging learners, especially in the context of indigenous languages like Irish. There are complex socio-cultural factors. The limited daily use of Irish outside educational settings, combined with outdated teaching methods and a lack of interactive resources, contribute to student disengagement. These issues are compounded by socio-cultural perceptions of Irish as less essential compared to global languages, influencing motivation negatively. Effective engagement requires easing these socio-cultural barriers and revitalising teaching approaches with relevant, dynamic content that connects learners with the culture of the language in a fun and engaging manner (Ward et al., 2019; Hickey and Stenson 2011).

This paper introduces an innovative approach to address this challenge. The original Cipher: Faoi Gheasa game (Xu et al. 2024), harnesses the power of game-based learning to learn languages. In Cipher VR, players immerse themselves in a magical world, engaging with language learning tasks enriched by fairytale and folklore elements, making the process both interactive and captivating. Cipher VR integrates VR to deepen immersion in indigenous culture, aiming to amplify socio-cultural contexts, bringing them to the forefront of language learning as means of enhancing learner motivation.

2. Background

2.1 The Irish Language: Socio-cultural Aspects

Irish belongs to the Celtic branch of the Indo-European languages. It has VSO (verb, subject, object) word order, case marking, a complex system of word-initial mutations and phonological harmonies, which means that is substantially different to English, the first language of many of the learners. Irish is taught as a compulsory subject in primary and secondary level education in Ireland. It is both the first language of the Republic of Ireland and also a minority language, while English is the dominant language.

The Irish language has been under pressure from English for many centuries. Over time as the status of Irish waned due to adverse economic and political factors, English was increasingly seen as the language of advancement. However, towards the end of the 19th century, scholars began to take an interest in the ancient

Irish tales and mythology which led to a renewed pride and interest in the Irish language (Gregory, 1904; Hyde, 1890; Ó Coileáin, 1986). Recent census data (Government of Ireland, 2017) reports that 1.76 million people can speak Irish, and approximately 74,000 use it on a daily basis outside the education system. Of these daily speakers, approximately one third are in native speaker regions (Gaeltachtaí), and two thirds are from outside of native speaker communities. Regardless of whether Irish is acquired as a first or second language, there is an urgent need for language learning support and for creative ways of increasing learners' contact with Irish on a regular basis (Dalton & Devitt, 2016).

Digital game-based language learning (DGBLL) has been shown to be an effective way of encouraging learner motivation and learner autonomy (Dixon et al 2022; Acquah & Katz 2020). Research has also shown that the enhanced immersion and interaction that VR offers is ideal for language learning and engagement (Çakır N 2024; Lan 2020). However, there is a significant lack of research on VR in Irish language learning, highlighting the need for further studies to understand its potential (Collins et al, 2019). The aim of Cipher VR is to harness VR features to provide an exciting and enjoyable digital game-based language experience which can transform learners' sometimes negative views of Irish as just a school subject. Through integrating ancient tales and mythology with modern technology in Cipher VR we hope to reinforce and renew pride and interest in the Irish language and its mythology. We believe that applying the philosophy of "reconnecting to the spirit of the language" (Napier and Whiskeyjack 2021) can help to increase learner engagement and motivation in the Irish context, and that this can be replicated in other endangered language scenarios.

2.2 Virtual Reality in Socio-cultural Context

Virtual Reality (VR) is an increasingly significant technology within the educational sector. One of the primary reasons VR has become popular is its ability to create interactive 3D models that help transform abstract concepts into tangible experiences, thereby enhancing comprehension (Christou, 2010). Virtual reality has been shown to be effective for various educational tasks, such as mathematics (Roussou et al. 2006) and language learning (Çakır, N. 2024; Lan, 2020).

The use of digital technology in the preservation and revitalisation of indigenous languages has become increasingly popular (Galla, 2018). Research indicates that VR can aid in revitalisation by providing immersive and interactive environments (Minestrelli et al 2024). Additionally, VR games have been shown to enhance cultural awareness and heritage through immersive experiences (Shih et al., 2015). VR is particularly effective in engaging the young, who are crucial for the continuity of language. It not only bridges the geographical and temporal gaps between native speakers and learners in a virtual world but also boosts learners' confidence by providing a safe space for practice without fear of judgement (Lan, 2020). Moreover, VR allows learners to immerse themselves in the landscapes and cultural contexts of the languages, fostering a deeper connection and understanding (Outakoski et al. 2018).

By immersing learners in the rich folklore and mythology of their languages, VR creates a connection to the language's roots, thereby not only teaching the language but also rekindling or initiating a cultural bond. This approach aligns with the growing recognition of the importance of culturally grounded education methods in the preservation and revitalisation of indigenous languages globally (UNESCO 2023).

3. Methodology

Cipher VR is built on the existing screen-based Cipher game (Xu et al. 2024) and has been transformed using VR technology to immerse users in the folklore and mythology of the target language, focusing on their cultural and linguistic awareness. Through narrative-driven gameplay, learners encounter vocabulary embedded in tasks that mirror language use. The vocabulary of the stories has been cross-referenced with the primary school curriculum and the overlap has been enhanced wherever possible. Stories and myths reinforce many everyday words relating to familial relationships, food items and physical elements such as fire, water, rivers, lakes and seas, to name a few. This methodological approach ensures that language learning is contextual, meaningful, and tied to both cultural heritage and everyday life, enhancing the likelihood of retention and engagement.

3.1 VR Game Design

The game's environment, cloaked in mysterious shadows due to magical spells, is gradually illuminated as players reverse the spells, enhancing the immersive experience. Utilising the hand-tracking feature in VR, the

game offers intuitive interaction, allowing players to manipulate objects and solve puzzles naturally with their hands.

The game starts with the mystical "Well of Wisdom," where players encounter the enchanted book. The book reveals an enchanted word, and a clue to reversing the evil spell. Using the clue and the letter tiles, the player must physically re-arrange the letters to restore the word and to open the gateway to a magical world. Within this world, players work to dispel enchantments on hazel trees and other folklore-related objects, each time using the clues and the letter tiles. Successive tasks guide players through a narrative journey that culminates in the cooking and eating of the mythical Salmon of Knowledge, symbolising the acquisition of language and wisdom. Each task is designed to introduce vocabulary contextually, ensuring learning is meaningful and integrated with the cultural heritage of the language. Figure 1 illustrates the progression of the story flow within the game.



Figure 1: Screenshots of Cipher VR

3.2 Pedagogical Design

Motivation is a key element in language learning (Dornyei and Usioda, 2021). Cipher is designed to enhance the learning process by increasing student motivation, particularly in encouraging students to persevere when they have difficulties. It also shows them their progress through the game and celebrates their achievements each time they complete an element of the game.

Pedagogically, Cipher VR is grounded in the principles of experiential learning, where engagement with the language is embedded in culturally relevant narratives, and learners learn by doing, and by engaging as many of their senses as possible. The use of the latest VR technology creates a more positive progressive view of the language and increased motivation to participate in the game, thereby gaining valuable language input through the game. The game's design follows a scaffolded learning approach within the context of a folklore story.

3.3 Integration with Indigenous Cultural Landscapes

A significant component of Cipher VR's methodology is its emphasis on reconnecting learners with the environment and cultural heritage through folklore and mythology. The game's environment includes not only the mystical "Well of Wisdom" but also the factual River Boyne. This design reflects both mystical and real geographical and cultural landmarks, enhancing the authenticity of the learning experience. This approach provides not only language skills but also respect and connection to the cultural heritage.

3.4 Technical Development

The SortingGameManager script creates an interactive letter-sorting game that can automatically load and respond to player actions by managing different game objects and events. Figure 2 is a screenshot of the sorting game prefab and the script.

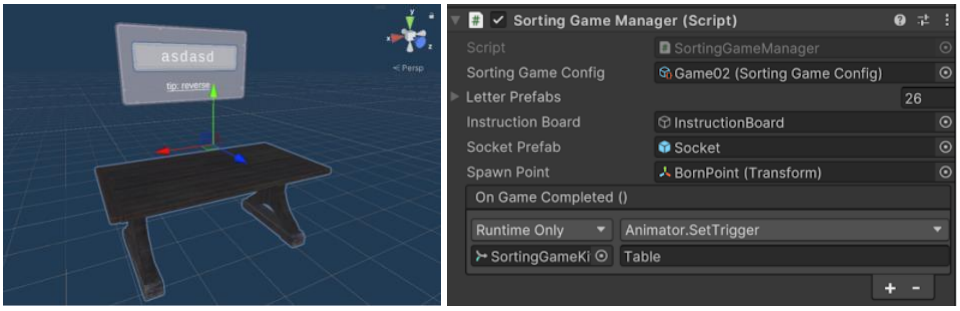


Figure 2: Sorting game prefab and script

The project utilises OpenXR and XR Interaction Toolkit to build the VR setup, using scripts such as XR Grab Interactable to achieve the actual grabbing effect of the player's hand with the letter card, as demonstrated in Figure 3.

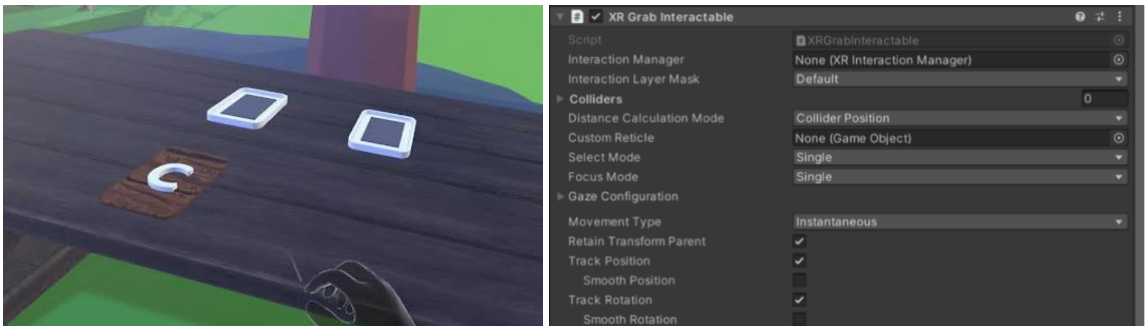


Figure 3: Hand-tracking implementation

4. Results and Discussion

In a small-scale pilot study of Cipher VR with 20 participants (school children), the initial questionnaire feedback was very positive regarding learning motivation, however the outcome regarding learning gains was not so clear. Detailed questionnaire results can be found in the Appendix. Users appreciated the integration of folklore and gamified elements in VR that made learning the language more enjoyable and engaging. Additional Verbal feedback from users include: “It’s really cool and I think it’s going to be incredibly useful for children in school” and “I like the way of combining folklore elements with language learning”. There is also room for improvement. While running the pilot study we could see the need for more explicit instructions, more stable controls, and clearer narrative connections to aid in the learning tasks. We intend to address these points by focusing on enhancing audiovisual feedback, refining interaction design, strengthening narrative integration, and simplifying the user interface to ensure that the game is both entertaining and effective in supporting language revitalisation in educational settings.

Future work includes standardised learning tests and detailed user studies to analyse the learning outcomes and engagement.

5. Conclusion

In this study, we aim to transcend conventional paradigms of language education by merging the immersive potential of VR with the dynamic engagement of game-based learning. This novel integration has the potential not only to facilitate the acquisition of language skills but also to deepen learners' connection to the cultural and historical contexts of the languages studied. By embedding the learning process within culturally rich narratives and landscapes, Cipher VR offers a promising avenue for both engaging with and preserving indigenous languages. The game’s modular design means that it is relatively easy to adapt it to a new language and learning context. This study contributes to the ongoing dialogue at the intersection of technology, pedagogy, and cultural preservation, and signals a new era in educational technology. As such, Cipher VR not only addresses the challenges facing language revitalisation but also provides a blueprint for future educational innovations in a globalised context, offering fresh insights and methodologies for engaging with the world’s linguistic and cultural heritage.

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Appendix: Questionnaire Results

Table 1: Proportion of participants' ratings

Question	Satisfaction (n = 20) positive (percentage)
Did you like the VR game?	20 (100%)
What do you think about learning Irish through the VR game?	20 (100%)
How would you compare learning or reading Irish through the VR game to normal	20 (100%)

Question	Satisfaction (n = 20) positive (percentage)
classroom teaching?	
Do you think you learned anything while playing the VR game?	14 (70%)
Did you find the VR game easy to play?	19 (95%)
Would you recommend this VR game to your friends?	20 (100%)
Do you feel motivated to learn Irish through the VR game?	17 (85%)
Do you think the VR game makes learning Irish more interesting?	20 (100%)
Do you think the VR game makes the Irish folklore story more interesting?	18 (90%)
Do you think the VR game brings the Irish folklore story to life?	18 (90%)
Would you like to learn Irish through more folklore stories like this in VR?	19 (95%)
Do you think the visual part of the VR game helps you understand the language better?	18 (90%)
Do you think the visual part of the (VR) game helps you pay better attention to the language challenge?	17 (85%)

Note: User satisfaction is measured by combining responses of 4 (positive) and 5 (very positive) on a 5-point Likert scale, while the remainder consists of responses of 1 (very negative), 2 (negative), and 3 (neutral).

Monopoly Reimagined: Cultivating Gaming Literacy for Tackling Real-World Complexities

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Abstract: Gaming literacy proposes specific ways of thinking and acting by providing cognitive, creative, and social skills, which are necessary in the face of complex (Zimmerman, 2008) and wicked problems we encounter in today's society (Rittel & Webber, 1973). This paper presents preliminary findings from an exploratory study of how students within arts, design and media might redesign board games and develop gaming literacy; helping them understand and make sense of the world "from the point of view of gaming" (Zimmerman, 2008, p. 156). Through research-based teaching at both bachelor and master levels, we developed a work-in-progress workshop where students must face complexity and practice navigating it. In the workshop, students redesigned the familiar board game Monopoly, using it as a metaphor, and our emergent findings suggest that it can provide a scaffold that enables students to map, prototype and simulate different complex problems and systems onto it - without prior game design knowledge. Monopoly introduced a balance between familiar and known rules and constraints on one side, and hackability and the freedom of play on the other. The monopoly workshop provides an experimental, hands-on, and collaborative approach to understanding complexity through intertwined actions of exploring, prototyping, testing, and reflecting (Zimmerman, Forlizzi & Everson, 2007). We found that the success of such a process seemingly depends on the facilitator and the participants. Here, allocating time for explicit reflection on learning outcomes was a necessary and vital part of the workshop (Alme & Hvidsten, 2022; Dewey, 2018). This work-in-progress workshop method contributes to studies of pedagogical games by focusing on how students might develop gaming literacy through board game redesign, offering a novel, hands-on model for engaging students in, and understanding, systemic complexity. We suggest that future research should validate this approach further, in other contexts and with other types of (board) games. Further, future research should investigate this approach as an introduction to the overarching model of gaming literacy in the face of complex problems.

Keywords: Monopoly, Game Literacy, Co-design, Wicked Problems, Hack, Complexity

1. Introduction

The use of games for educational purposes, particularly for teaching about wicked problems and future scenarios, is well-researched (Magnussen, 2011; Celis Vargas & Magnussen, 2022; Fernández Galeote, Legaki & Hamari, 2023; Fernández Galeote et al., 2022). However, there is a lack of concrete evidence regarding the effectiveness of this pedagogical approach compared to other methods (Dichev & Dicheva, 2017). Few studies explore how non-game design students might learn about complexity through designing and playtesting games, as well as the potential that lies in redesigning existing games in this context.

This paper presents preliminary findings from an exploratory pedagogical study of board game redesign for students within the fields of arts, design, and media. It introduces our *Monopoly workshop*, a novel and work-in-progress approach designed to engage students in higher education with systemic complexity by developing gaming literacy. Lasting half a day to a full day, the workshop utilizes the globally recognized game of Monopoly, known for its clear goals and familiar mechanics. This paper shares our experiences conducting the workshop, the insights gained, and our perspective on how this method can facilitate engagement with complex problems. We conclude with suggestions for future research, highlighting the potential of this novel approach to the fields.

2. Background

This part of the paper briefly presents the background of our workshop approach. First, it describes the gaming literacy model. Second, we explain its relevance to complexity and our argument for choosing the Monopoly game as a starting point.

2.1 Gaming Literacy

When relating to, and experiencing, the current world, literacy should be thought of more broadly than the ability to read and write (Gee, 2003; Zimmerman, 2008). Literacy is a *social achievement*. For example, reading a text is about the text—its meaning and its interpretation by the reader—which is influenced and determined by the social group to whom she/he belongs and through their social practice (Gee, 2003). Moreover, *New*

Literacy Studies argues that reading and writing are "social and cultural practices with economic, historical, and political implications." (Gee, 2003, p. 8). Gee (2003) combines *situated cognition*, the area of work that claims that human thinking and learning are tied to the body and its real-world experiences and sensing, with *new literacy studies* and *connectionism,* the power humans of for pattern-recognition, to explain how video games are learned and played.

Zimmerman (2008) adds the concept of *design*, highlighting it as an act of creating meaning and giving context to the experience of play. He introduces G*aming Literacy* which is based on three interrelated concepts: systems, play and design and claims that it is a way to understand and make sense of the world by providing cognitive, creative, and social skills – all important for addressing the complex challenges of contemporary society (Zimmerman, 2008). Any game is a system defined by the game rules; "a regularly interacting or interdependent group of items forming a unified whole" (Merriam-Webster, 2024). Games consist of rules that interact to produce outcomes based on the players decisions (Gee, 2005). Gee (2005) defines system thinking as a principle that players can understand through games: "People learn skills, strategies, and ideas best when they see how they fit into an overall larger system to which they give meaning" (Gee, 2005, p. 14). Then, a (good) game will help players see and understand the system it represents; navigate, think and act in the environment of this specific complex system (Gee, 2005). When players agree to follow the rules of the system *play* happens. "Play is human effect of rules set into motion" (Zimmerman, 2008, p. 159). In games, play happens with and within the system structure (Salen and Zimmerman, 2003). Playing with tangible parts of a system, such as game pieces, is an unconscious way to explore a system and change, converse and reflect on this playable system (Celik, 2023). Games are systems embodied into cultural material, thus acting as Metaphors (Slavin, 2014) - the exercise of abstraction allows us to stylize, rearrange and intensify these systems so that they become newly visible to us; we then can take these concepts back to the world and re-apply them (Lantz, 2014). Thus, [game-] design is the act of creation of a set of possibilities (Zimmerman, 2008), while for the players this leads to emergence playfulness, an outcome of meaningful gameplay (Fizek, 2014). Zimmerman (2008) introduced gaming literacy as a relevant model to understand and navigate the world in the coming century. Here, the double meaning of *gaming* is central: playing according to the rules while constantly checking their limits and bending them to our advantage (Zimmerman, 2008).

The use of games as a tool to explore co-creation, systems, and systems thinking has been extensively researched in educational contexts, highlighting their potential as effective pedagogical tools (Arnab, Clarke & Morini, 2019; Morini, 2022; Celik, 2023). This paper explores the use of board games to enhance the tangibility of the co-creation process (Celik, 2023) and suggests the importance of maintaining playtesting, while limiting game creation to a pre-existing game board (Morini, 2022). In the case presented in this paper, we use *Monopoly.* It is a popular board game first created by Elizabeth Magie, originally titled *the Landlord's Game*, to illustrate the negative aspects of concentrating land in private monopolies. Several variants of the game, based on her concept, were developed from 1906 through the 1930s with different game boards and components. The game was used to educate economic students and entertainment. It was later commercialized by Charles Darrow in 1935, who sold the game to Parker Brothers, leading to its widespread success. With this Monopoly offered participants an opportunity to work with a familiar and established system (already "made to be hacked"), to foster playfulness. For a short workshop with players with diverse and "low gaming literacy" starting points, we considered it advantageous to use a board game with familiar mechanics, goals, and components.

3. Method

This exploratory study is based on the hypothesis that gaming literacy might enhance students' ability to engage with and reflect on systemic complexity, and we ask the overall question of: *How might board game redesign develop students´ gaming literacy?* We attempt to answer this question through studying how a familiar system (the Monopoly board game) might help students unfamiliar with game design and systemic intricacy confront complexity, and possibly enhance their gaming literacy. Although we have chosen a well-known game, our research method aligns more closely with *game-like* learning as described by Magnussen (2011), rather than *educational games*. Magnussen (2011, p. 34) advocates for the design-research of learning environments motivated "by understanding of games, learning and play". This approach aims to create dynamic frameworks that encourage reflection. By promoting and practicing remixing and modifying ("modding") existing games as well as discussing this act with the students, we hoped to encourage playful creativity (El-Nasr & Smith, 2006). Extended from previous research within *Game-Based Learning*, we endeavour to make the students playful while creating meaning and fostering reflection. Our aim is for students to engage with the combined processes of cognitive, creative, and social elements of gaming literacy, rather than understanding these components as

separate principles. We encouraged them through the workshop's structure, to make and act, prototype and test, knowing it might be "wrong" but still a way to communicate and interact about their ideas, a process known as research through design (Zimmerman, Forlizzi & Everson, 2007).

This paper presents findings from two Monopoly workshops. The first workshop took place in a bachelor-level elective course with 26 students from multiple specializations within the broader field of arts, design, and media. The second workshop was with ten master students within one specialization. Each workshop was recorded and transcribed in full. The master students also partook in a group interview and answered a questionnaire where some of the questions focused on their experiences with the Monopoly workshop. The analysis was done through mainly qualitative interpretation; the transcripts were coded using thematic analysis (Bryman, 2015), aiming to explore and identify recurring patterns of meaning (indexing, categories, themes) across the dataset. Additionally, we quantitatively analysed the data from the questionnaires, using Microsoft excel.

3.1 The Monopoly Workshop

This section describes the workshop structure as well as our emergent findings. This work-in-progress workshop lasts between three to six hours and requires at least one group of 2-5 participants. This section presents how we structured the two workshops we held in the spring of 2024. The workshops were designed with theory-based assumptions which were then strengthened by the analysed data. Therefore, it includes our reflections and understanding of the importance of each step in the workshop as well as its objective within the whole workshop flow and its desired result.

3.1.1 Workshop Structure

Step 0: One-pager - your favourite board game. Since the participants were not required to have prior game-design knowledge, and to familiarize them with board games in general, they were asked to prepare a *one-pager* on their favourite board-game. This one-pager should include a *photo*, a list of *components*, the *goal* of the game, *feedback* mechanisms (how players track their progress in the game) and the *rules*. A template for the one-pager with an example (Monopoly) was provided as a guide, as most of these terms would be unfamiliar to them. Participants would bring their printed one-pager with them to the workshop and present it the rest of their group. The aim was that this would provide participants with a larger repository of game mechanics and components for next steps.

Step 1: Set-up and complex everyday challenge. Participants were given multiple "blank" Monopoly boards printed on paper in A4 and A3, different game components and blank cards (fig. 1). They were also allowed to repurpose components from Monopoly board games. Each group was given a complex everyday problem/challenge to map onto the game board; examples included planning a party, setting-up living collective, planning a family trip or vacation. These are all examples of dynamic systems, where different people involved have varying (and possibly conflicting) goals.



Figure 1: The workshop set up included two example Monopoly games (one old and one new), multiple almost-blank Monopoly boards, game components and blank cards (Photo: Magnus Hestad)

Step 2: Defining the goal-of-the-game. The next step was dedicated to agreeing on the *goal-of-the-game,* as this is one of the four traits of a game (McGonigal, 2011). This was challenging as it requires student to articulate and define their given system while understanding its complexity.

Step 3: Playtest and revise (Fig. 2). To promote constant engagement through playing, prototyping, and playtesting we encouraged the participants to "plan small" and play with the new scenario while discussing (and redesigning) the *rules*, *components,* and *feedback mechanisms*. Then, time was allocated for discussion and review within the groups regarding the different gameplay strategies and game progression to create a one-pager for the redesigned game.



Figure 2: Step 3 of the workshop promotes playtest and revise (Photo: Sarit Youdelevich)

Step 4: Present and reflect. Each group then presented their game to the rest of the class, followed by a discussion, and debrief. This is essential part of the workshop as this enhance switching to a reflection mode which is essential for learning (Alme & Hvidsten, 2022; Dewey, 2018).

The sections below discuss some of our emergent findings from running these workshops.

3.2 Emergent Findings

Monopoly is a well-known board game and therefore we assumed it would be familiar to the workshop participants, allowing them to quickly engage in playtesting. Despite the time constraints, students managed to create a game around a complex system in a short period. One student stated that it is "...nice to be given a concrete example of how easy it can be to just make a game, as long as you base it on things you are already familiar with". We believe that students gained confidence of game design when they did not need to "reinvent the wheel", but rather analyse what needs to change and what can remain as is. Hacking develops critical thinking, as students can question the limitations of a system and identify leverage points for changes and improvements. Here, we find that the scaffolding provided by the existing Monopoly game, as a metaphor of a complex system, was able to be adapted to their needs in the workshop. Most of the students stated that their knowledge and understanding of complex problems had increased following the workshop, as shown specifically in our survey for the master students (Fig. 3).

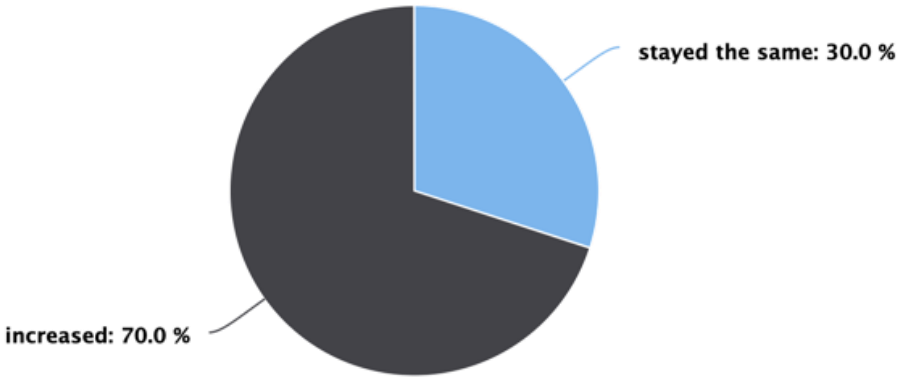


Figure 3: Knowledge and understanding regarding complex systems had increased.

Monopoly's monetary focus was found to be restrictive by some participants, and some felt constrained by this scaffold. Indeed, the groups varied in their ability to move beyond Monopoly as a starting point. As facilitators, we played a crucial role in emphasizing the importance of playtesting and co-designing. We found that most students were more inclined to engage in conversation and discussion, rather than always design and playtest. The master students in particular were eager to jump straight from long conversations into "the one" final

design; in contrast to the continuous playtesting, collaboration and negotiation we aimed for in this workshop. This was, however, a learning point form the presentation and discussion, where they regretted not playtesting sooner to create "better" games.

The workshop is too brief to fully experience a game-design process. However, allowing sufficient time for reflection on learning outcomes ensures meaningful discussion and understanding of the need and potential of this process through playtesting. This reflection helped students recognize how for example their playing strategies could represent their stakes in a specific situation or system, and vice versa. Further, it allowed them to reflect on the characteristics of complex systems, their dynamic nature as well as how playfulness can suggest better understanding of and navigating within them.

In retrospect, participants recognized that the process was both enjoyable and educational, for example, one student stated that: "...sometimes you just have to start straight to get started" and "It can help to set 'shorter' deadlines to get started, and everything doesn't have to be 100% thought out to get started" and another student stated: "...I also saw the joy in co-creation when we had the creative freedom that we had". Specifically, they had recognized the playfulness that emerges from balancing between restrictions and flexibility.

In addition, the master students continued using games to research and develop future scenarios for existing complex systems. They had the opportunity to practice redesign with their systems' stakeholders. By the end of the course, they reported having learned how to effectively co-create through redesign by answering the question: "How would you rate your knowledge of working with co-creation after this course?" with all of them stating "well" and above.

4. Discussion and Conclusion

In this paper, we have explored how board game redesign (using the case of Monopoly) can develop game literacy, which could provide important skills for addressing complex problems. We approach gaming literacy as explained by Eric Zimmerman (2008, p.164): "how playing, understanding and designing games all embody crucial ways of looking at and being in the world". We selected the game Monopoly as a scaffold (an existing complex system) which can play as a metaphor and aimed to facilitate playful interaction with a complex everyday challenge through its redesign. The educational goal was for students to experience and reflect through board game redesign as a process of restructuring human interactions (Fig. 4).

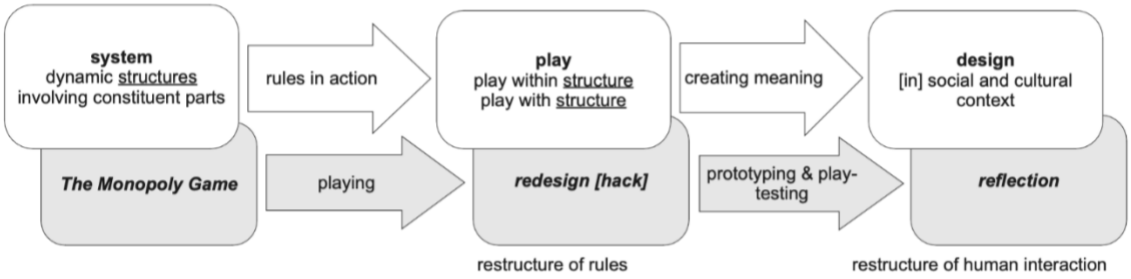


Figure 4: Gaming Literacy and its components (based on Zimmerman, 2008 and Fizek, 2014) applied as a method in the Monopoly workshop

The Monopoly Game acted as a metaphor for students to familiarize themselves with the nature of complex systems. The invitation to redesign and hack the game enhanced both playfulness within the workshop and as system, but also promoting learning about the opportunities and potential of being playful with everyday complexity.

Systems gain significance through their association with people and in the coming century, the focus will shift towards human-centred systems (Zimmerman, 2008). Using a board game and its tangible characteristics increased the immediacy of redesigning acts, facilitating open and informal conversations and social interaction around the table (Celik, 2023). When communicating an idea, we are required to articulate the concept in a way that people can understand and reflect; in doing so, we continuously design and evolve our ideas (Zimmerman, 2022). The process of prototyping and playtesting requires students to communicate: articulate and reflect on, fostering *social* understanding. Acting as a game design process, the students created a set of possibilities to play the game while also examining these possibilities' limitations and identifying where the system can be bent (Zimmerman, 2008). This required them to constantly shift between their role as designers and players. By

redesigning the Monopoly game, playing with its strict system while hacking it to create a different meaningful system, students gain understanding of the *cognitive* and *creative* elements of Gaming Literacy. Ultimately, we believe that the final step of the workshop helps students understand this process as a repeatable way to make sense of and interact with the current world (Lantz, 2014; Zimmerman, 2008), representing a new type of literacy.

We presented that gaming literacy can serve as a model for mutual learning, enabling students to restructure human interactions through game strategies, communication, and language. Here, we found that especially the reflection and dialogue portion of the workshop was essential (Alme & Hvidsten, 2022; Dewey, 2018).

The use of gaming literacy as a model for engaging with complex problems warrant further investigation. Specifically, the Monopoly workshop could be implemented and tested with students from diverse backgrounds and within cross-disciplinary educational programs. Different pre-existing board games might be tested as alternative metaphors for systems. Additionally, more research is needed to understand how the workshop serves as an introduction to the overarching method and to identify the potential outcomes in the face of complex and wicked problems.

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Learning from Designing a Board Game for Policy Thinking in Computer Science

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Abstract: Technology does not exist in a vacuum, but is influenced by society and at the same time shaping it. In order to educate future computer scientists to be able to assess and create technology in a conscious and responsible manner, we provide first-year Computer Science (CS) students with an introductory course on different ways of thinking about CS by offering them a transdisciplinary view of the field. As we continuously strive to use engaging teaching methods to foster long-lasting interest for the topics of the course, as well as enhancing students' learning experiences, we have introduced a unique game-based learning pipeline: In a game design course, advanced CS students design non-digital games that address various topics from the introductory course. These games are later played by first-year CS students, who are reflecting on the content and their experience as a part of their course assignments. In order to learn from the first iteration of this process, we analyse one of the games created, in particular its design and the educational objectives intended by the game designers, including the students' feedback. We found that the game was perceived to be good in achieving learning outcomes; however, it scored even higher in terms of being an interesting and entertaining game. Overall, we conclude that the game was successful in creating an engaging learning experience, demonstrating the potential for game-based learning with non-digital games. This case study also highlights the importance of creating a suitable environment for game-based learning approaches to enhance the educational effects and utilise individual strengths of educational games, providing inspiration and groundwork for future research.

Keywords: Game-based learning, Serious Game Assessment, Educational Board Game, Non-digital Game, Policy Thinking, Computer Science Education

1. Introduction

When working with or on technology, it is essential to recognise that technology does not exist in isolation, but within the broader societal context. Education in the field of Computer Science (CS) should not only provide foundational technical skills but also foster a broader understanding of the societal implications of technological advancements. Thus, it is crucial to lead students to explore their understanding of socio-technical systems, fostering their development into conscious and responsible computer scientists.

Recognising the potential of game-based learning to make students' educational experience more engaging, a significant addition to the curriculum was made: Advanced CS students in a game design course were tasked with designing non-digital games that address various transdisciplinary approaches of thinking about CS. These games were then utilised in a course for first-year CS students, who played and reflected upon the games and their experience as part of their course work.

Our analysis of this innovative teaching method focuses on one specific game designed by students - "The Policy Maker". Two of the authors of this paper, Naemi Luckner and Peter Purgathofer, acted as the educators of the game design course and utilised the resulting games in the course for first-year CS students. The other two authors, Shuyin Zheng and Victoria Fischer, designed the game "The Policy Maker" as students and participated in analysing the results.

In Section 2, a brief overview of the state of the art is given, before we present our methodology in Section 3. In Section 4, we describe and analyse the design of the game. Section 5 presents the results from the evaluation of first-year CS students' perception of the game and its effectiveness in achieving educational objectives. Section 6 is the discussion of our results, and we close with the conclusions in Section 7.

2. State of the art

Game-based learning (GBL) has found application across various educational institutions and purposes, showing positive effects in transferring educational content to learners in an engaging way, and fostering skills such as problem solving and creativity (Vlachopoulos and Makri, 2017; Qian and Clark, 2016). The games used in GBL are as varied as their usage contexts. Projects presented by Caldwell et al. (2017) and Castronova and Knowles

(2015) used off-the-shelf games to enhance their teaching, while others created games to target specific educational purposes (Einsenack, 2013; Iakovidis et al., 2023). Using the process of designing an educational game as a pedagogical method has found its application as well, e.g., in Mayr et al. (2016) and Kuo et al. (2023), showing beneficial outcomes in having context-specific knowledge while designing for specified target groups.

Designing an educational game entails great complexity. Natucci et al. (2023) pointed out the lack of generalisable results from game-based learning and serious games studies as an indication for this complex endeavour. Battistella and Wangenheim (2016) found in their systemic review that games used in GBL for CS education tend to focus on reviewing and reinforcing learned content and are often lacking in the game design aspect.

Natucci et al. (2023) located the key challenges for designing games for GBL in balancing game elements, pedagogical theories, and players' emotional experience. Similarly, Plass et al. (2015) emphasised the need for going beyond incorporating game elements in teaching, advocating for the integration of cognitive, motivational, affective and sociocultural perspectives into game design. Mitgutsch and Alvarado (2012) highlighted in their work the importance of basing the design of serious games on the intended purposes. They suggest that an effective serious game is a cohesive and coherent system based on different but inter-related elements: content, fiction & narrative, mechanics, aesthetics & graphics, and framing. These should reflect the core - the purpose of the game, and their relation to each other constitutes the cohesiveness and coherence of the whole game.

In summary, GBL can be realised in numerous different ways. Designing an educational game for a specific context and purpose involves many challenges, but has the potential of achieving learning goals effectively. The following case study analyses such a game, purposefully designed with the intention to enhance students' understanding of lecture concepts, grounded in game design theory. The analysis serves as an interesting addition to the corpus of educational non-digital games.

3. Methodology

The game "The Policy Maker" was designed by Shuyin Zheng and Victoria Fischer as part of the course "Gameful Design". In the summer semester of 2023, the course was held for Master students of Media and Human-Centred Computing at TU Wien (University of Technology Vienna, Austria) but also included a number of Bachelor students who planned on writing their Bachelor thesis around the topics of this course. "Gameful Design" aims to familiarise students with theoretical concepts of game studies and game design research as well as teach students to understand and apply game design methods to solve real-world problems. While these real-world problems vary from year to year, the challenge in this particular semester was for students to create non-digital games addressing the content of a first-semester lecture called "Ways of Thinking in Informatics".

Ways of Thinking in Informatics can be understood as a transdisciplinary approach to teach students about different perspectives that impact problem-solving approaches in CS. Through the lens of different "ways of thinking", students should understand the need for critical thinking and reflection in the design of technical systems, e.g. Scientific Thinking, Computational Thinking, Design Thinking, Responsible Thinking or Creative Thinking. This particular case study investigates the game, "The Policy Maker", that dealt with Policy Thinking.

Many games created in the context of "Gameful Design" were then used in "Ways of Thinking in Informatics" in the winter semester 2023. As part of their course work, first-year CS students played at least two games from a curated list of games, dealing with the lecture content. For each game, the students filled out a short survey. Additionally, they had to write a short reflection about the games, outlining their take aways as well as their understanding how the games transported their underlying way of thinking. Data collected in the survey and the students' reflections was anonymously analysed and used as a basis for this paper.

Quantitative data presented in Section 5 came from these surveys outlining the students' demographic data, and how the students experienced and rated the specific games they had played. Qualitative data was compiled from relevant quotes distilled from the students' short written reflections, using Thematic Analysis as coined by Braun and Clarke (2022). It should be mentioned that this data set is biased, since there was no hard requirements for these reflections, and students who had rather negative experience with the task or course might be less likely to have written elaborate reflections, thus eliminating their quotes from this data set as they were monosyllable or simplistic to add considerable information to the evaluation.

4. Design of "The Policy Maker"

The "Gameful Design" course provided the development structure of three prototype iterations with play-testing sessions in-between: the first prototype concentrated on basic game mechanics, the second prototype on learning outcomes using the SGDA Framework (Mitgutsch and Alvarado, 2012), and the third prototype mainly tackled the issue of balancing.

The game for three to four players involves a game board, game pieces and cards, as shown in Figure 1. One player assumes the role of the policy maker and the others are investors. The goal for the investors is to establish a monopoly in one of four business sectors; or, if no monopoly is established before the game ends naturally according to a fixed timeline, the investor with the highest investment score wins. The policy maker follows the diametrically opposite goal of preventing the forming of monopolies, in addition to pursuing their own, secret goal, all while ensuring balanced economic growth.

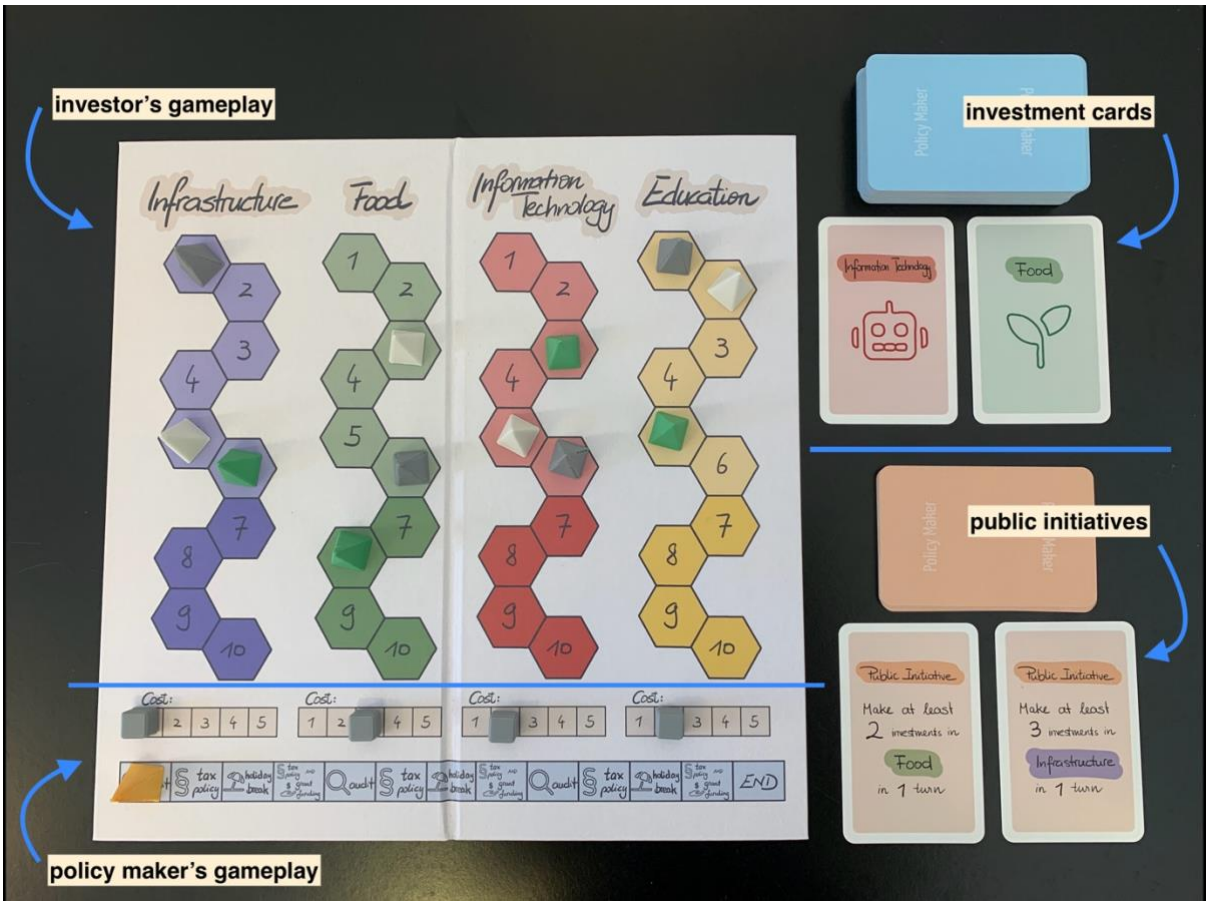


Figure 1: Game board with game pieces, investment cards and public initiatives.

Using asymmetry in board games is an effective way to simulate real-world scenarios (Schell, 2020), demonstrating the imbalance that can occur between political and financial players in real life. Unlike symmetrical games, where starting conditions, the set of actions and the gameplay are the same for all players, these aspects may differ in asymmetrical games, offering diverse players' experiences and therefore increasing the likelihood of replay-ability, and enhance strategic decisions (Shafer, 2013). Another benefit of asymmetrical game design is that it offers players with different game genre preferences different gameplay aspects, bringing diverse players together as a group (Harris, 2016).

4.1 Investors' Gameplay

In the game, two to three players assume the role of investors, managing investment cards in their hand, which they collect throughout the game in order to purchase investment tiles in the four sectors: Infrastructure, Food, Information Technology, Education. The objective of investors is the establishment of a monopoly in one of the business sectors, which wins the game for the investor immediately. In order to hinder others from establishing

a monopoly first, the investor has to either catch up to the leader of a sector, meaning that there will then be balanced growth in the sector; or use market manipulation to harm others' investment. In this case, the active investor, if they have the right amount of investment cards for the sector, forfeits their chance to make investments in a round, but instead uses the cards to engage in market manipulation, setting the targeted investor back in their business development.

Each turn, investors may aim to fulfil public initiatives that are open for everyone to see while investing, in which case the investor gets additional investment cards. Initiatives fulfilled are replaced immediately, so there are always two open initiatives to fulfil for every investor. They contain objectives like making certain amounts of investment in a specific sector at once, or using joker cards while investing. In the event of investors failing to establish any monopoly and the policy maker not reaching their secret goal before the fixed timeline reaching its end, the investor with the highest investment score, which is the sum of investment fields in each sector and public initiatives won, is declared as the winner. Introducing incentives that may not align with investors' immediate goals in mind opens up more possible strategic choices.

If an investor has more than 20 hand cards at any point during the game, a wealth tax is imposed, resulting in the targeted investors losing half of their cards. This mechanic was introduced to balance the game, preventing players hoarding investment cards until they can win the game at once.

After their turn, each investor draws two new investment cards. There are always two cards revealed and placed face up next to the closed deck. Investors may decide to draw one from the closed or the open deck. If the decision was for an open card, a new card is revealed and fills up the place just opened up. This enables the policy maker as well as the investors to gain information about others' plans.

Through this described gameplay, investors not only rely on luck in drawing investment cards each round, but are also able to play strategically: managing their own resources, reacting dynamically to fellow investors' actions, adapting their plans, as well as reacting to the policy maker's actions.

4.2 Policy Maker's Gameplay

The titular policy maker is assigned a secret goal each game, prescribing which business sectors the policy maker should focus on developing. This supplements their main objective of preventing the establishment of a monopoly. Fulfilling the secret goal ends the game, winning it for the policy maker; while maintaining the main goal is essential until the end of the legislative period, in order for the policy maker to not lose the game.

The game not only varies in objectives but also in the available set of actions for the different roles: while the policy maker has significant influence over the game's proceedings with their own set of actions, they cannot make choices on their next actions freely. This is instead constrained by the sequence of actions dictated by the timeline at the bottom of the board (shown in Figure 2), each tile also indicating the start of a new turn. This relatively strict sequence should reflect the real-world setting, where it takes time to implement regulations and laws, and there is a delay between change in jurisdiction and this taking effect on market and society.



Figure 2: Timeline with policy maker's actions.

Overall, there are four actions for the policy maker: audit, tax adjustment, grant funding and holiday break. With audit, the policy maker examines the investors' investment cards in hand. This allows the policy maker to gain insight into the next possible turns and actions of the investors, providing decision support for the policy maker's next actions in line. Tax policy allows the policy maker to regulate the market prices by lowering or raising the costs of investing in each business sector, creating incentives to invest in certain sectors, or discouraging from investing in others. Grant funding allows the policy maker to distribute investment cards among investors, giving the policy maker the opportunity to influence the trajectory of future investments, furthering they work towards their own secret goal, and ideally maintaining or restoring balance on the market.

The policy maker therefore has to observe the investors' actions and their dynamics closely, without knowing their plans. The decisions made by the policy maker may have immediate or long-term effects on the investments, upon which the policy maker cannot react immediately - notice that it is not possible to change the tax policy two turns in a row. This asymmetry in the gameplay is further enhanced by the fact that there are more investors than the single policy maker.

The investors' plans may get disrupted by the policy maker's actions, and they may engage in negotiations with each other while playing. While the policy maker tries to balance the economic progress, the investors try to get clues about the policy maker's secret goal from their actions while racing each other in the investment game.

In summary, the players experience the constant negotiations between political and financial institutions by interacting within the game. The policy maker takes actions that influence the market both directly and in the long-term. Reacting to changes in the political frame and each others' moves, investors adapt their plans and experience what it is like to pursue different goals in the same given system. At the same time, the policy maker learns to observe the dynamic market, to plan ahead and effectively achieve their development goal. The importance and far-reaching consequences of policies is transferred in a simple and understandable gameplay with strong, coherent framing, inviting players to think about real-life occurrences of such political and economic events.

5. Results

This section outlines the results of the first iteration of using "The Policy Maker" in the course "Ways of Thinking in Informatics". Students' survey responses from after having played the game constitute the basis for the quantitative results. The qualitative results give an insight into students' reflections on their perception of the GBL method and the game.

5.1 Quantitative Results

To engage in the topic of Policy Thinking, students were offered a variety of games to play. In addition to our non-digital game "The Policy Maker", there was also a themed version of the classic game "Memory" available. Furthermore, there were three digital, single-player games to choose from: "Green New Deal Simulator", "Moderator Mayhem", and "Bad News". A survey was conducted after students played their chosen game, asking them to rate ten statements (shown in Figure 3) on a scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree. The median of all responses is shown.

From the 514 students who handed in their exercise on the game-based learning part of the course, we received 78 survey responses regarding "The Policy Maker", and 108 regarding other Policy Thinking games. Since the students were asked to play at least two games in a two-hour play session for one selected "way of thinking" from the course, the survey responses on "The Policy Maker" each come from a different student, while the responses on the other Policy Thinking games are not. All in all, the analysis of the survey results shows that "The Policy Maker" is rated as more entertaining, recommendable, and interesting compared to the other evaluated games on the topic of Policy Thinking. Through the gameplay, participants mostly agree that they could deepen their understanding of Policy Thinking and gain new knowledge about this political topic. Additionally, with the help of the game, students were mostly able to connect different concepts of Policy Thinking, and perceived to have a better understanding of how these concepts are applied after they had played the game. The only considerable drawback of the game is that students thought they did not get to know or better understand concepts in Policy Thinking through the game.

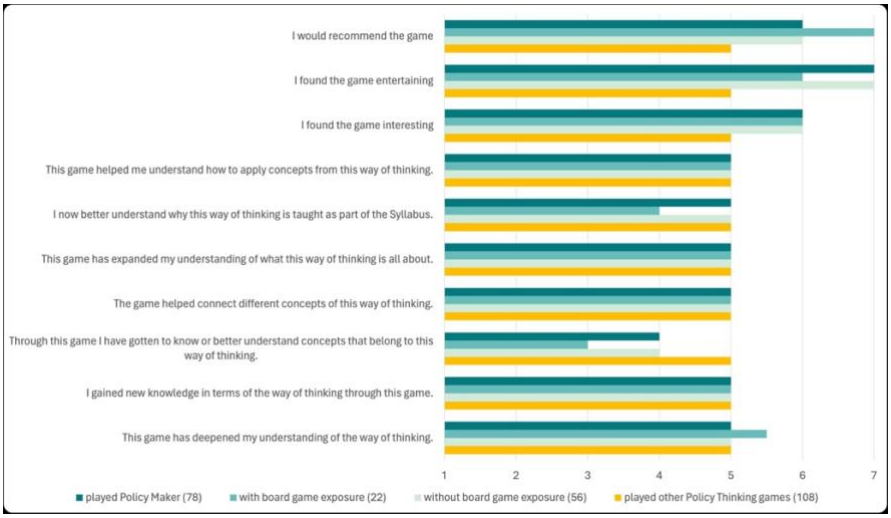


Figure 3: Quantitative data.

The data also revealed differences between students with (n=22) and without (n=56) self-reported prior board game exposure, among the 78 students who had played "The Policy Maker". Initially noticeable is that the interest in the game and the entertainment factor are both rated quite high by both groups. Additionally, students with board game exposure would highly recommend the game, while students without board game exposure beforehand found the game highly entertaining. For students with board game exposure, the game seems to have rather deepened their understanding of Policy Thinking, than achieved the effect of the students learning new concepts through playing. Furthermore, these student group stated that they did not gain a better understanding of why Policy Thinking is taught as part of the syllabus.

5.2 Qualitative Results

From the short reflections provided by the students after playing the games, 303 comments were distilled and selected for qualitative analysis, of which 16 referred to "The Policy Maker" specifically. We grouped the comments, according to their themes, into three non-exclusive overarching categories: learning, method, and feedback.

Eight comments touch on the topic of *learning*. Students reflected on recognising the concepts of Policy Thinking in the game and consolidating them through playing. While some students gained knowledge on the topic through the game, others strengthened their understanding thereof, making note of experiencing the different roles in the political system: "*You get a real sense of how 'investors' react to different policies.*"; "*Now I definitely have a little more appreciation for the actually quite difficult task of politicians*". The game also inspired students to reflect on the real world, with one student writing: "*[The game] offered a fascinating perspective on political and economic decision-making processes and stimulated reflection on the consequences of political decisions in the real world.*"

However, some students were neutral towards the aspect of knowledge gain through playing the game, reporting that since they already knew a lot about politics and Policy Thinking before, they did not gain new insights through the game. Other students had difficulties connecting the game to Policy Thinking, stating that it could be due to their limited knowledge about the topic. This raises the question of when to best introduce the game to the students — some seem to prefer to already knowing the basic concepts of the way of thinking before playing, while others appreciated playing the game first and amplifying their interest for the topic.

Students' comments in the category *method* are positive. They remarked on the variety the game-based learning approach provides in their study program, it being more practical as compared to the more theoretical nature of students' studies, and the game being engaging and fun. The gaming events also provided an opportunity for students to get to know fellow students, and through engaging in discussions that occurred naturally while playing, the learning effect was further enhanced, and more in-depth reflection about the topics was encouraged.

In addition, students provided *feedback* on the game and the organisation around the game events. The game was lauded for its unexpectedly high quality, but the game instructions were at times too complex to understand. It was also mentioned that one hour of playing time was not enough for fully understanding the game, with some students suggesting that the game instructions should start with an overview of general rules and go into detail and edge cases later.

6. Discussion

In general, the written reflections of the students support their reported perception of the learning outcomes, showing that "The Policy Maker" enhances understanding of the topic of Policy Thinking. The game's mechanics were designed with the intention of transporting the intricate relationships between political institutions and financial actors, with asymmetry being the core of the gameplay. Players also experienced the limiting nature as well as long-lasting possibilities and consequences of political decisions. The dynamics between different roles and their responsibilities received positive feedback as well, achieving the intended effect of students getting the, albeit abstracted, experience of working inside the political frame with different interests and thus having to act with constant negotiations and adaptations to one's plans. Following Mitgutsch and Alvarado's SGDA Framework (2012), we also created a coherent narrative frame by naming mechanics, e.g., policy maker and investors' actions, according to the theme. This naturally transfers events that occur through players' interaction into narrative story beats.

Although most students recognised the concepts of Policy Thinking in the game, and indicated that they were able to consolidate their understanding thereof through playing, the aspect knowledge gain is not the strongest in “The Policy Maker”. Some students did not see a firm connection between the game and the lecture content, failing to make the connection back to the broader context of CS. A possible explanation for this is the trade-off we made in the design: Since the game’s purpose is to deepen the players’ understanding for the complex interplay of political and financial interests, we did not put emphasis on the element of “content & information” (Mitgutsch and Alvarado, 2012), which would have entailed providing players with relevant facts and information on the topic. Another possible contributing factor is the abstraction level of the game. It is abstracted in a way that it focuses on general concepts of Policy Thinking rather than on specific contexts of e.g., scenarios related to CS. The decision for this approach is grounded in considerations regarding the complexity of the topic, and our attempt in making the game appealing to broader audiences.

Similar to the element of “content”, we did not focus on the element of “aesthetics” beyond creating a visually minimalistic board and card sets, relying on the asset of non-digital games that the aesthetic arises during dynamic social interaction itself. In regards to framing of the game, we think that we were successful in making the game appealing to the target audience of first-year CS students. Due to the nature of non-digital games, the play literacy required to play the game is generally lower, compared to digital games. However, as students’ feedback suggests, the game instructions can be improved to ensure a smooth start into the gameplay. Furthermore, we have seen interesting differences in perception of the game between students with or without prior board game exposure. The high recommendation rate by experienced board game players especially suggest that “The Policy Maker” is a board game of good quality, assuming that these more experienced players have a broader and deeper knowledge of the entertainment-focused corpus of non-digital games.

Drawing from the students’ reflections, we suggest that the point at which a game is introduced and used in a course is also influencing the learning outcomes. While playing a thematically suitable game before engaging with the course content can be beneficial for raising interest for the topic, playing the game after acquiring knowledge and understanding about the topic can further enhance these learning aspects, and possibly even prolonging and deepening interest in the topic. The decision for the ideal timeframe for game-based learning therefore depends on the intended effects of the approach for the specific educational context. Additionally, it should be considered that students have different previous knowledge and experiences, which can affect how they perceive certain lecture content and educational approaches, as demonstrated in the different ratings from students with or without prior exposure to board games. In the case of “The Policy Maker”, since the data from the first iteration of using the game in the course “Ways of Thinking in Informatics” suggest that our intended learning effects of enhancing understanding of Policy Thinking concepts are well received by students, we make the proposition of using the game after students have engaged themselves in the topics of Policy Thinking, so they can better see the concepts reflected in the gameplay.

In order to aid students in making this connection between their playing experience and the lecture content, we plan on refining the reflection step of the GBL pipeline, by providing reflection prompts that target each game’s educational strengths individually, to provoke deeper reflection in students. This can be approached by 1) eliciting explicit and elaborate design considerations on intended learning effects from the students designing future educational games, 2) analysing games we plan to use in these aspects, and 3) taking into account which parts of the lecture content can be best connected to the games.

7. Conclusion

In conclusion, our case study on “The Policy Maker”, a non-digital game designed by advanced CS students, highlights the successful first iteration of integration of game-based learning in an introductory Human-Computer Interaction course. This educational approach not only engaged first-year students, but also facilitated a deeper understanding of Policy Thinking, a crucial aspect of CS education that connects technology, market interests and political realities.

The game’s design, rooted in the SGDA Framework (Mitgutsch and Alvarado, 2012), effectively demonstrates the complex interplay between political and financial entities, allowing students to experience these dynamics in a social and reflective environment. Although the game was more successful in enriching students’ understanding for Policy Thinking rather than introducing new concepts, it enhanced the learning experience overall, fostering engagement and reflection.

However, the case study also identified areas for improvement, such as improving game instructions and better timing the introduction of the game with students’ learning progress in the course.

Future iterations of this game and others used in a game-based learning approach should consider these insights to further enhance the educational impact of games. This case study serves as a foundation for further research in the effectiveness of non-digital games in education, not only in fields like CS, but also across disciplines.

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PhD Research Papers

Construction Education through Virtual Reality: A Game-based Approach for Interior Architecture Students

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Abstract: This study investigates a novel method of instructing interior architecture students on building specifics pertaining to walls by utilizing the combination of virtual reality (VR) and game-based learning. The creation and application of a virtual reality game called "VR ConstructED," which aims to improve knowledge of wall construction methods, materials, and design consequences, is the study's focus. This project intends to improve students' understanding of wall-related construction elements and their applicability in real-world circumstances by utilizing the immersive and interactive properties of virtual reality technology in conjunction with gamification methods. Through a case study involving academic staff and students at Bahçeşehir University, the efficacy of this pedagogical strategy will be assessed. Using a mixed-methods approach, the study collects quantitative data from surveys and qualitative data from semi-structured interviews. These questionnaires will evaluate the academic performance, contentment, and VR game participation of the students. The main goal is to clarify the advantages and difficulties of using virtual VR to teach construction features, such walls, so that curriculum designers and teachers may make informed decisions. Additionally, by illustrating how gamification and the integration of VR technology may greatly improve student engagement and academic achievement, this study hopes to contribute to the larger area of design education. The results of this study are anticipated to add to the body of knowledge in architectural education and stimulate more research into specific VR applications for design pedagogy.

Keywords: Virtual Reality (VR) Education, Game-Based Learning, Construction Details, Interior Architecture, Wall Construction Techniques

Hypothesis: Utilizing virtual reality technology to create a design education game-based approach in interior architecture, will enhance students' learning experiences, increase engagement, and improve knowledge memory in construction education, particularly wall construction, compared to traditional design education methods.

Research Questions:

- How does Virtual Reality enhance understanding of wall construction techniques among interior architecture students compared to traditional teaching methods?
- What are the key factors in designing a VR game that effectively teaches wall materials, properties, and application methods?
- How do students perceive the use of VR in learning about wall construction details, and what impact does it have on their engagement and motivation?
- What challenges and barriers do educators face when integrating VR game-based learning into the interior architecture curriculum, specifically for teaching about construction?

Motivation: The idea to use walls as the main focal point of the Virtual Reality (VR) educational game was informed by the importance of walls in both interior and architectural design. Walls are among the first ideas taught in architecture and design schools since they are essential structural elements and have a significant impact on a building's usability and beauty.

There is significant educational benefit to concentrating on walls. Because walls are intricate constructions involving many different materials, techniques, and codes, they are a perfect topic for academic investigation. For instructing students on load-bearing capacities, insulating qualities, acoustics, moisture control, and much more, they offer a comprehensive context. Walls are a broad field of study because of the important theoretical and practical ramifications of each of these elements. Additionally, walls offer multidisciplinary learning opportunities since they touch on a variety of architectural and construction-related fields, such as environmental studies, structural engineering, and materials science. This multidisciplinary method supports a comprehensive educational experience and fits in nicely with VR's immersive qualities, which allow various disparate subject areas to be smoothly integrated.

Furthermore, a VR platform can be an efficient way to handle the actual difficulties involved in wall construction and design, such as choosing materials suitable for a given climate or guaranteeing adherence to building requirements. This helps students practice and learn from errors without facing real-world scenarios, which improves their ability to solve problems and make decisions.

VR education about walls takes advantage of the physical and visual qualities of these building components. Compared to typical 2D drawings or passive lectures, virtual reality offers a hands-on learning experience that can be more engaging and memorable. It promotes a deeper knowledge of wall assemblies' construction and design implications by enabling students to see and manipulate wall assemblies in a three-dimensional space.

Although interior architecture involves many other building features, the emphasis on walls was chosen because of their basic significance and potential for education. This doctoral thesis is the first of a planned series of studies. If it is effective, more construction elements will be added to future games, broadening the breadth of instruction, and utilizing virtual reality technology even further to improve architectural education. This methodical approach to expansion enables a comprehensive investigation of every aspect of construction, guaranteeing a strong basis of understanding and proficiency prior to delving into more intricate subjects.

1. Introduction

Virtual reality and game-based learning are emerging as revolutionary technologies in the rapidly changing field of architectural education, having the potential to completely upend conventional pedagogical approaches. Through immersive and interactive virtual settings, VR offers students a unique opportunity to engage closely with building details and explore architectural spaces in three dimensions, so enabling experiential learning. Through this immersive interaction, students are better able to bridge the gap between theoretical knowledge and practical application by comprehending complicated spatial relationships and design principles.

By including challenges, rewards, and interactive tasks in the learning process, the incorporation of game-based learning principles also improves student motivation and engagement. This method facilitates the practical application of theoretical information in a controlled yet dynamic environment by encouraging active engagement and problem-solving. As active players or designers in these virtual environments, students take on decision-making responsibilities that directly affect their learning outcomes, which increases their level of engagement with the learning process.

Even with these improvements, there are still many obstacles in the way of modern design education. Conventional techniques frequently make use of two-dimensional or static graphics, which fall short of accurately capturing the intricacies of architectural elements and spatial relationships. This restriction makes it more difficult for students to successfully convert conceptual concepts into real-world construction projects. To address these shortcomings and improve design education, there is thus a pressing need for cutting-edge teaching resources that make use of virtual reality and game-based learning.

Although interior architecture involves numerous building features, walls are the emphasis because they play a crucial role in defining the boundaries of space, both physically and aesthetically. In addition to being essential structural components, walls play a major role in establishing the usefulness and personality of architectural spaces. This thesis investigates the educational potential of virtual reality in strengthening understanding of wall building specifics. It is the first of a planned series of investigations by the researcher. If this initial focus proves to be successful, it is expected to serve as a springboard for further research into other construction elements, ultimately leading to the creation of a VR game series covering the whole gamut of architectural construction education.

2. Literature Review

2.1 Historical Background of Architecture and Interior Architecture Education

The education of architects originated in ancient times, although it did not take the form of formalized schools. In ancient Greece and Rome, individuals acquired knowledge of architecture through apprenticeships and practical involvement, supplemented by the study of geometry and technical principles. Vitruvius, a prominent Roman architect of the 1st century BCE, wrote "De Architectura," a seminal work that served as a cornerstone for architectural education for many years (Vitruvius 15 BCE).

The Renaissance era was characterized by a significant shift in the resurgence of classical architecture and the rise of notable figures like Leon Battista Alberti, who authored "De Re Aedificatoria" during the mid-15th century. Alberti's work, influenced by Vitruvius, established essential principles of architecture, and served as an instructional resource in the emerging architectural academies of Italy and other regions (Alberti 1452).

The establishment of the Académie Royale d'Architecture in Paris in 1671, under the patronage of Jean-Baptiste Colbert during the reign of King Louis XIV, marked a notable advancement in formal architectural education. The establishment mentioned here was the inaugural educational institution solely focused on architecture. It introduced a structured program encompassing theoretical lectures, drawing instruction, and the examination of mathematical and scientific principles in relation to construction (Blondel 1675).

Walter Gropius established the Bauhaus in Germany in 1919, which brought about a groundbreaking method of teaching design that combined aesthetics and practicality with the concepts of large-scale manufacturing. The Bauhaus curriculum integrated crafts and fine arts, prioritizing practical workshops above academic lectures. This approach had a significant impact on both architecture and the emerging field of interior design (Gropius 1919).

Architecture and interior architecture education had significant global expansion throughout the 20th century. In 1927, the Carnegie Institute of Technology in the United States established one of the earliest interior design programs, indicating an increasing acknowledgment of interior design as a separate professional subject from architecture (Abercrombie 1990).

The formation of professional organizations such as the American Institute of Architects (AIA, established in 1857) and the American Society of Interior Designers (ASID, established in 1975) played crucial roles in establishing educational standards and professional practices for both industries (Pile 2003).

Contemporary architectural and interior architecture education frequently incorporates cutting-edge technology, such as computer-aided design (CAD) and virtual reality (VR), to demonstrate the professions' embrace of digital advancements. Contemporary educational programs prioritize sustainability, ethical principles, and the social dimensions of design, to address worldwide difficulties and changes in societal requirements (Kostof 1985).

2.2 Historical Background of Construction Education

The inclusion of construction education has always been an essential component of architectural instruction, dating back to the skilled craftsmen of ancient civilizations such as Egypt, Greece, and Rome. In those times, the transmission of knowledge regarding construction processes relied on apprenticeships rather than formal schooling. Architects were required to possess an extensive understanding of both design and the pragmatic elements of building construction.

In the Renaissance period, the education of architecture started to become more structured, focusing on the theoretical elements of building, such as construction. Architects such as Leon Battista Alberti and Andrea Palladio authored treatises that encompassed comprehensive examinations of construction methods as an integral component of their extensive architectural education. These works frequently drew concepts from classical architecture and played a crucial role in instructing the connections between architectural design and structural soundness.

The inception of the Académie Royale d'Architecture in Paris in 1671 signified the commencement of a more structured type of architectural education, which therefore encompassed education in construction. However, it was in the 18th and 19th centuries, with the emergence of polytechnic schools in Europe, that construction education started to adopt a more organized framework. Institutions such as the École Polytechnique in France and the Bauakademie in Berlin included sophisticated mathematical and scientific concepts into their educational programs, instructing aspiring architects on the technical aspects of constructing structures.

The advent of the Industrial Revolution had a profound impact on construction education since the introduction of novel materials such as steel and concrete revolutionized the realm of architectural possibilities. To ensure that architects and designers have a comprehensive understanding of these materials, changes were made to the curriculum to incorporate courses in engineering and material sciences. The integration process was further assisted by the founding of engineering schools and technical institutions in the 19th century.

In the 20th century, there were significant changes in the way architecture and building were taught, leading to various philosophical shifts. The Bauhaus movement exemplified the fusion of craftsmanship, artistic expression, and technological innovation. It provided students with comprehensive education on both the practical elements of construction and the principles of design. Following World War II, the emergence of modernism placed a strong emphasis on practicality. This resulted in a curriculum that not only focused on aesthetic design, but also on efficient construction methods and the practical use of contemporary materials.

Presently, the field of construction education in architecture and interior design is significantly impacted by digital technology. Programs include instruction in software such as CAD (Computer-Aided Design), BIM (Building Information Modeling), and now VR (Virtual Reality), which provide intricate simulations of construction procedures. Contemporary educational programs prioritize sustainable construction methods, demonstrating an increasing recognition of environmental concerns in architectural training. Nowadays, universities and colleges frequently provide specialized courses on sustainable construction processes, energy-efficient design, and green building standards.

2.3 VR and Games in Architectural Education

According to Barab et al. (2001), traditional educational settings only expose students to the representational learning stage, which is equivalent to rote learning. According to Alkhalifa (2004), current learning methods are no longer an effective educational method because it places less emphasis on the learner's aptitude and on their creativity. According to Starkey (2011), the current method of teaching presents a challenge in terms of transforming theoretical education into inventive practice that is better suited to cultivating the new generation of individuals who were born in the digital age. According to Allcoat et al.'s research from 2021, virtual reality (VR) has introduced a hybrid experience that combines the real and digital worlds with its interactive methods.

Using "hands-on" and "interactive" teaching methods (Senthamarai 2018), additional benefits will be added to the process of perception (Hu-Au and Lee 2017). The primary advantage of interactive learning is that it encourages students to focus on learning activities and achieve the objectives set by instructors.

Advancements in technology have significantly impacted the field of architecture and design education, transforming the way students learn and interact with their environment. Traditional methods have given way to computer-aided design, virtual reality, augmented reality, 3D printing, and modeling applications, revolutionizing the design process. With the advent of technologies like 3D printers and visualization programs, students can create realistic models and immersive experiences, allowing for faster iterations and more complex designs. The shift to online platforms, exemplified during the Covid-19 pandemic, has further emphasized the potential of virtual online studios. Virtual Reality (VR) one of these technologies, has emerged as a vital tool in design education, offering immersive and interactive experiences for students.

2.4 Game-based Learning (GBL)

With the use of games' interactive elements, game-based learning (GBL) has become a popular and innovative method of teaching that encourages learning and participation. Digital game-based learning was first conceptualized formally by Prensky (2001), who proposed that educational games might improve learners' motivation and engagement in addition to making learning more fun. Constructivist learning theory, which holds that knowledge is constructed by learners by experiences and interactions with their surroundings, forms the theoretical foundation of GBL (Piaget 1976). Further investigation into the educational potential of GBL was conducted by Gee (2003), who noted that well-designed games may provide players a sense of agency, possibilities for problem-solving, and quick feedback, all of which are conducive to learning effectively. Gee's research established the groundwork for comprehending the learning concepts that video games may specifically promote.

2.5 Game-based Learning or Gamification?

Applying game design features and game ideas to non-gaming environments is known as gamification. This strategy offers competition or prizes for players who complete objectives to keep users interested. Point systems, leader boards, badges, awards, and other components are used in gamification to encourage and boost user participation in non-gaming activities. Gamification in the context of education might refer to enhancing standard tasks like quizzes with points or levels or using a badge system to incentivize students to turn in assignments on time. The important thing to note in this case is that while game components are used to boost motivation and engagement, the primary activity is not a game. On the other side, using games to accomplish learning objectives is known as "game-based learning" (GBL). The primary instrument for facilitating education in GBL is the game itself. This method makes use of games' natural ability to be participatory and interesting teaching tools for new ideas, skill development, and behaviour modification.

2.6 Educational Gaming

In recent years, educational gaming has emerged as a promising strategy for revolutionizing traditional teaching methods and enhancing learning experiences across all academic disciplines. Educational gaming provides an engaging and interactive platform that encourages active participation, critical thinking, and skill development by incorporating the principles of game design with educational objectives. In this case, it is possible to mention a method based on the constructivist approach, which asserts that experience is one of the most important methods in learning (Papert 1980). This element is also utilized in educational games. In an environment that adheres to the constructivist learning philosophy, the student will actively participate in the learning process. Earlier research (Chu and Chu 2010) indicates that perceived interaction is a crucial element in the formulation of a constructivist learning environment. Using "hands-on" and "interactive" teaching methods (Senthamarai, 2018), additional benefits will be added to the process of perception (Hu-Au and Lee 2017). The primary advantage of interactive learning is that it encourages students to focus on learning activities and achieve the objectives set by instructors.

2.7 Educational Gaming or Serious Games?

Constantly, the terms educational games and serious games are used interchangeably. In a broad sense, these definitions encompass games that are employed not just for entertainment, but also for the purposes of imparting knowledge and instructing. Educational games may be defined as the use of game technology for the goals of learning and teaching, with the inclusion of subject matter and the goal of achieving the desired educational outcomes for students (Ibrahim and Jaafar 2011). Act (1970), who introduced the notion of serial games to the literature for the first time, asserted that such games offer significant advantages due to risk-free active exploration. Achieving the objective, which is the primary objective of games, and rewarding the player for achieving this objective are also applicable to serious games. This circumstance is constrained by the game's rules. The characteristic that most differentiates the distinction between serious games and regular games comes into play at this stage. Whereas the primary objective of traditional games is to entertain the player, the primary objective of serious games is to educate the player. When doing so, entertainment and other considerations should be considered. There must be a balance between the user's attention, curiosity, and ability to learn.

Perhaps the most critical aspect in educational games is striking a balance between game elements and educational components. According to Brody (1993), the combination of education and gamification has led to games that are either not educational enough or not entertaining enough. To prevent this, it should be remembered that the primary focus in educational games is to teach the subject matter. Using digital technologies and interactive simulations, educational gaming creates immersive learning environments. Educational gaming's benefits reside in its capacity to promote engagement, motivation, and active learning. By integrating game mechanics such as challenges, rewards, and progression systems, educational games instill in learners a sense of accomplishment and motivation. The interactive nature of video games promotes exploration, experimentation, and collaboration, thereby enhancing comprehension and knowledge retention (Michael et. al 2006). In addition, educational gaming facilitates personalized learning by adapting to the requirements of each student and providing immediate feedback (Aldrich 2003). This approach to adaptive learning allows students to progress at their own pace, receive individualized instruction, and address their specific learning deficiencies.

Through an extensive review of the literature, it becomes evident that numerous studies have explored the integration of construction courses within the field of architecture. However, there appears to be a significant gap in the research when it comes to the specific domain of interior architecture. While construction plays a crucial role in shaping the built environment, it is essential to acknowledge the distinctiveness of interior architecture and the unique challenges it presents. Given the scarcity of studies focusing on construction courses within interior architecture programs, this research aims to address this gap and shed light on the specific educational needs and opportunities within this specialized field. By narrowing the scope to interior architecture, this study aims to contribute valuable insights and practical recommendations that are tailored to the context and requirements of this discipline.

3. Methodology

This study employs a comprehensive two-phase methodology aimed at systematically assessing the efficacy of the Virtual Reality game, "VR ConstructED," in instructing architectural construction elements, with a specific emphasis on walls. The methodology is designed to both develop an instructional tool and evaluate its influence

on the learning outcomes of interior architecture students. Every stage of the technique is carefully designed to target specific elements of the study objectives, guaranteeing a methodical approach to the creation and evaluation of the educational intervention.

3.1 Phase 1: VR Game Design and Development

The first stage of the process is on the creation and advancement of "VR ConstructED." The first stage of designing a VR game as a teaching aid is crucial, as its success depends on careful planning and ensuring that it aligns with educational ideas. The development process will integrate concepts from multimedia learning theory, constructivist learning principles, and experiential learning models to establish a dynamic and interactive learning environment. The VR titles will be created using Unreal Engine 5, a game engine, and will be compatible with major VR headsets such as Meta Quest Oculus and HTC Vive. A review of the literature on VR game development and pedagogical game design principles will precede the design and development of the VR game. This stage encompasses:

Designing the User Interface (UI): Developing a user-friendly and inclusive UI that enables effortless navigation and interaction within the virtual reality (VR) environment.

Content Development: Creating the teaching materials, such as 3D models, interactive components, and instructional text or audio, that will be utilized to educate students on wall construction procedures and materials.

Technical Implementation: Developing the required features of the game using an appropriate virtual reality (VR) development platform, ensuring that the game is compatible with widely used VR gear in educational environments.

During this phase, comments from potential users and subject matter experts will be included into the design process to enhance the educational efficacy and user involvement of the game.

3.2 Phase 2: VR Game Evaluation

The second stage of the process entails conducting an empirical evaluation of "VR ConstructED" to determine its influence on student learning and engagement. This stage is crucial for verifying the educational worth of the game and for pinpointing areas that require more improvement. The assessment will be carried out using a mixed-methods approach, which will offer both quantitative and qualitative insights into the success of the game:

Quantitative Assessment: Employing a pre-test/post-test strategy to objectively measure the learning results of pupils utilizing the virtual reality (VR) game. In addition, questionnaires will be conducted to assess students' level of involvement and contentment with the learning process.

Qualitative Assessment: Administering semi-structured interviews and conducting focus groups with participants to collect comprehensive feedback regarding their experiences, perceptions, and any discernible advantages or difficulties related to the utilization of the virtual reality game for educational purposes.

Participants of the study will be a sample of students studying interior architecture that will be split into two groups at random. The study will involve students enrolled in the Construction for Interior Architecture I (INT2051) course at Bahçeşehir University. Participants will be randomly assigned to either the experimental group (using the VR game) or the control group (receiving traditional methods).

The data gathered during this phase will be examined to ascertain the efficacy of "VR ConstructED" in enhancing students' comprehension of architectural construction specifics and to evaluate the overall usability and educational influence of the game.

Control Group: This group should use conventional teaching techniques like lectures, textbooks, and two-dimensional drawings.

Experimental Group: To guarantee a mixed learning strategy, the experimental group should employ the VR game in addition to conventional techniques.

Pre-Selection Survey: Before choosing participants for the virtual reality group, there will be a survey to ascertain their degree of comfort and familiarity with virtual reality and related technology. In this survey, there will be questions about frequency of use, perceived ease of use, and previous familiarity with VR devices. This pre-test

will be called "technological validity" survey. Candidates must have a rudimentary grasp of VR navigation and controls. The study will exclude anyone who find virtual reality extremely uncomfortable or difficult to use, as this could distort the game's educational efficacy findings.

4. Case Study: “VR ConstructED”

"VR ConstructED" is an immersive Virtual Reality game created exclusively for interior architecture students to enhance their education. The game's primary objective is to educate essential construction components, with a particular focus on walls. The game utilizes virtual reality technology to establish an interactive educational setting, enabling students to engage with digital models, replicate real-life situations, and implement theoretical understanding in a hands-on and captivating manner.

4.1 Game Structure and Levels

The game is structured into multiple levels, each designed to address different aspects of wall construction and design:

- **Level 1: Introduction to Wall Types**

Objective: Learn about various wall types (load bearing, partition, retaining walls) and their appropriate uses in architectural design.

Activities: Interactive tutorials that guide students through the identification and application of different wall types in virtual buildings.

- **Level 2: Materials and Properties**

Objective: Understand the materials used for wall construction (brick, concrete, wood, glass) and their properties (thermal insulation, soundproofing, fire resistance).

Activities: Virtual labs where students can experiment with different materials to see how they affect the overall structure and performance of walls.

- **Level 3: Construction Techniques**

Objective: Master the step-by-step processes involved in constructing walls, including framing, insulation, and finishing techniques.

Activities: Simulated construction projects where students must choose the correct techniques and tools to build walls according to specific design requirements.

4.2 Educational Instruments and Tools

"VR ConstructED" incorporates a variety of educational tools and instruments designed to facilitate learning:

Interactive 3D Models: Detailed models of walls and construction components that students can manipulate and explore within the VR environment.

Simulation Tools: Tools that simulate real-world physics and material properties, allowing students to see the practical impacts of their design choices.

Guided Tutorials: Step-by-step instructions embedded within the game to help students learn processes and techniques as they play.

Assessment Tools: Built-in quizzes and review sections that provide immediate feedback on students' knowledge and application skills, reinforcing learning objectives.

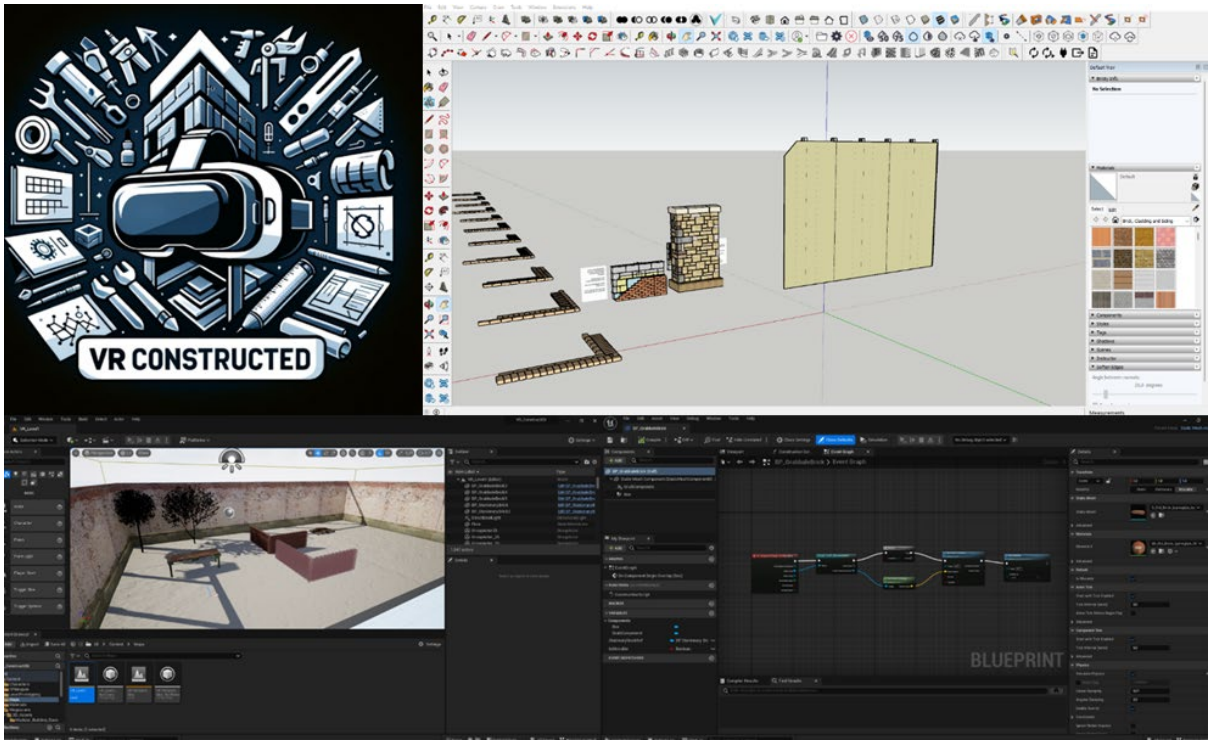


Figure 1: Development process of the VR game.

5. Time Schedule of the Thesis

- **Game Conceptualization and Preliminary Design**

Duration: October 2024- January 2025

Activities: Developing the initial design and concept for "VR ConstructED." This phase includes outlining the game's educational goals, user interface design concepts, and preliminary technical architecture. Collaborating with VR developers and subject matter experts.

- **Development and Initial Testing of VR ConstructED**

Duration: February 2025- July 2025

Activities: Beginning the actual development of the VR game. This stage involves programming, creating interactive content, and integrating educational materials into the game. Conduct initial internal testing and make iterative revisions based on feedback.

- **Pilot Testing and Refinement**

Duration: August 2025- December 2025

Activities: Performing pilot testing with a select group of users to collect initial feedback and identify any operational issues. Refining and adjusting the game based on the pilot feedback. Setting up comprehensive data collection methods for the full-scale evaluation.

- **Full-scale Evaluation and Data Analysis**

Duration: January 2026- June 2026

Activities: Implementing the full-scale evaluation of "VR ConstructED" with a larger participant group. Collecting quantitative and qualitative data. Beginnig data analysis to assess the educational impact of the VR game.

- **Finalization and Defense of Thesis**

Duration: July 2026- September 2026

Activities: Analyzing all collected data, draw conclusions, and draft the final thesis document. Revising the thesis based on feedback from supervisors and peers. Preparing for the thesis defense presentation, conduct the defense, and submitting the final thesis.

6. Conclusion

This study explores the possibilities of using a virtual reality (VR) game-based approach as an instructional tool for interior design students taking construction courses. The study exposes complex opinions and experiences of students playing with virtual reality games by utilizing a thorough approach that integrates quantitative data and qualitative insights obtained through techniques such as semi-structured interviews and theme analysis. The results highlight how VR may enhance construction education and even change preconceived notions about design education. In order to fully exploit the educational potential of virtual reality in design disciplines, future research areas include enhancing VR game applications in educational settings, which will require collaborative efforts among educators, industry experts, and game developers.

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Acceptance and use of Video Games for Education by Secondary School Teachers

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Abstract: Video games (VGs) are frequently described as a transformational force within education and the use of video game technology for learning is becoming more common across all education sectors. Despite this, most literature regarding VGs in education focuses on measuring specific learning or engagement outcomes, and there is less of an emphasis on the attitudes of teachers on the uses of VGs in the classroom. A comprehensive understanding of teacher attitudes towards VGs within education is essential for their successful implementation within the classroom. This paper will present the development and progress of a PhD project that aims to explore the factors that influence secondary Australian teachers' attitudes towards, and intentions to use, VGs within their own teaching. An online survey was used to collect data on teacher beliefs about technology and VGs and the factors that influence VG acceptance. A subsample of participants were also interviewed about their experiences and opinions in relation to VGs. This paper focuses on the proposed thematic analysis of semi-structured interviews. Respondents were divided into groups based on their opinions of, and level of experience with, VGs in teaching. The qualitative results provide a detailed and nuanced investigation of teacher attitudes and beliefs in relation to their competencies, obstacles, and facilitators of VGs use for teaching. The findings of this research will assist in building a deep understanding of VG use in secondary classrooms assisting game developers, administrators, teachers, and policy makers in decisions relating to effective and meaningful video game use within education.

Keywords: Video Games, Educational Video Games, Secondary Education

1. Research Background

Research concerning the educational potential of video games (VGs) has dramatically increased in recent years. While research in the early part of this century initially focused on the potential negative effects of VGs on behaviour, such as addiction, violence, or social isolation (Anderson et al., 2010), more recently there has been an increase in research related to the positive effects of playing VGs (Halbrook et al., 2019). Though much of this body of research is speculative about the potential of VGs to improve education through experiential learning, motivation, and engagement (Connolly et al., 2012), there is emerging empirical evidence to support the use of VGs for learning. This includes positive impacts of video game use on knowledge and skill acquisition, behaviour change, and supporting soft skill development, such as collaboration and empathy (Cole et al., 2023; Connolly et al., 2012). While the potential advantages of VGs in education are well established, the actual use of VGs in teacher practice is still relatively low (Pozo et al., 2022). To better understand this, it is essential to consider teacher attitudes towards VGs, as teachers are seen as change agents within schools when it comes to technology adoption (Teo, 2008), and the use of VGs within classrooms is dependent on teacher acceptance (Bourgonjon et al., 2013). There is a small but growing body of research on teacher perceptions and uses of VGs in education (Sánchez-Mena & Martí-Parreño, 2017). Various studies have found that teachers' positive beliefs towards VGs influence their intentions to use them in teaching (Bourgonjon et al., 2013; De Grove et al., 2012; Huizenga et al., 2017), and that other teacher attributes may influence this decision, such as age, gender, personal VG use, and teaching experience.

1.1 Factors Contributing to Teachers' Uptake of Video Games

In the field of VG use in education, studies are primarily qualitative case studies that focus on student outcomes and attitudes (for a review, see Martinez et al., 2022; Nash & Brady, 2021). In addition to this, research that has explored teacher attitudes towards the use of VGs for education are becoming more common. These focus on pre-service teacher attitudes towards VGs (Kaimara et al., 2021; Hu & Sperling, 2022), teachers within specific subject areas (Gutierrez et al., 2023; Bacalja, 2018; An et al., 2016), or using specific games (Liu et al., 2024; Karsenti & Parent, 2020). In addition to case studies, there are several quantitative studies that use structural equation modelling (SEM) to determine the factors that influence teacher attitudes towards VGs (De Grove et al., 2012; Bourgonjon et al., 2013; Hsu et al., 2020). Despite the increasing research being undertaken in the area of teacher perceptions and uses of VGs, there is still a lack of consensus on the factors that influence teacher

attitudes to VGs, the ways VGs are used in teaching, and the supports and barriers to this within a wider school context.

The quantitative studies that have investigated teacher acceptance of VGs suggest that factors that influence teacher acceptance of VGs are unclear. For example, Bourgonjon et al.'s (2013) model found 'usefulness' to be the strongest predictor of teacher behavioural intention to use VGs, and teachers' personal experience using VGs was a weak predictor of intention to use them. This contradicts an earlier study that found that teacher personal experience with VGs was an important factor in classroom VG use (Becker & Jacobsen, 2005). De Grove et al. (2012) found that learning opportunities, curriculum-relatedness, and experience using VGs in the classroom were the most significant predictors of teacher intention to use VGs. Interestingly, factors at a school level, such as perceived support of ICT infrastructure, ease of implementation, usefulness, and cost, were not found to impact individual teachers' adoption intentions. This contradicts other research findings that school level factors, such as IT infrastructure and technical support, are important for individual behavioural intentions to use VGs in their teaching (Sánchez-Mena & Martí-Parreño, 2017). In 2020, Hsu et al. found that teachers with high levels of pedagogical competency were better able to incorporate games into teaching. They found that knowledge of VG content was not a significant influence on teacher ability to use VGs in teaching, which supports the findings of Bourgonjon et al. (2013) and indicates that personal experience or knowledge of VGs is not required for teachers to be able to implement them within teaching. This contradicts the findings of Kenny and McDaniel (2011), who found that teachers who are unfamiliar with VGs were less likely to integrate them into their lessons. De Grove et al. (2012) found that how easily VGs can be integrated into a curriculum influenced teacher attitudes towards them, but has not been tested in any other SEM models. Furthermore, the relationship between ICT acceptance the use of VG in teaching is complex. Hamari and Nousiainen (2015) paradoxically found that that ICT attitudes are not the most relevant factors in the adoption of VGs for teachers. This may indicate that teacher attitudes towards ICT and broader technology use will differ from their attitudes and intentions to use VGs specifically, and this is a significant gap that this research project proposes to investigate.

There are limited studies which use interview data to explore teachers' opinions on VGs and teaching. Steiler-Hunt and Jones (2015) interviewed primary and secondary educators on their uses of VGs in teaching and found that teachers who use VGs in their teaching practice considered themselves specialists, or enthusiasts, and felt they were different to their peers in their passion for using VGs in teaching. Huizenga et al. (2017) interviewed secondary teachers in the Netherlands regarding their perceptions of digital games with respect to engagement, motivation, and cognitive learning outcomes. Teachers reported that student engagement and motivation was increased when using digital games, and student learning was increased due to games providing an authentic context and safe learning environment. Ruggiero (2013) conducted surveys and interviews with pre- and in-service teachers on their perceptions of gaming in the classroom and found that teacher perceptions of VGs were mixed. Teachers felt that games should be used as a reward, or supplementary material, rather than the main instructional activity within a class. Additionally, the teachers noted that game playing within classrooms is distracting, and the balance of instruction to gameplay is often not successfully achieved (Ruggiero, 2013). Despite this, the majority of interview participants also noted that VGs are useful for engaging and motivating students, and that gaming overall is a value-add to classroom practice.

Xie et al. (2021) combined surveys and interviews with students, parents, and teachers about their perceptions of the implementation of a specific game during an experimental case study. The study found that, compared to the positive views of students, teachers and parents held more neutral views of VG use. While teachers agreed that VGs increase student motivation, they also believed that VGs were not appropriate for older students who should be focusing on exams. Huizenga et al. (2017), Xie et al. (2021), and Steiler-Hunt and Jones (2015) sampled from a population of teachers who were already interested, and had used, VGs in their teaching. In addition to this, these studies were atheoretical when analysing the results of the data collected. Bourgonjon et al. (2013) emphasised the need for further qualitative research on teacher experiences with VGs in education, and the specific ways in which teachers planned to use games in their own teaching (rather than behavioural intention, which is what most studies in this area measure). It is essential for research to consider the nuances of teacher uses of VGs, the pedagogy used surrounding VGs, the beliefs around success or failure of VG use, and the ways in which teachers learn about VG use to implement in their own teaching. There are no studies of which we are aware that analyses qualitative interview data from teachers with a wide range of opinions and experiences with VGs through the theoretical lens of the existing frameworks of technology and VG acceptance.

2. Research Approach/Context

This study is part of a broader PhD study using a mixed-methods approach that builds on the existing theoretical models of teacher technology acceptance and applies them specifically to VG use in the classroom. The research's overall theoretical framework is guided by Teo's (2011) model of teacher technology acceptance, and includes additional factors of personal innovativeness (Bourgonjon et al., 2013), personal VG use (Hsu et al., 2020; Bourgonjon et al., 2013), previous VG use (De Grove et al., 2012), and perceptions of pedagogical usefulness of VGs (curriculum relatedness, classroom management, student engagement). These factors, that have previously been found to influence teacher attitudes towards VGs in separate quantitative studies, underpin both the quantitative and qualitative methodologies of this project. For the quantitative survey analysis, SEM will be used to test this theoretical framework by combining factors from multiple models of technology and teacher VG acceptance studies, as well as additional factors from quantitative studies. While the additional factors have been tested separately in research, this project plans to test the interrelationships of these factors in a novel way, and to compare teacher acceptance of broader technology to their acceptance of VG use. The qualitative component of the study uses the aforementioned theoretical frameworks to inform the interview themes and questions, and these will underpin the thematic analysis of the resulting data. We hypothesise that teacher acceptance of VGs will be different to their acceptance of technology more broadly. Therefore, the following research questions were developed to direct the project:

- What are the factors that influence secondary Australian teachers' attitudes towards, and intentions to use, VGs in education?
- How do Australian secondary teachers' beliefs and intentions to use VGs in education differ from their beliefs and intentions to use technology more broadly?
- What are the barriers to, and promoters of, Australian secondary teachers' intentions to use VGs in teaching?
- In what ways are the theoretical frameworks of existing models of teacher VG (Hsu et al., 2020; Bourgonjon et al., 2013; De Grove et al., 2012) and technology (Teo, 2011) reflected or contradicted by teacher attitudes towards, and uses of, VGs in teaching?

The study is being conducted in two phases. Phase one consisted of the development of a measure of teacher acceptance and intention to use VGs, and the testing of this measure with a population of teachers via an online survey. Phase two is testing the refined and improved model with a larger sample of teachers, again via an online survey. There are two versions of the online survey; one that collects data on teacher attitudes and acceptance of technology broadly, and a second that focuses specifically on VG attitudes and acceptance. This part of the research is still underway until participant numbers are sufficient to carry out in depth statistical analysis with the use of SEM and Multiple Indicators Multiple Causes Models (MIMIC Models) for example. Concomitantly during this phase, the collection of qualitative data in the form of teacher interviews is being carried out. This paper focuses on the qualitative data collected in this project. Figure 1 outlines the plan for this research project.

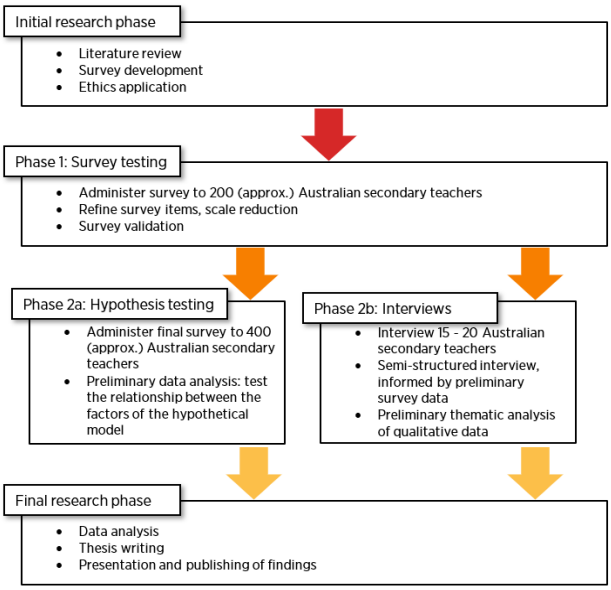


Figure 1: Research project outline

2.1 Methodology

A three-part survey was developed, using items developed from the literature review and previously validated scales from my own Masters thesis, De Grove et al. (2012), Bourgonjon et al. (2013), Teo (2011), and Justice & Ritzhaupt (2015). The survey collected responses related to participant demographic data, as well as experiences, beliefs, pedagogical uses, skills, and external support for either technology broadly, or VGs, depending on the version of the survey they were randomly allocated.

The second phase of the research project included semi-structured interviews with Australian secondary teachers on their attitudes towards, and use of, VGs. The focus of the interviews was on the perceptions of teachers related to the use of VGs in teaching practice. Interview questions were structured around the theoretical framework of technology and VG acceptance models (De Grove et al., 2012; Bourgonjon et al., 2013; Teo, 2011; see Appendix A for interview questions). While the list of questions was pre-planned, the interview was flexible in response to the information shared, so that teacher experiences could be explored (Minichiello et al., 2008). Interviews were conducted to gain a more in-depth perspective that will be combined with the findings and data analysis of the survey. Interviews were planned to take 20 to 30 minutes per participant, although this was up to 60 minutes in some cases. Interview questions are detailed in Appendix B.

2.1.1 Participants

The target population for this study was Australian secondary teachers. The survey was generated using the Qualtrics platform and was distributed to teachers via targeted social media advertising, email, and sharing through professional teacher networks. The study was approved by the Human Research Ethics Committee at the authors' university. Written consent was collected at the beginning of the survey. Survey collection took place from December 2023, currently ongoing (May 2024).

Interview recruitment was completed through an expression of interest after completion of the survey online. Participants were redirected to a separate form after completing the survey and asked if they wished to be contacted for an interview. If participants indicated yes, they were asked one multiple choice question about their level of experience using VGs and to provide their email address. Personal details were not linked to their survey responses. A total of 20 interviews were planned for this project, purposively sampled to gather a wide range of opinions on technology, VGs, and education. The initial multiple-choice question posed to participants when agreeing to an interview was used to ensure that interviews captured teachers with a wide range of VG experience (five multiple choice options, see Appendix B). Determining qualitative sample size a priori is problematic (Sim et al., 2018), and so the proposed sample size of 20 interviews is approximate and aimed at meeting practical demands for the time available, saturation of data, and depth of data to be collected.

Interviews were conducted online via video conferencing and transcribed using the recorded audio data. Written consent was collected prior to the interview, and verbal consent was also asked before the beginning of the interview itself, after the details of the interview process were explained. Transcriptions were emailed to participants for verification and approval for inclusion in the dataset. Interviews took place from April 2024, currently ongoing (May 2024).

2.1.2 Analysis

Analysis of qualitative data from interviews will be completed using thematic analysis. The audio recordings of the interviews were uploaded into transcription software. The resulting transcripts were re-read and checked by the research student, during which any notable or significant quotes were recorded as 'pre-codes' (Saldana, 2021) written down in a research journal as preliminary memos. Interview data was then uploaded to NVivo software. Within the software, transcribed data was initially read for tentative ideas for codes, topics, or noticeable patterns or themes. From this stage, all interview data was split into smaller sections, and assigned codes depending on the content. Deductive coding was used for codes which were related to teacher attributes (i.e., gender, teaching subject, school socioeconomic status, years of teaching experience). Beyond these categories, coding was inductive, with codes being created as data was reviewed. The codes were then grouped into themes, which were then studied for connections within and among them (Seidman, 2019). During the analysis of all qualitative date in this project, concerns, questions, goals, and new thought directions were recorded by the research student in a journal, to allow for the linking of researcher practice, raw data, thematic codes, and the final analysis. Additionally, analytic memos (recorded via cumulative writing while coding was being completed) enabled the synthesis and integration of ideas as they occurred during data collection and

analysis. Data collection is currently ongoing, and full results of the qualitative analysis will be provided at the conference.

3. Significance and Future Directions

Understanding teacher perceptions of video game use within education is essential for their successful implementation within the classroom (Clark et al., 2018). This project has the potential to provide a model that will explain the factors that influence teacher beliefs and intentions to use VGs within their own teaching practice. A detailed understanding of these factors will allow school administrators, policy makers, and teachers themselves to make more informed decisions around increasing the use of VGs within secondary classrooms. Being able to distinguish between teacher attitudes towards technology, and VGs specifically, will enable school administration and policy makers to make nuanced decisions to effectively support and promote teacher VGs use in the classroom in the future.

Furthermore, a greater understanding of the factors that influence teacher acceptance and use of VGs will provide a more balanced view of the future of video game technology in the classroom. There has been considerable optimism surrounding the integration of VGs in the classroom; claims that Pokémon can teach children critical literacy skills (Neiburger, 2011), that VGs can assist teachers with differentiation (Aranas et al., 2021), and that digital play can make children smarter (Toppo, 2015). Research that examines the classroom level implementation of VGs, and the attitudes of teachers towards them, will provide an in-practice view of how these claims translate into classroom use.

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Appendix A: Interview questions

- Demographic questions
  - What KLA/s do you teach in?
  - What year groups do you teach?
- Do you use video games within your teaching?
  - Do you use video games in certain subjects more than others?
  - Do you use video games with certain age groups, or across all age groups?
  - How do you find video games to use in your teaching?
- If you do not use video games in your teaching, why not?
  - Have you tried to use games previously?
  - What have your experiences been with video games? Have you heard or seen examples of game use?

    - Do you think you will use video games to teach in the future?
- Reasons for game use within the classroom
    - What sort of teaching do you use video games for?
    - What, if any, benefits do you perceive by using video games for teaching?
    - Are there any challenges or downsides you have experienced using video games in your teaching?
- What barriers and promoters exist in video game use within the classroom
    - How does your school leadership feel about your use of video games for teaching?
    - How do your colleagues feel about your use of video games?
    - How do your students feel about your use of video games?
    - Have you received any support (professional development, availability of technology, material support) for using video games in your teaching?
    - Are there any barriers within your school to you using video games?
- What strategies, if any, have you used to teach with video games/technology
    - Do you have a planned teaching strategy to use video games in your classroom? If so, where did you learn about this?
    - Where did you source information about using video games to teach?
    - Are there any specific considerations when you choose to use video games? (Classroom management, year group, topic, timing within the school year?)
- Differences in beliefs between video games and technology more broadly
    - How do you feel about using technology in the classroom?
    - Do you consider video games different to using technology more broadly in your teaching? If so, in what ways?
    - Do you consider yourself to be innovative with technology in your teaching in general?
    - Do you consider technology to be useful for education? If so, how?

Appendix B: Interview expression of interest multiple choice question

Thank you for your interest in being interviewed! This question is being asked to categorise our interview participants. While you may have answered this question previously, all of your survey answers are anonymous - so we don't know how you answered! This will be linked with your name, so we can contact you.

How would you describe your use of video games in your own teaching practice?

- I have not used video games in my teaching, and I do not wish to in the future
- I have not used video games in my teaching, but I would like to use them more
- I use video games in my teaching, but I would like to use them more
- I use video games in my teaching, but I would like to use them less
- I am happy with my level of video game use in my teaching

Impact of Digital Game-based Learning Experiences on Reasoning Skills and Science Engagement

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Abstract: This research seeks to use games to promote scientific reasoning and inquiry skills among middle-school children. Particularly, it focuses on the Control of Variables Strategy (CVS), a fundamental component of scientific thinking which enables individuals to test hypotheses and make valid causal inferences based on evidence. The present study draws on and combines existing streams of research in the fields of science education, embodied cognition, and game-based learning to investigate the efficacy of an intervention using the Preparation for Future Learning paradigm in which students play an online text-based adventure simulation game about solving escape rooms in order to prime them for later formal instruction in CVS via a randomized-controlled trial, as well as whether structured or unstructured access to the game has a differential impact on immediate learning vs. retention after a delay. Students were given tests of scientific reasoning at baseline, immediately following the training phase, and a week thereafter. The impact of playing this game on motivation and engagement with science is also analyzed in this trial through the use of survey data. The study found significant effects of study condition on all measures, with students assigned to the game groups outperforming control students, and the unstructured play group showing the strongest performance in the post-study test while the structured play group performed the most poorly in the retention test. The unstructured play group also showed the highest level of intrinsic motivation, as well as higher self-determination and self-efficacy than the structured playing group in the science engagement survey.

Keywords: Embodied Cognition, Educational Technology, Game-based Learning, Scientific Reasoning

1. Introduction

The ability to design controlled, unconfounded experiments to test hypotheses via the Control of Variables Strategy (CVS) is fundamental to all scientific reasoning and inquiry, considered a cornerstone of critical thinking as a whole, which enables individuals to make valid causal inferences (Kuhn, 2005a). CVS is considered so crucial to science and science education, in fact, that various scientific and governmental agencies a have begun including it in student curricula (National Research Council, 2012; NGSS Lead States, 2013). However, despite its unique power and flexibility as a cognitive tool and its centrality to the entire architecture of scientific inquiry, most children do not spontaneously develop use of CVS without some form of instruction or scaffolding, and students of various ages still have difficulty manipulating variables and conceptualizing controlled experiments. For example, Kuhn et al. (1995) showed that even after sustained training, less than a quarter of 4th graders, and less than 75% of adults produced valid inferences when confronted with scientific discovery tasks.

A significant amount of research effort thus has gone into the examination of the circumstances under which the learning and transfer of CVS is best supported. In a meta-analysis by Schwichow et al. (2016), for example, two factors were found that positively impacted students' ability to master CVS: cognitive conflict and demonstration. Cognitive conflict is the Piagetian notion of challenging a student's established framework of beliefs to create a new understanding. In the context of CVS instruction, cognitive conflict involves introducing "anomalous or discrepant" information in the form of a confounded comparison such that students might be able to parse that any conclusions or interpretations made based upon it is invalid. The other factor Schwichow highlighted was demonstration, with interventions that showed demonstrations of valid vs. invalid designs having a significantly larger effect size than those which don't.

Ross (1988a), meanwhile, identified two other factors that were associated with significantly higher effect sizes in intervention studies: feedback and practice. Intervention studies in which students were given feedback about their performance on training tasks showed larger effect sizes in terms of the outcome measures, as compared to those studies where students received no feedback. Similarly, intervention studies had higher effect sizes when students were afforded the opportunity to practice the CVS skills they were learning both within a school context and outside of it, as opposed to merely one or the other.

The computerization of instructional and assessment materials in this area has also met with some success in increasing the flexibility, efficiency, and accessibility of CVS training. Klahr, Triona, and Williams (2007), for example, found virtual training tasks in CVS to be equally effective as training tasks with real physical equipment, a result replicated by various studies. Nonetheless, even in these studies, the virtual tasks undertaken by

students appear to largely be an extension of a classroom lecture, merely replicating the experience of a physical task without taking advantage of the more unique qualities of the medium. One avenue of research which has attempted to do so has been within the realm of embodied cognition. Embodied cognition is a concept in Cognitive Science which suggests people create mental perceptual simulations of concepts in order to understand them (Barsalou, 2008), and work such as Triona and Klahr (2003) and Glenberg (2011) has offered evidence that the positive effects of embodiment are reproducible with imagined and surrogate embodiment, determining that computer simulations of actions engage the same mechanisms as in embodied cognition.

An educational video game can bring together several of these individual threads of research; cognitive conflict via demonstration can be introduced through a game's narrative, for instance, while a game by its very nature is inherently a feedback loop designed to respond dynamically to the player's evolving competencies. This brief review will focus on the primary insight that for a gaming intervention to be successful, it needs to be engaging and motivational on top of delivering its material accurately and efficiently.

To this end, Black, Khan, and Huang (2014) adapted the Preparation for Future Learning (PFL) framework originally established for rethinking the field of transfer to game-based learning, presenting a compelling argument for video games as perceptually rich grounding environments for learning. He argued video games can serve as an embodied foundation upon which to build formal instruction on abstract concepts, thereby improving students' understanding of the material as compared to students who only received the formal instruction. For instance, they found that students who played a historical simulation game, Civilization, were then able to learn much more from reading a difficult history textbook (in terms of propositional, procedural, imagery, and system knowledge) than students who played an unrelated game (Sim City). Building on this evidence, Han and Black (2011) discovered that adding force feedback via a simple game joystick could accentuate scientific reasoning in a physics lesson about gears and Newton's laws, respectively.

The question of why people find playing games motivating, meanwhile, and how that engagement can be captured and replicated in the classroom can be addressed by flow theory (Csikszentmihalyi, 1975) and the construct of the learner hero (Rigby & Przybylski, 2009), both key elements in the development of the present study. The learner hero construct focuses on the "why" of the question. Utilizing Self-Determination Theory, Rigby & Przybylski argue that gaming fulfills three core components of intrinsic motivation: autonomy, competence, and relatedness. The common practice of setting up the user/avatar as a heroic actor allows a game world to establish its player's capacity to achieve the goals and challenges of the game and the significance of their choice to participate (autonomy). As the player progresses through the game, more and more of the virtual world's challenges and goals are met (competence), and the hero gradually becomes beloved and trusted, with their continued actions becoming ever more important to the world of the avatar and becoming self-perpetuating (relatedness). Thus, the process of playing the game itself provides intrinsic motivation to keep playing, which the authors argue has strong applications to educational technology—which aims to make learning a similarly self-sustaining process, motivation-wise.

Flow theory can be said to address the "how" of gaming motivation. In other words, what specific design features promote the experience that characterizes immersion in a game? As described by Csikszentmihalyi (1975), flow entails a sense of meaningful action, a personal locus of control, and a focus on a goal. Research discussed in Bressler & Bozdin (2013) suggests that not only does increased flow improve learning, especially in educational technology environments, but that a flow experience in enhances intrinsic motivation to participate in the game—enabling the self-perpetuating process discussed earlier.

Therefore, the present study investigates the impact of an interactive simulation game on scientific reasoning skills and science engagement, specifically effective use of CVS.

2. Current Study

2.1 The Great Escape

The game played by students was designed by the PI for the study. Its story follows five friends who participate on a reality TV gameshow in which contestants solve the puzzles of an escape room within a time limit. The primary mechanic to this end is a "choose your own adventure"-style set of branching passages: players must make individual choices through clicks in these passages to solve puzzles and gain keys to advance the story without making enough mistakes to trigger a game-over.

The game supports learning the CVS strategy through its use of narrative. Throughout the game, the characters interact with the scientific principles of the game, and the player makes choices based on their theories. In each "escape room", the characters are presented with a puzzle to solve by gathering evidence and formulating hypotheses based on the clues they find and must set up a valid test of their hypotheses to continue.

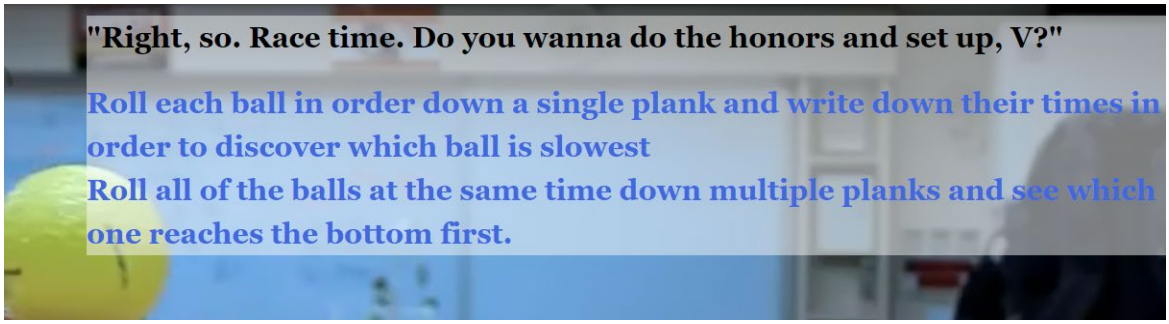


Figure 1: Example of a choice between valid and invalid experimental setups

As the player works through each puzzle, the characters discuss the evidence discovered via one's choices of clicks, and if the player makes a mistake, there will be a screen of further narrative with another character "correcting" them and/or realizing their own error. This shows the player why their answer is incorrect, as well as reinforcing the CVS principles at work in the game narrative—thus fulfilling the two factors identified by Ross (1988a) as significant to effect size in interventions: feedback and practice. Further, having the player choose between a valid and an invalid experimental design before observing the outcome of their choice also hits the instructional features identified by Schwichow et al (2016) as having a significant impact on effect sizes in interventions: cognitive conflict (created by introducing anomalous information, such as a confounded experiment), and demonstration.

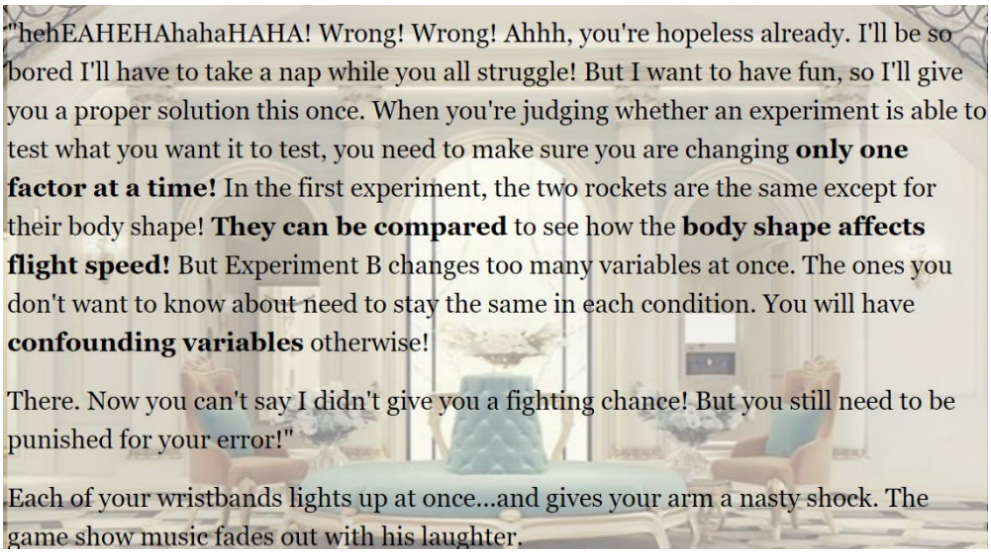


Figure 2: Example of game feedback after an incorrect answer

More broadly, this design of gameplay, wherein players explore puzzles while gathering clues and evaluating evidence, is inspired by the notion of educational video games as "objects to think with" (Holbert and Wilensky, 2019). Although the environments players explore are somewhat more structured and the construction and testing of hypotheses occurs under the constraints of the medium, The Great Escape is intended to reflect the idea of a game serving as a playful experience to engage in knowledge construction with, which can be used to expand one's thinking and reasoning outside the confines of the game.

2.2 Participants

Participants were 143 7th grade students (70 female, 73 male) from a public middle school in New Jersey. Recruitment was done through email correspondence with the superintendent and principal, who directed the

PI to a teacher willing to participate, at which point participating students had parents fill out consent forms and signed assent forms.

2.3 Method

Participants were given an initial test on Control of Variables Strategy (CVS) knowledge, then randomized into three groups: 1) unlimited access to the game for three consecutive days, 2) three structured play sessions over a total of three consecutive days, and 3) a control group with access to an alternative online experience—i.e. a document formally explaining the concept and application of the control of variables strategy (CVS) available for three consecutive days. After the three-day training period, all students in the first two conditions will also receive access to the document the third group received. All students will then take another CVS test following the study. One week afterward, all students will take a retention test. The assessment instruments are from the instrument developed by Chen and Klahr (1999). The baseline and post-study tests have twelve questions each, and the retention test has 24 questions, with Cronbach's alpha for each test at 0.71, 0.729, and 0.819 respectively. Each day during the training phase, the teacher gave the unstructured playing and control groups a free class period during which they could work on whatever they wished for the class, including playing the game or reading the CVS document if they wanted. Students could also view the document or play the game at their leisure at home. The structured group, meanwhile, played the game for 30 minutes at a set time for all three days.

Students in the game conditions were asked to keep a record their thoughts, feelings, and reactions while in the process of playing the game and submit them after the study.

2.4 Measures

The primary outcome measures in this study were the baseline test, post-study test and retention test scores from the instrument developed by Chen and Klahr (1999). There were two additional measures for the study, in the form of surveys filled out by the participants. The first was a science engagement measure, using a questionnaire designed by Glynn et al. (2011) to determine participants' engagement in and motivation to learn science. The scale has 25 items, including five subscales with five items each. The subscales are as follows, with corresponding reliabilities, assessed by Cronbach's alpha: career motivation (0.92), intrinsic motivation (0.89), self-determination (0.88), self-efficacy (0.83), and grade motivation (0.81), with an overall reliability for all 25 items of 0.92.

Science Motivation Questionnaire II

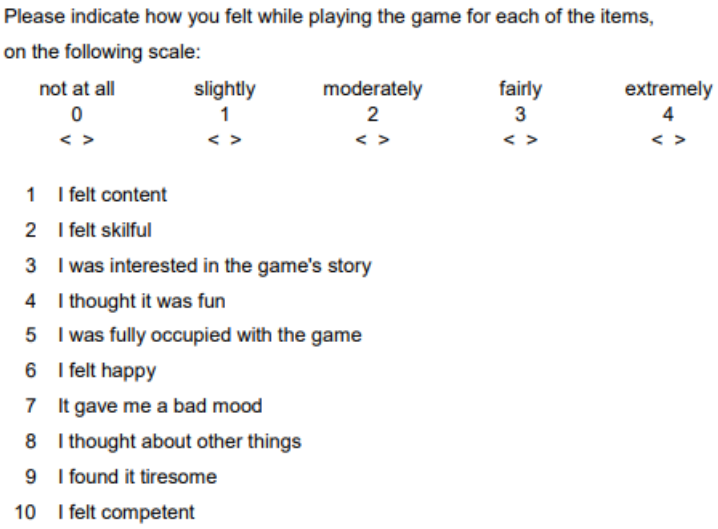
In order to better understand what you think and how you feel about your college science courses, please respond to each of the following statements from the perspective of "When I am in a college science course…"

[Response scale: ○ Never ○ Rarely ○ Sometimes ○ Usually ○ Always]

01. The science I learn is relevant to my life
02. I like to do better than other students on science tests
03. Learning science is interesting
04. Getting a good science grade is important to me
05. I put enough effort into learning science
06. I use strategies to learn science well
07. Learning science will help me get a good job
08. It is important that I get an "A" in science
09. I am confident I will do well on science tests
10. Knowing science will give me a career advantage
11. I spend a lot of time learning science
12. Learning science makes my life more meaningful
13. Understanding science will benefit me in my career
14. I am confident I will do well on science labs and projects
15. I believe I can master science knowledge and skills
16. I prepare well for science tests and labs
17. I am curious about discoveries in science
18. I believe I can earn a grade of "A" in science
19. I enjoy learning science
20. I think about the grade I will get in science
21. I am sure I can understand science
22. I study hard to learn science
23. My career will involve science
24. Scoring high on science tests and labs matters to me
25. I will use science problem-solving skills in my career

Figure 3: Science engagement Questionnaire

The second was a Game Experience Questionnaire, designed by IJsselsteijn, de Kort, & Poels (2013). This measure was included to determine how positively or negatively participants reacted to the game, and whether they felt motivated and engaged while playing it. The GEQ has 33 items and seven subscales, each with 5 or 6 items and the corresponding Cronbach's alphas: sensory and imaginative immersion (0.891), tension (0.821), competence (0.843), flow (0.883), negative affect (0.728), positive affect (0.838), and challenge (0.718). Both surveys use scales from 0-4 for each response, with 0 indicating the least amount of agreement with the survey item, and 4 indicating the most. Scores are calculated for each subscale separately; there is no composite score for either instrument.


Please indicate how you felt while playing the game for each of the items,
on the following scale:

not at all	slightly	moderately	fairly	extremely
0	1	2	3	4
< >	< >	< >	< >	< >

1 I felt content
2 I felt skilful
3 I was interested in the game's story
4 I thought it was fun
5 I was fully occupied with the game
6 I felt happy
7 It gave me a bad mood
8 I thought about other things
9 I found it tiresome
10 I felt competent

Figure 4: Sample questions from Game Experience questionnaire

3. Research Questions and Hypotheses

3.1 Research Questions

1. What is the impact of game-based learning on scientific reasoning skills?
2. Do students who play an interactive narrative simulation game requiring the use of a scientific reasoning strategy (CVS) have better retention following formal instruction on the strategy when retested after a delay than those who only received the formal instruction on CVS?
3. Does structured vs. unstructured access to the game have a differential impact on immediate learning and retention after a delay?
4. Does playing the game increase students' engagement with science or motivation to learn science?

3.2 Hypotheses

- **Hypothesis 1:** The structured play group will have the strongest performance on the posttest.
- **Hypothesis 2:** The unlimited play will have the strongest performance on the retention test.
- **Hypothesis 3:** The two game groups will outperform the control group on the post-test and retention test.
- **Hypothesis 4:** Playing the game will improve science engagement.

4. Results

The CVS tests were analyzed via logistic regression—specifically the case of binomial response, which examines the number of successes in n trials with constant probability of success. This corresponds to an investigation of how many questions are answered correctly (successes) out of a total of 12 similar questions (trials) with two options each. This method was selected due to the bounded range of values of the data, which made the sample a better fit for the binomial distribution than the normal distribution used for ANCOVA. Survey data did not show significant deviations from normality and was thus analyzed with MANOVA.

All subjects' responses were anonymized, with the only identifier for each data point the IP address of the participant. However, the school's network did not retain unique IP addresses for each student terminal, so individual student data ended up completely de-identified, and data from the baseline test was unable to be matched with the post-study test and follow-up retention test data for analysis. Because of this, the three tests have been analyzed separately.

4.1 CVS Tests Descriptive Statistics

Mean score on the baseline test in the unstructured playing condition was the lowest, at 7.65. The structured playing condition was in the middle at 8.44. The control condition was the highest at 9.16.

The mean on the post-study test in the unstructured play group, however, was the highest, at 9.57. The mean on the post-study test in the structured play group was again in the middle, at 9.15. The control group scored the lowest, this time, at 8.65.

The structured play group had the lowest retention test scores, with a mean of 17.05. The unstructured play group and the control group, meanwhile, had nearly identical overall means, at 18.68 and 18.69, respectively.

4.2 Regression Results

Table 1: Parameter estimates for logistic regression on baseline test scores

			95% Wald C.I.		Hypothesis Test				95% Wald C.I. for Exp(B)	
	B	SE	Lower	Upper	Wald Chi-Square	df	*p*	Exp(B)	Lower	Upper
(Intercept)	1.17	.10	.97	1.38	128.03	1	.00	3.23	2.64	3.96
[Group=unstructured]	-.61	.14	-.89	-.33	18.07	1	.00	.54	.41	.72
[Group=structured]	-.31	.13	-.57	-.05	5.49	1	.02	.73	.57	.95
[Group=control]	0[a]	.	.	.	.	.	.	1	.	.
(Scale)	1[b]									

Events: Pretest

Trials: 12

Model: (Intercept), Group

As seen in Table 1, instead of being identical, the data from the baseline test shows a significant effect of group, where the first group (unstructured/unlimited play) did the most poorly, 46% less likely to get any particular question correct than the third (Wald chi square = 18.067, $p < 0.001$), and the second group (structured game play) 27% less likely than the third to get any particular question correct (Wald chi square = 5.490, $p = 0.019$).

Table 2: Pairwise comparisons for baseline test scores

						95% Wald C.I. for Difference	
(I) Group	(J) Group	Mean Difference (I-J)	SE	df	*p*	Lower	Upper
unstructured	structured	-.07	.03	1	.06	-.13	.00
	control	-.13[a]	.03	1	<0.001	-.20	-.06
structured	unstructured	.07	.03	1	.06	.00	.13
	control	-.06	.03	1	.05	-.12	.00
control	unstructured	.13[a]	.03	1	< 0.001	.06	.20
	structured	.06	.03	1	.05	.00	.12

Pairwise comparisons of estimated marginal means for groups based on the events/trials proportion. Significance measured with Bonferroni adjustment.

Events: Pretest

Trials: 12

Pairwise comparisons (Table 2) back up this effect of group, showing that the unlimited play group (Group 1) performed more poorly than the control (Group 3), significant at the 0.001 level even after Bonferroni correction for multiple comparisons. The second (structured play) group also did more poorly than the control, though that is only marginally significant in the pairwise comparisons.

Table 3: Parameter estimates for logistic regression on post-study test scores

			95% Wald C.I.		Hypothesis Test				95% Wald C.I. for Exp(B)	
	B	SE	Lower	Upper	Wald Chi-Square	df	*p*	Exp(B)	Lower	Upper
(Intercept)	.95	.10	.76	1.14	93.51	1	<.001	2.58	2.13	3.13
[Group=1]	.42	.15	.12	.72	7.50	1	<.01	1.52	1.13	2.06
[Group=2]	.39	.16	.09	.70	6.41	1	.01	1.48	1.09	2.01
[Group=3]	0[a]	.	.	.	.	.	.	1	.	.
(Scale)	1[b]									

Events: Posttest

Trials: 12

Table 4: Pairwise comparisons for post-study test scores

						95% Wald C.I. for Difference	
(I) Group	(J) Group	Mean Difference (I-J)	SE	df	Bonferroni *p*	Lower	Upper
unstructured	structured	.00	.027	1	1.00	-.06	.07
	control	.08[a]	.027	1	.016	.01	.14
structured	unstructured	.00	.027	1	1.00	-.07	.06
	control	.07[a]	.028	1	.03	.01	.14
control	unstructured	-.08[a]	.027	1	.016	-.14	-.01
	structured	-.07[a]	.028	1	.03	-.14	-.01

Pairwise comparisons of estimated marginal means based on the events/trials proportion

Events: Posttest

Notably, the pattern from the baseline test completely reverses in the post-study test, and the unlimited play group outperforms both other groups, becoming 150% more likely to answer a question correctly than the control group (Wald chi square = 7.499, $p < 0.01$). As before, this is corroborated by the pairwise comparison (Table 4), which shows the unlimited play group with a higher probability of answering questions correctly than the other two groups, significant at the 0.05 level after Bonferroni correction. It's also worth mentioning that the analysis for the post-test scores was performed twice. During the study, the students in the structured play group (Group 2) were interrupted during the post-test by a fire alarm, and 27 of them did not finish the test before having to leave the building. Since this occurred on a Friday, these students could not complete the test until the following Monday, resulting in a delay of three days between the training phase and the post-test for these students. The analysis was therefore re-done with the students who were affected by the fire alarm excluded, with the results reported in Table 3. This reanalysis largely supports the results of the original, which are not reported here out of space considerations. However, while pairwise comparisons in the original analysis do not show that the structured play group was significantly different from the control group, the analysis with the fire alarm students excluded does, at the 0.05 level with Bonferroni correction.

Table 5: Parameter estimates on logistic regression for post-study scores

			95% Wald C.I.		Hypothesis Test				95% Wald C.I. for Exp(B)	
	B	SE	Lower	Upper	Wald Chi-Square	df	*p*	Exp(B)	Lower	Upper
(Intercept)	1.26	.08	1.09	1.42	228.94	1	<.001	3.52	2.99	4.14
[Group=1]	-.002	.12	-.23	.23	.00	1	.985	1.00	.79	1.26
[Group=2]	-.36	.10	-.56	-.16	12.52	1	<.001	.70	.57	.85
[Group=3]	0[a]	.	.	.	.	.	.	1	.	.
(Scale)	1[b]									

Events: Retention

Trials: 24

The study also found a significant effect of group in the retention test scores, as seen in Table 5. However, in this case, the difference was that the second group (structured play) performed significantly more poorly than either the unstructured play group or the control group, 31% less likely to answer any particular question correctly than the control group (Wald chi square = 12.520, $p < 0.001$). Again, this was confirmed by the pairwise comparisons (Table 6), which showed no significant difference between the unstructured play and control

groups, but a highly significant difference between the unstructured play and structured play groups, as well as one between the structured play group and the control group.

Table 6: Pairwise comparisons for retention test scores

(I) Group	(J) Group	Mean Difference (I-J)	SE	df	Bonferroni p	95% Wald C.I. for Difference Lower	Upper
unstructured	structured	.07[a]	.019	1	.001	.02	.11
	control	.00	.020	1	1.00	-.05	.05
structured	unstructured	-.07[a]	.019	1	.001	-.11	-.02
	control	-.07[a]	.019	1	.001	-.11	-.02
control	unstructured	.00	.020	1	1.00	-.05	.05
	structured	.07[a]	.019	1	.001	.02	.11

Pairwise comparisons of estimated marginal means based on the events/trials proportion

Events: Retention

Trials: 24

4.3 Survey Data: MANOVA Results

There was a significant difference between the groups on the combined dependent variables, $F(6, 172) = 2.667$, $p = 0.017$. Planned contrasts show that there is a significant difference between the unstructured play and structured play groups on self-determination and self-efficacy ($p < 0.01$), and between unstructured play and control on intrinsic motivation and self-efficacy ($p < 0.05$), though when adjusted with Tukey's HSD correction for multiple comparisons, only the effect of group on self-determination remains, with Group 1 having a higher mean than Group 2 by about 2.64, $p < 0.05$.

Table 7: Planned contrasts for survey data

	Group Simple Contrast[a]						
	Level 2 vs. Level 1						
						95% C.I. for Difference	
Dependent Variable	Contrast Estimate	Hypothesized Value	Difference (Estimate - Hypothesized)	SE	p	Lower Bound	Upper Bound
Intrinsic_motivation	-1.54	0	-1.54	1.01	.13	-3.558	.475
self_determination	-2.64	0	-2.64	.96	< .01	-4.540	-.736
self_efficacy	-1.80	0	-1.80	.87	.04	-3.519	-.072

[a] Reference category = 1

Level 3 vs. Level 1						
					95% C.I. for Difference	
Contrast Estimate	Hypothesized Value	Difference (Estimate - Hypothesized)	SE	p	Lower Bound	Upper Bound
-1.95	0	-1.95	1.01	.056	-3.95	.05
-.72	0	-.72	.95	.451	-2.61	1.17
-1.67	0	-1.67	.86	.056	-3.38	.04

5. Discussion

This study sought to determine whether game-based learning could provide an embodied cognition foundation upon which formal learning of scientific reasoning principles could be enhanced. It further sought to investigate whether structured or unstructured access to this material would have a differential impact on learning, and whether the experience of playing this game would have an impact on students' science motivation. Both the game and the study itself were designed based on combining insights from the literature on transfer, game-based learning, embodied cognition, and scientific reasoning. The creation of a largely blank-slate protagonist for the player to project onto was inspired by the "learner hero". The choose-your-own-adventure format gives autonomy to the player as they control the protagonist, and a sense of competence as they advance through the puzzles. The protagonist's friends foster relatedness as well, with their enthusiasm or disappointment based on player answers. Providing an overarching goal—to solve the puzzles before the characters are "trapped forever" on game over—and the ability to meaningfully affect the chances of winning or losing based on player choices were intended to recreate elements identified as promoting a "flow" experience.

The study was also designed to avoid some of the pitfalls from previous research on game-based learning, by incorporating various insights from meta-analyses and Barnett and Ceci's (2002) transfer taxonomy. For instance,

it attempts to control for transfer distance in terms of functional context by providing a tutorial within the game in a similar format to the eventual questions on the CVS tests, accounting for the potential advantage in control group students' awareness that they are learning a scientific principle. It also accounts explicitly for the impact of repeated training sessions and supplemental instructional supports, elements that were neglected in studies that claimed mixed or inconclusive results. Further, the narrative of the game is inextricable from the scientific principles to be taught, as opposed to irrelevant set dressing—a distinct weakness of a previous study claiming a disadvantage for a gaming condition over a matched Powerpoint slides condition. It also addresses a concern put forth by Young et al. (2012) about science games on the necessity for students to be prompted on the skills they learned from a game to utilize those skills in practice outside the game by explicitly drawing the connection to experiments in the tutorial section. Survey results and reflection comments speak to successfully promoting intrinsic motivation within the game. Over a third of the survey respondents in both game conditions noted finding the game enjoyably challenging, and a similar amount mentioned a deep curiosity about the plot and a strong drive to find out what was going to happen next as they played.

The CVS tests also provide interesting evidence on the impact of the game on scientific reasoning. The significant effect of group on the pretest scores is particularly surprising, as the students in each group are as similar as possible, with the entire sample from the same grade learning at the same school under the same teacher. It is conceivable, if improbable, for this pattern of baseline scores to have occurred by chance. Even if there was some manner of unobserved latent variable responsible for the group differences at baseline, however, the reversal of outcomes between groups from pretest to posttest creates an implication (albeit one that cannot be verified statistically) that the unstructured playing group improved over the course of the study period—perhaps enough so to overcome any unknown advantage the control group may have had. This notion is worth further examination, especially if it might mean that the utility of the game as an intervention has an interaction with student ability—in other words, students with the weakest scientific reasoning abilities at the outset benefit the most from the game.

What's especially interesting about the retention test results is that the expected learning loss after a delay is significantly greater in the structured game play group than the other two. One potential interpretation is the unstructured playing group took full advantage of their unrestricted access to the game and played it a great deal more than the structured group's three exposures to the game. The second group, with less overall exposure, would then experience learning loss faster. If so, it would imply not only that the game is helpful in promoting learning, but that students sought it out to play more times than would've been necessary simply to have solved all the puzzles, a suggestion supported by the significant effect of group observed in the survey data for the intrinsic motivation subscale. In future post-pandemic work, a longer study period with a mechanism to record gameplay time could draw out more subtle differences between the groups.

One notable limitation of the study design was the ceiling effects observed in the CVS tests. A few factors may explain this trend—the original instrument used by Chen & Klahr (1999) was used to evaluate CVS in slightly younger children, finding robust effects in 4th grade students. The present study works with middle-school children, when experimental design and scientific reasoning begins to be formally taught for the first time. It is possible that the observed skew in the data might be a result of some older children not finding the instrument challenging enough, or a latent variable such as SES or cognitive ability in the student population at the school. Teasing apart the impact of the individual study components may shed further light on the matter. With the PFL paradigm, this study investigates the impact of exposure to the game on a child's ability to benefit from formal instruction later. However, it would also be interesting to examine the direct impact of the game itself on learning prior to any formal instruction, as well as to perform comparisons between the use of the game alone, formal instruction alone, and the game combined with formal instruction.

Perhaps the most important potential future direction of this work would be its potential to be adapted for use in communities in which students have low engagement in science or may be at risk for school failure, especially low-income and minority communities, and for students with learning disabilities for whom conventional instruction methods are often insufficient, and for whom engagement with school and learning often suffers as a result. The current study had sample expected to be varied in its demographics to be as generalizable as possible, but future work can be targeted toward these more vulnerable demographics for the development of efficient and low-cost interventions along these lines.

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A Simulation-based Education Platform for Security Investments Through Culture and Knowledge Convergence

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Abstract: Cybersecurity is one of the most critical sectors of information systems and is considered a strategic priority for many Organizations. Information security investments are a crucial aspect of cybersecurity. However, it often happens that the economic decisions, which aim to improve information security, have poor efficiency. One reason is the lack of background on economics of the Chief Information Security Officers who are often not familiar with the evaluation of the non-technical aspects of security, e.g. economics. The other reason is the cultural gap between the different persons related to business management and administration. In this paper we present an interactive - simulation software designed to familiarize the aforementioned persons with information security investments. The software is actually a game that aims to boost learning for all the stakeholders who are involved in the investment process. A better understanding of the processes, the technical, economic and human factors, along with the cultural convergence of the stakeholders will help boost the efficiency of investments. Design Science is used as the research method. The creative method, a brainstorming technique, is combined with the five steps of Design Science, i.e. explicate the problem, define the requirements, design and develop the artefact, demonstrate the artefact, and evaluate the artefact, to develop a process framework that will be able to cope with this problem. The artefact is an interactive-simulation platform in which a person could take the decision maker role and (a) deal with events that happen and (b) investigate different aspects of information security investment complexity. The evaluation of the artefact is made with a case study in the Industry, where real world data are used to feed the simulation and real-world decision makers play the game in order to better understand the different aspects of the problem and help us trim and enhance the functioning of the platform. Finally, limitations are elaborated and future work is also discussed.

Keywords: Information Security Investments, Game Based Learning, Serious Games, Educational Software, Simulation

1. Introduction

Information security is the practice of protecting an organization's important information and data by mitigating information risks. Information can be physical or electronic, and information security strategies typically encompass a range of measures to safeguard digital data and related assets from cyber threats and attacks, ensuring confidentiality, integrity, and availability of data.

The study of information security investments focuses on understanding and optimizing the allocation of resources to protect information assets from cyber threats. It involves evaluating the effectiveness and return on investment of security measures, identifying critical success factors, and developing strategies to mitigate risks while supporting organizational objectives. The study encompasses various aspects like strategic alignment, economic impact analysis, risk assessment, and the integration of security practices into business processes.

Cybersecurity is a part of information Security and is one of the most critical sectors of information systems since most organizational data are available or can be accessed through the Internet. Thus it is considered a strategic priority for many Organizations. Information security investments are a crucial aspect of cybersecurity. However, it often happens that the economic decisions, which aim to improve information security, have poor efficiency. One reason is the lack of background on economics of the Chief Information Security Officers (CISO) who are often not familiar with the evaluation of the non-technical aspects of security, e.g. economics. The other reason is the cultural gap between the different persons related to business management and administration.

However, despite substantial investments in information security, many organizations find that their economic decisions in this domain often lack efficiency (Schatz & Bashroush, 2017). A key factor contributing to this inefficiency is the lack of economic expertise among CISOs, who traditionally focus on the technical and the

regulatory compliance aspects of security and may not be well-versed in evaluating the economic implications of security investments. Furthermore, a cultural gap often exists between technical security professionals and business management, complicating the alignment of security investments with organizational objectives.

The evaluation of the artefact is conducted through a case study in the industry, utilizing real-world data to validate the simulation and involving actual decision-makers to refine and enhance the platform's functionality. The primary research question guiding this study is: *How can an interactive simulation platform improve the efficiency of information security investments by enhancing the understanding and collaboration among stakeholders?*

The present paper continuous as follows. In Section 2 the background is elaborated. In Section 3 we present the Methodology used for this research, while in Section 4 the artefacts of our approach are presented. Section 5 focuses on the inner workings of the prototype platform. In Section 6 some limitations of this first approach are discussed. Finally, the last Section presents conclusions and makes suggestions for future research.

2. Background

2.1 Importance of Cybersecurity and Information Security Investments

Cybersecurity has emerged as a critical sector within information systems, becoming a strategic priority for many organizations globally. The primary goal of cybersecurity is to protect information by mitigating information risks. This includes preventing unauthorized access, use, disclosure, disruption, modification, inspection, recording, or destruction of information. The increasing prevalence of cyber threats and attacks has highlighted the necessity for robust information security strategies to safeguard digital data and related assets, ensuring the confidentiality, integrity, and availability of information.

2.2 Challenges in Information Security Investments

One of the key aspects of cybersecurity is the investment in information security measures. Nontheless, the economic decisions aimed at improving information security often suffer from poor efficiency. This inefficiency can be attributed to several factors.

CISOs, who are typically focused on the technical aspects of security, may not be well-versed in evaluating the economic implications of security investments. This gap in economic understanding can lead to suboptimal investment decisions that do not fully address the complexities of information security risks. Additionally, the cultural divide between technical and business management teams further complicates the alignment of security investments with organizational objectives.

2.3 Game-Based Learning in Cybersecurity

In order to address the lack of economic expertise of the CISOs and the cultural divide between technical and business management teams, innovative approaches such as game-based learning and serious games have been explored. Game-based learning leverages the engaging and interactive nature of games to facilitate education and training. In the context of cybersecurity, serious games can simulate real-world scenarios, allowing stakeholders to experience and respond to cyber threats in a controlled environment. This method not only enhances learning but also helps in bridging the cultural gap between different teams by providing a common platform for interaction and collaboration (Venter et al., 2019; Williams et al., 2024)

Recent studies have shown that serious games can be an effective tool for teaching complex subjects, including cybersecurity and information security investments. By simulating realistic scenarios, these games enable players to understand the consequences of their decisions and improve their decision-making skills (Williams et al., 2024). Moreover, game-based learning can increase engagement and motivation among learners, leading to better retention of knowledge and skills (Jin et al., 2018e).

For example, a study conducted on the use of game-based learning in cybersecurity education for high school students found significant improvements in both engagement and understanding of cybersecurity concepts (Venter et al., 2019). Another study highlighted the effectiveness of gamification in inspiring and engaging students who are not traditionally inclined towards cybersecurity topics (Williams et al., 2024). These findings are supported by various implementations of game-based learning tools in different educational settings, which

have consistently shown positive outcomes in terms of learning effectiveness and user satisfaction (Tareque et al., 2024; Jin et al., 2018).

2.4 Design Science in Developing Educational Tools

The development of effective educational tools for cybersecurity also involves the application of design science. Design science is a research methodology that focuses on the creation and evaluation of artefacts designed to solve identified problems. This approach is particularly suitable for information systems research, where practical and innovative solutions are needed to address complex challenges (Hevner et al., 2004).

In the context of the current study, design science is used to develop an interactive simulation platform for information security investments. The platform incorporates game-based learning principles and aims to enhance the understanding and efficiency of security investments among various stakeholders. The design process involves iterative cycles of designing, building, and evaluating the platform to ensure it meets the specified requirements (Peffers et al., 2007; Balakrishna & Charlton, 2022).

2.5 Evaluation of Educational Tools

The effectiveness of educational tools like the interactive simulation platform is evaluated through detailed case studies and user feedback. Case studies provide real-world data to validate the simulation, while user feedback helps in refining and enhancing the platform's functionality. The evaluation focuses on several key performance indicators, including user engagement, learning outcomes, decision-making efficiency, and stakeholder collaboration (Balakrishna & Charlton, 2022).

For instance, user engagement can be measured by the time spent on the platform and the frequency of interactions with different simulation scenarios. Learning outcomes can be assessed through pre- and post-interaction assessments to measure improvements in users' understanding of information security investments. Decision-making efficiency can be evaluated by comparing the outcomes of simulated investment decisions with historical data and expert recommendations. Lastly, stakeholder collaboration can be assessed through user feedback and observation of decision-making processes during the simulation (Veneruso et al., 2020).

3. Methodology

Our research adopts the design science approach, a well-established method for creating and evaluating artifacts that solve identified organizational problems. Design science involves iterative cycles of designing, building, and evaluating artifacts until they meet the specified requirements effectively. This methodology is particularly suited for information systems research where practical and innovative solutions are necessary to address complex problems ((Hevner et al., 2004; Peffers et al., 2007).

1. **Explicating the Problem:** The first step in design science is to clearly define and understand the problem. In our case, the problem is the inefficiency of information security investments due to the lack of economic expertise among Chief Information Security Officers (CISOs) and the cultural gap between technical and business management professionals. This step involved a thorough literature review and consultation with industry experts to identify the key challenges and requirements for an effective solution (Peffers et al., 2007).
2. **Defining the Requirements:** Based on the problem analysis, specific requirements for the interactive simulation platform were defined. These requirements included the need for a user-friendly interface, realistic simulation scenarios, and the ability to track and measure the impact of decisions on security investments. The requirements were refined through brainstorming sessions with stakeholders and subject matter experts (vom Brocke et al., 2020).
3. **Design and Development of the Artefact:** The interactive simulation platform was developed using agile software development practices, allowing for iterative improvements based on the feedback from initial users. The platform incorporates game-based learning principles to engage users and enhance learning outcomes. The design process involved creating detailed mockups, developing the software, and conducting initial testing to ensure functionality and usability (vom Brocke et al., 2020).
4. **Demonstration:** The developed platform was demonstrated to a food industry company with 15 million Euro revenue and a workforce of 350 employees over full production periods, and included the CISO, business managers, and other stakeholders. This demonstration aimed to showcase the platform’s capabilities and gather initial feedback on its effectiveness and user experience. The demonstration

also included simulated scenarios where users could make decisions related to information security investments and observe the outcomes (Hevner et al., 2004).

5. **Evaluation:** The final step in the design science approach is the evaluation of the artifact. This was conducted through a detailed case study in the food industry, where real-world data was used to validate the simulation. The evaluation involved actual decision-makers using the platform to simulate information security investment scenarios. The effectiveness of the platform was assessed based on user feedback, the accuracy of the simulation outcomes, and improvements in the understanding and collaboration among stakeholders (Jin et al., 2018 ; Fischer-Hübner et al., 2021).

3.1 Data Collection Methods

Data collection for this study included both qualitative and quantitative approaches:

1. **Interviews and Brainstorming Sessions:** Interviews with industry experts and brainstorming sessions with stakeholders were conducted to gather insights into the challenges of information security investments and to define the requirements for the simulation platform (Hevner et al., 2004).
2. **Case Study:** A case study approach was employed to evaluate the platform in a real-world setting. Data was collected from the participating organization, including historical security investment data, decision-making processes, and feedback from users who interacted with the platform (Hevner et al., 2004). Our Case study was the aforementioned food industry company located in northern Greece.
3. **Surveys and Questionnaires:** Surveys and questionnaires were distributed to users after they interacted with the simulation platform. These instruments were designed to collect feedback on the usability, effectiveness, and educational value of the platform (Hevner et al., 2004), in order to improve the artefacts.

3.2 Evaluation and Analysis

The evaluation of the simulation platform focused on its ability to improve decision-making efficiency and stakeholder collaboration. Key performance indicators (KPIs) were used to measure the platform's impact, including:

1. **User Engagement:** The level of user engagement was assessed based on the time spent on the platform and the frequency of interactions with different simulation scenarios (Williams, Anthi, Cherdantseva, & Javed).
2. **Learning Outcomes:** Improvements in users' understanding of information security investments were measured through pre- and post-interaction assessments.
3. **Stakeholder Collaboration:** The platform's impact on fostering collaboration between technical and business stakeholders was assessed through user feedback and observation of decision-making processes during the simulation (Fischer-Hübner et al., 2021).

The analysis involved both descriptive and inferential statistics to determine the effectiveness of the simulation platform. Qualitative data from interviews and surveys were analyzed using thematic analysis to identify common themes and insights.

4. Artefact Presentation

In this section we present three artefacts. A cybersecurity capability heatmap used for assessing maturity in the organization, some specially crafted key performance indicators (KPIs) to indicate the current preparedness status of the company, and a digital platform used to examine different investment scenarios.

4.1 Maturity Heatmap Artefact

Table 1 is a cybersecurity maturity to technological measurement deployment capability heatmap. The table shows, at a given moment, the cybersecurity maturity of the organization in the three core elements, People, Processes and Technology. For example, people may have the abilities that are demanded for a given measurement, but the technologies used in the organization could be too old. In this case a new investment or a new process is needed to efficiently cope with the specific aspect. To make this simple, imagine the lack of a deployed anti-malware solution in the company, where we must purchase one, or, even worse, the case of an existing anti-malware solution that is not correctly deployed because processes are missing.

Table 1: An instance of the cybersecurity capability heatmap used in the platform

Maturity	Measures	Technology	Process	People
Initial	Physical Security	1	1	1
	Asset Inventory	1	1	1
	Device Hardering	1	1	1
	Patch Management	1	1	1
	Access Controls	1	1	1
Managed	Unidirectional Gateway	2	1	2
	IDS/IPS	1	2	2
	Anti-Malware	2	1	1
	Firewall	1	2	3
Defined	Zone Firewalls	1	1	1
	Device Firewalls	1	2	1
	Whitelisting	2	1	2
Quantitatively Managed	SIEM	2	2	3
	Incident Management	2	2	4
Optimizing	Threat Intelligence	3	3	3

Maturity levels have the following meaning:

Level 1: Basic capability in the organization. Success depends solely on individual non-repeatable non scalable efforts. High risk still exists as effort is inconsistent and attacks unpredictable.

Level 2: Some basic processes are defined, established and documented which makes it possible to have repeatable efforts with goals and measurements.

Level 3: Documentation, standard implementation, maintenance, learning and training are gaining focus which reflects in advanced capabilities.

Level 4: Data collection and monitoring is semi-automated and human capability expertise is proven by acting proactively. Metrics are tracked and not just implemented.

Level 5: Constantly improving through feedback from processes**,** people capabilities are expert, cutting edge technology is implemented. Security is automated, integrated and predictive.

4.2 Key Performance Indicators on Investments Artefact

Key Performance Indicators (KPI's) help to convert raw data to information that provides the user with a quick understanding of security investment decisions. Below we present some KPI's specific for security investments.

Table 2: KPIs of information security investments.

KPI Name	Calculation	Explanation
Maturity ratio Ability of knowledge acquisition	Is the sum of all heatmap Current capability levels for the organization divided to total levels for the three categories.	The heatmap ideal level for each implementation is five, but each organization has a different target level and goals that is driven by asset-to-protect value.
Acceptable Risk Exposure KPI	An Economic value GOAL set by management as acceptable cost in self-assessment minus current cost divided by current incident costs.	A value close to zero or negative means that incidents are more that the accepting risk one. Such a value is an indicator of investment need.
Human capability ratio	It's the total achieved score for people capabilities in the heatmap divided by the sum of total score for human capability for this number of measures (see table 1).	It shows the ability of people to support the current and new investments. A value close to zero means little maturity for the organization and people need training. Comparing with organization maturity or solution needed maturity the expert can identify need for improvement.

KPI Name	Calculation	Explanation
Technology capability ratio.	Its the total achieved score for technology capabilities in the heatmap divided by the sum of total score for technology capability for this number of measures (see table 1).	It shows the ability of the technology implemented to support processes and security needs. A value close to zero means little maturity for the organization. Comparing with organization maturity or solution needed maturity the expert can identify need for improvement.
Process maturity ratio.	Its the total achieved score for process capabilities in the heatmap divided by the sum of total score for process capability for this number of measures (see table 1).	It shows how processes add value (above maturity level of the organization) or create risk for security effort. Comparing with organization maturity or solution needed maturity the expert can identify need for improvement.
Cybersecurity Risk Asset Ratio (CRAR)	It the acceptable cost for security minus current assets at risk divided to acceptable cost for security.	When a risk takes the High flag in the risk register an estimation of asset at risk is made. CRAR is calculated to show the organizational exposure to risk. This should not be higher from the acceptable risk. A value below 0 means that if total assets at risk exploit simultaneously, the cost could be higher from acceptable cost.

5. A Prototype Platform for Security Investments

In this Section the inner workings of the prototype platform, which have been designed in order to help cybersecurity practitioners and managers to assess security risks and related investments are presented.

In Figure 1 the structure and the logic of the platform is depicted. As can be seen in the diagram, a self-assessment procedure is needed in order to generate the company's cybersecurity capability heatmap. Another prerequisite is that the organization's cybersecurity staff should assess, evaluate or even guess the probable risk of malicious or destructive events happening, and file the values in the appropriate Risk Register. Finally, the cost of any security related problems that either happened or may happen, e.g. infrastructure failure or data breaches, should be elaborated and added to an appropriate input screen (table). These costs include the cost of labour to solve the problem, the cost of any equipment and/or software procured to replace any damaged one and of course the cost of the losses due to the incident, e.g. loss of data, reputation, stock value, etc. All these are used as inputs to estimate and generate the Key Performance Indicators which are then used to provide clues for decisions on whether an investment on security is needed along with the size and the type of the investment. Should my company invest on hiring or training personnel? Should we invest on technology procurements, whether hardware of software solutions? Or shall we invest on elaborating the existing (on not existing) procedures within the organization?

The platform presented in Figure 1 is a game where the Security Officer of the company can compete with other decision makers. By competing in this game players will create an understanding of different aspects of security investments (technical and economic), and by trying to self-assess and improve processes, people skills and technology, the stakeholders will create a common culture through knowledge convergence. KPIs thresholds were selected by stakeholders of the case study company and the Security Officer. The development of the game took many iterations with feedback brainstorming sessions in order to be able to satisfy both technical and managerial stakeholders.

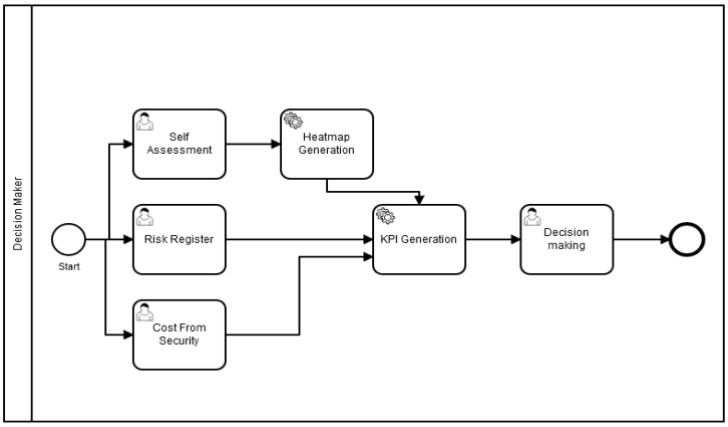


Figure 1: Diagram of the platform's logic and structure

The capability matrix presented in Table 1 is generated by the self-assessment and is a screen where the user can choose to add/edit/delete measurements. The user can add a new measurement and the system dynamically adjusts the corresponding values and automatically presents the updated self-assessment. Figure 2 shows the self-assessment screen.

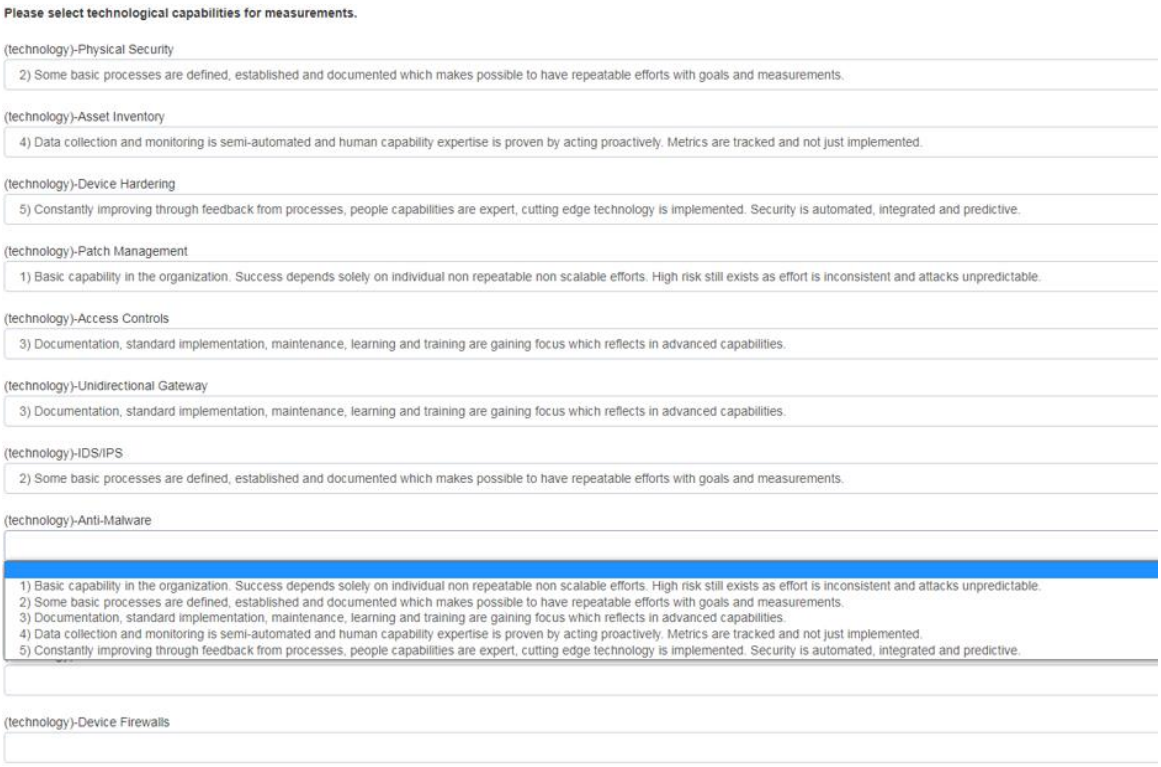
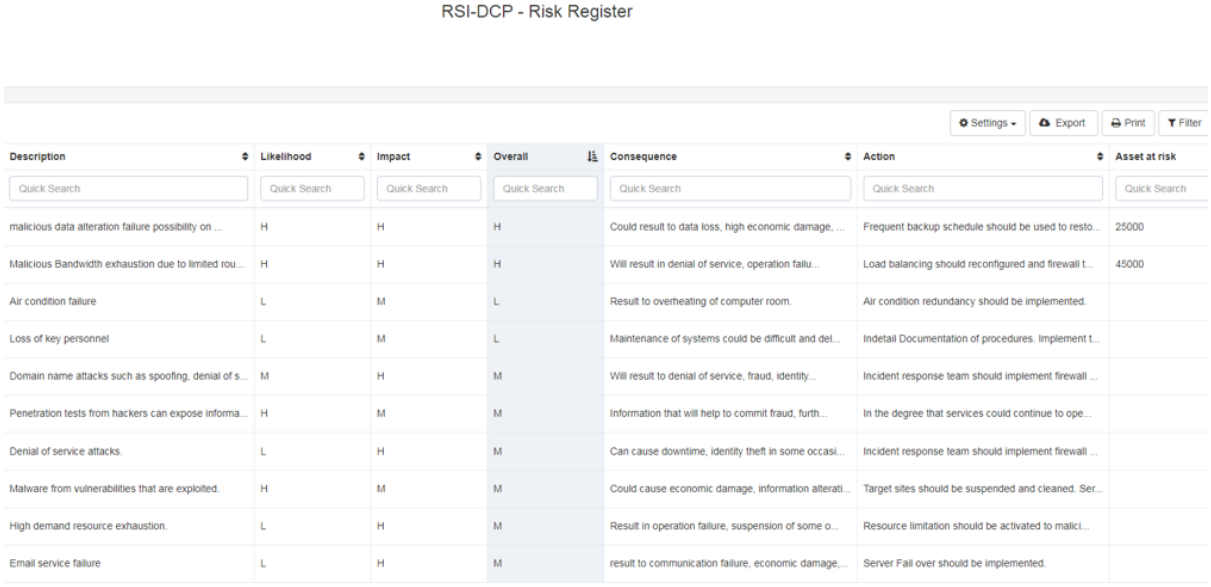


Figure 2: Self-assessment screen

The Risk Register contains all the information about threats for the company. If a threat is changed to a High score, then the decision maker has to put an asset at an estimated risk value. This is an estimateof the possible cost if the asset is exploited. Data from a former real incident may also be used here. The user can add/edit/delete and filter threats. Also, the user can add new threats and set threat name, Likelihood, Impact, Overall score, Consequence if exploited, and action if exploited. Figure 3 show the Risk Register screen.



Description	Likelihood	Impact	Overall	Consequence	Action	Asset at risk
Quick Search	Quick Search	Quick Search	Quick Search	Quick Search	Quick Search	Quick Search
malicious data alteration failure possibility on ...	H	H	H	Could result to data loss, high economic damage, ...	Frequent backup schedule should be used to resto...	25000
Malicious Bandwidth exhaustion due to limited rou...	H	H	H	Will result in denial of service, operation failu...	Load balancing should reconfigured and firewall t...	45000
Air condition failure	L	M	L	Result to overheating of computer room.	Air condition redundancy should be implemented.	
Loss of key personnel	L	M	L	Maintenance of systems could be difficult and del...	Indetail Documentation of procedures. Implement t...	
Domain name attacks such as spoofing, denial of s...	M	H	M	Will result to denial of service, fraud, identity...	Incident response team should implement firewall ...	
Penetration tests from hackers can expose informa...	H	M	M	Information that will help to commit fraud, furth...	In the degree that services could continue to ope...	
Denial of service attacks.	L	H	M	Can cause downtime, identity theft in some occasi...	Incident response team should implement firewall ...	
Malware from vulnerabilities that are exploited.	H	M	M	Could cause economic damage, information alterati...	Target sites should be suspended and cleaned. Ser...	
High demand resource exhaustion.	L	H	M	Result in operation failure, suspension of some o...	Resource limitation should be activated to malici...	
Email service failure	L	H	M	result to communication failure, economic damage,...	Server Fail over should be implemented.	

Figure 3: Risk Register Screen

In the Cost of Events screen (Figure 4) the user can add a new security breach event that had a financial impact to the company. The user can add/edit/delete events. The events have a date, an IT labour cost, the cost of products that bought in order to fix the breach, and the financial loss due to breach. Also, the user can automatically see the total cost graph of all the events until now.

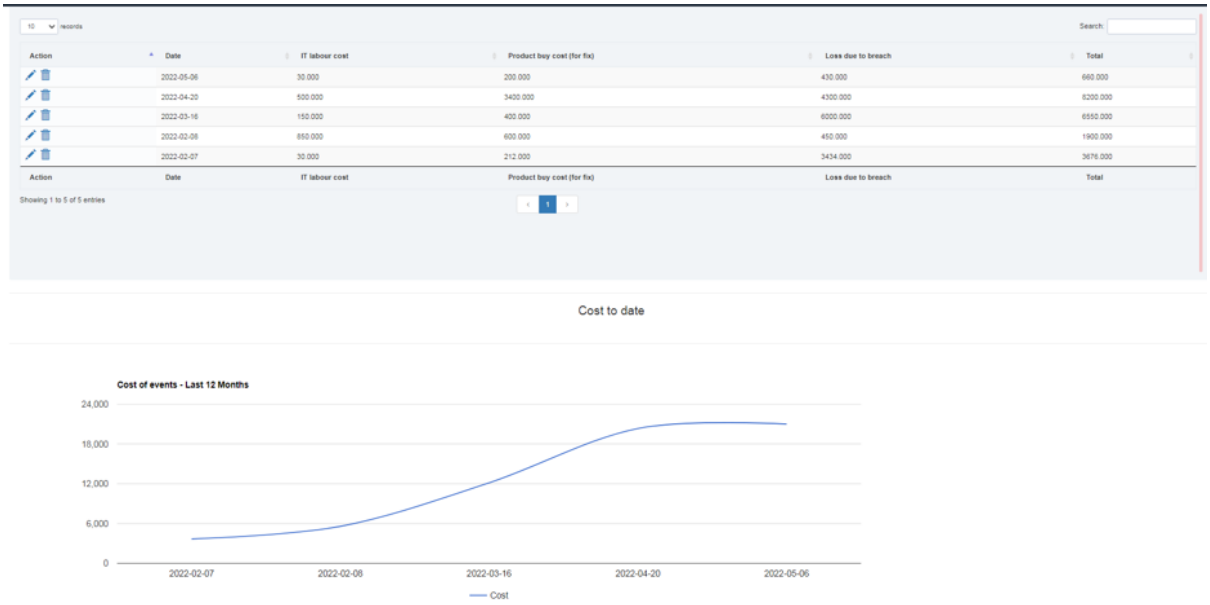


Figure 4: Cost of Events screen

The Calculated KPI screen (Figure 5) shows the automated calculations of the KPIs based on the self-assessment, the risk register and the Incident costs. The user can see the KPI name, the description that explains how the KPI works and what it means, the current KPI value and status. If the KPI status is “AT RISK” it means that some action is required such as a security investment.

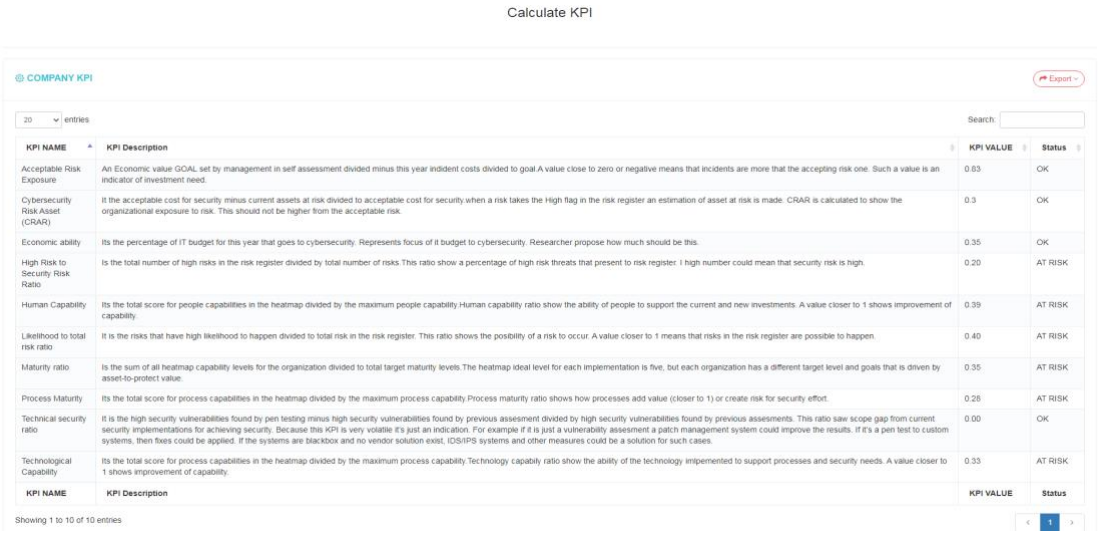


Figure 5: Calculated KPI screen

6. Limitations of our Approach

This research tries to improve the problem of IS investment efficiency by educating CISOs and business managers on risk assessment and optimum security investments. However, limitations apply. First of all, the findings from the case study come from a single industry and may not be applicable to other companies with different characteristics and challenges. Next, while useful for educational purposes, the simulation game may not fully capture the complexities and unpredictability of real-world information security investment decisions. The effectiveness of the simulation relies heavily on the accuracy and relevance of the real-world data used to feed

the platform, so the design and development could introduce biases based on the assumptions and perspectives of the developers. The evaluation of a single case study might not be sufficient to thoroughly assess the effectiveness and efficiency of the simulation platform. Finally, the study may not provide sufficient evidence on the long-term impact of the simulation-based learning on the actual decision-making and investment efficiency because of the limited time used. Our future research will try to alleviate, handle or eliminate these limitations.

7. Conclusions and Discussion

The development of an interactive simulation platform for information security investments addresses significant challenges faced by organizations in aligning technical and economic aspects of cybersecurity. This platform leverages game-based learning principles to bridge the knowledge gap between Chief Information Security Officers (CISOs) and business managers, fostering a collaborative environment where stakeholders can enhance their understanding of investment impacts. By simulating real-world scenarios, the platform enables users to make informed decisions, by promoting efficient allocation of resources to mitigate cyber threats. The design science methodology underpins the development process, ensuring that the platform is iteratively refined based on user feedback and real-world data.

The evaluation through a case study demonstrates the platform's potential to improve decision-making efficiency and stakeholder collaboration. Users' engagement, learning outcomes, and decision-making efficiency are key performance indicators that validate the platform's effectiveness.

To enhance the generalization of the findings, future research could involve conducting case studies across a variety of industries. This would help to identify industry-specific challenges and adaptations needed for the simulation platform, providing a more comprehensive understanding of how different sectors can benefit from such educational tools. Conducting more deployments to assess the long-term impact of the simulation platform on decision-making and investment efficiency is essential. Also, future work should focus on developing customizable modules within the simulation platform to address the unique needs of different organizations. By embedding knowledge, data and feedback from a specific company into the platform will make it capable to cope with scenarios specific to this company. The influence of non-economic factors, such as regulatory compliance, ethical considerations, and psychological impacts, on information security investments should also be explored. Finally, incorporating advanced gamification techniques, such as adaptive learning paths, personalized feedback, and competitive elements, could enhance user engagement and learning outcomes.

In conclusion, this interactive simulation platform aids cybersecurity education, providing a practical tool to improve information security investment efficiency through enhanced stakeholder collaboration and understanding.

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Gamification Powered by a Large Language Model to Enhance Flipped Classroom Learning in Undergraduate Computer Science

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Abstract: The flipped classroom in computer science has become a popular pedagogy where students complete preparatory reading and videos before class, leaving class time for hands-on practice. In theory, students come to class predisposed with knowledge to complete programming tasks, quizzes, and homework assignments. However, if students do not complete or do not fully understand the preparatory material, those students will not be equipped for class and may also be embarrassed to ask questions during class. In this study, we created a gamified quiz that is powered by a Large Language Model (LLM) that loads in questions from the flipped content transcripts. The game offers students a fun assessment after completing the flipped content that will both motivate them and prepare them for class. The game also provides an anonymous way for students to ask questions as they progress through the game content. Those questions can then be analysed by the instructor and reviewed in class. The study compares in-class quiz scores of a control group versus a group that had access to the gamified quiz in an undergraduate software engineering course over three consecutive course modules. The results obtained from both quantitative and qualitative data are promising, showing an increase in student in-class quiz scores along with positive student engagement with the gamified quiz. Students also reported that the game made them more comfortable with asking questions. Future work would extend this research to more students and over a longer period. The LLM and gamification also have much potential, where games can be created dynamically and be customized and personalized for each student's needs. This work shows an exciting gap in research that could lead to gamified experiences for students in the flipped model that are both relevant and personalized with the use of a LLM, offering the students the greatest chance for success.

Keywords: Gamification, Computer Science Education, Engagement, Satisfaction, Games, Feedback, Large Language Models, Flipped Classroom, Gamified Learning

1. Introduction

The flipped classroom model is a popular teaching method where students are required to complete preparation activities before coming to class, such as watching lecture videos or reading relevant content. By doing this work in advance, the intent is that students are better prepared to come to class with more specific questions and more understanding of the content, ready to perform hands-on tasks. However, the flipped model also creates challenges for instructors whereby students may not be fully grasping the flipped content, yet do not ask questions during class. Students often skip the flipped content due to time constraints or lack of motivation, as stated by Nielsen (2023). Assessing the students' understanding with quizzes can result in poor grades, leaving the instructor and students feeling discouraged.

Alahmari et al. (2023) define educational gamification as the idea of adding game elements to a course environment to help motivate and engage students in a playful manner while also teaching the content. This pedagogy is a teaching tool yet has its own challenges of striking the right balance between fun and learning. Creating an educational game that can be modified with different questions depending on the course module is time consuming for the instructor. Both flipped classrooms and educational games are making use of Large Language Models (LLMs) to provide a more personalized learning experience and increase student motivation and performance. LLMs are becoming a strategy for saving time for the instructor and for keeping content relevant and up to date.

In this study, the use of a game powered by a LLM was studied in conjunction with a flipped classroom. Specifically, the following research questions (RQs) were investigated:

RQ1: Does preparatory flipped content reinforced with a LLM-powered gamified quiz increase student learning outcomes?

RQ2: Does classroom material enhanced with gamification increase student motivation?

RQ3: Does the allowance of asking anonymous questions on a gamified quiz increase student comfort level?

2. Literature Review

2.1 The Flipped Classroom and Computer Science Education

The flipped classroom model increases student performance and high order thinking. Zheng et al. (2020) stated that the flipped model had "significant impact" on the motivation of students. Subramaniam et al. (2019) suggested that in the flipped model, the teacher is the "guide on the side" as opposed to the "sage on the stage". Jdaitawi (2019) found that students in a flipped classroom have a higher level of self-regulation and social connectedness.

In a different study, Nielsen (2023) looked at the frustrations that students experience in a flipped classroom. Nielsen found that some students lacked motivation to do preparatory work, leading to unpreparedness in class. Urquiza-Fuentes (2023) suggested that a motivating factor for students to complete the flipped content was to use rewards, such as assessments that contribute towards a final grade. The common theme among the studies was that the flipped classroom model had the potential to help student engagement and self-regulation, but that there is "no one size fits all" model, as noted by Subramaniam et al. (2019). Hwang et al. (2019) commented that it is not a question of whether the flipped model works, but how to make it more effective.

To address some of the student frustrations, such as student questions that arise while completing the preparatory work, Uchiyama et al. (2023) proposed a system that added a LLM to give immediate answers to students. However, the uncertainty of the LLM responses could lead to more work for the instructor, having to filter through the LLM-student conversations and correct any errors or misconceptions. Huang et al. (2023) looked at student motivation in the flipped classroom and the use of a personalized recommendation system powered by a LLM as part of a flipped classroom model.

The flipped classroom model has been shown to be an effective pedagogy in computer science classrooms while also having challenges. By leveraging LLMs with the flipped classroom, there is the potential for more personalization for students as well as immediate feedback to student questions.

2.2 Gamification and Computer Science Education

Gamification is the idea of adding game elements to an area that does not otherwise relate to games, as stated by Alahmari et al. (2023). In one study, Khaldi et al. (2023) revealed that the trio of points, badges, and leaderboards (PBL) are used the most. Alahmari et al. (2023) looked at the impact of gamification on student learning, concluding that gamification makes the learning experience more enjoyable, helps with engagement in social situations, and is good for psychological skills. Sadiku et al. (2023) conducted research on gamification in computer science with an angle towards competition. Cao (2023) researched using gamification and a LLM to help students learn programming concepts and increase their sense of belonging. Lanzi et al. (2023) used a LLM for collaborative game design to simulate the process performed by human game designers.

Like the flipped classroom model, gamification has the potential to be more effective with the addition of personalization for each student. Leveraging LLMs, educational games could be created with personalized feedback and personalized design to better motivate students.

2.3 Gamification and the Flipped Classroom

Combining gamification with the flipped classroom provides a modern way of engaging students. In a review of flipped learning with gamification, Ekici (2021) shared that students learn at their own pace using both intrinsic and extrinsic motivation. Ekici (2021) suggested combining the flipped classroom with gamification, "bringing the best of both worlds together to promote learning".

Gamification combined with the flipped classroom is a new theoretical framework being used and one that still needs more research. The game must be well designed and be a source of enhancement to the flipped material but not incur a novelty effect that could wear off, as stated by Ekici (2021).

2.4 LLMs and Computer Science Education

LLMs are being used in the context of computer science education as well as in the context of gamification. One motivation for using LLMs is to reduce instructor load while creating educational content. Song et al. (2024) created a novel LLM with prompt chains to generate multiple-choice questions according to a course outline, showing promising results in the quality of the questions. Tran et al. (2023) analysed LLM capabilities around

generating high-quality multiple-choice questions and answers for computing. The results showed accuracy, but that human intervention was still needed to vet the output of the LLM. Meißner et al. (2024) introduced a novel EvalQuiz to generate self-assessment quizzes via a LLM. The results showed that the auto-generated quizzes covered the appropriate material and saved instructor time, but still needed better prompt engineering to achieve "originality and versatility" between the questions.

While the flipped classroom, gamification, and the use of LLMs are each being used as pedagogical tools, combining the three techniques together is an area in need of research and one that has a large gap. This research will use a LLM to generate multiple-choice questions for a gamified quiz using transcripts from the flipped content videos. The use of the gamified quiz will then be used in this study to answer the proposed research questions.

3. Methods and Experiment

In this study, the flipped classroom model was already being utilized in three sections of a college software engineering course. The sections included 161 undergraduate sophomore-level students. This author was the instructor for all three sections, giving the students flipped content videos to watch before each class, followed by pop quizzes sporadically in class. Before this study, results showed that students were not performing well on the pop quizzes, but also not asking questions in class even when encouraged.

To try to better understand how students were performing in the flipped model, this project used a gamified quiz to add motivation and help with knowledge retention. The quiz was loaded with questions created by a LLM to make it more scalable across modules and require less instructor interaction. With this balance of fun and learning, this study looked at how adding a gamified quiz to a flipped model could help with student performance on pop quizzes.

3.1 Project Description

GameMaker Studio YoYo Games Ltd (2023) was used to create the novel game, "Engin-AIR-ing", where the player would answer multiple-choice questions related to the flipped content. While reading the question and answers, a clock would be running to encourage speed and leaves would be floating to the ground to encourage game play. The player would try to select the correct answer while also keeping leaves afloat to earn more points. To make the game accessible from any computer, it was built as an HTML5 package, then launched via a flask server written in python.

The flask server connected to GPT-3.5 Turbo using an OpenAI (2023) key. Using the python library from Liu (2022), llama_index, the transcripts from the flipped content videos were loaded into the LLM query engine. Once all the documents were loaded, a detailed prompt was sent to the query engine as follows:

"Create at least 10 unique multiple-choice questions with 4 different answers from the content. Be sure the questions are unique and cover all the content. There should be a variety of topics in the questions. Start each question with the word Question. One answer should be correct, the other 3 should be incorrect. Separate the question and answers with a newline. End the line with the correct answer with the word Correct in parentheses, like (Correct). Then give an explanation sentence for why the correct answer is correct. Return your response in json format. The json for each question should have fields for the question text, array of answers, explanation text, and correct answer text, like: \{"question": ,"answers": [ ],"explanation": ,"correct_answer": \} The final json will be an array named "questions" of these structures, one for each question. Do not put the word "Correct" after any answer. Be sure and include questions that span all the content."

The LLM json response was stored in memory until requested by the game via an HTML call. To ensure the questions were relevant, accurate, and not too similar to those that would be presented on the pop quiz in class, the instructor reviewed the questions and re-executed the LLM prompt until a suitable set was created.

Once the game had access to the quiz questions, it would begin displaying them one at a time, starting a timer, and sending leaves floating. The student would move the game player back and forth along the bottom of the screen using arrow keys. The spacebar key would cause the game player to blow air at a leaf above, keeping it afloat. The question and answers were displayed at the top of the screen where choosing an answer involved using the number keys.

As the player completed a question, a detailed explanation would be displayed along with a textbox area for the student to ask any questions. Data, including the number of correct answers, incorrect answers, leaves that

were kept afloat, and time on the question, was sent back to the flask server to be stored in a file. Any questions typed into the textbox were also sent back to the flask server to be stored for the instructor. Once the student completed all ten questions, the final score would be displayed in a leaderboard with any other students that had played. See Figure 1 for a screenshot of the game.

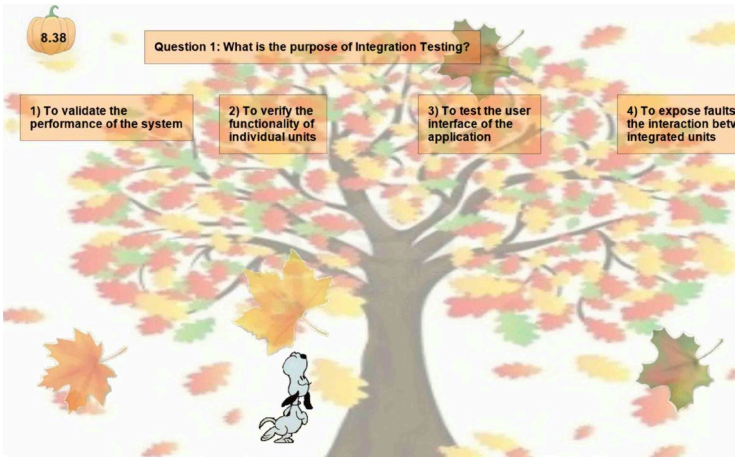


Figure 1: Engin-AIR-ing game, tenor (2015)

3.2 Experiment

Once the game was completed, the research experiment began with volunteer students from the software engineering course. Of the 161 students enrolled in the course, 23 students chose to be part of the project and signed informed consents. From the 23 students, 13 were chosen at random to receive access to the game while the other 10 students were the control group, not receiving access to the game.

The experiment ran over three lesson modules. The students were given access to the usual flipped content videos to prepare for class. The recipients of the game were also given access to play the game, being quizzed in a gamified way on the content from the videos. In class, all students were given a non-graded quiz. At the end of the experiment, students were administered a post-survey with questions about the flipped model and the game.

Quantitative data collected included in-class quiz scores, game scores, number of game attempts, number of correct and incorrect answers to each game question, number of leaves (floaters) left after each game question, and amount of time spent on each question. Statistical pre-condition tests were performed to determine if the data was normally distributed and had non-significant differences in variances, followed by the use of a two-sample t-test. Quantitative data was also analysed manually looking for trends in the data, such as how individual student's game scores or times improved across the three modules. Qualitative data collected in the post-survey offered questions with a likert scale as well as open-ended feedback questions.

4. Results and Discussion

4.1 RQ1: Does Preparatory Flipped Content Reinforced with a LLM-powered Gamified Quiz Increase Student Learning Outcomes?

After each of three modules, the 23 participating students were given an in-class ungraded quiz. The hypothesis was that the 13 students who had watched the flipped content and played the gamified quiz would score higher than the 10 students who had only watched the flipped content. After completion of the first two modules, students who had access to the flipped content and the gamified quiz scored higher than students who only had access to the flipped content. However, the third module had the opposite results, as shown in Figure 2.

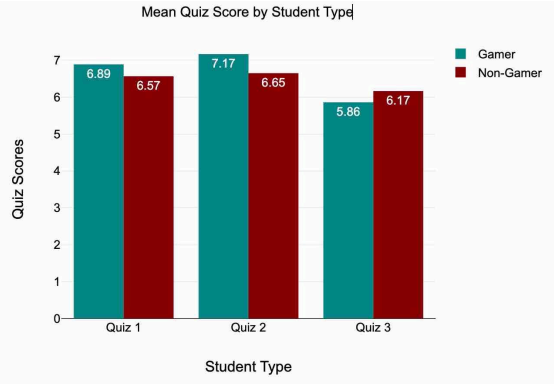


Figure 2: Mean Quiz Score by Student Type

This unexpected result from the third module could be due to the small sample size. This result could also have been related to the dwindling number of students per-module. By module three, the number of students playing the gamified quiz had decreased 30%.

To further analyse the results, statistical tests were performed on the two groups of students: the control group and the group that had access to the gamified quiz. First, a Shapiro-Wilk test was used to ensure the data was normally distributed. Running this test on all of the quiz data (N=65) did not show a significant departure from normality, $W(65) = 0.98$, $p = 0.396$. Second, a Levene test was performed to compare the variances in the data. This test concluded that the difference between the sample variances was not big enough to be statistically significant.

Because the data was found to be normally distributed and with similar variances, a two-sample t-test was performed to compare the means of the two groups in hopes of supporting the research hypothesis. Using a t-test calculator, the t-score and p-value for each of the three modules was determined, as shown in Table 1. In each case, however, the p-value was not less than the significance level of 0.05, meaning there was not enough evidence to show that the mean quiz scores between the two groups were different. This also could be due to the small sample size of students and the drop in motivation by the third module.

Table 1: Two Sample t-test

Module	t score	Degrees of freedom	p value
1	0.52	20	0.31
2	0.74	20	0.23
3	-0.39	20	0.35
1-3	0.43	64	0.33

The experiment running over three classes led to less participation as time went on, possibly due to busy student schedules and/or a lack of motivation over an ungraded in-class quiz. The participation level dropped in each class, possibly due to overall semester burnout or the novelty of the experiment wearing off.

4.2 RQ2: Does Classroom Material Enhanced With Gamification Increase Student Motivation?

To measure motivation, both quantitative and qualitative data were used. While playing the game, the study collected the number of floaters that were remaining after each question was answered, how long each question took to answer, and how many attempts of the gamified quiz were made. The post-survey also asked some questions related to student motivation with and without the gamified quiz.

Game play included having to keep leaves in the air while reading and answering multiple-choice questions, adding points to the total score. The leaves did not affect the correct answer in any way, they were purely a game play element. Results showed an upward trend of floaters across all 30 quiz questions, possibly a result of student motivation to interact with the game.

Looking at students who participated in the gamified quiz for all three modules, game scores and times were analysed. Specifically, three players consistently played all three module quizzes, resulting in total quiz scores and total time spent on the quizzes. Figure 3 shows that students who completed all three modules earned

better overall game scores across the three modules, improving their interaction with the game. This could be a measure of student motivation, showing the students tried harder on each attempt with the game.

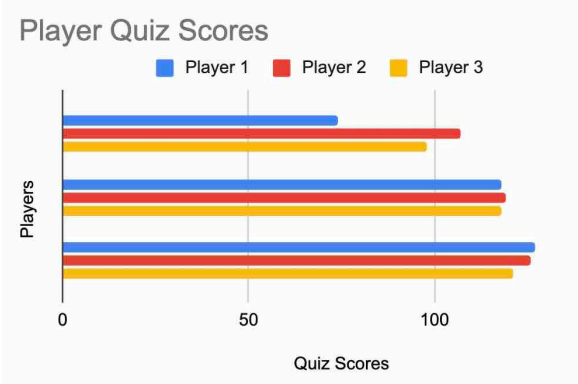


Figure 3: Player Quiz Scores Across Three Modules

Similarly, Figure 4 shows that students' time with the game decreased across the three modules, possibly showing their improved interaction with the game as they were able to answer questions correctly in less time as they continued to play. There were also students who replayed the game multiple times. Replaying the game resulted in the student being presented with the same game questions in the same order. The multiple game play attempts showed another form of motivation: students wanting to play the game more than once simply to improve their total score, total time, and leaderboard ranking. This is an exciting result, showing students are motivated by game elements of points and a leaderboard.

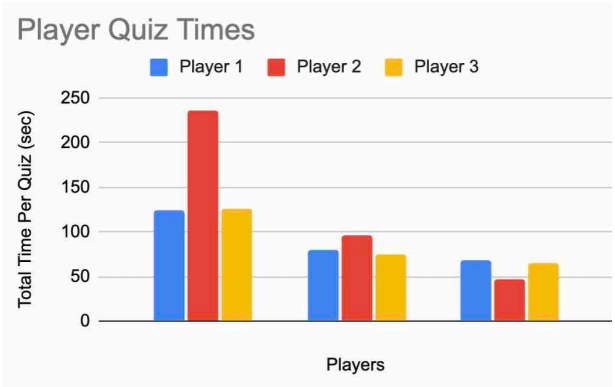


Figure 4: Player Quiz Times Across Three Modules

Qualitative data was collected from a post-survey that included questions related to student motivation, the flipped model, and its effectiveness. When asked which parts of the flipped model were most effective, students admitted to liking the flexibility of the flipped model, the short duration of videos, and the pop quizzes in class to reinforce their learning. When asked which parts of the flipped model were the least effective, students commented that having to do preparatory work was time consuming and many times they did not watch the videos due to lack of engagement.

When asked about how the game made a difference in learning, there were seven student responses. Overall, they found the game motivating, reinforcing, and enjoyable. When asked about its effectiveness, students commented that they liked the number of questions, they liked that the game immediately reinforced the video content, they liked the leaderboard, and they liked the timer as a speed element. When asked about ineffectiveness, the timer and leaves were mentioned as causing stress or making it hard to concentrate.

Specifically, some of the student comments included:

- *"I liked the time aspect of it, my brain was forced to recall the information quicker and that helped."*
- *"The leaderboard, it made me want to keep playing, to beat the other players' scores."*
- *"I think that this game is a step towards a better flipped classroom."*
- *"I thought I should note that I didn't get to play the game one of the times before class and I noticed I got a much lower score on the quiz."*

Overall, these results showed student motivation to play a gamified quiz, but not necessarily a quiz enhanced by a LLM. Future work would include adding more levels to the game where difficulty of the LLM questions would increase. Levels could also be personalized, allowing students to choose the content they would most like to see in the game.

4.3 RQ3: Does the Allowance of Asking Anonymous Questions on a Gamified Quiz Increase Student Comfort Level?

The gamified quiz provided a way for students to submit anonymous questions at the end of each quiz question. These student questions were saved into a text file for the study, the intent being that they could be used by the instructor in class. In this study, there was only one question asked over the duration of the three modules. Although this is a small number, it aligns with the current number of questions asked in class. The post-survey showed 100% agreement that an anonymous format for questions made students more comfortable. It is likely that students prefer asking a question in an anonymous way, but this could be provided outside of a gamified quiz. As LLMs become more reliable, future work would include a way to interact with the LLM in the game, being able to ask the LLM a question and receive an immediate answer.

5. Conclusion

The results of this experiment are promising, showing that students who played the gamified quiz performed better on pop quizzes and were motivated to play the game. Using a LLM as the source of the game questions is a newly adopted approach, allowing for the game to be filled with content from any source. Student feedback shows exciting promise for future work around adding gamification to the flipped classroom model.

We do acknowledge several limitations in this research project. First, the sample size of participants was small, only 23 total students out of a class of 161 students volunteered to be a part of the study. There could have been an internal validity threat of selection whereby those 23 students were better overall performers in the class and had the extra time for a research study. Second, the game itself could have been overwhelming for non-visual learners or learners that do not read quickly.

Third, the game used a LLM in a limited capacity due to the LLM being inconsistent with its responses. We found that even when giving the LLM a directory of content to use as its question bank, it tended to load the bank with very similar questions from one of the transcript files instead of across all transcript files. The questions generated by the LLM had to be vetted as they tended to contain duplicates, focus too much on one concept of the transcript, or were too similar to the pop quiz questions, which would give the game students a huge advantage.

Fourth, the experiment was short in duration due to the semester time constraints. The in-class pop quiz was ungraded to be fair to the entire class. This could have resulted in less reliable student scores as students were made aware of the ungraded pop quiz. The game itself was created in a very limited time frame so was constrained to only one level and a simple user interface, which could have led to the loss of interest by students.

There are many future directions for this project. Using a LLM-powered game to supplement flipped content in computer science education is a novel approach. This project showed the promise of this idea with its small sample size and short duration. Future work could take this project across an entire semester of a course using the entire student population in that course. Future work would also involve a much more complicated game engine that would utilize a LLM in more powerful ways, allowing more personalization of the game for each individual student. In doing so, student performance and engagement could be measured with a game containing more hands-on activities that better align with the flipped classroom pedagogy. Lastly, future work could analyse three groups: 1) students who only watch the flipped content, 2) students who watch the flipped content and do a simple practice assessment, 3) students who watch the flipped content and play a gamified quiz. This would add the dimension of simple assessment versus gamified assessment to the research.

The flipped model pedagogy has many benefits for students, giving them more time in class to put their knowledge into practical applications. However, students must be motivated to complete the preparatory flipped content, or the pedagogy fails for everyone. The flipped content must also remain relevant and have the right balance of engagement and learning. Gamification is a strategy for adding game elements to a classroom, but also must strike the right balance that meets the needs of any student. This study looked at the novel idea of adding a gamified quiz of content provided by a LLM to supplement the flipped material. The results of the study showed increased assessment scores in class and student motivation to play the gamified quiz. Future

directions for this could leverage the LLM in more powerful ways, leading to gamified experiences for students in the flipped model that are both relevant and personalized. This would offer students the greatest chance for success both in and out of the classroom.

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An Anti-Bullying and Therapeutic Interactive Visual Novel: TheraBuddy

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Abstract: This proceeding is an ongoing doctoral dissertation that will examine the effect of a serious game on bullying participant roles and social-emotional well-being. "This serious game, which is called TheraBuddy, is a Turkish interactive visual novel that is aimed at helping children and youth using cognitive-behavioral counseling and solution-focused counseling techniques." The protagonist of TheraBuddy is the player. According to story, the player is transfered to a school where bullying incidents occur. The player makes friends named Elma, Den, and Lu at this school. The player's goal during the story is to offer solution-focused or cognitive-behavioral help to friends involved in bullying incidents, whether as victims or perpetrators. TheraBuddy consists of nine parts, including an introduction and eight chapters. Throughout the story, two characters named Ozguro and Bilgin help the player make choices, and the story of TheraBuddy continues according to the player's choices. TheraBuddy was coded and hosted using the Ren'Py game engine. Characters and backgrounds were designed through Canva, and the TheraBuddy characters were voiced using Elevenlabs AI Voice Generator. As a result, an interactive anti-bullying game that is currently only playable offline has been developed. Work is currently being done to make this offline game a web-based game. It is believed that TheraBuddy will be helpful in combating bullying and strengthening students socially and emotionally. In the future, when the online version of TheraBuddy is completed, this belief will be tested under experimental conditions.

Keywords: Anti-bullying Games, Bullying Participant Roles, Social-emotional Health

1. Introduction

In modern schools peer bullying is one of the prevalent issues that threatens the socio-emotional development of children and adolescents. According to a recent report published by The United Nations Children's Fund (2018), half of the youth aged 13-15 worldwide are subjected to bullying at school and in its surroundings. The same report states that one in three students globally is involved in bullying, regardless of age group. Experiencing peer bullying at an early age can have devastating effects on children and adolescents in both the short and long term (Callaghan & Joseph, 1995; Juvonen & Graham, 2014; Lereya et al., 2015; Moore et al., 2017; Schoeler et al., 2018). These are evident that combating bullying in schools is of paramount importance. There is a rich body of literature on traditional intervention methods developed for this purpose (Farrington & Ttofi, 2009). Moreover, the use of information and communication technologies to combat bullying in schools is becoming increasingly widespread. Interventions are implemented through games, forums, online social networks, and simulations (Nocentini et al., 2015).

Some of these interventions include Be Internet Awesome (Seale & Schoenberger, 2018), Cooperative Cybereduca 2.0 (Garaigordobil & Martinez-Valderrey, 2018), Mii-School (Carmona, Espinola, Cangas, & Iribarne, 2010), Stop the Mob! (Walsh & Schmoelz, 2015), and QUEST for the Golden Rule (Rubin-Vaughan, Pepler, Brown, & Craig, 2011). Additionally, SMART Talk, Fear Not!, and KiVa are among the most evidence-based games for preventing bullying. However, SMART Talk and Fear Not! are no longer accessible, and KiVa is only available to specific partner schools (Calvo-Morata, Alonso-Fernandez, Freire, Martinez-Ortiz, Fernandez-Manjon, 2020). Be Internet Awesome is an adventure game composed of 4 games and various sections, aiming to raise cybersecurity awareness among children through exercises. The game emphasizes themes such as thinking before sharing online, distinguishing between fake and real content on the internet, keeping personal secrets, being kind, and talking to someone when a problem arises (Seale & Schoenberger, 2018). Cooperative Cybereduca 2.0 is another anti-cyberbullying serious game developed for adolescents with similar goals (Garaigordobil & Martinez-Valderrey, 2018). This game, which can be played as a group in the classroom and is freely accessible, requires players to answer a total of 120 questions embedded in the game's storyline. These questions cover topics such as cybersecurity, cybersexuality, the consequences of bullying/cyberbullying, and coping with bullying/cyberbullying. It was recorded that the experimental group, who played the game for one hour a week throughout the semester, exhibited less bullying and aggression but higher prosocial behavior by the end of the term.

In an anti-bullying game Mii-School, developed by Carmona, Espinola, Cangas, and Iribarne (2010), students are presented with 17 different scenes set in various contexts. During these scenes, players are expected to choose

one of the predefined behaviors to respond to the situation. These responses include ignoring the bullies, protesting, responding with irony, fleeing in fear, confronting them, or feeling embarrassed. Stop the Mob! is an anti-bullying point-and-click serious game, designed by preschool teachers, that can be played on both computers and mobile phones and is freely accessible (Walsh & Schmoelz, 2015). In this game, players view the world from the perspective of an anonymous girl student, and Bob, a character in the game, faces various bullying situations at school. Players are given the opportunity to choose from possible actions such as participating in the bullying, avoiding and escaping the situation, or helping Bob, and to see the positive and negative changes these responses can bring to Bob's school life. Besides the few examples mentioned here, there are many other ICT interventions against bullying. Calvo-Morata et al.'s (2020) meta-analysis examined 33 games and game-like applications developed for this purpose and drew several conclusions. Firstly, it was noted that these games share common mechanics such as making choices, managing dialogues, and completing adventures. Secondly, the primary goals of these games are to teach players strategies and raise awareness. The same study also highlighted that very few of these games have been evaluated using pre-test, post-test, and follow-up measurements, and many of them are no longer accessible. Furthermore, there is a lack of evidence-based serious games against bullying available in Turkish.

In recent years, interactive visual novels, which have become increasingly popular and highly favored among children and adolescent populations, are starting to appear among the best-selling games of large-scale game studios such as Steam, Nintendo, and Playstation (Klotz, 2021). These games can serve as models for designing serious games, given their growing popularity. First of all, According to Hakkun et al. (2018) These games, which are as simple as point-and-click simulations, are suitable for use even among young age or disavantaged groups. In interactive visual novels, emphasis is placed not only on players' gaming skills but also on how they influence the story through the choices they make. Secondly, interactive visual novels offer opportunities for not only knowledge and comprehension but also application and higher-level learning through interactions that provide a simulation experience (Bloom, 1956). Thirdly, interactive visual novels can be designed to include visuals, dialogue texts, voiceovers, choices, videos, and even mini-games. Consequently, they serve as a functional game type that offers an engaging learning experience and keeps players actively involved. An interactive visual novel with voiceovers for anti-bullying is an inclusive method that can also reach groups with reading, writing, or hearing difficulties.

Fourthly, fostering empathy is crucial in preventing peer bullying (Orpinas & Horne, 2006). Since interactive visual novels offer players a deep narrative and character development, they can encourage players to form emotional connections with characters, better understand the situations of both victims and perpetrators, and develop empathy. Lastly, interactive visual novels can be developed at a lower cost and in a shorter time compared to other ICT-based games. This makes them a more economical model for producing a greater number and variety of games. Experimental research has shown that Interactive visual novels are used for purposes such as facilitating foreign language education (Camingue, Melcer, & Carstendottir, 2020) and improving healthcare services (Yin, Ring, & Bickmore, 2012). However, in the national and international literature, only two studies have been found concerning the development of an interactive visual novel specifically aimed at addressing peer bullying (Keat, 2012; Wibisono, Fredlina, & Wijaya, 2020). Neither of these studies includes experimental testing of the developed game/intervention tool, and access to these relevant games is also limited.

As a result, there is a need to develop an interactive visual novel that can protect students from peer bullying and its effects. Therefore, the initial phase of this ongoing doctoral thesis is to develop a web-based interactive visual novel aimed at bystander intervention to bullying and contributing to students' socio-emotional well-being. The second phase involves testing the effects of this intervention tool under experimental conditions. At the current stage of the study, the first phase is nearing completion, and an offline anti-bullying interactive game has been developed so far. Work is currently being done to transform this offline game into a web-based format. The aim of this paper is to introduce an anti-bullying computer game (TheraBuddy), which has not yet been experimentally evaluated for its effects.

2. Theoretical Framework of TheraBuddy

TheraBuddy's grounding in solution-focused and cognitive-behavioral counseling is influenced by several key factors. Firstly, both approaches have been scientifically proven to effectively address behavioral and emotional difficulties in children and adolescents (Beck, 2019; de Shazer et al., 2021; Gingerich & Peterson, 2013; Hofman et al., 2012). Additionally, the utility of these approaches in educational settings is robustly supported in the literature (Franklin et al., 2008; Joyce-Beaulieu & Sulkowski, 2015). On one hand, solution-focused approach plays a significant role in helping children experiencing peer bullying and related problems to establish positive

social relationships, gain problem-solving skills, and enhance their self-efficacy and social competencies (Myers, 2009). On the other hand, the cognitive-behavioral approach modifies negative and destructive thought patterns associated with peer bullying, promotes the development of prosocial skills such as assertiveness and problem-solving, and enhances students' emotional regulation skills. Thus, it equips them to combat peer bullying (Warner et al., 2016; O'Moore & Minton, 2005; Smith et al., 2004). TheraBuddy promotes using these approaches' problem-solving methods to assist other characters with their bullying-related issues. They will understand cognitive errors such as catastrophizing or selective abstraction, ways to identify these errors, and various cognitive-behavioral techniques like evidence examination, cognitive restructuring, mental rehearsal, and opposite scaling. Additionally, players are trained in solution-focused thinking and setting positive goals, breaking solutions into achievable steps, focusing on strengths, examining exceptions, and techniques such as the miracle question.

3. Methodology

3.1 Development Process of TheraBuddy

The development of TheraBuddy utilized the open-source Ren'Py game engine, version 8.2.3 (Ren'Py, 2024). It has an easy-to-learn scripting language based on Python. TheraBuddy's characters and backgrounds were designed through the Canva Pro. For some scenes, ready-made photos from the Canva library were used, while for others, a design was created from scratch by giving commands to AI assistants like Canva Magic Design. For example, for the background design of the scenes in Ozguro's room in TheraBuddy, the command given to the Canva Magic Design AI assistant was, "Create a colorful school counselor's office with a desk, computer, bookshelf, chair, large windows, and sunlight." Character visuals are designed in the same way as the backgrounds. Approximately 35 character visuals and around 250 location visuals have been designed for TheraBuddy. Below are examples of two locations in TheraBuddy (see Figure 1 and Figure. 2) and the main characters' visuals (see Figure 3).



Figure 1: School Counselor's Room in TheraBuddy (Created on Canva Pro)



Figure 2: Cafeteria in TheraBuddy (Created on Canva Pro)



Figure 3: The main characters in TheraBuddy are, from left to right: Den, Elma, Lu, Ozguro, Glen, Juli, and Bilgin. (Created on Canva Pro)

To voice characters in TheraBuddy, a subscription to the ElevenLabs AI Voice Generator was purchased. All characters in TheraBuddy were voiced in Turkish using synthetic voice actors provided by ElevenLabs AI Voice Generator (an English demo of the game is also available). The game's script was completed by the author of this paper, İsa Özgür Özer, in approximately one year, including the preliminary and pilot phases. When selecting appropriate voice tones, factors such as the characters' appearances and roles in the game were considered. For example, a fatherly tone was used for Bilgin, a middle-aged, rational, and didactic character, while a mocking and harsh young male voice was used for Glen, one of the bullying characters.

Prior to the writing of the script, well-known interactive visual novels such as Doki Doki Literature Club version 1.1.1 (Salvato et al., 2018) and My Childhood Friends version 1.2.0 (WitPOP, 2022) were played to understand the general mechanics, game features, and narrative styles of this genre. The characters that the protagonist (the player) would befriend and help were designed, and what would happen to each of them was decided. Following this, the story was structured to allow choices to be made by the player every 8-10 lines of dialogue. The artistic aspect of the game was driven by spontaneous creativity, while the methodological structure (therapeutic and educational methods used throughout the game) was inspired by the counseling approaches described in the theoretical framework section. Ultimately, the game script consists of over 37,000 words and involves at least 100 interactions with the player.

TheraBuddy features a simple game mechanic. Players can advance scenes and dialogue by clicking with the mouse or pressing the enter key on the keyboard. When a choice menu appears, players can interact using the mouse or the arrow keys. The choices affect the storyline rather than the game or chapter endings. For instance, in one scene (see Figure 4), players choose between two questions to ask Elma: "What's on your mind?" or "What would you like to happen?" Selecting the first leads to a cognitive-behavioral conversation, where they try to reframe Elma's thoughts, addressing upsetting thoughts and identifying cognitive distortions. Choosing the second initiates a solution-focused discussion, including the miracle question and goal-setting through scaling. Regardless of the choice, the story returns to the main path with Den and Lu's arrival, and Elma feels better. Players earn badges for helping friends, which appear in the top right corner of the screen. The game features five symbolic awards: the Helpfulness Badge, Empathy Badge, Peer Mentor Badge, Anti-Bullying Badge, and Cybersecurity Badge.



Figure 4: The player selects one of the cognitive-behavioral or solution-focused questions to help Elma.

The beta tests of the current offline version of TheraBuddy were conducted with eight elementary and middle school students aged 11 to 15. It took an average of 120 minutes for the participants to play through the game once. The participants were observed as they played the game, notes were taken for debugging, and their feedback was recorded at the end. For example, in one scene, players were asked to enter their grade numerically. However, it was noticed that the players generally used string inputs. To fix this, code was written in the game's script to restrict string inputs. The students mentioned that some concepts were unfamiliar and difficult to understand (such as 'selective abstraction'). These were replaced with more easily understandable terms for children and adolescents. For example, 'focusing on the negative' was used instead of 'selective abstraction.' In addition to debugging and corrections, the participants' suggestions for performance improvements were also considered. For instance, a 12-year-old student found the game enjoyable but suggested it would be more engaging with character voiceovers. As a result, Turkish voiceovers were added throughout the game, which initially lacked this feature.

3.2 Characters of TheraBuddy

TheraBuddy features eight main characters: Ozguro, Bilgin, Elma, Den, Lu, Glen, Juli, and the player (the protagonist). Ozguro and Bilgin serve as adult mentors throughout the game. Ozguro is a young, friendly school counselor, while Bilgin acts as a didactic, charismatic, middle-aged, paternal inner voice. Elma is a victim with orange hair, glasses, and a dental brace. Lu, from a poor background, is small and frail. Den, who is in love with Elma, is a clean-cut, docile youth who experiences both bullying and victimization. Glen, who has family issues, is muscular and gathers supporters as a bully. Juli, who is overweight, is tough and plays roles of bully, supporter, and victim. The player befriends Elma, Den, and Lu, offering social support to friends who are victims of bullying. The pathways of bullying interactions among the characters are illustrated below (see Figure. 5).

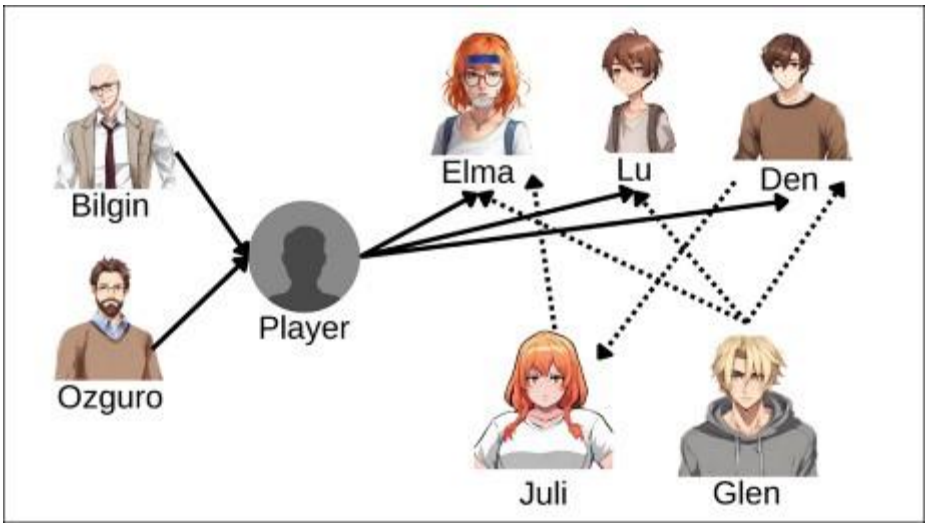


Figure 5: The pathways of bullying interactions among the characters. Solid arrows show acts of helping. Dashed arrows show acts of bullying.

3.3 Content of TheraBuddy

TheraBuddy begins with the scene where the protagonist meets Ozguro, the school counselor. In this scene, the player is prompted to choose a name they will use throughout the game. During this intro, the player is taught the game mechanics by making choices. Upon arriving at their classroom, the player meets Elma. They accept Elma's invitation to sit together, marking the beginning of the first chapter. The first chapter is titled "First Lesson." In this chapter, Elma introduces the player to Den, and they wait for their history teacher, Mr. Tev, to arrive. When Mr. Tev arrives, he asks the new students to introduce themselves. The player stands up as one of them and mentions their age, gender, and where they live (these details are collected for future work as demographic variables). When the player sits down, they accidentally wet their pants and notice two students giggling at them. At that moment, Bilgin appears and asks the player what happened. Through the player's responses, they engage in a conversation about the distinction between events, thoughts, emotions, and behaviors. After the lesson ends, the player begins to search for a way to dry their wet pants, marking the beginning of the second chapter.

The second chapter is titled "Eyewitness." In this chapter, while the player is searching for a way to dry their wet pants, they witness Glen cornering and teasing Lu, damaging his glasses. Bilgin appears and encourages the player to help Lu. They think solution-focused to find a way to deter Glen. The player resolve the situation, rescue Lu, and this leads into the third chapter. The third chapter is titled "Another Perspective." In this chapter, the player learns about what has been happening between Glen and Lu. According to the story, Lu had been completing assignments for others in exchange for money at one point. Glen and his friends found out about this and have been coercing Lu to do what they want under the threat of reporting him and getting him expelled from school. Additionally, they sometimes physically harm Lu or his belongings and ridicule him. The player convinces Lu to consult with Ozguro. In Ozguro's office, they address the cognitive distortions that make Lu feel helpless. Through the player's choices, they discuss Lu's catastrophic thinking and polarized thoughts. Ozguro and the player work together to suggest more functional ways of thinking for Lu.

The fourth chapter is titled "Peer Mentor." In this chapter, the player and Lu go to the school yard to meet Elma, whom they find crying. When they approach Elma, she does not want to talk and leaves angrily. Den then comes and explains to the player and Lu what happened. According to Den, a girl named Juli mocked Elma's jaw brace. The player learns that this verbal and social bullying has been going on for a long time. During the next break in the cafeteria, the player is alone with Elma. Elma is very upset. Bilgin appears to help the player support Elma through her distress. Bilgin and the player collaborate to have a solution-focused or cognitive behavioral conversation with Elma, shaped by the player's choices. They try to reframe Elma's thoughts, address upsetting thoughts, identify cognitive distortions, or they attempt to answer the miracle question and set goals. The fifth chapter is titled "Yin Yang." It begins with an interlude where we see Den expressing his love for Elma through an acrostic poem. Following this, we observe Den preparing a poster with "obese of the year" written over Juli's picture, believing this to be his way of getting revenge on Juli. As the interlude ends, Elma meets the player in the school yard, showing them the poster and revealing that someone has been leaving these around the school. They are unaware that Den is behind this. When they enter the classroom, they see Ozguro has arrived with Juli. Ozguro seats everyone and gives a speech against bullying. Afterwards, he organizes two interactive drama games focusing on bullying and empathy for the entire class. Once the games conclude, the sixth chapter begins.

The sixth chapter is titled "Confronting the Bully." In this chapter, Lu is saddened by the ineffectiveness of confronting Glen. Bilgin and the player collaborate to have a solution-focused or cognitive behavioral conversation with Lu, shaped by the player's choices (see Figure 6). The player and Elma attend Mr. Gav's computer class. The topic covered in class is cyber security. Mr. Gav facilitates two games aimed at raising awareness about cyberbullying and cyber security. At the end of the lesson, the seventh chapter begins.



Figure 6: The player is trying to understand Lu's cognitive distortions.

The seventh chapter is titled "Who is the Victim?" In this Chapter, Elma learns that Den was the one who made the posters mocking Juli. She becomes very angry and disappointed with Den for his actions. Den leaves in a huff, upset with Elma. Subsequently, the player helps Elma recognize her use of overly perfectionistic criteria and 'should' statements when judging Den. Ozguro asks the player to mediate between Juli and Den. Although

Den resolves his issue with Juli, another problem awaits him. Later that evening, Glen sends the photo of Den's love poem to the school's WhatsApp group, leading some members to make disparaging remarks about Den. Despite the player's attempts to talk to Den, they cannot reach him, and the eighth chapter begins.

The eighth chapter is titled "He Need Us." In this chapter, the player and Elma decide to visit Den at his home after school. Den believes he has embarrassed himself in front of Elma and the entire school. Bilgin and the player work together to rate Den's negative feelings, understand the overgeneralizations and mind-reading that cause these feelings. Den begins to build enough self-confidence to confront the bullying by Glen and his friends, and the final chapter begins. The final chapter is titled "Time to Say Goodbye." It opens in Ozguro's office, where Ozguro engages in an emotional farewell conversation with the player. In this dialogue, Ozguro summarizes what the player has achieved since arriving, emphasizing that the player has become a staunch advocate against bullying. At the end of the game, the player is encouraged to replay the story, making different choices.

4. Future Work and Expected Results

The effect of TheraBuddy on bystander intervention and social-emotional health will be investigated using a pre-test, post-test, and control group experimental design. Participants will be randomly selected from primary and secondary schools in Ankara, Turkey. In the pre-test, the Olweus Bullying Questionnaire for Students (Olweus, 1996) will be used to assess their participation in peer bullying. Bystander intervention to bullying will be evaluated through the measurement model of Nickerson et al. (2014). The Social-Emotional Health Scale will be used to assess students' social-emotional well-being (Furlong, You, Renshaw, O'Malley, & Rebelez, 2013; Furlong, You, Renshaw, Smith, & O'Malley, 2013). After the pre-test application, students will be randomly assigned to experimental and control groups. Each student in the experimental group will be given a www.therabuddy.com.tr membership so that they can play TheraBuddy online. The students in the experimental group will be given one month to play TheraBuddy as much as they want. During this time, how long users played the game, how much of the game they completed, and which parts of the game they played more than once will be recorded. At the end of one month, a final test will be given to the experimental and control groups. The collected data will be analyzed with ANCOVA and repeated measures ANOVA in IBM SPSS 24 Statistics.

TheraBuddy is expected to positively impact users' attitudes toward bystander intervention in bullying and their socio-emotional well-being. To measure this effect, the following hypotheses will be tested in a future study using a pre-test, post-test, control group experimental design:

1. After controlling for pre-test scores, there will be a significant difference in the post-test scores on the Bystander Intervention in Bullying Scale and Social-Emotional Health Scale between the experimental and control groups in favor of the experimental group.
2. Within the experimental group, there will be a significant difference between the pre-test and post-test scores on the Bystander Intervention in Bullying Scale and Social-Emotional Health Scale in favor of the post-test.
3. After controlling for pre-test scores, students in the experimental group who play TheraBuddy for more than hours within a month will have significantly higher post-test scores on the Bystander Intervention in Bullying Scale and Social-Emotional Health than those who play for less than 4 hours.
4. After controlling for pre-test scores, students in the experimental group who complete more than 50% of TheraBuddy within a month will have significantly higher post-test scores on the Bystander Intervention in Bullying Scale and Social-Emotional Health than those who complete less than 50%.

5. Conclusion

This paper discusses the development of TheraBuddy, an interactive visual novel designed to enhance positive socio-emotional health and bystander intervention attitudes among students aged 10-16. TheraBuddy has the potential to be an effective game-based intervention for several reasons. Firstly, focusing on bystander intervention is critical in preventing peer bullying (Ttofi & Farrington, 2012). TheraBuddy directly targets this by placing the player in the role of an active bystander who responds to incidents involving their friends. Through this approach, students learn to defend bullying victims in their own schools. Secondly, research shows that the longer bullying continues, the more children and adolescents perceive their coping strategies as inadequate (Craig et al., 2007). TheraBuddy addresses the need for adult support and feedback by featuring characters Ozguro and Bilgin, who mentor players and provide immediate feedback throughout the game. This mentorship can help young people develop effective strategies to tackle bullying-related issues (Offrey & Rinaldi, 2017).

Thirdly, TheraBuddy employs solution-focused and cognitive-behavioral counseling techniques to assist characters within the game. Cognitive-behavioral skills are vital for maintaining socio-emotional health in bullied students, reducing bullying behaviors, and preventing bullying at a school-wide level (Gokkaya, 2017; Hutson et al., 2021). Solution-focused interventions are also effective in helping bullied students protect themselves, reduce bullying behaviors, address socio-emotional issues like social anxiety, and build academic resilience (Copur & Kubilay, 2021; Oktava et al., 2022; Yandri et al., 2023). Therefore, TheraBuddy aims to teach players evidence-based techniques for safeguarding their own and others' socio-emotional health, avoiding bullying, and assisting those who are bullied (Beck, 2019; de Shazer et al., 2021).

Common game mechanics in anti-bullying computer games include choices, dialogues, adventures, independent scenarios, explanations, quizzes, and inventory collection (Calvo-Morata et al., 2020). While many games offer a gameplay experience involving player choices, fewer games incorporate mechanics like quizzes or inventory collection. TheraBuddy is advantageous as it encompasses all these mechanics. Additionally, TheraBuddy's goals align with other effective serious games in the literature (Calvo-Morata et al., 2020; Carmona et al., 2010; Garaigordobil & Martinez-Valderrey, 2018; Seale & Schoenberger, 2018; Walsh & Schmoelz, 2015). These goals include teaching students strategies to handle specific situations, understanding the consequences of actions, fostering empathy for victims, promoting safe and responsible internet use, and learning new socio-emotional skills.

Currently an offline digital game, TheraBuddy's next research procedure (experimental) will begin once its web software is complete. Future research predicts that children and adolescents who play TheraBuddy will increase their bystander intervention in bullying situations and develop various traits indicative of healthy socio-emotional development, such as emotion management and positive relationships with others. If these predictions are validated under experimental conditions, TheraBuddy could be the first example of using interactive visual novels to prevent or reduce antisocial behavior problems like bullying in educational settings. Such a game could become part of school-wide or community-wide prevention policies and programs, forming the gamification and learning component of these initiatives.

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Unleashing Creativity Through Paidia: Free Play in Learning and Work

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Abstract: This paper explores the transformative potential of paidia—unstructured and spontaneous play—in enhancing creativity and learning outcomes in educational and professional settings. Drawing from Roger Caillois's theoretical distinctions between paidia (free play) and ludus (structured play), this study advocates for the integration of paidia to foster environments conducive to innovative thinking and creative expression. Central to our discussion is the critique of the 'tyranny of software', a concept inspired by Lev Manovich, which posits that despite the utility of digital tools, they often confine creative expression within pre-established boundaries, thus stifling genuine innovation. The research methodologically analyzes how paidia, as a pedagogical approach, facilitates a more liberated form of interaction with technology, thereby rehumanizing the digital learning experience. It contrasts traditional game-based methodologies that prioritize rule-based learning with the dynamic, rule-free nature of paidia, presenting empirical evidence from various educational settings where the integration of paidia has notably enhanced creativity. This exploration contributes to the broader discourse on the effectiveness of game-based learning by providing a nuanced understanding of how unstructured play can be systematically integrated into educational and professional domains to foster a culture of innovation and creativity.

Keywords: Paidia, Creativity, Free Play, Creative pedagogy, Creative Emancipation, Pedagogy, Professional Education, Higher Education, Educational innovation

1. Introduction

In contemporary learning environments for creative disciplines, there is a significant challenge in balancing the necessary structure for imparting knowledge with the essential freedom to foster creativity. Within this context, the concept of paidia, understood as unstructured and spontaneous play, emerges as a crucial element. Creativity and freedom of expression, fundamental components of artistic education, are often constrained by pedagogical approaches that prioritize conformity and productivity. This paper argues that achieving genuine creative emancipation necessitates advocating for and promoting paidia in educational settings.

The term paidia, introduced by Roger Caillois in his work "Man, Play and Games" (1958/1997), describes a type of play that is free, improvised, and not bound by strict rules. Unlike ludus, characterized by structured games with defined objectives, paidia allows imagination to flourish without the constraints of a rigid framework. This distinction is particularly relevant in education, where creating spaces that enable students to explore and experiment without the pressure of achieving specific outcomes is necessary (Caillois, 1997).

Throughout history, from the Industrial Revolution to the current digital age, the perception and value of creativity have undergone significant transformations. Today, technology, particularly software, plays a central role in both our professional and personal lives. However, this reliance on software can limit our creative processes. Lev Manovich, in "Software Takes Command" (2013), suggests that software has assumed a dominant role in the creative field, shaping our possibilities within the parameters established by its design and functionality (Manovich, 2013).

The concept of the "tyranny of software," derived from Manovich's analysis, posits that while digital tools can facilitate creativity, they also impose restrictions that can limit our freedom of expression. This subtle but pervasive influence of software raises crucial questions about the nature of creativity in the digital age: Are we truly free in our creative endeavors, or are we confined within the digital limits set by software developers? Addressing this question requires exploring how we can rehumanize our relationship with technology and regain control over our creative tools (Cañas Fernández, 2010).

Rehumanization, as described by Cañas Fernández (2010), involves recognizing and resisting how software dictates our creative processes. This process is not about antagonizing technology but understanding and reaffirming our control over these tools. In this sense, paidia presents a valuable strategy to counteract the rigidity imposed by software, providing a space where imagination and creativity can thrive without restrictions.

The concept of metapoiesis, introduced by Dreyfus and Kelly (2011), offers a framework for understanding and facilitating creative emancipation. Metapoiesis, meaning "creating beyond," involves transcending traditional forms and functions of creative production. Applied to the arts and design, this concept invites us to look beyond conventional tools and techniques to discover new forms of expression and meaning. In combination with paidia, metapoiesis could transform educational environments into spaces where creativity and freedom are nurtured and valued (Dreyfus and Kelly, 2011).

This discussion proposes that integrating paidia into learning spaces is essential for fostering authentic and unrestricted creativity. The free and unstructured exploration that paidia offers allows students to develop innovative and adaptable skills, fundamental in an increasingly technology-dominated world. The combination of paidia and metapoiesis provides a comprehensive approach to rehumanizing our relationship with software and promoting true creative freedom.

2. Understanding Paidia in Play

Roger Caillois' influential book “Man, Play, and Games” (1958/1997) explores the fundamental nature of play and its role in human society. Building on Johan Huizinga’s foundational work, “Homo Ludens” (1954/2000), Caillois expands the scope to include a broader range of play activities beyond competitive games. He defines play with six core characteristics: it is free, separate from ordinary life, uncertain, unproductive, governed by rules, and involves make-believe (Caillois, 1997).

Caillois categorizes play into four primary types: agon (competition), alea (chance), mimicry (simulation), and ilinx (vertigo). These categories are positioned on a continuum between two types of play: ludus and paidia. Roger Caillois introduced the terms paidia and ludus to differentiate between types of play with distinctive characteristics. While ludus is characterized by structured play aimed at specific goals, paidia allows for free and creative exploration, where improvisation and fantasy are predominant elements (Caillois, 1997; Sutton-Smith, 1997). Paidia represents a state of free and spontaneous play, not bound by rigid rules. It encourages creativity and improvisation, allowing individuals to engage in activities driven by their imagination. In contrast to ludus, which is structured and goal-oriented, paidia is about the joy of playing itself, without the pressure of outcomes or objectives. This form of play is crucial for cognitive and emotional development as it fosters a safe space for exploration and innovation (Caillois, 1997; Sutton-Smith, 1997).

By embracing paidia, educators and professionals can cultivate environments that nurture creativity and experimentation. This approach aligns with contemporary educational theories that value holistic development and the importance of play in learning (Gordon, 2014; Brown and Leigh, 2018). Understanding and integrating paidia into educational and professional contexts could lead to more dynamic, innovative, and emotionally fulfilling experiences for learners and workers alike.

3. Paidia as a Driver of Creativity and Innovation

Paidia manifests in activities that allow participants to play without the pressure of adhering to established norms or achieving specific goals. This type of play is fundamental for cognitive and emotional development, offering a safe space to explore new ideas, test hypotheses, and experiment without fear of failure. The inherent freedom in paidia fosters imagination and creativity, essential elements for personal and professional development, especially in creative disciplines.

The importance of paidia can be observed in various historical and cultural contexts. In many traditional societies, free play has been an integral part of childhood and learning. Children learn about the world around them through play, developing social, cognitive, and emotional skills. This natural and self-directed form of learning contrasts with the more structured educational methods that dominate many contemporary institutions (Fontan del Junco et al, 2019; Children's Creativity Museum, 2021; Huizinga, 2000).

In modern education, the trend towards standardization and continuous assessment has led to a decrease in the time and space dedicated to free play. Students often find themselves in highly structured environments where they are expected to follow a rigid curriculum and achieve measurable goals. This approach can limit students' ability to think innovatively and solve problems creatively. By incorporating paidia into the educational curriculum, educators can provide students with opportunities to explore and experiment without the constraints of a formal structure (American Academy of Pediatrics, 2007).

Moreover, paidia plays a crucial role in developing soft skills such as resilience, adaptability, and cooperation. By engaging in free play activities, students learn to manage uncertainty, adapt to changing situations, and collaborate effectively with others. These skills are increasingly valued in the workplace, where the ability to innovate and work as a team is fundamental (Orlandi, 2010; Oxman, 2016).

Free play can also significantly impact mental health and emotional well-being. The pressure to meet academic and professional expectations can be overwhelming, and paidia offers a way to release accumulated stress and tension. By allowing individuals to engage in enjoyable activities without judgment or evaluation, a conducive environment for relaxation and well-being is created (Friedrich, 1992).

The integration of paidia in learning environments benefits not only students but also educators. Teachers can use free play as a tool to observe and better understand their students' strengths and needs. By observing paidia activities, educators can identify areas where students excel and where they may need additional support. This allows for more personalized and effective teaching that adapts to the individual needs of each student (Freire, 2007).

In the professional realm, paidia can be a powerful tool for innovation and product development. Companies that foster an environment of free play and experimentation often find their employees more creative and proactive in problem-solving. By removing restrictions and allowing employees to explore ideas without fear of failure, a culture of continuous innovation can be fostered (Schwab, 2016).

An example of paidia in a professional setting is the use of "game jams" or game development marathons, where participants have the freedom to create and experiment with new ideas in a short period. These sessions encourage creativity and collaboration and often result in innovative ideas that can be developed and applied to larger projects (Global Game Jam, 2021).

The challenge of integrating paidia into educational and professional contexts lies in changing the prevailing mindset that values structure and productivity over exploration and creativity. A paradigm shift is necessary to recognize the value of free play not only as a recreational activity but as an integral part of learning and human development. Under this framework, paidia is a fundamental concept for developing creativity and freedom of expression. By providing a space for unrestricted exploration and experimentation, paidia enables individuals to develop essential skills for personal and professional success. Integrating paidia into learning and workspaces can transform how we approach education and innovation, promoting a culture of creativity and collaboration crucial for facing the challenges of the 21st century.

4. Practical Applications of Paidia in Learning

The integration of paidia, or free play, in educational and workplace environments offers a unique opportunity to foster creativity, innovation, and emotional well-being. Below, various strategies and examples are explored to demonstrate how paidia can be effectively implemented in different contexts.

4.1 In Educational Settings

4.1.1 Unrestricted Creativity Workshops

Creativity workshops can be designed to allow students to explore their ideas without the pressure of specific outcomes. For instance, art workshops where diverse materials are provided, encouraging students to create freely without following precise instructions. This approach promotes self-expression and experimentation, crucial elements for developing creativity.

4.1.2 Open Brainstorming Sessions

Instead of structured brainstorming sessions with defined goals, open sessions can be organized where any idea is welcome. These sessions might include playful activities such as word association games, free drawing, or collective storytelling. The goal is to create an environment where students feel free to share and develop ideas without fear of judgment.

4.1.3 Interdisciplinary Collaborative Projects

Collaborative projects that involve students from different disciplines can be an excellent way to integrate paidia. For example, a project that combines art, engineering, and social sciences students to design an

interactive installation can create an environment where exploration and creativity intersect. The diversity of perspectives and skills enriches the creative process and promotes mutual learning.

4.1.4 Free Play Spaces in Classrooms

Allocating time and space within the school schedule for free play activities can be highly beneficial. This might include play zones with various materials such as building blocks, toys, musical instruments, and art supplies. Students can use this time to explore their interests and develop skills through unrestricted play.

4.1.5 Using Technology to Promote Paidia

Technology can also be a powerful tool to promote paidia. Applications and digital platforms that allow for free creation, such as graphic design programs, video editing software, and visual programming tools, can provide students with a medium to express their creativity. It is essential to present these tools in a way that makes students feel free to experiment without being constrained by strict instructions.

4.2 In Workplace Settings

4.2.1 Innovation Marathons (Hackathons and Game Jams)

Hackathons are events where employees can work on projects of their choice for a set period, free from the usual workday constraints. These events encourage creativity and innovation, allowing participants to explore new ideas and solutions without the pressures of typical deadlines.

4.2.2 Free Play Days

Some companies have implemented free play days where employees can dedicate their time to activities not directly related to their work. This might include prototyping, developing new skills, or simply exploring personal interests. These days can help reduce stress, boost morale, and foster a culture of innovation.

4.2.3 Flexible Workspaces

Creating workspaces that encourage collaboration and creativity is essential. This might include rest areas equipped with play and creation materials, open work areas that facilitate communication and collaboration, and environments that inspire employees to think innovatively.

4.2.4 Training Programs Based on Paidia

Training programs that incorporate elements of free play can be very effective for professional development. For example, workshops that use theatrical improvisation techniques to improve communication skills or creative design sessions where employees can experiment with new ideas and approaches. These programs not only develop specific skills but also promote flexible and adaptable thinking.

4.2.5 Wellness Initiatives

Incorporating paidia into wellness initiatives can have a significant positive impact on employees' mental and emotional health. Activities such as board games, recreational sports, and art workshops can provide a break from daily work and help build stronger relationships among colleagues.

4.3 Some Examples

A notable example is Google's "20% Time" program, which allows employees to dedicate 20% of their work hours to projects they are passionate about. This initiative has led to the creation of innovative products such as Gmail and Google News (Google Blog, 2021). In educational settings, the Reggio Emilia approach employs "ateliers" or studios equipped with a variety of materials, encouraging children to engage in free play and creativity (Children's Creativity Museum, 2021). The LEGO® SERIOUS PLAY® methodology, which utilizes Lego blocks (a very structured toy, but still using free-play exploration) in sessions, is another effective application that promotes creative thinking and problem-solving within corporate environments (Seriousplay.training, 2021; Strategicplay.com, 2021). Additionally, Game Jams provide a platform where game developers collaborate intensively to create games within a short timeframe, thereby fostering a spirit of innovation and creativity (Global Game Jam, 2021).

5. Insights and Future Perspectives

The integration of paidia and metapoiesis in educational and workplace settings represents a paradigm shift in how we understand and foster creativity. This approach challenges traditional norms of learning and work, opening new possibilities for innovation and creative emancipation. As we progress, it is essential to reflect on the implications of this integration and explore future directions for its implementation and development.

The combination of paidia and metapoiesis offers a methodology that emphasizes the freedom of exploration and the capacity to transcend established conventions. This approach not only fosters individual creativity but also promotes a culture of innovation and experimentation. By allowing students and professionals to engage in free play activities, an environment is created where ideas can develop organically and without restrictions. This is particularly relevant in a world increasingly dominated by technology and digital tools, where creativity is often limited by the rigid structures imposed by software and technological systems (Manovich, 2013; Cañas Fernández, 2010).

A crucial aspect of this integration is the rehumanization of our relationship with technology. Manovich (2013) describes how software can act as a form of "tyranny," shaping our creative possibilities within the limits established by its design. Paidia counters this tendency by providing a space where creativity can thrive without restrictions, allowing a more balanced and human relationship with technological tools.

Moreover, the combination of metapoiesis and paidia fosters a holistic approach to education and work. This approach values not only creative production but also the process of learning and personal development. By emphasizing the importance of free exploration and improvisation, it recognizes that creativity is a continuous process of discovery and transformation. This approach is fundamental for preparing individuals for the challenges of the 21st century, where the ability to adapt and create freely is more valuable than ever (Dreyfus and Kelly, 2011; Acaso and Megías, 2017).

As we move forward, several key areas where the integration of paidia and metapoiesis can have a significant impact include the development of pedagogical frameworks and tools that incorporate these principles, the exploration of applications in various professional fields, and the promotion of interdisciplinary research.

5.1 Development of Pedagogical Frameworks

It is essential to develop pedagogical frameworks that integrate the principles of paidia and metapoiesis into the educational curriculum. This can include creating study programs that allow students to explore and experiment freely, as well as implementing assessment methods that value the learning process as much as the outcome. These frameworks can be adapted for different educational levels, from primary to university education, ensuring that the principles of paidia and metapoiesis are incorporated integrally into the educational experience.

5.2 Exploration in Various Professional Fields

The application of paidia and metapoiesis is not limited to the educational sphere. These principles can be applied in a variety of professional fields, from engineering and design to medicine and business administration. For example, in engineering, teams can use free play methods to explore new solutions to technical problems, while in medicine, professionals can employ these principles to develop innovative approaches to patient care. By fostering a culture of experimentation and exploration, significant advancements can be achieved in various fields.

5.3 Interdisciplinary Research Promotion

Promoting interdisciplinary research is crucial for fully understanding the implications of paidia and metapoiesis. By bringing together perspectives from different disciplines, such as psychology, education, technology, and the arts, we can gain a more comprehensive view of how these principles can be effectively implemented. This research can explore how different cultures and societies approach creativity and innovation, providing a global framework for the application of paidia and metapoiesis.

5.4 Creation of Spaces and Experiences

A promising future direction is the creation of spaces and experiences that foster creative emancipation through paidia and metapoiesis. This can include the creation of innovation labs, creative workshops, and collaborative spaces where individuals can explore and experiment freely. These spaces can be designed to facilitate

interdisciplinary collaboration and experimentation, providing an environment conducive to the development of new ideas and solutions. Additionally, immersive experiences, such as game jams and hackathons, can be used to foster creativity and innovation in a structured yet flexible context.

6. Final Thoughts

The integration of paidia and metapoiesis in educational and workplace settings provides a robust framework for fostering creativity, innovation, and emotional well-being. Through free play, individuals are allowed to explore and experiment without the limitations imposed by rigid structures, which is essential for developing critical skills and creative problem-solving abilities. Metapoiesis, by going beyond traditional forms and functions, complements this creative freedom by fostering a mindset of continuous exploration and discovery (Dreyfus and Kelly, 2011).

Furthermore, this approach rehumanizes our relationship with technology, countering the "tyranny of software" that can restrict creativity (Manovich, 2013). By implementing pedagogical frameworks that value both the learning process and outcomes, and by fostering work environments that promote innovation through paidia, individuals can be prepared to face the challenges of the 21st century with adaptability and originality. Ultimately, the synergy between paidia and metapoiesis opens new frontiers for creative emancipation and innovation in a world that is increasingly complex and technologically advanced.

This approach to paida can be effectively integrated into classroom settings by encouraging students to engage with their digital tools in an unstructured and exploratory manner. Rather than directing students towards specific outcomes, educators can create a space where the instruction is simply to "play with your tools as you wish." Students are then invited to produce any form of output, whether it aligns with conventional expectations or not. The key lies in guiding them through the process—offering support and feedback—but without pointing them towards a predetermined outcome. By allowing students to reflect on their learning experiences and share their results with the class, this method fosters creativity, self-directed learning, and critical reflection. Such an approach not only enhances technical skills but also empowers students to discover new ways of thinking through the act of free play.

Declaration of Interest

This is to acknowledge that the authors report there are no competing interests to declare.

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Impact of LEGO® Based Therapy on Skills Development and Quality of Life in People With Neurodevelopmental Disorders

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Abstract: This research sets out to evaluate the impact of LEGO® Based Therapy on the development of skills and quality of life for people with neurodevelopmental disorders, as well as for those close to them. Widely used in the United States and the United Kingdom for almost 20 years, LEGO® Based Therapy was developed by Daniel Le Goff, psychologist licensed in Florida and New Jersey who has practiced for over 20 years with children, adolescents and adults with developmental disabilities, including autism, Asperger's syndrome and congenital disabilities, as well as acquired and traumatic brain injuries. Daniel Le Goff has extensive experience as a consultant and expert witness, as well as in direct clinical services, including applied behaviour analysis, cognitive behaviour therapy and cognitive rehabilitation. In 2008, Gina Gómez de la Cuesta completed her PhD at the Centre for Autism Research at the University of Cambridge, where she led and evaluated LEGO®® Based Therapy under the supervision of Daniel LEGO®ff, Simon Baron-Cohen and Ayla Humphrey. She is a teacher and psychologist by training and has worked at the National Autistic Society as Head of Action Research. She founded Play Included in 2018, with support from the Cambridge Social Ventures incubator programme, University of Cambridge to support children's development through play and promote LEGO®Therapy.

Initially designed to improve the social skills of people with autism spectrum disorders but no intellectual disabilities, its effectiveness has been demonstrated by studies targeting this specific population. However, no research has yet been carried out in France on its application to a wider population, including various forms of neurodevelopmental disorder. Furthermore, existing studies have not considered the impact on the quality of life of beneficiaries and their families, which this thesis sets out to examine.

Keywords: Neurodevelopmental Disorders, Therapy, LEGO®, Quality Of Life, Social Skills, Interactions.

1. Previous Studies

LEGO® Based herapy is a social skills intervention for school-aged children based on LEGO® collaborative play. It is based on the idea of using the child's natural interests to motivate learning and behaviour change. A typical LEGO® therapy project involves building a LEGO®® game, with a social division of labour. In a group of three people (which can be made up of autistic children, peers and/or adults), one person is designated as the 'engineer', another as the 'supplier' and the last as the 'builder'. Individuals must communicate and follow social rules to complete the LEGO® construction. Each activity requires verbal and non-verbal communication, collaboration, joint problem solving, joint creativity and joint attention to task.

The idea of using LEGO® as a therapeutic tool in a structured and comprehensive way arose from a chance observation in the mid-1990s. Dr Daniel Le Goff noticed two of his patients, both aged eight and diagnosed with Asperger's syndrome, playing and chatting enthusiastically in his waiting room. These two children, previously reluctant to interact socially, showed a sudden and marked interest in each other thanks to their shared passion for LEGO®.

Faced with this promising clinical observation, Daniel Le Goff initiated an initial short-term study in the United States in 2004 to demonstrate the benefits of LEGO®-based therapy. He divided 47 individuals into five groups of seven and two groups of six, who received 60 minutes of individual therapy and 90 minutes of group therapy weekly for 12 or 24 weeks. Of these participants, 34 were boys and 13 girls, aged between 6 and 16.

Various scales were used, such as the Gilliam Autism Rating Scale (GARS-SI), the Vineland Adaptive Behaviour Scale (VABS) and the Wechsler Intelligence Scale for Children (WISC-III). The results showed a marked improvement in social skills, social contact, duration of social interactions, social behaviour, social cognition, and verbal and non-verbal language.

In 2006, Daniel Le Goff teamed up with Sherman to carry out a longer-term study involving 60 subjects who had received individual and group LEGO® therapy and 57 subjects who had undergone conventional therapy. All the participants, diagnosed with autism spectrum disorder (ASD), received 60 minutes of individual therapy and 90 minutes of group therapy per week for 36 months. The same assessment scales as in the first study were used, showing that the LEGO® therapy group showed significant improvements in social skills, a reduction in maladaptive behaviour, better communication and improvements in verbal and non-verbal language over the 36 months, unlike the group without LEGO® therapy.

In 2008, UK doctoral student Gina Owens compared the effectiveness of LEGO® therapy with the Social Use of Language Programme (SULP). The study involved 47 children, divided into three groups: 16 receiving LEGO® therapy, 15 SULP training, and 16 forming a control group. All were diagnosed with ASD and received 60 minutes of weekly intervention for 18 weeks. Several scales, such as the Vineland Adaptive Behaviour Scale (VABS), the Wechsler Abbreviated Intelligence Scales, the Gilliam Autism Rating Scale (GARS), the Spence Child Anxiety Scale, the Child Behaviour Checklist and the Conner ADHD Index, were used. The results showed that LEGO® therapy improved interaction, socialisation and communication, while the SULP programme reduced maladaptive behaviour.

Since these three landmark studies, around ten others have been carried out in the United States, the United Kingdom and the Netherlands. Nine have focused on individuals with autistic disorder, while only one has looked at those with ADHD. Of these ten studies, eight showed moderate or high improvement in social skills following the implementation of LEGO® therapy. Two of them, which proposed a robot-mediated LEGO® intervention, showed no significant improvement after the sessions.

As part of our study, we addressed the following research questions:

1. **Effectiveness of LEGO® therapy on adults :** what are the effects of LEGO® therapy on adults, compared with its effectiveness on children and adolescents?
2. **Applicability of LEGO® therapy to other neurodevelopmental disorders or disabilities** : to what extent can LEGO® therapy be adapted and effective for subjects with neurodevelopmental disorders other than ASD, such as ADHD or dys, as well as for people with other disabilities ?
3. **Assessment of beneficiaries using alternative tools to the VABS** : can we find an alternative assessment tool to the Vineland Adaptive Behaviour Scales (VABS) to measure progress and changes in people receiving LEGO® therapy, while maintaining a similar level of validity and reliability
4. **Impact of LEGO® therapy on patients' quality of life** : what are the effects of participation in LEGO®® therapy sessions on the subjective quality of life in terms of emotional well-being, social relationships and perceived relationships and perceived autonomy?

2. Development of LEGO® Based Therapy in France

Despite its international success, LEGO® therapy remains relatively unknown in France and is not well integrated into local therapeutic practices. I thought it would be interesting to explore the potential positive impact of this therapy in our country, as well as its effect on participants' well-being.

However, envisaging an exact replication of the initial study seemed compromised for several reasons:

- Professionals needed to be trained in the use of assessment scales such as the Vineland Adaptive Behaviour Scales (VABS) and the Gilliam Autism Rating Scale (GARS) to ensure accurate and consistent assessments, thus minimizing bias and guaranteeing the reliability of the data, as these assessment tools are expensive and difficult to access, sometimes reserved for certain professionals, thus creating financial and practical obstacles for institutions and families;
- The majority of participants had Autism Spectrum Disorder, but this is not the only neurodevelopmental disorder, suggesting that LEGO® therapy could be effective with other populations (for people with ADHD, intellectual disabilities or dyslexia, for example, as these are also neurodevelopmental disorders);
- Quality of life had never been studied in previous research carried out abroad.

Given the positive results of the studies carried out abroad and mentioned above, it seems crucial to facilitate access to this therapeutic model so that it can help a large number of people in France.

To overcome these obstacles, we decided to create a dedicated training module including an evaluation grid developed specifically for this therapeutic tool. The grid covers 4 areas of skills: pre-construction, construction, language and vocabulary, and social skills. This would make it possible to train as many people as possible so as to include as many participants as possible in the study.

The main idea being the possibility of adapting LEGO® Based Therapy to meet the needs of people with neurodevelopmental disorders other than ASD, such as attention deficit hyperactivity disorder (ADHD) or dys disorders, as well as people with other disabilities. Dys disorders are specific cognitive disorders affecting skills such as reading (dyslexia), writing (dysorthographia), arithmetic (dyscalculia), coordination (dyspraxia) and language (dysphasia), unrelated to a general intellectual disability. This exploration will help determine the

extent to which LEGO® Based Therapy can be modified to be inclusive and accessible to a wider range of beneficiary populations.

In addition, there was the question of evaluation by proposing other alternative tools to the Vineland Adaptive Behaviour Scales (VABS), while maintaining a similar level of validity and reliability.

Finally, we wanted to study the impact of LEGO® Based Therapy on the subjective quality of life of beneficiaries, focusing on the dimensions of emotional well-being, social relationships and perceived autonomy.

3. Method

Our study involved French subjects only. Our aim was to gather a sufficient number of participants, children, adolescents and adults, in order to have a fairly significant sample and thus make this study reliable.

Recruiting a large number of participants who would be assessed and trained by just one person seemed compromised by the number of sessions involved and their duration.

We therefore created a training module that incorporated both the fundamental principles of LEGOTherapy and new and enriching perspectives from our professional practice, creating a dynamic and comprehensive educational content that would provide participants with an in-depth understanding of LEGO® Based Therapy whilst offering innovative and practical ideas for their own work in this field.

This 15-hour course has been developed to be delivered in several formats: face-to-face, synchronous distance learning and asynchronous distance learning. In the case of asynchronous distance learning, it also includes two live discussion sessions of 1.5 hours each in order to answer participants' questions. At the end of each module, trainees are invited to complete various activities and MCQs to check their understanding of the concepts taught. These tasks include designing practical tools and activities and planning future LEGO® Therapy sessions.

Each trainee receives an individual assessment of their work, with the opportunity to receive personalised advice if necessary. The main aim is to ensure that trainees acquire the knowledge they need to be competent and autonomous in the practice of LEGO® Therapy once in the field. By offering detailed feedback and personalised advice, we aim to support each participant's professional development and ensure that what is taught is put into practice effectively.

As part of the practical application of LEGO® Therapy, the trainees were given the task of conducting either individual or group sessions, adapting to the different audiences they encountered according to the types of support they usually offer. This approach involved several inseparable stages.

Firstly, the learners had to gather relevant information about each individual being assessed, which enabled them to gain a better understanding of their specific needs and challenges. Secondly, a preliminary assessment was carried out before the start of the sessions using the grid I produced, providing a baseline against which progress could be measured over time.

Planning the sessions was also an important stage, requiring thought to be given to the objectives to be achieved and the activities to be put in place to achieve them. This often involved preparing or even creating specific material adapted to the needs. Once the LEGOTherapy sessions were underway, the learners were responsible for running them with professionalism and sensitivity, taking care to create a safe and stimulating environment for the participants.

Finally, a reassessment was carried out after a certain number of sessions in order to measure the progress made and, if necessary, adjust the objectives and activities for the following sessions.

At the same time, each caregiver was asked to complete the PedsQL scale before and after each session. This scale was used to assess the quality of life of the beneficiary and their family, providing an objective measure of the impact of LEGO® Therapy sessions on their overall well-being.

4. Results of the Study

The study was conducted over 2 years, between 14 February 2022 and 9 June 2024. During this period, 317 learners were trained and a total of 76 practitioners, including both parents and professionals, implemented LEGO® Therapy with the service users they supported. Of these practitioners, 21 conducted group sessions involving 72 subjects, while 55 offered individual sessions with 55 subjects.

The subjects evaluated, aged between 5 and 88, presented with a variety of disorders, including neurodevelopmental disorders, psychological disorders and degenerative conditions. I will describe the different groups of participants and the scores they obtained below.

Some of the data collected proved unusable. In particular, the data from 19 practitioners could not be used (16 from the group sessions and 3 from the individual sessions). Reasons for this included incomplete evaluation grids or the absence of reassessments necessary to measure progress.

Consequently, the results presented in this study will be based on a final sample of 108 subjects: 56 participants who took part in group sessions and 52 who took part in individual sessions. This selection guarantees the reliability and validity of the conclusions drawn from the study, by ensuring that all the data analysed comply with the rigorous methodological criteria established for this research.

The data reveal a predominance of children aged 8 to 12 benefiting from LEGO® Based Therapy sessions, whether in individual or group sessions. However, an interesting observation emerges when comparing the two types of session: in individual sessions, there is a more marked presence of children aged between 5 and 7, while adolescents aged between 13 and 18 are less represented. In group sessions, on the other hand, there were more teenagers aged 13 to 18, and fewer children aged 5 to 7. It is also noteworthy that no participants over the age of 25 attend group sessions, while a few attended individual sessions. It should also be noted that the 2-4 age group is not represented in this study, and that the 18-25 age group is under-represented.

Let's now move on to analysing the progress made after a LEGO® Based Therapy session by looking at the scores obtained by each age group, across all disabilities, individually and in groups. To do this, we will calculate the average points gained per age group in order to better understand the impact of LEGO® Based Therapy on these different groups.

Among children aged 5 to 7, we observed that pre-construction skills and social skills progressed more in groups than in individuals. On the other hand, language and vocabulary skills showed greater progress in the individual group than in the group. As for construction skills, they progressed in a similar way in both groups and individuals.

For young people aged 8 to 12, pre-construction skills, construction skills and social skills progressed fairly similarly, whether the sessions were conducted in groups or individually. However, progress in the area of language and vocabulary was more significant when the sessions were conducted in groups.

Among adolescents aged 13 to 18, progress in the areas of language, vocabulary and pre-construction was similar, whether the sessions were conducted in a group or individually. However, social and construction skills showed more significant progress in group sessions.

For young adults aged 18 to 25, progress was more significant in individual sessions, whatever the domain.

For the over-25s, no comparison was made between individual and group sessions, as this group did not participate in group sessions.

These initial data show that individual sessions appear to be more effective for young adults aged 18 to 25, as well as for children aged 5 to 7, particularly for improving language and vocabulary skills. For the other age groups, and in all the areas assessed, group sessions appear to be more beneficial.

I then examined the benefits of LEGO® Based Therapy sessions, both individual and group, depending on the type of disability or difficulty of the beneficiary.

In the case of individual sessions, we observed the following trends:

- Pre-construction: subjects suffering from epilepsy, dementia or ADHD associated with another pathology make greater progress in this area.
- Construction: the greatest progress is made by subjects with dementia, ADHD associated with a Dys disorder or another pathology. On the other hand, people with ADHD associated with IDD make slower progress;
- Language and vocabulary: the most significant progress was observed in people with ADHD and IDD, epilepsy, or autism spectrum disorder (ASD);
- Social skills: subjects with a Dys disorder or epilepsy make less significant progress, while those with ADHD associated with a Dys disorder, dementia or simply ADHD make considerable progress.

In group sessions, we observe the following trends:

- Pre-construction: subjects suffering from ADHD associated with another pathology, or ADHD or another pathology alone make greater progress in this area;
- Construction: the greatest progress is made by subjects with ADHD associated with another condition and by people with ASD;
- Language and vocabulary: subjects with ADHD associated with another pathology, or with ADHD or another pathology alone make greater progress in this area;
- Social skills: subjects with another pathology, Down's syndrome and ASD make considerable progress in this area.

It should be noted that people with schizophrenia who took part in group workshops made the least progress. This is not necessarily linked to their condition. In fact, these subjects obtained very high scores during the first evaluation, which could indicate that the proposed grid is not adapted to their level, as their skills were already sufficiently high.

5. Quality of Life Study

Secondly, I used the PedSQL scale to measure the beneficiaries' quality of life. This measurement tool is mainly used in medicine to assess health-related quality of life in children and adolescents. Developed by Dr James W. Varni and his colleagues, this scale consists of specific questionnaires adapted to different age groups, making it possible to assess different aspects of the daily lives of children and adolescents, including their physical, emotional, social and academic functioning. The questionnaires are designed to be completed by the children themselves or by their parents, depending on the age and ability of the respondent. Responses are scored on a multi-point Likert scale. The scores obtained provide an overall measure of the child or adolescent's health-related quality of life, as well as individual scores for each dimension, offering a more in-depth understanding of their overall well-being and specific needs.

In the course of our study, 37 professionals had the PedSQL scale completed by the people they cared for and their families, representing a total of 67 subjects. Of these, 40 took part in group sessions and 27 in individual sessions.

For the individual sessions :

- 9 children completed the 5-7 years grid
- 12 children completed the 8-12 years grid
- 5 adolescents completed the 13-18 grid

For the group sessions :

- 9 children completed the 5-7 years grid
- 17 children completed the 8-12 grid
- 4 teenagers completed the 13-18 grid

Some data could not be used. A group of four people and one individual who attended the individual sessions were over 25 years old, and there was no adapted grid for their age. In addition, two professionals were unable to assess two young people in individual sessions because they were non-verbal and, despite adaptations, they were unable to communicate their feelings. Finally, three professionals who offered individual sessions did not reassess the young people or their parents at the end of the session.

In our analysis, we focused on the scores obtained on the PedSQL scale during the reassessment after the sessions, distinguishing between individual and group sessions and differentiating between the opinions of the children and their parents for each area of the grid.

The data analysed in this study are based on the feelings of children and their parents, as assessed by the PedSQL scale. This feeling, which is crucial to understanding the impact of interventions, encompasses various aspects of children's quality of life, such as their physical, emotional, social and academic well-being. Children's perceptions offer a direct and personal perspective on their own experience, while their parents' perceptions provide a complementary, often more global and observational, view of the changes perceived in their children. By analysing these perceptions separately, it is possible to gain a clearer picture of the effectiveness of the sessions, whether group or individual, and to identify the areas where the interventions have been most beneficial or where adjustments are needed. The feelings of children and their parents, although subjective, are

an essential dimension in assessing the results of support programmes and in guiding future professional practice.

Overall, whether the sessions were conducted individually or in a group, and whatever the age of the children, we observed improvements in all areas. However, when broken down by domain, it appears that the children who attended individual sessions reported a moderate improvement in the physical and academic domains. Indeed, a significant proportion of subjects observed no change before and after the sessions in these two areas. On the other hand, over 70% of the individuals questioned reported a significant improvement in the areas of emotions and social relationships.

The parents of children who had attended individual sessions seemed to have more mixed feelings than their children. In the physical and social areas, a significant proportion of parents did not observe any significant change after the sessions. However, more parents noted improvements in the academic and emotional areas. These observations suggest that, although parents perceive benefits from the interventions, these are felt more in the emotional and academic aspects of their children's lives, rather than in their physical and social well-being.

This divergence in perception between children and parents highlights the complexity of measuring the impact of interventions and the importance of including the perspectives of all those involved in order to obtain a complete and nuanced view of the effects of the sessions.

6. Discussion

The results of our study show that, regardless of age or type of disorder or pathology, all audiences benefit from LEGO® Based Therapy sessions. Participants, whether children, adolescents, young adults or adults, show significant progress thanks to this model.

Although some groups progress more rapidly than others, the overall data confirm the effectiveness of LEGO®-based therapy in improving various skills, such as pre-construction, construction, language, vocabulary and social skills. These results underline the importance and versatility of LEGO® -based therapy as a therapeutic tool for a wide variety of profiles and needs.

Concerning the assessment of participants' quality of life, children who had benefited from group sessions felt an overall improvement in every area, with fewer areas where they observed no change. Over 80% of individuals reported an improvement in the area of emotions, over 70% saw an improvement in the area of social relations, and over 65% perceived progress in the area of schooling.

Parents of children who had benefited from group sessions were more likely to agree with their child. Over 70% saw an improvement in emotional skills, and over 65% saw an improvement in social and academic relationships.

These results underline the importance and positive impact of the interventions, from both the children's and their parents' point of view, on the emotional and social dimension of children's lives, aspects that are often crucial to their overall development and well-being.

Group sessions have a more favourable impact on children's development, particularly in the areas of emotions and social relationships. The children taking part in these sessions feel significant improvements in these areas, with over 80% reporting an improvement in their emotional state and over 70% observing improvements in their social relationships. This perception is also shared by the parents, who see similar progress in their children, confirming the effectiveness of the group sessions. However, the individual sessions also showed significant progress in these areas, although the perceived improvements were slightly less pronounced. This shows that, although group sessions are particularly beneficial for children's emotional and social development, individual interventions remain effective and also make a positive contribution to these essential aspects of their quality of life.

With regard to the rating scale, although we have previously established graded rating criteria that enable us to automatically calculate a base score and an evolution score, the assessment does not allow us to know whether or not there is a problem.

Indeed, to establish an appropriate rating, it is important to determine in advance the prompts to be presented to the person being assessed. These prompts are essential if we are to support people with special needs.

Prompts are defined as instructions, gestures, demonstrations, guidance or prompts that we offer to increase the likelihood of a correct response. The use of prompts offers many advantages, not least helping students to progress by encouraging their learning.

Furthermore, during training sessions or when completing the grid, learners have told us that they don't always know whether they should take into account the denomination or the receptive. It's important to clarify this distinction to avoid any confusion. Naming refers to the act of naming or designating something accurately, using exact and appropriate terms. This includes the ability to identify concepts, objects or situations and to express them clearly and comprehensibly. Receptive, on the other hand, refers to a person's ability to receive, understand and interpret information transmitted by others.

Some areas of the grid could be evaluated taking into account both receptive and naming. However, only one box is provided for scoring, and I haven't specified how to proceed in this case. Let's take the “Language and Vocabulary” domain as an example: do numbers need to be known in order to be recognized, or do they need to be named? Ideally, both, but the current grid does not allow these two aspects to be rated separately.

Finally, some participants, depending on their age or pathology, already validate a majority of skills during the first assessment. For these participants, the aim is to work on more specific and detailed skills than those currently offered.

The grid will therefore have to be updated to take these elements into account, and to refine the results and objectives to be worked on.

7. Conclusion

The study carried out in France, with a sample of French participants only, confirms that it is entirely feasible to offer an alternative assessment tool that is accessible to the general public. The results show that participants who benefited from LEGO® Based Therapy sessions showed significant progress, both in individual therapy and in groups, regardless of their disability or pathology.

In addition, quality of life assessments revealed a significant improvement in the well-being of both the participants and their parents. These findings reinforce the idea that LEGO® Based Therapy may be a promising and beneficial therapeutic approach that deserves to be more widely integrated into clinical practice in France.

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Investigating the Role of Adaptivity in Video Games for Attitude Change

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Abstract: Video games have become one of the most widespread forms of media in the 21st century, bringing interactive digital narratives to over 3 billion people globally. Like other media, video games feature topics from our society, culture, and history. Research has shown that narrative-driven video games have a unique potential to influence explicit and implicit attitudes toward the topics they depict. However, the concrete mechanisms through which video games shape our attitudes remain unclear. Identifying the mechanisms behind the attitude-shaping effect would help to design more effective educational games and simulations. One aspect that reduces the potential of video games to change attitudes is a so-called credibility bias, a phenomenon where information contradicting one's pre-existing beliefs is deemed less credible. For this reason, our work focuses on employing adaptivity to improve the attitude-shaping effect of video games. We hypothesize that adapting gameplay elements based on players' pre-existing attitudes will mitigate the credibility bias, leading to greater attitude changes and enhanced game enjoyment compared to a static presentation. We propose assessing players' attitudes before playing and adapting the game content accordingly, utilizing in-game metrics to track players' actions to further refine the content. This work focuses on adapting highlights in user interfaces, narrative-related messages, and in-game goals. To empirically test our hypothesis, we have developed two versions of a video game – an experimental version featuring adaptive game elements and a control version with static content. For this proof-of-concept experiment, we have chosen the topic of electromobility, but we designed the adaptive elements to be usable with any topic. The experimental game is a delivery manager simulator featuring electric and combustion engine cars, with the aim of showcasing the usability and advantages of electric cars. Our experimental design involves a pretest-posttest setup with an experimental and a control group. We utilize measures for implicit and explicit attitudes and game enjoyment. This empirical study will bring valuable data reacting to the identified research gap. Should the adaptive approach prove to be usable, it could be widely utilized to improve the attitude-shaping potential of educational games.

Keywords: Game-based Learning, Video Games, Implicit and Explicit Attitudes, Persuasive Games, Attitude Change, Adaptivity

1. Introduction

Video games are no longer just entertainment products. They increasingly address real-world topics from our culture, history and society (Muriel and Crawford, 2018). Enough empirical evidence exists to support the idea that video games have the potential to affect our attitudes toward the topics they depict (Kolek et al., 2023). This makes games arguably one of the most important forms of informal education media, as they might significantly influence popular culture representations of violence, stereotypes, conflicts, or history, among other things.

However, not every game designed to change attitudes has the desired effect, as evidenced by several studies examining the impact of video games on attitude change. Both positive and negative findings regarding the potential of games to affect attitudes have been reported (Kolek et al., 2023). One of the reasons that some games do not shape attitudes as intended might be a phenomenon referred to as credibility bias, which makes us perceive information from a source that we do not trust or do not view favourably as less credible (Pornpitakpan, 2004). We also tend to deem information conflicting with our beliefs as less credible and vice versa. Such phenomenon is known as motivated reasoning (Epley and Gilovich, 2016).

As research has shown that the credibility of the source of a message impacts the resulting attitude and behaviour change, and that information perceived with high credibility has greater attitude change potential (Flanagin and Metzger, 2020), the aforementioned phenomena make it challenging for games for attitude change to convey their message in a way that achieves the desired attitude change.

We propose adapting a game's persuasive content based on players' initial attitudes to mitigate credibility bias. To our knowledge, adaptive persuasive content in the context of games for attitude changes has not yet been investigated before, especially in relation to its potential to overcome credibility bias. This makes our study a first-of-its-kind experiment to employ this technique in a game's design and to gather data on the phenomenon.

This work presents the experiment design of a planned empirical study. We will present the experimental games that have been developed, the design of the experiment, our game design solutions to implementing adaptivity for persuasive content, and the design strategies that allow the usage of our methods for other game genres and attitude-bearing topics.

If our initial results are positive, we will conduct further studies, testing the approach with more topics, game genres, and target groups. The adaptive approach could, as a result, prove very useful in educational games that target socially sensitive topics (e.g., a game for peace-making among two parties of a conflict). It might also be a powerful tool for games for attitude change in general.

1.1 Hypotheses

We hypothesize that games gradually providing players with attitude-related information based on their initial attitudes will lead to more significant attitude changes and to greater enjoyment compared to games providing players with intensive attitude-related information from the beginning.

Hypothesis 1. *The adaptive version of the game will cause greater positive explicit attitude change towards electromobility than the static version, especially for players with negative initial attitudes.*

We expect that tuning down the persuasive content for players with negative and neutral initial attitudes towards electromobility will reduce the otherwise highly induced credibility bias, which will, in turn, help to accept new information about the topic (Flanagin and Metzger, 2020).

Hypothesis 2. *The static version of the game will cause greater positive implicit attitude change toward electromobility than the adaptive version.*

We do not expect the adaptive version to enable greater implicit attitude change than the static version because implicit attitude changes are mediated mainly by frequent co-occurrences of concepts with positive values, and electromobility will more frequently occur with positive values in the static version (Gawronski, 2022).

Hypothesis 3. *The adaptive version of the game will be more enjoyable than the static version.*

We expect players' enjoyment to increase when the game's content and roles are better aligned with their attitudes, as previous research confirmed increased enjoyment when players identify themselves with the character or the role offered by the game (Hefner, Klimmt and Vorderer, 2007; İskender, 2023).

2. Theoretical Background

When discussing one's thoughts, we use the term attitude to talk about the evaluation of an object of thought (Vogel and Wänke, 2016). The important feature of attitudes is that they tend to view the object positively or negatively, thus giving us a form of assessment. As attitudes play an important role in how we process information, they influence how we shape our views of the world (Pratkanis, 1989).

We use the Associative-Propositional Evaluation model (APE model), which was reported to be the most prominent dual-process theory of evaluative learning, in the design of our experiment (Hütter, 2022). The model distinguishes between explicit and implicit attitudes. Explicit attitudes involve reasoned evaluations based on information we already have available, leading to logical conclusions about an object of thought. Such attitudes can change when new information challenges existing beliefs, prompting a reassessment (Gawronski and Brannon, 2019). Explicit attitudes are measured using self-reported questionnaires.

The fundamental means of altering explicit attitudes is by processing information associated with the object of that attitude. But when we encounter information that contradicts our existing attitudes, it influences our assessment of the source's credibility. In cases where the information conflicts with our attitudes, we tend to perceive the source as less credible. If the information aligns with our attitudes, we might perceive the source as more credible and devote it more time (van Strien et al., 2016; Brannon, Tagler and Eagly, 2007). This phenomenon is known as credibility bias, and it typically leads to the formation of filter bubbles and polarization in society (Spohr, 2017).

Implicit attitudes are immediate affective responses based on associative evaluations and their structure in our memory (Hütter, 2022). The associations we recall concerning an object of evaluation influence the resulting response. The associations recalled may depend on the context of the information (Gawronski, 2022). They are typically measured using response time measurements (Greenwald, McGhee and Schwartz, 1998).

Implicit attitudes are formed mainly by stimuli co-occurrences. The quantity and frequency of these co-occurrences in our life and socio-cultural environment shape our implicit biases (attitudes). If a stimulus is often encountered in relation to another stimulus, which we perceive positively, we start associating the first stimulus with a positive response. Our implicit attitudes do not necessarily reflect what we consider right. To some extent, our implicit attitudes contribute to our behaviour and decision-making. It was shown that implicit attitudes can be influenced by stimuli co-occurrence (Gawronski, 2022).

Video games can present attitude-related information and, as such, can play an important role in attitude changes. The most recent meta-analysis by Kolek et al. (2023), which focused on narrative video games' effect on players' attitudes, identified that narrative video games can affect players' explicit and implicit attitudes.

Narrative video games incorporate storytelling elements into the gameplay, allowing players to interact with the narrative, shape outcomes through their actions, and become immersed in the game world (Kolek et al., 2021; Smethurst and Craps, 2014). It was shown that narratives, compared to non-narrative formats, reduce audience resistance towards changes in beliefs, attitudes, intentions and behaviour, with narrative engagement being pointed to as one of the possible factors (Ratcliff and Sun, 2020).

However, although it was proven that video games, especially narrative ones, have a significant potential to alter players' attitudes, not every game alters them towards the topics that it presents (Kolek et al., 2023). Therefore, it is important to determine the key game elements responsible for attitude change. One option is that the key element is the experience of playing the game itself, which would make flow, immersion and engagement the key elements for attitude change (Tussyadiah, 2018). Another option is that it is a game mechanic, or a combination of a few, which determines the persuasion potential (Orji, Vassileva and Mandryk, 2014). It is also possible that the respondents' characteristics influence the resulting attitude change, but a study by Kolek et al. (2024) did not confirm this. Identifying the elements responsible for attitude change is a key task for the whole game-based learning area, which is experiencing significant growth in recent years (Allied Market Research, 2022).

2.1 Adaptive Video Games

There currently exist many adaptive learning systems (Kabudi, Pappas and Olsen, 2021) that utilize a wide variety of AI methods and change the educative content based on a student's individual needs, e.g., by adapting the difficulty of the content and the hints provided (Hooshyar et al., 2021), but adaptive games for attitude change are mostly in their beginnings.

A serious game by Bjørner (2023) uses Dynamic Difficulty Adjustment in a game about ocean pollution, but the only measure is how successful the players are at the game and only the game's difficulty is tweaked. There is no adaptivity of the persuasive content.

Regarding persuasive content, Orji, Mandryk and Vassileva (2017) adapted a serious game's persuasive strategies to players' personality types, which was reported to improve the game's effectiveness in promoting positive attitudes. It also showcased that it is possible only to adapt the persuasive content while leaving gameplay unchanged. However, players' initial attitudes were not considered.

We did not find any work that adapts a game's persuasive content based on players' initial attitudes. This identifies a research gap our work aims to fill by bringing the experiment design to collect the first empirical data.

3. Experimental Games

3.1 Genre Selection

We needed to select a game genre that provided us with a lot of game elements that we could adapt to allow us to properly test our experimental approach and to discover which game elements are best suited for adaptation. We also wanted the game to alter between more and less intensive gameplay periods so that the player can get immersed but also has the opportunity to have a mental pause and to reflect on their choices.

The genre of a package delivery simulator game fits such needs because it provides us with several rounds of 1) managing a fleet of vehicles, possibly buying new ones, 2) the main gameplay, when the player sends their vehicles (with varying properties) to deliver packages, and 3) a level summary with various statistics. This gives

us numerous elements we can adapt and explore their effects on players, including round and bonus goals, vehicle properties, statistics highlights, pop-up tips, and many more.

Such a game also fits the need to alter intense gameplay with reports and management, as the main gameplay (sending vehicles to handle parcels) is interleaved with post-level reports and management of the player's vehicle fleet.

3.2 Topic Selection and Approach

We have searched for a socially sensitive topic towards which we can expect varying attitudes in the Czech Republic. According to a survey by the European Investment Bank in 2022, less than one-fifth of Czech residents is planning to buy an electric vehicle as their next one. A public opinion research conducted by the Ipsos agency earlier this year reported that compared to other EU countries, Czechs have the lowest interest in electromobility in the upcoming year.

Before designing the attitude-bearing content, we read news reports, motorsports magazines and scientific papers regarding electromobility. We also searched for electric car reviews and documentaries. These proved to be very insightful, as people mentioned their experience with daily electric car usage and the common issues regarding owning an electric vehicle.

3.3 Gameplay

The experimental game is a casual strategy game where the player takes on the role of a manager for a delivery service company. The game features several levels, with the main game loop being:

1. Manage your vehicle fleet – choose the vehicles to use in the next level, buy new ones at the mechanic, assign equipment to vehicles.
2. Play the level – control your vehicles on a map, pick orders up and deliver them to their target location. Ensure that sent vehicles are capable of carrying the given packages.
3. View a summary of the level – successful and failed parcels, income statistics, and the cost of maintenance and fuel/electricity.

Figure 1 shows an example of the main gameplay – the player planning delivery routes for their fleet of vehicles. Here, a car is on its way to pick up a package. We can see that the car has two free slots and the icons on the right showcase that this type of vehicle can carry packages and food.

Other vehicles in the game include motorcycles and vans. The vehicles differ in the amount and type of goods they can carry. All of the vehicle types feature both combustion and electric alternatives.

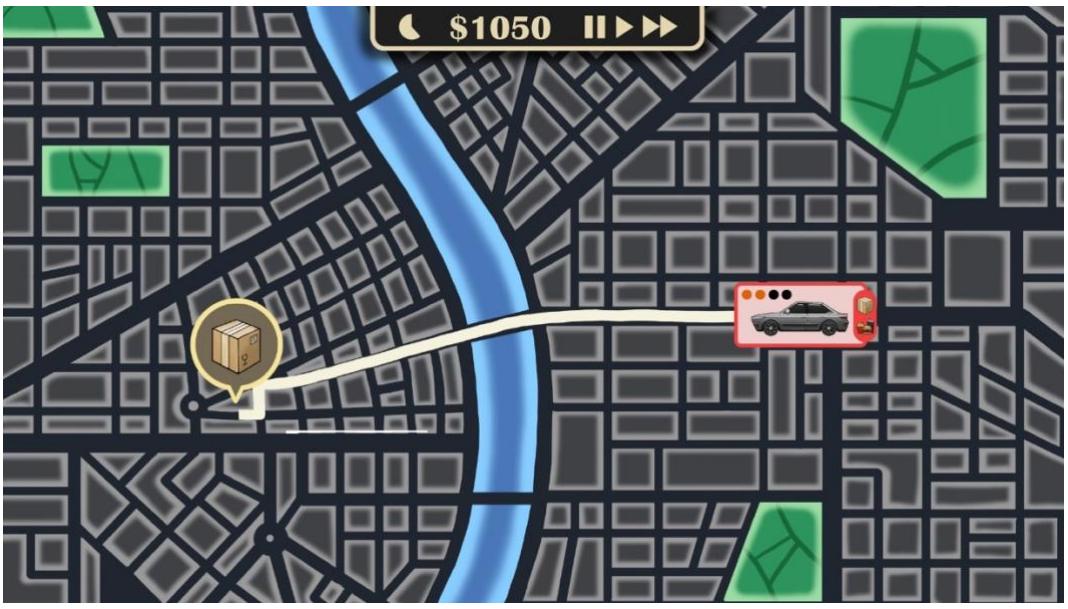


Figure 1: An example of level gameplay. We can see the remaining time, current earnings and time controls at the top.

3.4 Adaptivity

We first selected the game elements that we will adapt. The meta-analyses by Braddock and Dillard (2016) and Kolek et al. (2023) identified narrative games as generally more successful in attitude change. The meta-analysis by Kolek et al. further identified meaningful feedback and stereotyping as efficient persuasive game mechanics.

We choose the attitude-bearing, and thus the adaptive game elements, to be a) in-game goals (meaningful feedback); b) narrative messages; and c) UI highlights. Future work could include the addition of in-game dialogues or stereotyping of customers and rival companies.

We have decided to adapt the chosen elements in two ways – either alter their content or not include them in the game at all. For example, in the case of in-game goals, a bonus task to deliver a certain percentage of orders using electric vehicles may appear. The player would receive extra income for completing the task. To weaken the persuasive strength, we can omit the task altogether. To boost the persuasive strength, we might change the task so that the player gets penalized if the task is not completed successfully.

In the case of UI highlights, let us use the post-level report as an example. Here, we can include or hide a section about savings on money and CO_2 emissions thanks to electric vehicle usage.

Regarding the intensity of the attitude-bearing content, we use three levels for the pilot experiment. The levels are as follows:

a) **Max:** The content strongly promotes electric vehicles (e.g., the player gets penalized if electric vehicles are not utilized enough, or a mechanic in the garage tells the player that combustion engine cars are outdated).
b) **Mid:** The content lightly pushes the player to give electric vehicles a try to see their advantages (e.g., the player gets rewarded for using electric vehicles, or a mechanic tells the player to try using electric vehicles since they are cheaper to operate).
c) **Low:** The content very slightly hints at the advantages of electric vehicles to the player or presents great bonuses for using them (e.g., the player gets a huge reward for using electric vehicles, but the goal is optional, or a mechanic just slightly tosses in that the electric cars are cheaper to operate).

Future works may include more levels of attitude strength and adapting to specific topic concerns, i.e., focusing more on the issues of electromobility that the player is concerned about.

3.5 Experimental and Control Version of the Game

We have developed two versions of the game for our experiments. In the experimental (adaptive) version, the initial attitudes of players are considered, and the pacing of the game's attitude-related information adapts accordingly. If the initial attitudes of the player towards the topic are negative, the persuasive content of the game is tuned down (**Low** level from the previous section). If they are positive, the persuasive content is presented at full strength (**Max**). If they are mostly neutral, we present the **Mid** level of the content.

The control (static) version shows the attitude-related information without any adaptation to the players, always in full strength (**Max**).

Figure 2 shows an example of how the UI content is adapted. To tune down the persuasive content, a section of the report table, which contains information about the amount of money and the CO_2 emissions saved (the green one on the right), can be hidden (**Min**). On the other hand, if the persuasive content is shown at its maximum (**Max**), the section is present, the benefits are visually highlighted, and there is a hint emphasizing the advantage of electric vehicles.

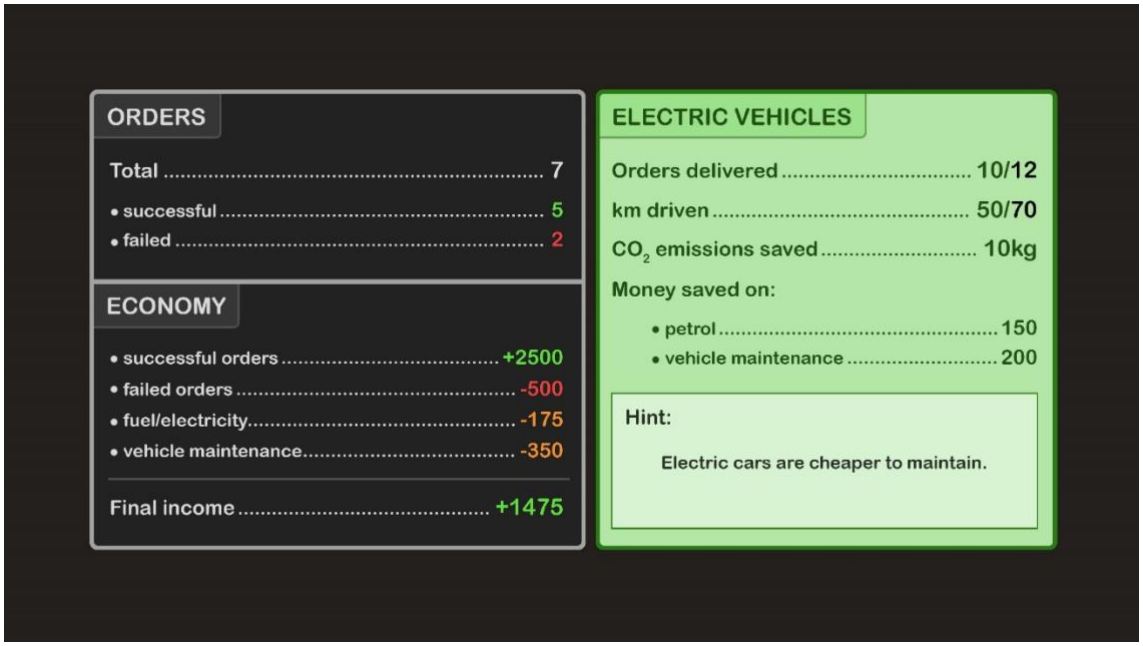


Figure 2: One of the adaptive elements is the user interface, which can adaptively show or hide a section of the post-level report that presents the benefits of using electric vehicles (the green one on the right).

Figure 3 shows the different information presented by the car dealership mechanic, an example of how the narrative messages that one can encounter are adapted. In a **Min** version (on the left), the mechanic provides an attitude-neutral tip for the game. In a **Mid** version (on the right), he tells the player about how he thinks that electric cars are the way to go.



Figure 3: The mechanic in the game's car dealership can provide the player with various tips, whose persuasive strength adapts to the player's initial attitudes.

Figure 4 shows how we adapt the attitude-bearing content of in-game goals. In the left example, the player is presented with a special subgoal to deliver a given number of packages using electric vehicles, which motivates the player to use electric vehicles, possibly even to buy more of them, as that might be required to fulfil the goal (this is a **Mid** setting of the persuasive content). In the example on the right, the player must use electric vehicles to avoid getting penalized (**Max** setting).

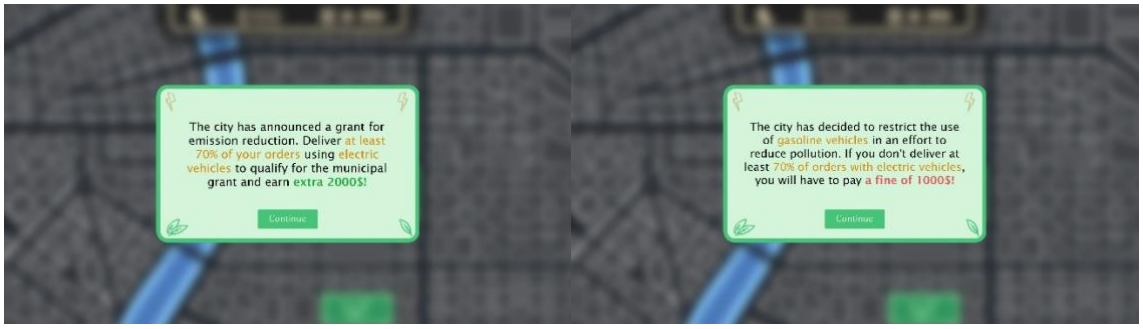


Figure 4: Examples of how the in-game goals adapt to player attitudes.

4. Experiment Design

This chapter describes the planned intervention and the tools we will use. We will introduce our target participants and the experimental and control intervention design.

4.1 Participants

For the pilot experiments, we will gather participants among university students, who will be rewarded with a course credit for their participation. Further experiments might include paid respondents. As we will be testing for the difference between our experimental and control intervention, we set the optimal sample size of each group to 64. Such a number of participants is required to show a medium (Cohen's d = 0.5) between-group difference in effect size in attitude change, given a two-sample t-test with a significance level α set to 0.05 and power 1–β set to 0.80.

4.2 Measures

All of our measures will be collected electronically, as the questionnaires will be included in the game application. We combine self-reporting with the Implicit Association Test (IAT) (Greenwald, McGhee, and Schwartz, 1998), which is less susceptible to faking or self-presentation, because it is based on response time measurements.

Participants' explicit attitudes will be tested with self-reported questionnaires using 5-point Likert scales (Likert, 1932) (e.g., "Electric vehicles are cost-effective alternatives to traditional gasoline-powered vehicles.") and Semantic differentials (Osgood, Suci and Tannenbaum, 1957) (e.g., "How do you view the cost-effectiveness of electric vehicles compared to traditional combustion engine vehicles?" with a 5-point scale between two opposite adjectives: "Expensive" and "Cost-effective"). Both of these questionnaires will consist of 5 questions.

Implicit attitudes will be tested using IAT (e.g., tasking participants with pairing electromobility with positive attributes and combustion engine vehicles with negative attributes, then reversing the task). Participants' background information will be collected, including gender, age and the highest level of education. Participants' enjoyment will be measured using the Game User Experience Satisfaction Scale (Phan, Keebler and Chaparro, 2016).

4.3 Procedure

Figure 5 shows the experiment's procedure. We will first collect data about implicit and explicit attitudes. Implicit attitudes will be measured first because they are context-dependent. Then, we will collect basic demographic data and randomize our participants into experimental and control groups.

During the intervention, they will play the adaptive (experimental group) or the static (control group) version of the game for approximately 30-40 minutes. After that, we will collect data on implicit attitudes, explicit attitudes and enjoyment (GUESS). After the posttest, we will debrief the participants.

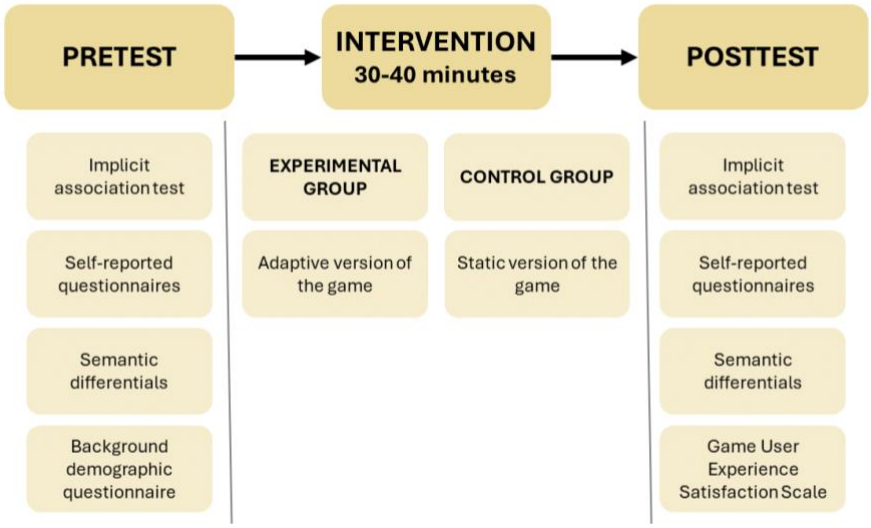


Figure 5: The experiment procedure.

4.4 Data Analysis

We will use two-sample *t*-tests to compare the two groups (experimental and control) in pre-post changes. Next, we will use regression models to analyse the influence of respondents' characteristics on their post-intervention attitude and enjoyment scores.

We will analyse the differences in attitude changes between the experimental and the control version to investigate whether adaptive content is more effective in influencing players' attitudes than static content. We will also examine the difference in enjoyment between the groups to answer our hypothesis that the adaptive version of the game will be more enjoyable.

5. Conclusion

We have identified a research gap in the game-based learning area regarding adapting a serious game's persuasive content to players' initial attitudes. Based on data available about credibility bias, motivated reasoning and games' effects on attitude change, we have designed the first study to validate the usability of adaptivity based on initial attitudes for improving the attitude-shaping effects of games.

Our approach was to choose a game genre that makes it possible to incorporate a wide range of adaptive game elements, which will allow us to validate out hypotheses. We selected a topic that ensures varying opinions among our target group, and we created the first game design approaches for implementing adaptivity in a game for attitude change. The study aims to bring unique insights to the whole game-based learning field.

5.1 Scalability and Future Research

The main goal of this study is to examine the effects of adapting all of the persuasive narrative elements present in the experimental game. Should the initial empirical data support our hypotheses, we will conduct further studies aimed at examining which game elements have the greatest effect. This will subsequently help to adapt this approach to other game genres, topics, and for respondents with varied demographic backgrounds. We aim to validate the approach's usability for both educational and commercial games.

To allow the usage of the adaptive methods designed for this study with other topics and game genres, we have strived to select the most common game elements as the adaptive ones to maximize the chance that the same game elements will be testable in other genres. Further, the adaptive mechanisms that we have developed, including narrative messages, user interface highlights, and in-game goals, are modular by nature, and it should be easy to integrate them into various game genres and thematic areas.

Acknowledgements

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Integrating Learning and Serious Game Design: The Development and Application of the Learning and Game Integration (LGI) Framework Using the 'Blackout' Serious Game

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Abstract: Serious games are increasingly recognised as effective educational tools capable of simulating complex scenarios that traditional methods cannot replicate. This paper introduces the Learning and Game Integration (LGI) Framework, designed to seamlessly integrate educational content with interactive game design. Utilising the "Blackout" serious game, which simulates real world complex problem, this study demonstrates how the LGI Framework can be utilised as learning intervention to enhance learning by teaching Design Thinking to university students. The framework consists of four stages: Educational Content Integration, Theoretical Underpinning, Case Study Selection, and Game Design. The "Blackout" game enables students to engage with various stakeholder perspectives, deeply analyse problems, and develop innovative solutions under crisis conditions. Preliminary feedback from its implementation in an undergraduate business course (N=753) indicates increased student engagement and confidence in applying Design Thinking concepts. This paper contributes to the field of business education by presenting an innovative approach to teaching innovative problem-solving skills through serious games, emphasising the need for holistic educational frameworks that bridge theoretical learning with real-world application.

Keywords: Serious Games, Design Thinking, Business Education, Experiential Learning, Game Design Framework

1. Background

Serious games have emerged as promising educational tools, distinguished from other educational games by their ability to simulate complex scenarios that are unattainable in traditional settings due to various constraints (Susi et al. 2007). As a form of digital pedagogy, serious games leverage technology to create immersive, experiential learning environments where students can apply theoretical concepts in simulated real-world scenarios (Lewin and Lundie 2016; Shachar and Neumann 2003; Smetana and Bell 2012) and provide environments that foster engaging and comprehensive skill development (Cocks 2020; De Jans et al. 2019; Liew et al. 2021; Ritterfeld et al. 2009; Zhang et al. 2019). Existing notable frameworks such as Activity Theory-based Model of Serious Games (ATMSG) integrates principles from activity theory to provide a structured approach to serious game design (Carvalho et al. 2015). It emphasises the alignment of game activities with educational objectives. However, its focus is primarily on the activities within the game rather than a holistic integration of educational content and game design. The Four-Dimensional Framework (De Freitas and Oliver 2006) categorises serious games into: learning, learner, context, and pedagogy. It provides a comprehensive analysis of how these dimensions interact within serious games. However, it tends to compartmentalise these dimensions rather than integrating them into a cohesive framework. The RETAIN Model (Gunter et al. 2007) focuses on evaluating the effectiveness of serious games in achieving learning outcomes. It emphasises the importance of retention, engagement, transfer, and immersion, yet, it lacks guidance on the actual design and integration of educational content within games. The LM-GM Model (Arnab et al. 2015) differentiates between learning mechanics and game mechanics, aiming to bridge the gap between educational goals and game design. It provides valuable insights into how these mechanics interact but does not offer a unified framework for their integration. Furthermore, literature reveals a significant gap between the design objectives of serious games and their educational goals, particularly highlighting a lack of emphasis on preparing learners for future-ready skills (Adams 2023); the integration of real-world cases into gameplay (Papoutsi et al. 2022; Romero et al. 2015); the necessity for an interdisciplinary approach to provide a holistic perspective on the educational value of serious games (Carvalho and Neto 2023) and balancing the educational purpose with entertainment in serious games design (Natucci and Borges 2020). To address this gap, our study introduces the "Learning and Game Integration (LGI) Framework," utilising "Blackout" serious game to demonstrate the framework's application. "Blackout," developed for university students, aims to teach the Design Thinking concept. Design Thinking is

believed to significantly foster innovative problem-solving skills by promoting an empathetic approach, ensuring that solutions not only address problems but also resonate with the intended users (Klaassen et al. 2008). By applying the Design Thinking concept, it is anticipated that solutions will be crafted to not only resolve immediate issues but also to be adaptable, resilient, and considerate of the broader ecosystem (Brown 2008; Razzouk and Shute 2012).

2. Framework Development: LGI Framework

The "Learning and Game Integration (LGI) Framework" proposed in this study is designed to integrate educational content with interactive game design seamlessly. This framework facilitates the integration of theoretical concepts into practical application, enhancing the educational impact of serious games within academic curricula. As presented in Figure 1, the LGI Framework consists of four interconnected stages: (1) Educational Content Integration: Identifies and aligns the educational objectives with the game's design, ensuring that learning outcomes are effectively met through gameplay, (2) Theoretical Underpinning: incorporates relevant learning theories, such as Experiential Learning Theory (ELT), to support the pedagogical aims of the serious game. This stage emphasises the transformation of theoretical knowledge into practical skills through active engagement, (3) Case Study Selection: Involves choosing real-world scenarios that are relevant and challenging, providing students with opportunities to apply their learning in complex, real-life contexts, and (4) Game Design: Focuses on creating engaging and educational game mechanics that reflect the identified educational goals and the selected case study, culminating in a game that is both educative and entertaining.

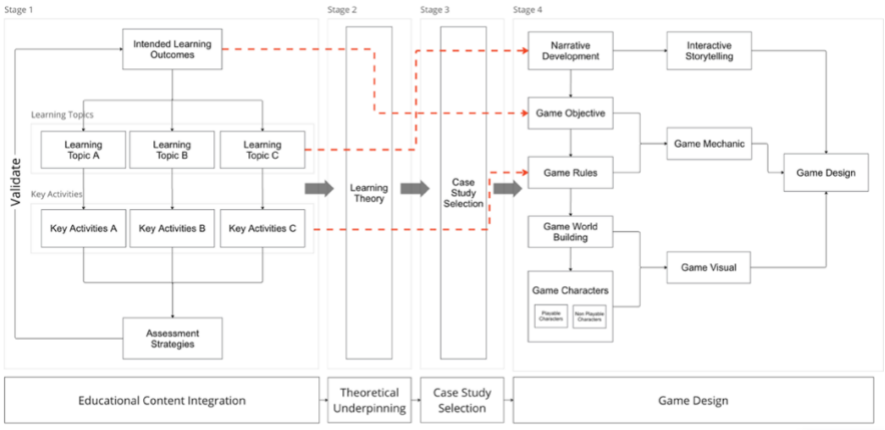


Figure 1: Proposed Framework: Learning and Game Integration (LGI) Framework

3. Application of LTI Framework in developing "Blackout" Serious Game

The "Blackout" serous game serves as a practical application of the LGI Framework, specifically designed to teach Design Thinking through real-world case study. This scenario enables students to assume the role of a problem-solving consultant to the city's mayor. In this capacity, they engage with various stakeholders, deeply analyse problems, and devise innovative solutions under pressure, thereby embodying the skills essential for effective leadership and decision-making in real-world crises.

3.1 Stage 1: Educational Content Integration

This stage is methodically structured to enhance learning outcomes through a constructive alignment (CA) principle (Biggs 1996) which consists of four main components (1) learning outcomes, (2) teaching and learning activities, (3) assessment, (4) feedback. This approach ensures that all components of the educational process—objectives, activities, and assessments—are seamlessly integrated, adhering to the principles of CA, ensuring students are evaluated on tasks that are directly connected to what they are taught and need to learn. The implementation begins with the formulation of intended learning outcomes. These outcomes are detailed into specific topics that follow the stages of the Double Diamond Design Thinking process: Discover, Define, Develop, and Deliver, as developed by the UK Design Council in 2019. As illustrated in Figure 2, each stage is designed to progressively build on the students' innovative problem-solving skills. To reinforce these stages, relevant activities are created to unpack and explore the Design Thinking concept at each phase of the Double Diamond process. This is complemented by the development of targeted assessment strategies that align with the

activities and the overarching educational goals, thereby operationalising the methodology in a practical, application-focused educational setting.

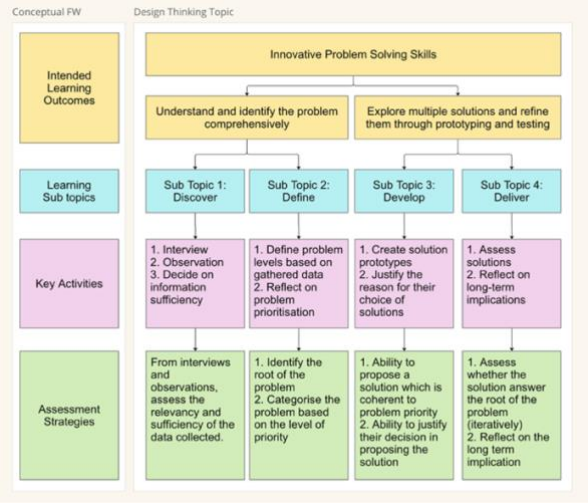


Figure 2: Application of LGI Framework in Blackout Serious Game – Stage 1

3.2 Stage 2: Theoretical Underpinning

In the LGI Framework, Stage 2 serves as the theoretical underpinning that bridges educational content integration (Stage 1) and the selection of a case study (Stage 3). This stage is crucial as it ensures that theoretical concepts are not only understood but are also applied effectively in practical, real-world contexts. The integration provided by this stage is critical for developing learning experiences that are deeply rooted in learning theory while being directly applicable and relevant to the complexities of real-world scenarios. The primary function of this stage is to provide a structured framework that guides how learners engage with the material. By embedding a solid theoretical foundation, this stage ensures that the subsequent educational activities and case study applications are cohesively aligned with the learning objectives, thereby enhancing both the effectiveness and the impact of the learning experience. For this study, Experiential Learning Theory (ELT) was selected as the ideal theoretical framework due to its robust emphasis on learning through experience. Developed by David Kolb (1974), ELT is grounded in constructivist principles, positing that knowledge is constructed through the transformation of experience. This learning paradigm is particularly aligned with the aims of the LGI Framework because it supports a dynamic learning process where students are not merely passive recipients of information but active participants in their learning journey. ELT advocates for a cyclical process of learning consisting of four stages: Concrete Experience, Reflective Observation, Abstract Conceptualisation, and Active Experimentation. This cycle ensures that learning occurs in a structured yet flexible manner, promoting deep engagement and the continuous application of learned knowledge to new and complex situations (Kolb et al. 2014). The theory is celebrated for its effectiveness in fostering critical thinking and adaptive skills, essential for resolving real-world problems by applying abstract concepts to tangible contexts (Morris 2019; Seaman et al. 2017). Further, ELT's application in various educational settings, including product development (Babu et al. 2020), management (Xue et al. 2021), environmental education (Cheng et al. 2019), art (Chiu et al. 2022) demonstrates its versatility and efficacy in enhancing learning outcomes through experiential contexts. These instances underscore ELT's capacity to bridge the gap between theoretical education and practical experience, making it an invaluable asset for integrating serious games into educational frameworks. Recent advancements have extended ELT's application into digital learning environments, utilising technologies such as role-play games, 3D virtual worlds, and real-world event simulations, which further exemplifies its adaptability and relevance in modern educational contexts (de Oliveira et al. 2015; García-Sánchez and Luján-García 2017). However, the integration of actual case studies in digital formats remains underexplored. Our study addresses this gap by embedding ELT within a Design Thinking framework to develop the serious game "Blackout," aiming to enhance the educational realism and impact for students, enabling full immersion in a business environment reflective of real professional settings. However, despite these technological integrations, there remains a gap in studies utilising real-world environments that leverage actual case studies for immersive experiential learning. Addressing this, our study integrates ELT within a Design Thinking framework to inform the development of the web-based serious game "Blackout." This integration is designed to enhance the realism and educational impact of the learning experience, ensuring that students can

fully immerse themselves in a business context that mirrors true professional environments (de Freitas & Neumann, 2009).

3.3 Stage 3: Case Study Selection to design the Serious Game

Stage 3 of the LGI Framework, focused on case study selection, is integral for bridging theoretical learning with real-world application. This stage contextualises learning by having students apply theoretical concepts to complex, real-life situations, thereby enhancing the realism and relevance of their learning experience. Selecting appropriate case studies is pivotal for direct applicability and engagement, representing real-world problems that require innovative, systemic thinking and collective action. This approach ensures that students are not only learning to solve hypothetical problems but are also prepared to tackle real-world challenges that mirror the complexities they will face in their professional lives. Literature suggests that games addressing wicked problems should simulate real-world scenarios necessitating collective action and continuous adaptation to changing circumstances (Fabricatore et al. 2020). The 2012 massive blackout in India serves as an exemplary scenario, encompassing a range of problems from immediate technical failures to long-term strategic vulnerabilities, requiring multifaceted solutions (Jim Yardley and Harris 2012). This simulation challenges students to engage with various stakeholder perspectives, analyse underlying causes, and develop innovative solutions under pressure. Modelled on the Double Diamond Design Thinking process, the game aligns problem-solving stages with practical business scenarios, enhancing students' ability to connect theoretical knowledge with practical application (Classe et al. 2019). This approach prepares students for professional environments by developing skills like innovative problem-solving and strategic decision-making, crucial for seamless transitions into corporate roles (Azadegan et al. 2012). The immersive, real-world scenario of the "Blackout" game boosts engagement and depth of learning, encouraging emotional and intellectual investment. The game's safe and controlled environment allows for risk-free experimentation and iterative learning, fostering confidence and competence in handling real-life challenges (Adisusilo et al. 2018; Taleb et al. 2019).

3.4 Stage 4: Game Design

This final stage is essential for transforming the theoretical insights and case study findings from previous stages into a tangible serious game. It entails the strategic development of the serious game, integrating storytelling, mechanics, visuals design to inform the game design and development. (1) The narrative development shapes the storytelling, ensuring it aligns with the learning topics and engages the players meaningfully. (2) Game mechanics are crafted based on clear game objectives and rules, facilitating a structured yet dynamic gameplay experience that challenges the learners which were informed by key activities in each learning topic. (3) Game Visual, created by designing world building and character design, enhance the immersive quality of the game, making the learning experience both engaging and visually appealing. Each component is tailored to reinforce the educational goals established earlier in the framework, ensuring that the game not only educates but also captivates the audience. In the final stage of the LGI Framework, the integration of Experiential Learning Theory (ELT) and the selected case study crucially informs the overall game design of "Blackout". As presented in Table 1, the integration of ELT into the game design leverages its structured learning cycle—Concrete Experience, Reflective Observation, Abstract Conceptualisation, and Active Experimentation.

Table 1: Conceptual Application of LGI Framework in Blackout Serious Game – Stage 4

ELT	Learning Objectives	Learning Topics	Key Activities	Assessment Strategies
Concrete Experience	Gather extensive information to develop empathy and other related skills	Discover	Interview stakeholders, observe the city, decide on information sufficiency	In-game reflection to consolidate findings and insights; overview explaining the stage and how concepts apply to real life.
Reflective Observation	Identify and categorise the root problems	Define	Define problem levels based on gathered data, reflect on problem prioritisation	Reflective question at the end of the stage to justify prioritisation of issue
Abstract Conceptualisation	Develop solutions for identified problems	Develop	Create prototypes using resources from stakeholders, justify the use of solutions	Answer the question, "Who should be the first to use this solution, and why?" for each developed solution
Active Experimentation	Evaluate the effectiveness and impact of the solutions	Deliver	Assess solutions based on feedback, reflect on long-term implications of the blackout	Overall game explanation at the end, followed by an open reflection question on long-term wicked problems related to the blackout.

Each phase of ELT directly influences how the game's narrative, mechanics, and visuals are developed, ensuring that every element of "Blackout" contributes effectively to the learning objectives. The case study of the 2012 India blackout provides a real-world context that enriches the game environment, making the theoretical aspects more tangible and relatable for the players. This real-world grounding not only enhances the realism of the game scenarios but also ensures that the challenges and tasks within the game mirror actual issues that need innovative solutions under pressure. This integration ensures that the game is not only a tool for applying learned concepts but also a platform for developing innovative problem-solving skills, crucial for managing real-life crises.

3.4.1 Narrative Development

The narrative development process for the serious game based on the 2012 India blackout involves a detailed exploration of the incident's complexities. It begins with gathering extensive data about the event's causes, impacts, and stakeholder responses, primarily sourced from old digital news articles from reputable global media outlets (Yin et al. 2012). These real-world elements are integrated into the game's storyline, creating an immersive narrative that challenges players to think critically and make strategic decisions, mirroring real-life crisis management (Naul and Liu 2019). This narrative development uses thematic analysis (Peel 2020) to ensure coherence between the actual case, Design Thinking Framework, and ELT, reflecting intended learning outcomes, key activities, and assessment strategies.

In the ELT learning cycle's first phase, Concrete Experience, players begin their journey as business consultants during a major power outage. They gather information through stakeholder interviews and city observations, providing direct engagement essential for learning (Kolb 2014). Decisions on seeking additional information or proceeding with available data simulate real-life decision-making (Bell and Kozlowski 2008). The game's time constraints add pressure, enhancing the learning experience. In-game reflection helps consolidate findings, reinforcing learning objectives (Henry 2013).

The second phase of ELT cycle, Reflective Observation corresponds with the game's "Define" stage. During this phase, players critically analyse and reassess the information gathered during their initial exploration. Players categorise the issues they have encountered into critical, moderate, and slight, based on the collected data. This reflective process compels players to deeply consider their observations and the implications of the identified problems, paving the way for more profound analytical and conceptual thinking (Hughes and Scholtz 2015). This integration of reflection into design thinking equips players to manage challenging situations more effectively by uncovering tacit knowledge and modifying future actions based on gained insights (Grund and Schelkle 2020; Schoormann et al. 2023). Moreover, the act of reflection helps distinguish between high and low-performing students, thereby enhancing their problem-solving capabilities in design-oriented tasks (Hong and Choi 2019). It aligns with recommendations that mapping business process elements into game design elements effectively helps players understand and reflect on process challenges (Classe et al. 2019). Players answer a reflective question at the end of this stage to explain why they selected these issues as their top priorities, which serves as a formative assessment to gauge their understanding and application of the stage's objectives. Building on the reflective insights from the Define stage, players transition into the Abstract Conceptualisation phase which involves cognitive process of synthesising the lessons learned from experience into new ideas, theories, or plans (Kolb et al. 2014). This phase is crucial for learners as it encourages them to think beyond the specific instances of their experiences and formulate generalisable rules or concepts that can be applied to new, different situations (Han 2016). In this stage, players develop actionable solutions to the identified problems. This involves critical and creative thinking as players conceptualise prototypes and strategies on using resources efficiently. They engage in high-level problem-solving and decision-making, directly applying the theoretical knowledge and strategies explored earlier in the game. For each solution they create, players must answer the question, "Who do you believe should be the first to use this solution, and why?" This question assesses their ability to practically apply and justify their designed solutions, reflecting a deep engagement with the Abstract Conceptualisation phase. The final phase of ELT, Active Experimentation, is embodied in the Deliver Stage. Players implement their solutions within the simulated environment of the game to observe and evaluate their effectiveness. This is seen in the game when players have to deliver the solution by reporting back to The Mayor and receiving a response whether the solution proposed is built upon sufficient data collected from stakeholders or not. This stage allows players to experiment with their conceptualised ideas and adjust their strategies based on the outcomes and feedback (Fewster-Thuente and Batteson 2018), particularly the evaluation from the mayor. The game concludes with a reflective question about potential long-term implications of their solutions, encouraging players to think about the broader impact of their decisions and the sustainability of their approaches. This

reflective assessment serves as both a summative and formative tool, helping players consolidate their learning and consider future applications of their skills and knowledge. Figure 3 presented the practical application of LGI framework to the actual “Blackout” game design.



Figure 3: Practical Application of LGI Framework in Blackout Game Design – Stage 4

3.4.2 Game Objective

A game objective is a specific goal that players aim to achieve within the context of a game. It serves as the primary focus or purpose driving player actions and decisions throughout gameplay. Game objectives can vary widely, from simple tasks like reaching the end of a level or scoring points, to complex missions involving strategy, problem-solving, or narrative progression. Game objectives were designed to align with the intended learning outcomes. As the literature suggests, integrating these intended outcomes as attributes within game mechanics begins with setting clear game objectives (Lameras et al. 2021). As presented in Table 2, in the "Blackout" game, each objective is designed to engage players actively and align closely with the educational goals of fostering critical thinking and problem-solving skills. The first objective, Finding Character, challenges players to locate specific non-player characters (NPCs) scattered throughout the virtual city. Each NPC represents a unique problem related to the blackout crisis and finding them triggers different features in the subsequent level. The number of NPCs found directly influences the conditions and available resources in the next level, integrating the consequences of player actions into the game’s progression. The second objective, Choosing Options, requires players to select the three most appropriate solutions from a set of options. The diversity and number of these options are contingent upon how many NPCs were encountered previously, demonstrating the cumulative effect of earlier decisions and enhancing the game’s complexity. If players successfully locate all NPCs, they are presented with nine options, from which they must judiciously choose three. The third objective, Creating Item, involves players gathering materials to construct a specific item that can mitigate the impacts of the blackout. This task necessitates synthesizing information and resources gleaned from interactions with NPCs and previous levels, underscoring the game’s emphasis on resource management and strategic planning. The final objective, Solving Quest, culminates in players navigating through the game’s challenges to reach the endpoint where they present their created item to Mayor Anderson as a potential solution to the crisis. This sequence of objectives not only enhances engagement through a structured yet flexible gameplay framework but also mirrors real-life processes of crisis management, where understanding problems, making strategic decisions, and implementing solutions are crucial. By integrating these objectives into "Blackout," the game effectively simulates a realistic problem-solving environment, thereby reinforcing the learning outcomes aimed at preparing players for complex, real-world challenges.

Table 2: Conceptual Blackout Game Objectives

Game Objectives	Description	Key Actions
Finding Character	Locate a specific NPC within the game.	• Find one of six NPCs scattered throughout the city. • Each NPC presents a unique problem and triggers a different feature in the next level. • Number of NPCs found affects conditions in the next level.
Choosing Options	Select the three most appropriate options from those provided.	• The number and type of options available depend on the number of NPCs encountered in the previous level. • If all NPCs are found, nine options are available, from which three must be selected.
Creating Item	Create a specific item based on previous choices.	• Gather required materials with clues from NPCs. • A minimum of three different materials is needed to create the target item.
Solving Quest	Reach the endpoint of the game.	• Complete all quest activities from the previous levels. • Return to Mayor Anderson with the created item as a solution.

3.4.3 Game Rules

Game rules are the guidelines and constraints that define how a game functions and how players interact with it (Djaouti et al. 2008). These rules set the structure of the game by establishing what players can and cannot do, the objectives to be achieved, and the consequences of players' actions. They provide a framework that ensures fairness and clarity, guiding player behaviour and helping to create a predictable and enjoyable gaming experience. As presented in table 3, in the "Blackout" game, the rules are designed to structure gameplay and ensure a coherent and engaging experience across various levels. These rules not only define the boundaries within which players operate but also enhance the realism and educational value of the game. One of the fundamental rules is the (1) Time Limitation, where players are given a real-world limit of 30 minutes to simulate a six-hour crisis management scenario. This rule applies to all levels and adds a sense of urgency, pushing players to make quick and effective decisions, thereby simulating the real-world pressure of managing a crisis within tight deadlines. (2) The Third-Person Movement rule utilises the WASD keys for navigation and the mouse for camera orbit, allowing for fluid movement and interaction within the game environment. This setup is consistent across all levels, facilitating a stable and intuitive control scheme that players can easily adapt to from the start. Level Navigation is another crucial rule, with transitions between game levels managed through designated buttons that correlate to different phases of the Design Thinking process. Once players exit a phase, they cannot return, which emphasizes the need for careful planning and decision-making in each phase. Finally, (3) Dialog Interaction is specifically designed for the Discover level, where players can initiate conversations with NPCs by approaching them and pressing the E key. This feature enhances the immersive experience, allowing players to gather crucial information and insights from various stakeholders, which are essential for progressing in the game. Lastly, the Quest User Interface (UI) supports specific gameplay mechanics in later phases, such as drag-and-drop quizzes in the Define phase and crafting in the Develop phase, enhancing interactive learning and application of concepts through hands-on activities.

***T*able 3: Conceptual Blackout Game Rules**

Rule Category	Description	Specific Phase(s)
Time Limitation	The game is time-limited to 30 minutes (real-world), simulating 6 hours (in-game). Players must complete all levels within this period or face a game over with a "failed" status.	All levels
Third-Person Movement	Movement is controlled via WASD keys, with camera orbiting enabled via mouse. This setup supports navigation and responsive action in the game environment.	All levels
Level Navigation	Transition between levels is managed through designated buttons, representing each phase of Design Thinking. Exiting a phase disables its features and blocks return.	All levels
Dialog Interaction	Dialogue with NPCs is possible by approaching and pressing the E key, but this feature is available only during the Discover level.	Discover (Level 1)
Quest User Interface (UI)	Activatable UI features support secondary mechanics: drag-and-drop quizzes in the Define phase and crafting in the Develop phase.	Define (Level 2) and Develop (Level 3)

Overall, the game rules in "Blackout" are integral to shaping a structured yet dynamic learning environment. They guide player behaviour, ensure fairness, and help maintain a focused narrative flow, making the game not only enjoyable but also a powerful tool for learning and applying Design Thinking principles under pressure.

3.4.4 Game World Building

This web-based game features a 3D environment where players interact within an immersive world. The game includes five main buildings that represent the core narrative and several NPCs enhancing interactivity. Studies

indicate no significant difference in player engagement between web-based and mobile games (Arif et al. 2022). However, web-based games reduce average network delay by 50% and improve the user's Quality of Experience by 20% in cloud gaming (Zhang et al. 2019). "Blackout" uses a Third-Person Perspective, enhancing player immersion. The WASD control scheme and mouse for camera control provide intuitive navigation in Designville, facilitating smooth gameplay and responsive actions (Tan et al. 2001). Additionally, "Blackout" has a robust backend architecture to monitor and record player activities, capturing gameplay data like login times, decisions, and play duration.

3.4.5 Game Characters

There are two types of characters developed: the player-controlled characters, which consist of three playable characters that players can choose, and six non-playable characters (NPCs) who act as stakeholders. Each game asset character represents diversity and inclusivity of gender, race, and background, reflecting a broad spectrum of the community. This inclusion not only enriches the gameplay by providing a variety of perspectives and solutions but also enhances the realism of the game, making it more relatable and engaging for a diverse player base (Chee et al. 2022). Additionally, interactions with key NPCs in "Black Out" simulate extensive chaos and require immediate, effective responses. These interactions between players and non-player characters in serious games are crucial for enhancing the gaming experience (Baffa et al. 2017; Crenshaw and Nardi 2015), deepen players' understanding of the crisis and fosters empathy (Ho and Ng 2022). This multifaceted interaction enriches the learning experience by effectively merging theoretical knowledge with practical, problem-solving activities, making it more dynamic and impactful.

4. Conclusion

This paper introduces the Learning and Game Integration (LGI) Framework, illustrated using the "Blackout" game as a case study. Implemented in March 2024 in a large, foundational first-year undergraduate business course at the College of Business and Law of an Australian university, "Blackout" has received positive preliminary feedback. Students and staff have highlighted its effective integration into the curriculum, noting increased student enthusiasm, deeper understanding of design thinking concepts, and heightened confidence in reflecting on lessons learned. Educators observed that teaching design thinking through the "Blackout" serious game notably enhanced students' engagement, curiosity, and peer interaction during class. This innovative approach to teaching design thinking through serious gaming has thus made a substantial contribution to business education. Moreover, the LGI Framework, which guided the development of the "Blackout" game, offers a significant advancement in the field of serious games and higher education. Unlike traditional frameworks that focus solely on learning design or game mechanics, the LGI Framework integrates these elements holistically through four interconnected stages. It also promotes continuous improvement by incorporating iterative feedback and assessment strategies, allowing for ongoing refinement of educational outcomes and game design. These features position the LGI Framework as a pioneering tool in the integration of serious games into higher education, enhancing innovative problem-solving skills and seamlessly connecting theoretical learning with practical application.

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Children's Expressed Emotions During Playful Learning Games

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Abstract: Studies on software tutoring systems for complex learning have shown that confusion has a beneficial relationship with the learning experience and student engagement (Arguel et al., 2017). Causing confusion can prevent boredom while signs of confusion can serve as a signal of genuine learning and as a predecessor for frustration. There is little to no research on the role of confusion in early childhood education and playful learning, as these studies primarily focus on high school and university students during complex learning tasks.

Despite that, the field acknowledges that confusion may be caused by inconsistency between information and a student's internal model referred to as cognitive disequilibrium known from the theory of cognitive development, which was originally theorized based on observational studies on young children (D'Mello and Graesser, 2012). Therefore, there is reason to expect that the virtues of confusion also apply to young children engaging in learning activities, such as playful learning.

To investigate the role of confusion in playful learning, we conducted an observational study, in which the behavior and expressed emotions of young children were collected by familiar pedagogues, using a web app, while they engaged with playful learning games designed for kindergartens. The expressed emotions were analyzed using a likelihood metric to determine the likely transitions between emotions (D'Mello and Graesser, 2012).

The preliminary results showed that during short play sessions, children express confusion, frustration, and boredom. Furthermore, the observed emotional transitions were matched with previously established models of affect dynamics during complex learning. We argue that games with a learning objective can benefit by purposely confusing the player and how the player's confusion may be managed to improve the learning experience.

Keywords: Academic Emotions, Affect Dynamics, Early Childhood Education, Playful Learning, Affective Computing

1. Introduction

Assessing the educational benefits of playful learning can pose challenges. Play is inherently voluntary, meaning participants can shape the context around their engagement often in a frivolous manner (Sutton-Smith, 2001). Consequently, planning and evaluating a curriculum around play becomes complex, as it arguably gauges participants' willingness to adhere to it rather than the effectiveness of the curriculum itself. Gathering data from early educational games utilizing playful learning strategies and comparing such data with studies on learning, in general, may produce some evidence for the effect of playful learning. Not to mention provide some guidance for future endeavors in playful learning games.

Studies on Academic emotions have shown that students engaging in learning activities, experience affective states categorized as epistemic emotions (Pekrun and Linnenbrink-Garcia, 2012). Affective state is a term used to describe emotions and moods more specifically as a felt affect with a positive or negative valence (Feldman Barrett and Russell, 1998). Positive affective states such as enjoyment and negative affective states such as frustration and boredom are shown to be related to study activities (Pekrun and Linnenbrink-Garcia, 2012). This study set out to investigate if young children express the same emotions and epistemic affective states during playful learning games for their age group as university students have been observed expressing during complex learning. In particular, studies that model transitions between emotions, called model on affect dynamics, have proved effective as a guide for automated tutoring software as they only have to detect and address certain emotions to optimize the learning experience (D'Mello and Graesser, 2012). To investigate this, the following research question was formulated.

Do young children experience academic emotions such as confusion, frustration, and boredom while engaging in playful learning games and do these emotions adhere to the model on affect dynamics?

Emotions are an integral part of humans and an important factor for certain activities such as learning, where confusion, frustration, and boredom have been shown to have positive and negative effects on deep learning (D'Mello and Graesser, 2014). Furthermore, studies of the model on affect dynamics have shown that students tend to transition between engagement ↔ confusion ↔ frustration ↔ boredom, which means that students do not go directly from engaged to frustrated without passing through a stage of confusion (D'Mello and Graesser, 2012). Therefore, detecting and acting on confusion may alleviate frustration and prevent boredom.

Other studies suggest that engagement can transition directly to boredom and can be prevented by intentionally causing confusion (Arguel et al., 2019b).

The model on affect dynamics has been supported by multiple accounts (Arguel et al., 2019a; Mulqueeny et al., 2015; Munzar et al., 2021). The original studies used self-reporting during a short (30 min) individual interaction with a program called AutoTutor which is developed to teach complex subjects via dialogue (D'Mello and Graesser, 2012). Participants had to select an emotion or epistemic affective state from a list: Engagement/flow, confusion, frustration, boredom, anxiety, curiosity, delight, and surprise. More recent studies are based on one or more observers' frequent observations of the individual participant's activities and expressed emotions or epistemic affective states (Baker et al., 2020). Activities can be either on task, on task while having a conversation, off task, or using the system in a way that is not intended or unknown. The expressed emotions or epistemic affective states are reduced to boredom, engagement, confusion, frustration, or unknown. These studies have been developed into a standardized protocol called BROMP (Ocumpaugh et al., 2015) associated with a certification program and a phone app to record observations. The protocol can be utilized for single participants or multiple participants interacting with a system simultaneously, by observing each participant in the group in iterations. Although teachers are expected to possess the ability to discern confusion among students and respond appropriately (Arguel et al., 2017), BROMP emphasizes the necessity of training to consistently generate accurate observations (Ocumpaugh et al., 2015). Unfortunately, the studies of the model on affect dynamics focus mainly on students learning complex subjects, such as mathematics, in higher education (Arguel et al., 2017). The role of confusion in early childhood education and what can be considered equivalent complex learning for young children remain almost scientifically unexplored.

To get an idea of how confusion and complex learning affect early childhood education, we can examine the term complex learning in general. Complex learning is often exemplified as something that causes cognitive disequilibrium (D'Mello and Graesser, 2012). Cognitive disequilibrium can be caused by information that does not fit with an internal conceptualization of the world or an impasse that cannot be resolved with the current set of skills (Ormrod, 2019). Studies on confusion have shown a correlation between cognitive disequilibrium and confusion (D'Mello and Graesser, 2014, 2012). Studies of young children have documented that children experience cognitive disequilibrium around the age of 6 years (Ormrod, 2019). These studies observed that children were intrinsically motivated to reestablish cognitive equilibrium, which led them to develop more complex levels of thought and knowledge, which suggests that young children also benefit from confusion management strategies (Arguel et al., 2019b).

This tells us that confusion may be as important for early childhood education as it is for complex learning, but the question remains, how can we utilize this knowledge? We may have to turn the problem on its head and ask if this knowledge can be used to optimize already established educational tools, such as playful learning. To do this, four hypotheses were formulated, which will show if young children engaging in playful learning adhere to the model on affect dynamics.

H1. Young children engaging in playful learning transition from concentration to confusion.
H2. Young children engaging in playful learning transition from confusion to concentration and not directly from frustration to concentration.
H3. Young children engaging in playful learning transition from confusion to frustration and not directly from concentration to frustration.
H4. Young children engaging in playful learning transition from frustration to boredom and not directly from confusion to boredom.

2. Review

Since gaining widespread popularity, digital games have captivated researchers for their teaching potential (Greenfield, 2014). Researchers have studied how young players were able to learn complex behaviors using deduction to master a game (Gee, 2007; Greenfield, 2014). The idea of presenting curriculum learning through games like Edutainment seemed apparent (Klawe and Phillips, 1995) but, in reality, turned out to be more complicated than expected (Arnseth, 2006; Egenfeldt-Nielsen, 2006).

More recent research on game-based learning has split up into different approaches, some of the promising being Serious Games (Zhonggen, 2019), where a game is based around an educational context, and Gamification (Sailer and Homner, 2020) where game elements are introduced to non-game related tasks such as learning. While Gamification primarily focuses on the motivational aspect of games (Mekler et al., 2017), studies have shown that ease of play and clear instructions are important factors for player engagement in serious games

(Iten and Petko, 2016; Zhonggen, 2019). This aligns with the Flow theory which stresses the importance of balancing difficulty with player competence along with clear communication of goals and feedback (Csikszentmihalyi, 2014). Flow theory focuses mainly on experience and how to optimize it, identifying flow as a favorable experience while more negative emotions such as frustration and boredom should be avoided by adapting difficulty to the competence of the player. The difficulty adaption aspect of Flow theory has been studied in game settings, by adjusting difficulty based on performance (González-Duque et al., 2020; Kristensen et al., 2022) or based on player experience (Yannakakis and Togelius, 2011). However, a recent review questions the efficacy of Dynamic Difficulty Adjustment (DDA) techniques which aim to merely archive Flow (Guo et al., 2024) and suggest assessing both objective (performance) difficulty and subjective (perceived) difficulty to adjust game tasks in alignment with design goals. For example, an educational game can impact the effect of learning with objective performance while subjective difficulty is determined by player experience.

Studies on confusion during complex learning may prove useful in assessing player experience. Confusion has been identified as a signal for genuine learning (D'Mello et al., 2014) while the experience of confusion can be negative or positive depending on how it is managed (Arguel et al., 2019a). In one study, students were assigned to solve a particularly unintuitive and frustrating puzzle called Lights Out, the study showed that providing the students with a strategy positively changed the experience of confusion (Arguel et al., 2019a). Hence the experience of confusion may be influenced by a student' available strategies resulting in productive confusion or hopeless confusion and eventually enjoyment or frustration (D'Mello and Graesser, 2012). Furthermore, confusion has been shown to precede frustration (D'Mello and Graesser, 2012) and as a means to prevent boredom (Arguel et al., 2019b). Arguably player confusion may be a suitable guide for subjective difficulty in learning games and may be managed by providing the player with helpful strategies. This may be particularly important for early childhood educational games, as young children may not have accumulated many problem-solving or emotional management strategies.

3. Study

The objective of the study was to observe young children expressed affective states during relatively complex playful learning games. Pedagogues familiar with the children were deemed suited to recognize expressed emotions based on feedback from professional pedagogue educators and practitioners. Analysis of the observations determines the likelihood of one emotion transitioning to another, which is used to prove or disprove the hypotheses and provide an answer to the research question.

3.1 Procedure

Participants played three selected games in random order. For each game, the participant was briefly instructed on how to play, after which the participant had seven minutes to find as many unique solutions as possible. While the participant was engaged in the activity, a pedagogue who was acquainted with them observed and documented their behavior and affective state. To collect observations, a mobile-friendly web app was developed by following the specifications of the mobile application used in BROMP (Ocumpaugh et al., 2015). Before the first play session, the pedagogue was instructed on how to use the web app, randomize the game order, and not intervene with the activity unless the participant gave up entirely or requested help.

3.2 Material and Equipment



Figure 1: The digital YOLI board, some YOLI game tiles, and a phone with the YOLI app running (picture from playyoli.com).

YOLI has developed a digital platform for tile-based games, see Figure 1. YOLI Games comes in sets of thirty tiles featuring a picture on each and an RFID chip with information about the tile. The YOLI board has room for five tiles, each fitted with an RFID reader and an electromagnet which allows it to shake or even throw off tiles that are placed on it. A smartphone can connect to the board and extend the possibilities using the YOLI app, which will also fetch anonymous activity logs from the game and report them to YOLI.

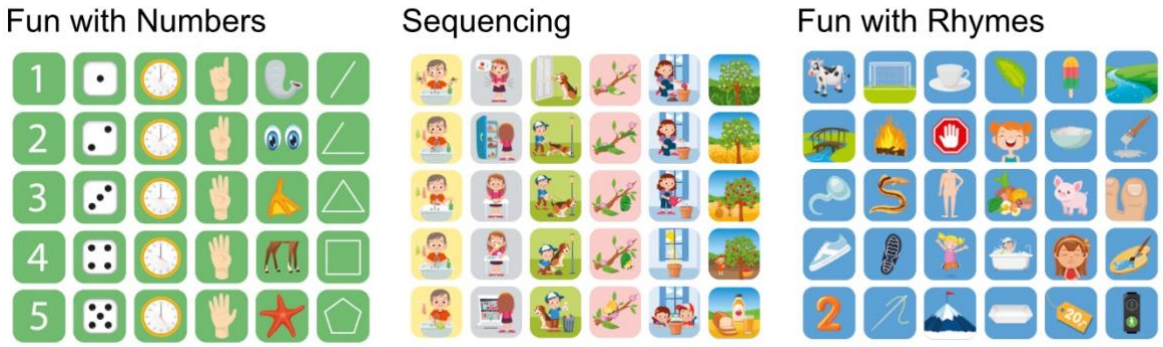


Figure 2: Overview of all tiles for the three selected games, where tiles are placed in the "correct" order top-down and horizontally for the Fun with Numbers game.

The goal of a YOLI game is commonly to place five tiles on the board following the rule of the game, which is normally to match the different tiles on one or multiple parameters. For the study, three games were selected in collaboration with YOLI and feedback from pedagogues. We aimed to select games with diverse learning areas to raise the likelihood of having at least one game which all participants would find harder than the others.

The games that were selected, shown in Figure 2, were: Fun with Numbers, Sequencing, and Fun with Rhymes.

3.2.1 Fun with Numbers

The goal is to place five tiles on the board either by their numeric value or in numerical order for a specific symbol. An example of the same numeric value for multiple symbols is the top horizontal line for Fun with Numbers in Figure 2 which shows: 1, one rolled on a six-sided die, a watch showing one o'clock, a single finger, an elephant trunk, and a single line. Combining five of these different symbols with the same numeric value in any order will complete the goal.

This game was chosen because of its emphasis on numbers and the ability to identify the numeric value of symbols.

3.2.2 Sequencing

The goal is to arrange five tiles into the correct sequences. The sequences are: Washing dirt off your hands using soap, reacting to hunger by making a sandwich and cleaning up after it, taking the dog for a walk and cleaning up after it, the life cycle of a butterfly, planting and growing a seed, the seasonal cycle of apples and wheat ending with consumer products.

This game was chosen because of its diversity in sequence, which requires some knowledge of multiple subjects plus the ability to identify the small clues in the images.

3.2.3 Fun with Rhymes

The goal is to place five tiles on the board that rhyme, this is particularly tricky as it may not be apparent to the child which word is associated with the image on the tiles. Under normal circumstances a pedagogue would help identify the word, but for the study pedagogues were asked not to help unless the child explicitly asked for help.

3.3 Participants

Recruitment attempts on social media groups specifically targeting pedagogues did not provide any interest. Directly contacting twenty kindergartens and after-school daycare centers provided 3 pedagogues/institutions willing to participate. Participants were selected by the pedagogies of the willing institutions.

The participants were 10 children, seven from kindergarten and three from after-school daycare. There were four five-year-olds and six six-year-olds. Seven of the participants were male and three were female. Informed consent forms were gathered from parents by the pedagogues and no reward was provided for participating.

3.4 Data Analysis

The study produced 1113 observations with an average of 37 (SD = 8) observations per game, meaning that the pedagogues recorded observations every 12 s (SD = 9) per average. There were 810 observations of concentration, 175 confusion, 45 frustration, 17 boredom, and 66 unknown.

The analysis for this study followed the procedure from the original study on transitions between epistemic affective states (D'Mello and Graesser, 2012). First, redundant observations of the same affective state (X -> X -> Y) were removed so that transitional observations were left (X -> Y), this reduced the observations to 220 with an average of 7 (SD = 5) transitions per game, with a transition every 51 s (SD = 55) on average.

$$L(M_t \rightarrow M_{t+1}) = \frac{P(M_{t+1}|M_t) - P(M_{t+1})}{1 - P(M_{t+1})} \quad (1)$$

A likelihood metric was produced to compute the likelihood of a transition between two affective states (see equation (1)) where M_t is the current affective state and M_{t+1} is the next affective state (D'Mello and Graesser, 2012). The likelihood is calculated by taking the conditional probability $P(M_{t+1}|M_t)$ of the next affective state being M_{t+1} if the current affective state is M_t, this is then subtracted by the probability $P(M_{t+1})$ of the next affective state being M_{t+1} by chance. By dividing these probabilities by the probability of M_{t+1} not being the next affective state, we get the association between affective states. If the current and next affective states are positively associated, the result will be positive, indicating that M_t is likely to transition into M_{t+1}, a negative value indicate the opposite, that M_t is not likely to transition to M_{t+1}. A result of zero indicates no association between the two states. The probabilities were calculated by counting the number of next affective states observed divided by the total number of observations. For the conditional probability the number of next affective state was divided by the number of observations for each of the different affective states.

3.5 Ethics Statement

The study has been discussed with the local ethics council of the university as well as pedagogical researchers. There was an emphasis on the experience of the child during and after play, which should result in the child leaving the session with an uplifted feeling, therefore the study was presented as an opportunity for the child to help improve the games, followed by some uplifting comment and asking if the child had fun and acknowledging their helpful feedback. Informed consent forms were formulated for the parents of the participants and cleared by the legal department.

3.6 Results

The likelihood was calculated for every conceivable shift in affective states, using equation (1), resulting in 20 possible transitions within a 5x4 matrix. Out of the 20 possible transitions, seven were chosen as the ones that could prove or disprove the hypotheses. The transition from concentrating to bored was not included since the original study on affect dynamics as well as later studies have shown that participants can go directly from concentrating to bored (supposedly because of a lack of confusion) (Arguel et al., 2019b; D'Mello and Graesser, 2012). Four of the transitions are directly related to hypotheses, those are Concentrating → Confused related to H1, Confused → Concentrating related to H2, Confused → Frustrated related to H3, and Frustrated → Bored related to H4. Three transitions were selected as their positive association would contradict the hypotheses, those were Frustrated → Concentrating to contradict H2, Concentrating → Frustrated to contradict H3, and Confused → Bored to contradict H4. A one-sample *t*-test was applied to test whether there was a significant likelihood of association between a current- and a next affective state. While all participants were observed as concentrating, two participants did not experience confusion, two did not experience frustration, and seven did not express boredom. Five participants were noted as expressing emotions that were not among the pre-defined ones at one point during the play session. One participant was only observed as concentrating during the entire session.

Descriptive statistics on the likelihood of the transitions and the results of the *t*-test are presented in Table 1, where the average is calculated between game trials (3 per participant) and the N-column is the number of trials where the given transition was observed.

Table 1: Transition likelihood for select transitions.

Transition	Descriptives			One-sample *t*-test		
	N	Mean	SD	t	df	p
Excitatory						
Concentrating → Confused*	17	.562	.484	5.07	18	.000
Confused → Concentrating	17	.312	.835	1.87	24	.074
Confused → Frustrated	4	-.145	.526	-.995	12	.339
Frustrated → Bored	1	-.009	.319	-.061	4	.954
Inhibitory/baseline						
Frustrated → Concentrating*	8	-.328	.772	-2.13	24	.044
Confused → Bored	1	-.138	.216	-1.43	4	.227
Concentrating → Frustrated*	7	.283	.389	2.62	12	.022
No prediction						
Concentrating → Bored	4	.113	.140	1.80	4	.146
Frustrated → Confused	5	-.385	.867	-1.93	18	.069
Bored → Confused*	1	-.776	.443	-7.65	18	.000
Bored → Concentrating*	4	-.566	.645	-4.39	24	.000
Bored → Frustrated*	1	-.316	.356	-3.20	12	.008

Notes. *p < .05.

The results show that hypothesis 1, which predicts the transition from concentrating to confused was supported by a significant positive association. There is some support for hypothesis 2, which predicts a transition from confused to concentrating and a significant negative association between frustrated and concentrating. Hypothesis 3 is rejected by a negative association between confused and frustrated and a significant positive association between concentrating and frustrated. The weak negative association for the transition from frustrated to bored contests hypothesis 4, whereas the negative association for the transition from confused to bored supports the constraint, none of them significant. This indicates insufficient data to prove or disprove hypothesis 4.

Additionally, there appears to be a significant negative association between boredom and any of the other three pre-defined affective states, however, these were only observed in very few trials.

3.6.1 Emotion Assessment

While all three pedagogues agreed that a pedagogue who is familiar with the participant is best suited to accurately observe emotions in the participant, two of the pedagogues did express difficulty with confusion and frustration. Arguably, confusion is not an emotion that pedagogues are as acquainted with as teachers, and it can be hard to distinguish between confusion and frustration. When asked the pedagogues explained that they mainly look for confusion in the eyes of the participants. Studies have associated facial expressions linked lowered brows and tightened eyelids as indicators of confusion (D'Mello et al., 2014). This supports the claim that observers should receive some training in recognizing confusion and frustration (Ocumpaugh et al., 2015).

4. Discussion

The study was originally designed as two parts, one was to video record children playing the game and then at a later point have multiple pedagogues individually annotate the same videos with labels of emotions. The alignment between pedagogue annotations, plus an additional automated facial expression detection algorithm would provide data for the affective state transitions. This would not only provide evidence for the study but also allow for a critical analysis of automated facial expression detection of young children. The study was redesigned into the final observational study, as we were unable to recruit pedagogues to annotate videos. The pedagogues did not fully condone video recording children in institutions and argued on multiple occasions independent of each other, that emotional recognition could only reliably be done by a pedagogue that is familiar with the child. The pedagogues who conducted the observations agreed with this argument, even

though they found it difficult to recognize the confusion and frustration, also in situations where the child's behavior could indicate confusion and when the child actively asked the pedagogue to help. Upon reflection, pedagogues agreed that the child must have been confused, however, they did not observe that the child explicitly expressed confusion or frustration in the situation. Since the study relied on pedagogues' ability to recognize confusion, frustration, and boredom, it is relevant to discuss: 1) based on their experience with the children they care for are pedagogues suited to detect complicated emotions such as confusion and frustration? 2) should complicated emotions such as confusion and frustration and how to manage them, be a focus of pedagogues? Arguably, more data, than this study has produced, is needed to enrich such a discussion.

Another aspect that the researchers have taken note of, is the reluctance of pedagogues and pedagogical institutions to participate in evidence-based research. While the reason for this reluctance is outside the scope of the study, it did have a direct consequence on the study's validity due to the scarcity of data. Furthermore, researchers encountered multiple accounts of pedagogues who independently of each other questioned the practice of this study to produce evidence. Arguably the evidence is considered superficial due to the unnatural environment of the study, where children are placed in unfamiliar circumstances and asked to perform a task.

5. Conclusion and Future Research

This study set out to find evidence that young children experience the same academic emotions during playful learning games, as students have been observed during complex learning tasks. To do this, we observed children play a selection of playful learning games, which can already be found in some kindergartens today. Professional pedagogues familiar with the child observed the expressed affective states during play. The results showed that young children do experience confusion, frustration, and boredom during playful learning. The results were further analyzed to check if the transition between emotions follows the model on affect dynamics, which states that students tend to transition from concentration, through confusion to frustration and eventually boredom. To answer this, four hypotheses were formulated and tested. The result showed that young children do tend to go from concentrating to confusion when engaging in playful learning. However, the evidence also showed that there was a tendency to transition from concentration to frustration directly. Therefore, we are unable to prove that young children adhere to the model on affect dynamics, which we speculate is due to a lack of training of the observers. Furthermore, the results were insufficient to prove or disprove whether young children are inclined to transition from frustration to boredom and not directly from confusion to boredom.

While we can say that children experience these emotions, more research is needed to reliably say if young children adhere to the model of affect dynamics during playful learning games.

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Game-design Workshops with Co-creation Toolkit to Support Game-based Learning for Heritage Museum

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Abstract: In the context of heritage museums, the integration of game-based learning and gamification has garnered significant interest from academia and educational stakeholders. However, barriers such as high costs and lengthy development cycles hinder wider adoption of game-based learning, particularly among educators who lack of software development skills. This paper introduces a series of game design workshops supported by a card-based toolkit aimed at simplifying the process of creating location-based games. These workshops serve a dual purpose: providing educators and museum stakeholders with an accessible toolkit for data collection and offering engaging game-based learning activities for young museum visitors aged 15-30. To achieve this goal, a pilot study was conducted in collaboration with the Guangzhou Maritime Museum, focusing on 48 university students aged 18-26 and 10 museum staff members visiting the Sea God Temple, a heritage site with a 1400-year history. Qualitative and quantitative data collected from this study indicated positive feedback on the value of co-creation toolkit acting as the instructional scaffolding to support informal learning. Insights gained from this research informed the refinement of the toolkit design, while the game ideas from workshops served as a foundation for mobile game development tailored to young museum visitors.

Keyword: Game-based Learning, Heritage Museum Learning, Co-creation, Card-based Design Toolkit

1. Introduction

Gamification in learning has been a prominent topic at educational conferences for many years, akin to the current discussions surrounding AI in learning. Renowned for its significant advantages in enhancing learners' motivation and engagement, gamification has garnered considerable attention from researchers and educators, leading to numerous studies and initiatives. However, despite the initial enthusiasm, the application of gamification in education has not become as widespread as anticipated. This limited adoption can be attributed to three primary challenges.

First, game design is inherently complex, requiring substantial investment in both time and financial resources. Educational games often generate less profit compared to other types of games, making it difficult to achieve a return on investment from a commercial perspective. Second, game designers typically possess expertise in interaction design or software programming but lack sufficient knowledge of educational principles. Conversely, educators, who are key stakeholders in this field, often show interest in integrating game-based learning methods but face obstacles due to their limited skills in game design and software development. Consequently, the creation of educational games frequently relies on funding from universities or government bodies, which often demand extensive learning data to justify and support game development projects.

Drawing from these insights, I have investigated and compared various types of games within informal learning environments, such as museums and heritage sites. This research has informed the development of key research questions aimed at identifying potential solutions to broaden the adoption of gamification in learning.]

Research Question (RQ): Is it possible to develop an easy-to-use design tool for educators that serves three purposes?

1. A tool that allows educators to develop game-based learning activities tailored to specific educational needs.
2. A tool that enables the design of educational games with minimal cost and time investment.
3. A tool that facilitates the collection of learning data to test game design concepts, thereby increasing the likelihood of successful implementation.

To ensure that this research adheres to the principles of usability and practicality, I conducted a comprehensive literature review across multiple disciplines, including museum learning, game-based learning, and game design. This review served as the foundation for developing a card-based design toolkit, which integrates several conceptual and theoretical frameworks. A pilot study was subsequently carried out in collaboration with a historical museum in China. Both qualitative and quantitative data were collected and subjected to constant comparative analysis. The overall findings of this research indicate very positive outcomes, highlighting significant potential for enhancing heritage education and developing social skills.

2. Background

The integration of game-based learning and gamification in heritage museums has garnered significant interest in recent years. Museums have sought to create more inclusive and engaging spaces by embracing new technologies, interactive exhibits, and participatory approaches. These strategies aim to enhance visitor engagement and learning, incorporating digital games as mainstream entertainment mediums.

In exploring gamification within the museum context, a notable trend is the creation of location-based games, which are mobile games with pedagogic purposes prominently featured role-playing elements (Avouris & Yiannoutsou, 2012).These games allowed users to immerse themselves in realistic roles, particularly within cultural heritage sites such as museums and historical cities. A notable example is 'Intrigue at the Museum', a game-based mobile application designed for children aged 7-13 visiting Palazzo Madama-Museo Civico d'Arte Antica in Turin, Italy (Xhembulla et al., 2014). Such locations, with their tangible objects and physical spaces, provided rich grounds for developing location-based games with significant learning potential. This aligns with the concept of 'Meaningful Gamification' introduced by Nicholson (2012), which integrates play elements into real-life settings like museums and historical sites. This approach creates spaces for participants to explore, engage in play, discover personal meaning, and reflect on their experiences, ultimately fostering transformation.

Despite the benefits, Ribeiro et al. (2021) highlighted several challenges in the development of location-based games. They called for the creation of easier-to-use frameworks for such games. Educators have shown interest in incorporating game-based learning with new technologies, such as virtual reality (VR), mobile technology, and programming. However, the high costs and lengthy development cycles associated with full game development, along with educators' potential lack of software development skills, act as significant barriers to wider adoption. As illustrated by Olesen, Holdgaard, and Laursen (2018), there is a tendency towards tech-driven development that sometimes overshadows the educational, participatory, and engagement purposes.

A low-tech solution with tool-support and guidance for practical application, as suggested by Tahir and Wang (2020), may offer a viable compromise. In fact, it is quite common to use physical objects such as cards, maps, dice, and other props in gamification. These objects help support focus shifts, make arguments tangible in a dialogue (Hornecker, 2010), and frame collaboration by improving idea generation and easing communication. They introduce a playful thinking mode and encourage participants to take risks within the game's framework (Brandt & Messeter, 2004).

3. Methodology

This section details the research methods employed in this study. Participatory action research served as the primary approach to achieving comprehensive results. Initially, a prototype of a card-based game design toolkit was developed, drawing upon theoretical frameworks identified in the literature review. Subsequently, a pilot study, in collaboration with a historical museum, was conducted. Five workshops, involving 48 university students and 8 museum staff, were held to test the usability of the design tool. The development of the game design tool followed an iterative process, guided by feedback from each workshop. The research team, acting as participants, was fully engaged in the process, co-creating and co-learning to generate new knowledge. A mix research method was employed to gather both qualitative and quantitative data.

3.1 Game Design Tool Development

The card-based toolkit guided participants through the learning process, transforming abstract theoretical frameworks into tangible references. The idea of using a card-based toolkit to transform the abstract theoretical framework was introduced by Tahir & Wang (2020). They presented a ten-step process for transforming the LEAGUE framework into the GBL ideation cards toolkit. The use of card-based toolsets for gamification design is quite common, which previously employed by researchers to gather knowledge or ideas from diverse stakeholders in a tangible and accessible form.

The genesis of designing this card-based toolkit is rooted in the three fundamental elements of the location-based game setup framework (Avouris & Yiannoutsou, 2012): the player, physical space, and virtual space. This framework, intersecting with Amory's (2007) Game Object Model, expands to convey more profound meanings. The player, beyond merely identifying themselves in the game space, embodies roles as a role-player, an actor immersed in the story space, and a learner in the real world. The physical space represents the real world, encompassing museums, heritage sites, cultural relics, and physical objects, providing a rich context and primary

material for multifaceted learning, with a focus on cultural learning in this paper. The virtual space encompasses the game space dominated by game mechanics and the story space where storytelling takes precedence.

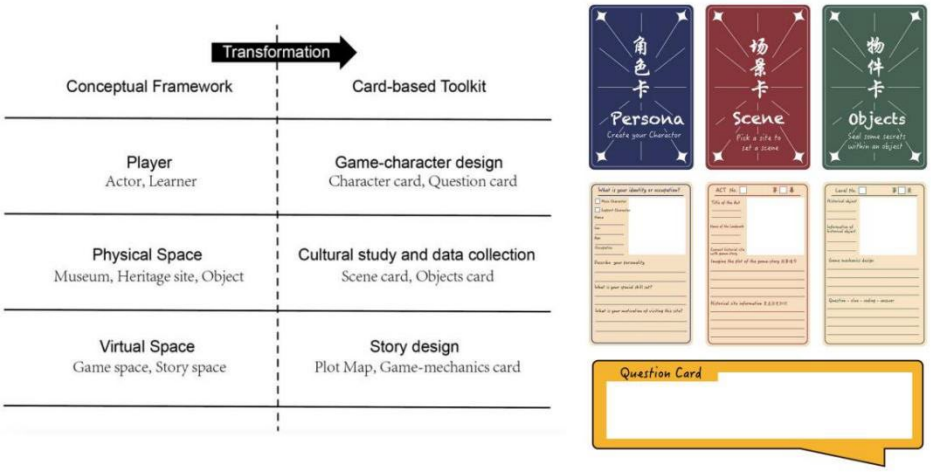


Figure 1: Transformation framework: from location-based game conceptual framework to card-based toolkit

The dimensions, factors, and relations extracted were translated into a set of ideation cards, featuring five distinct types: Character Card, Scene Card, Object card, and Mechanics card, Question card. Additionally, a plot map incorporates a co-creation board was created to collective ideas and formula the conceptual game.

Character Cards: the primary focus on the initial step of game character creation, considering the character as the participant's avatar throughout the entire process. Participants were prompted to provide four layers of information to shape their characters with detailed information, including images, basic details, descriptions, and optional hidden identities.

Scene Cards: designed to craft scenes using real-world landmarks, descriptions, and events. These cards align with Robert McKee's (2014) the five-act narrative structure 'Setup, Catalyst, Crisis, Climax, and Resolution', effectively addressing logical inconsistencies and chaotic storytelling. Serving as a bridge between storytelling and the physical world, Scene Cards require participants to select a landmark for each scene, shaping the environment and context in which the story unfolds.

Object Cards: drawn from 'Object-based Learning,' a pedagogical approach that encourages direct engagement with tangible artifacts to deepen the connection to the subject matter (Lainie Schultz, 2018). In gaming and storytelling, objects often function as the Object of Desire, serving as triggers to reveal secrets or solve problems. Object Cards bridge learning and gaming by prompting participants to capture real-world images and descriptions to design game puzzles.

Mechanics Cards: encompasses four primary types of mechanics design, including coding table, conditions, procedures, and AR recognition, providing examples from existing games to assist in game design.

Question Cards: encourage participants to document insights and questions throughout the workshop, fostering critical thinking and group discussions.

Co-creation Story Board: served as a prototype, helping teams visualize and discuss the game's structure. Made with simple materials, it was accessible to all participants, encouraging diverse input and iterative improvement. The board aligned with the design tasks and card toolkit, presenting the game design clearly and organized.

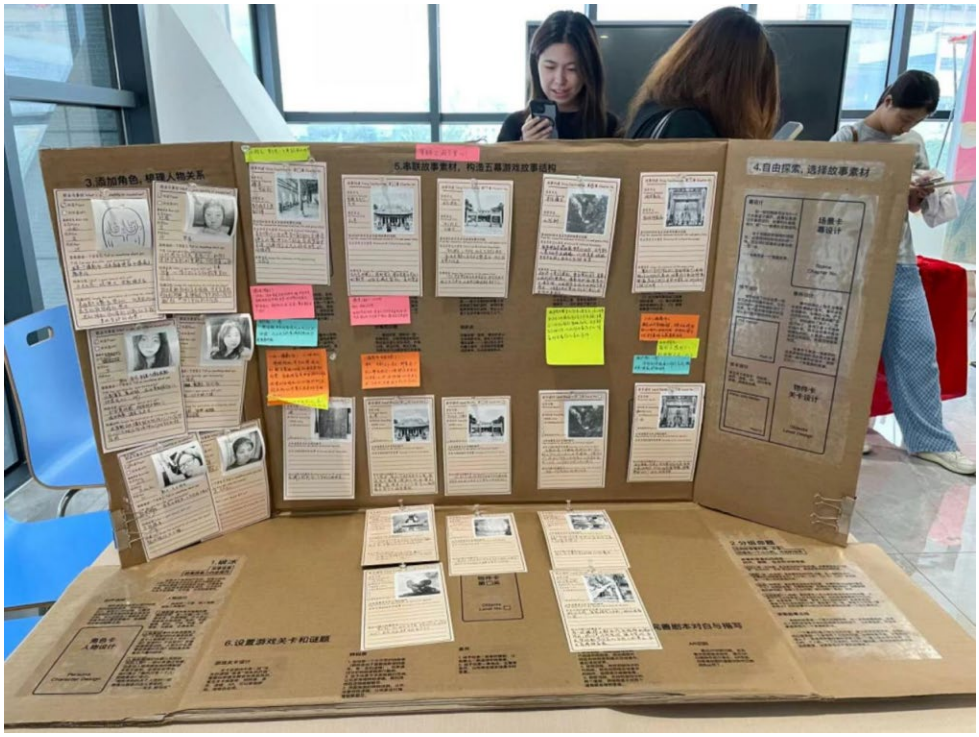


Figure 2: An example of a game-story prototype in a co-creation board form

Design Handbook: Feedback from initial workshops indicated a need for more systematic teaching materials. In response, the researchers developed a Design Tasks Handbook, breaking down the game design process into seven tasks, such as character design, backstory design, character relationship design, plot design and level design. Each task included knowledge points, reference cases, and design tasks to aid participants learning journey.

3.2 A Pilot Study Setting

A pilot study was conducted in the South Sea God Temple, part of the Guangzhou Maritime Museum in China. The temple, a key point along the ancient Maritime Silk Road, has a 1,400-year legacy. Despite its rich history, visitors often find the narrative fragmented and less engaging. The game design workshop set a mission to apply gamification and storytelling approaches to enhance museum learning experiences.

3.2.1 Duration and Workshop Layout

The duration of the game design workshop lasted for six hours. Three hours in the morning, students experienced two times field exploration of the heritage site. One was guided, and the other was a free-choices exploration based on participants' stories. Game-design knowledge was embedded into seven tasks design, such as character design, game backstory design, 5-acts story structure plot design and game level design. In the afternoon, students collected all the information they needed and returned to the museum education room. A complete game prototype needed to be built up within the next 3 hours. In the end, a round-table focus group discussion was conducted to provide the opportunity for participants to reflect on their learning experience and to feedback on the workshop design and toolkit.

3.2.2 Participants Composition

The participants in the game-design workshops were divided into two primary groups. The first group consisted of a research team made up of three individuals. One member acted as the moderator, usually a workshop designer or an experienced teacher, responsible for organizing and guiding the workshop, fostering a conducive atmosphere, and managing participant expectations. The other two members were research assistants with experience in game design. These assistants supported group activities and received pre-training for the research. They functioned both as participants and researchers, with the moderator addressing broader issues from an objective perspective and the research assistants providing empirical insights due to their active

involvement.

The second group comprised recruited participants, typically numbering 10-12 co-creators per workshop. These participants were divided into two teams to complete tasks within specific game mechanisms. Participants were selected based on their prior gaming experience, including familiarity with escape rooms, scripted quests, or narrative-driven computer games.

3.3 Data Collection and Evaluation

As we know, there is considerable debate in the educational world about the possibility of measuring learning, especially in relation to informal learning or what are sometimes called the "soft outcomes" (attitudes, key skills, learning skills, etc.) In this research, I employed a conceptual framework - Generic Learning Outcomes (Hooper-Greenhill, 2008), which identified five categories of learning outcomes covering (1) knowledge and understanding, (2) skills, (3) attitudes and values, (4) activity behaviour and progression, and (5) enjoyment, inspiration and creativity. GLOs help researchers develop research questions, design research tools, and analyze and interpret research findings that are particularly appropriate to the multi-dimensional, creative, and open-ended learning environment of the museum and other cultural organizations.

The data collected in these co-creation workshops mainly focused on three aspects:

First, the research assistants observed and recorded the entire learning process. They specifically recorded the participants' utilization of the game-design toolkit at different stages, their involvement in each learning segment, the difficulties they encountered, and how they resolved those difficulties.

The last 30 minutes of the workshop consisted of a retrospective session for all members, where three topics were discussed in a focus group. First, participants described their overall learning experience in the game design workshop. Then, they discussed the advantages and disadvantages of the traditional tour and the workshop. Finally, suggestions for improving the game-design toolkit were collected.

The above two types of data are qualitative, derived from both researchers and participants and are inherently subjective. Therefore, on the 14th day after the workshop, additional feedback was collected from participants through questionnaires. This "14-day-later" timeframe was chosen to allow participants a cooling-off period, enabling more objective feedback on the learning experience. The questionnaire consisted of 9 questions, all of which were multiple-choice and rating questions, allowing for the collection of quantitative data through statistical analysis. By using a mixture of quantitative and qualitative research methods, data from the three sources was repeatedly compared to obtain objective conclusions.

4. Findings

4.1 Game Concepts from Workshop

Within the support of the game design toolkit, ten game design prototypes were produced during the research (table 1). It was surprised to see that all of the games presented in a state of wholeness, which consists of three basic elements as characters design, plots design, and levels design. Take the game ***the Lost Stone*** for example, six main characters (table 2) created by the participants gave a strong sense of dramatic intense.

Table 1: 10 games created in workshops

1. Nanhai Treasure Hunting: Wonderful world	6. The Old Man and The Sea
2. The Riddle of Nanhai: A girl disappeared	7. The Crazy Magic Chicken
3. Time Travel: I am not 007	8. Forbidden Tree
4. Pavilion Quest	9. One day Poet
5. ***The Lost Stone***	10. A Gate to Reborn

Table 2: Six main characters in example game: The Lost Stone

1. *The Retired Fisherman:* A mysterious figure with an unknown past.
2. *The Street Food Shop Owner:* Descendant of an imperial chef, running a humble food stall.
3. *The Eldest son:* Heir apparent involved in the violent scramble for inheritance within an overseas royal family.

4. *The Second Son:* Younger brother caught in the same struggle for the royal inheritance.
5. *The Real Estate Developer:* Ambitious and shrewd, always looking for the next big opportunity.
6. *The Fortune Teller:* A liar who manipulates others by pretending to have mystical insights.

At the same time, all the game presented in a quite complex level, but with a logical structure that includes climactic moments and engaging twists. In the level design, participants heavily referenced historical artifacts from the South Sea God Temple. Both the research team and the participants remarked, 'It is hard to imagine that a six-hour workshop could have allowed participants with no experience in game design to achieve such creative outcomes.'

4.2 Feedback from Participants: Learning Experience in the Workshop

There were 48 participants in the workshop, and 45 valid questionnaires were received. The ages of the participants were concentrated among first-year students between 18-19 years old (47%), with the rest being senior students (27%) and post-graduate students (20%). Participants came from various professional backgrounds, including product design, interaction design, art management, art history, architectural design, and fashion design. The age-group statistics indicated that participants had no theoretical knowledge or practical experience in game-design. Their diverse majors and academic levels also showed that this workshop was based on a teamwork experiment involving strangers.

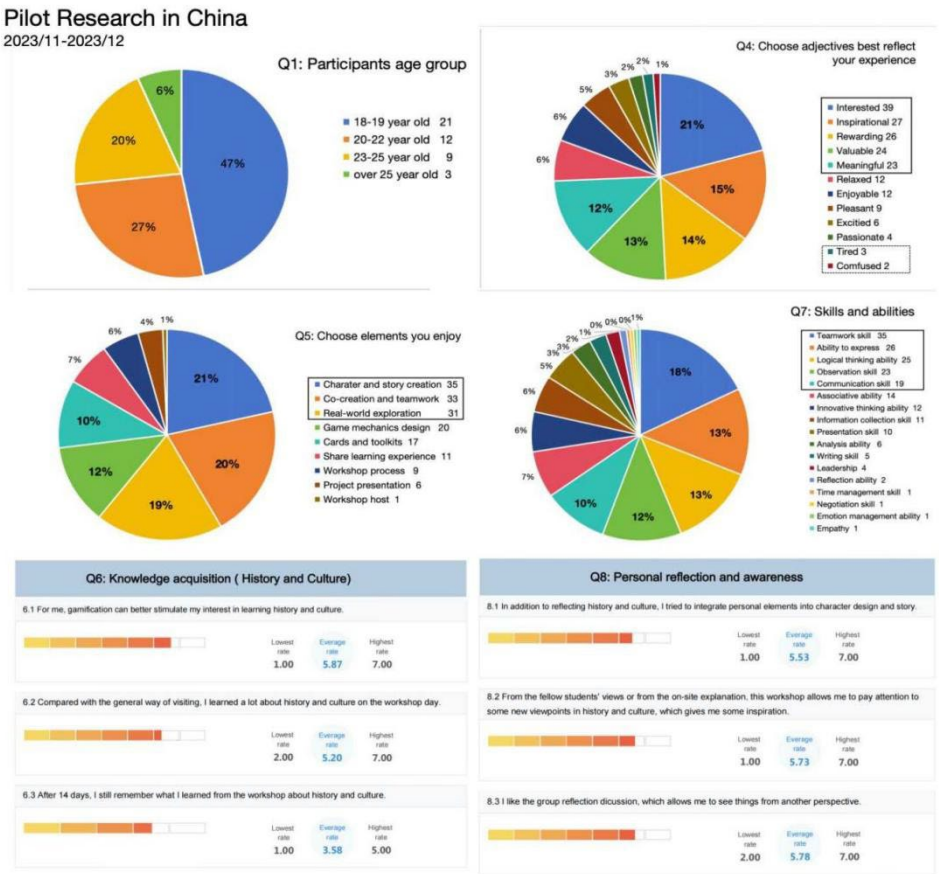


Figure 3: Data collected from Pilot study

In focus groups, participants often described their learning experience as 'happy' and 'very happy', frequently mentioning 'fun' and 'good experience'. Due to limited Chinese vocabulary and students' tendency to hide personal feelings, I expanded the questionnaire's keywords for better expression. Students could choose 3-5 words reflecting their experience. Positive options included interested, meaningful, valuable, exciting, pleasant, relaxing, enjoyable, passionate, inspirational, and rewarding, while negative ones included 'boring', 'waste of time', 'frustrating', 'tired, confused', and 'negative'.

Most participants had a positive experience, with five keywords standing out: interesting (39), inspirational (27),

rewarding (26), valuable (24), and meaningful (23). These accounted for 75% of the feedback. Some participants mentioned the learning experience exceeded their expectations and was different from typical historical museum learning. One participant stated, 'I thought the teaching process would be very tedious and serious, and I was worried that I would fall asleep. However, the workshop was very relaxing and fun, and I was able to participate in the whole process.'

Q5 focuses on feedback regarding the process of workshop and the usage of the game-design toolkit. After reviewing the feedback from the first two workshops, significant adjustments were made to the toolkit, and some game-specific items were added, resulting in stronger positive feedback from participants in the third and fourth sessions. Participants felt that the learning sessions were 'interlinked' and the process was smooth. Three learning sessions received particularly high praise.

The first was the character-design as icebreaker. The toolkit offers 24 occupations for participants to choose from, as well as dice items to add randomness to the game. Character cards provide a writing outline for character development. The detailed design of the toolkit 'instantly put me in character and created a strong sense of immersion'. The second highly praised component was the Co-creation Story Board. Participants felt that it allowed them to 'clearly understand the whole framework of game creation'. Finally, the workshop included two real scene explorations. The project-based learning method, which involved 'collecting information and inspiration from real historical relics and then applying it to game design', was well received by participants.

The feedback aligned with the questionnaire statistics, showing that 21% of participants highlighted the character design, 20% mentioned the co-creation story board, and 19% pointed out the reality exploration as significant sections. The questionnaire also included a special option regarding the level of attention paid to the workshop facilitator, and only one participant selected this option. This result is noteworthy because an important goal of this study was to guide the learning process through the Game-Design Toolkit, diminish the teacher's dominant role, and achieve a decentralized, student-centered learning model. One participant remarked, 'I found the toolkit to be friendly to a novice and even to some of the more professional game designers. The Design Tasks Handbook, in particular, very helpful to me.'

4.3 Assessment of Participants' Learning Outcomes

In addition to the discussion around the 'feelings and experiences' of the participants, a self-assessment of the learning outcomes from the workshop followed. This assessment referred to the General Learning Outcomes (GLOs) framework used in museums and evaluated the learning effect from five aspects: knowledge, skills, personal development, creativity, and environment & society.

In the interview, participants discussed the value of game-based learning in historical and cultural contexts. Most participants did not deny the value of traditional guide in museums, acknowledging several advantages. Firstly, guided tours can objectively and systematically present real historical knowledge. Secondly, they cater to a broad audience, being suitable for people of all ages, from the elderly to children. Lastly, this form of learning is straightforward and simple, requiring neither a significant time investment nor intensive cognitive effort.

When participants were asked to objectively and independently rate the questionnaire, their opinions were fully expressed. Questionnaire Q6 specifically focuses on the role of gamification in historical and cultural learning and divides it into three subdivisions. Participants rate their agreement or disagreement on a scale from 1 to 7, with 1 indicating complete disagreement and 7 indicating strong agreement.

Q6.1: In my opinion, gamification enhances my interest in learning about history and culture. Overall, this viewpoint received a score of 5.87. Eleven participants strongly agreed with this perspective, rating it 7 points. Conversely, one participant gave a rating of 1 point, indicating complete disagreement. However, this participant chose to remain anonymous and did not provide further feedback during the discussion.

Q6.2: Compared to traditional methods of exploration, I gained significant insights into history and culture during the workshop. The overall score for this perspective is 5.2. Nine participants strongly agreed, assigning a rating of 7 points.

Q6.3: Even after 14 days, I retain what I learned about history and culture during the workshop. The comprehensive score for this viewpoint is 3.82, comparatively lower than the other scores. The highest rating received was 5, with 10 participants giving this score. On the contrary, 3 participants rated it 1 point.

In summary, it is evident that game-based learning plays a significant role in acquiring historical and cultural knowledge. This is primarily seen in the shift from passive to active learning, and the clear learning goal (game

design) makes the learning tasks more specific and in-depth. However, based on a 6-hour learning activity, the effectiveness of achieving systematic learning and enhancing knowledge retention is not significant.

In terms of assessing learning skills, the most frequently mentioned keyword by participants in the interviews was 'teamwork'. Related words included 'together', 'clear division of team roles', 'brainstorming', 'high efficiency', and 'high involvement'. Another set of keywords focused on 'creativity and imagination' with related expressions such as 'out-of-the-box thinking', 'inspirational', 'enlightening', and 'novelty'. These feedbacks thoroughly illustrate the participants' sense of achievement in teamwork and the significant learning outcomes facilitated by the co-creation approach for the first time.

In Q7, 17 skills were included in the questionnaire, and participants were asked to select 3-5 skills that they used and developed during the workshop. These skills included: Teamwork, communication, presentation, writing, logical thinking, negotiation, reporting, leadership, observation, information gathering, analysis, time management, emotion management, association, innovative thinking, reflection, and empathy. The top five skills mentioned were teamwork (18%), presentation (13%), logical thinking (13%), observation (12%), and communication (10%). From a statistical perspective, all skills were mentioned, highlighting the significant potential of game-based learning in cultivating students' comprehensive abilities. Compared to merely acquiring specific knowledge, developing students' capacity to acquire knowledge is deemed more crucial in assessing learning outcomes.

In the real world, imagination and creativity require nourishment; they cannot simply arise from nothing. In the final part of the evaluation, I delved into some deeply personal questions with the participants: Did they incorporate elements of themselves into the character creation or story setting? Some participants affirmed this perspective. For instance, one student named his character after his idol, imagining the character possessing the star's appearance and temperament. Another participant crafted a character who excelled in math because she struggled with the subject herself, using the character to fulfill a wish she couldn't achieve.

Regrettably, due to concerns surrounding personal privacy, this aspect of the discussion remains incomplete, as only certain participants with distinct personalities have been willing to share their experiences. Consequently, questionnaire Q8 has been formulated to delve deeper into participants' self-reflective tendencies within this informal learning context and gauge their awareness of this reflective behavior. Likewise, three statements have been presented, inviting participants to rate their agreement level on a scale from 1 to 7. Following the scoring, participants are encouraged to provide additional insights or ratings of their own.

Q8.1: Apart from reflecting on history and culture, I endeavored to infuse personal elements into character design and narratives. The overall score for this viewpoint is 5.53. Thirteen participants strongly agree with this statement, awarding it 7 points, while one participant completely disagrees, granting it 1 point. Surpassing our initial expectations, this rating even exceeded the feedback received during the focus group.

Q8.2: Through interactions with peers and guided explanations during the workshop, I found myself drawn to fresh perspectives on history and culture, sparking inspiration. The overall score for this viewpoint is 5.73. Fourteen participants strongly agree with this statement, assigning it 7 points, while one participant completely disagrees, assigning it 1 point. In their additional comments, some participants shared profound insights: 'I sensed the transformation of values through story creation and exploration of history and culture', 'It encouraged me to boldly enjoy and engage in courageous practice', 'I've become more subjectively attentive to historical sites.'

Q8.3: I value the group reflection discussions, as they provide me with alternative viewpoints. The overall score for this viewpoint is 5.78. Fourteen participants strongly agree, giving it 7 points. One participant's comment left a lasting impression: 'Indeed, allowing ideas to flow freely without constraints often leads to rich outcomes. Whether in work or life, embracing diverse possibilities and employing critical thinking enhances our perception and experiences.' This feedback transcends mere commentary on teaching activities; it serves as personal encouragement and reinforces individual beliefs. Another participant questioned, 'The story crafted by another group was vastly different from ours. The facilitator noted that this disparity stemmed from differing modes of thinking. This raises my curiosity about the distinctions between these thinking processes and what specific differences led to such divergent final outcomes.'

These learning reflections align closely with my expectations when designing gamified teaching activities. Despite being students, the participants are young adults aged between 18 and 25 years old. They exhibit a profound capacity for self-reflection within game-based learning, demonstrating a depth of thought that exceeds my initial anticipations. This highlights the considerable potential of game-based learning, particularly within young

groups.

5. Discussion and Conclusion

This section will discuss the implications of the research findings and further evaluate the potential of the game design workshop and co-creation toolkit to address the research question posed at the beginning of this study.

5.1 Game Design Assists Personal Meaning Generation in Heritage Learning

In heritage learning, young visitors often face challenges in connecting with historical artifacts and deriving meaningful experiences from them (Piscitelli & Weier, 2002). Motivational theories suggest that effective learning in museums is driven by several factors: the opportunity to construct personal meaning, the ability to make choices, the willingness to accept challenges, the capacity to take control of one's learning, the opportunity to collaborate with others, and the presence of positive consequences or benefits for actions (Paris, 1997).

The use of game design as a bridge to create a meaningful context between history and visitors has proven to be effective in this research. One participant remarked in a focus group, 'By immersing myself in the game through the character, I established a weak connection with the museum, which makes me feel like a part of the museum and less sense of foreignness.' This highlighted the potential of game design to enhance personal engagement and reduce the sense of alienation often felt by visitors in heritage learning environments.

5.2 Game Design Workshop Supports Active Learning

Furthermore, the game design workshops supported active learning in a very natural way. Active learning, rooted in constructivist learning theory, posits that learners are active participants in their own learning process rather than passive recipients of information. Learners construct their own understanding and knowledge of the world through experiences and interactions with their environment, and by reflecting on those experiences. This process involves assimilation (integrating new information into existing schemas) and accommodation (modifying schemas in response to new information) (Pardjono, 2016). The observations and findings of this study are fully consistent with this description.

There was a noticeable difference between the participants' engagement during two field explorations in the workshop. During the initial visit, participants displayed a sense of blandness, daze, and even boredom. However, once they formed teams and began the story creation process, they became deeply engaged and excited. They actively explored and discovered creative materials at the site, enthusiastically rushing around the scenic spots of the temple, examining the patterns on cultural relics, and looking up historical information on the Internet.

One participant noted that game-based learning could serve as an extended learning opportunity, complementing the museum's traditional guided tours, making them more 'targeted and interesting' for young people. Another participant used an intriguing metaphor to compare the two learning styles: 'The traditional guide is a bit like a sponge; the guide squeezes out a little information, and then I absorb a little. In the workshop, my subjective initiative became stronger, a bit like panning for gold. I would take the initiative to seek and acquire knowledge, and incorporate my interests, hobbies, or academic abilities into our game story.'

5.3 Game Design Workshop Breaks the Boundaries of Social Group

After more than three years of online education during the COVID-19 epidemic, students' social and communication skills showed a significant decline. It was exciting to find that the game design workshop played a significant role in enhancing these skills through the co-creation process.

Vygotsky's theory (1978) of social context highlights the role of social interaction and cultural context in learning, emphasizing the importance of collaborative learning activities. Learning in activity has become a new approach differing from traditional education (Engeström, 2022). Learning studies are no longer focused solely on the individual but expand to the context of larger collective formations, such as small groups, classrooms, communities, or social groups.

Compared to formal learning, playing in a social group provides the freedom and low-risk environment to explore 'the possibilities inherent in things and events' (Rennie and McClafferty, 2002). Play is pleasurable and enjoyable, intrinsically motivated, spontaneous and voluntary, and involves the player in active engagement (Garvey, 1990).

At the beginning of the workshop, all participants were perfect strangers to each other and showed some initial

caution. However, after the ice-breaker session where they created their characters as avatars for the game, everyone relaxed. Discussions related to the story and conversations about personal interests flowed naturally in the museum study room. Participants took great pride in creating imaginative stories comparable to TV series, which seemed effortless to generate. One participant noted, 'I felt like I was playing a script-kill game rather than learning.' This indicates that the game design workshop not only facilitated social interaction but also made learning an enjoyable and engaging experience.

5.4 Limitation

This study faces several limitations. Firstly, the game design toolkit was tested with a narrow demographic of undergraduate and graduate students aged 18-25 from the Guangzhou Academy of Fine Arts in China. Consequently, due to the constraints of age, location, and educational background, the study data can only offer insights into the effectiveness of the toolkit within a specific region. Future research could aim to recruit young participants from diverse regions and countries, as well as individuals from various disciplinary backgrounds, to provide a broader perspective.

Secondly, the testing site was confined to the South Sea God Temple, a historical site with cultural relics and specific geographical features. This limitation significantly influenced the co-creation outcomes, resulting in a predominance of stories revolving around themes such as sea gods, time travel, and treasure hunting. Future iterations of the study could explore different theme museums, such as science museums or industrial museums, to broaden the application scope of game-based learning activities.

Finally, the main result of this research, game design co-creation toolkit, has certain limitations in its application. One participant said in an interview that the toolkit 'did not succeed in guiding us to a great story.' This suggests that the primary goal of the toolkit is not to train professional game designers but to guide young people in learning about history and culture through game design. The next stage of this research will involve further developing the online game design tool and extending the teaching time to achieve deeper learning outcomes.

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Masters Research Papers

Fostering Inclusivity and Creativity: A Card Game for Color Perception and Inclusion

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Abstract: The gaming industry has undergone a dramatic transformation in recent years, with inclusivity emerging as a core value in the development of new games. Despite these efforts, there remains a gap in the inclusivity of visually impaired individuals in gaming. This paper seeks to address this gap by asking: How can game design enhance colour perception and inclusivity for visually impaired players? The industry has recognized the importance of addressing the needs of individuals with diverse needs and abilities and has responded with innovative approaches aimed at creating games that are accessible to all. One such approach is the development of a card game that has been meticulously designed to stimulate color perception and promote the inclusion of visually impaired individuals. Chroma Harmony is a pioneering mobile application meticulously crafted to facilitate users' understanding of color concepts and the outcomes of different color combinations. Its primary aim is to promote inclusivity by offering features tailored to individuals with visual impairments. Leveraging the innovative ColorADD system, it revolutionizes the perception and communication of color, thereby paving the way for enhanced participation in gaming among those with vision impairments. Its main objective is to paint a cube by combining cards in the player's possession to achieve the closest or exact combination to the objective. With each move, a new card is presented, challenging players to choose the best one to achieve their goals and improve their color perception abilities. By the end of the game, players will have a better understanding of how colors are combined, preparing them for real-world scenarios. Furthermore, the game features a multiplayer mode to foster a sense of community and healthy competition among players. This multiplayer mode not only promotes inclusivity but also provides an opportunity for players to collaborate and challenge each other fostering community sense. In terms of competencies and skills, this game aims to develop several key abilities in its users such as the ability to identify colors, the ability to combine different colors effectively and the necessary motivation and drive for results. By focusing on these competencies and skills, Chroma Harmony strives to provide a comprehensive and engaging experience for all players, regardless of their abilities or background. This study highlights the ongoing challenge in the gaming industry to enhance accessibility and inclusivity, especially for visually impaired individuals, while also standing as a testament to the industry's commitment to inclusivity and innovation, pushing the boundaries of what is possible in gaming.

Keywords: Inclusive Gaming; Color Perception; Visual Impairment; Game Design; Accessibility.

1. Introduction

The gaming industry has experienced a significant transformation in recent years, with inclusivity becoming a central focus in the development of new games. This shift reflects an acknowledgment of the diverse needs and abilities of players, leading to the creation of innovative games that prioritize accessibility for all. However, there is a notable gap in game development that fully integrates visually impaired players. This paper aims to explore this gap by addressing the research question: How can game design techniques be innovatively applied to enhance color perception and inclusivity for visually impaired individuals? One approach is the development of Chroma Harmony, a groundbreaking card game that stimulates color perception and promotes the inclusion of visually impaired individuals.

Chroma Harmony uses the innovative ColorADD system to facilitate players' understanding of color concepts and outcomes of different color combinations. The game also includes a multiplayer mode that fosters community and healthy competition, encouraging collaboration and friendly challenges among players. Furthermore, the game helps players develop key abilities such as color identification, effective color combination, and motivation for achieving goals. By emphasizing these competencies, Chroma Harmony delivers a comprehensive and engaging experience for all players, regardless of their abilities or background. This is an approach that not only contributes to the discourse on inclusive gaming but also provides a practical example of how game design can be utilized to bridge the accessibility gap for visually impaired individuals.

Chroma Harmony can extend its impact by collaborating with educational institutions to teach color theory and inclusivity, as well as with museums, art galleries, and cultural centers. Its availability on various devices will allow it to reach a wider audience and foster a community of players who share their art and experiences online. Ultimately, Chroma Harmony's focus on inclusivity, accessibility, and education positions it as a leading example of the industry's dedication to creating immersive and welcoming gaming experiences for all.

Moreover, the paper is structured as follows: the Introduction section provides an overview of the project, discussing the motivation and background for developing Chroma Harmony, as well as its innovative features and impact on the gaming industry. The Related Work section reviews existing literature and projects related to inclusivity in gaming, color perception, and similar game concepts. The Methodology section outlines the core idea and design philosophy behind Chroma Harmony, including the project's objectives. The Game Design & Development section discusses the game design and the use and implementation of Dynamic Difficulty Adjustment (DDA) in Chroma Harmony. The Evaluation & Quality Control section covers the evaluation process and quality control measures, including testing methodologies and results. Finally, the Conclusions section summarizes the findings and discusses the implications of the project, as well as future research and development.

2. Inclusive Education through Gamification

The concepts of inclusive education and serious games have been extensively studied in recent years. These themes intersect to provide a pathway toward addressing broader societal challenges and promoting access to education and technology for individuals with diverse needs and abilities.

G. K. Verma (2016) emphasizes the importance of UNESCO's initiatives and global conferences that support educational and social inclusion for children with special needs. Although progress has been made in promoting inclusive education, gaps still exist in the implementation of these policies across different countries and regions. Vulnerable and marginalized groups often face significant challenges related to social exclusion and limited access to educational opportunities.

Jayalath and Esichaikul (2020), as well as Molina-Carmona and Llorens-Largo (2020), explore the impact of gamification and advanced technology in motivating and engaging learners, particularly in blended e-learning environments and vocational training. By incorporating game dynamics, mechanics, and components, these approaches aim to enhance learning experiences and improve educational outcomes.

Furthermore, engaging in playful activities can enhance the learning process through multisensory stimulation and immersive experiences. That's why authors like Paula Escudeiro et al. are developing assistive technologies and inclusive pedagogical models to provide the blind and deaf communities with access to digital educational content. This highlights the importance of inclusive educational environments and technological solutions to promote accessibility and integration (Escudeiro et al., 2017, 2022; Marques et al., 2019).

These authors also discuss the potential of serious games to help individuals develop new skills and improve existing ones (Escudeiro et al., 2017, 2022; Marques et al., 2019). These games are particularly beneficial for populations that face barriers to traditional educational resources, such as the visually impaired or those with other disabilities. Inclusive games utilize cognitive models and multimedia learning principles to support learning for diverse audiences.

In fact, the utilization of serious games for educational purposes, as explored by Carvalho and Coelho (2022), has become an increasingly common practice. Serious games leverage the inherent motivation and engagement of games to support education, health, marketing, and social awareness.

Overall, these studies and projects provide valuable insights into how inclusive education, digital empowerment, and serious games can intersect to address societal challenges and create more equitable access to education and technology. This research supports the development of innovative approaches to game-based learning and digital inclusivity, such as the Chroma Harmony project, which leverages these concepts to promote understanding and inclusion for visually impaired individuals in gaming.

However, in comparing our study with these prior works, the Chroma Harmony project contributes a unique focus on the intersection of inclusive game design and colour perception training for visually impaired users. Unlike previous studies that broadly address inclusivity or focus on general gamification strategies, Chroma Harmony specifically aims to improve colour differentiation skills using the ColorADD system, a novel approach that has not been extensively explored in the context of serious games.

By addressing these points, future iterations of Chroma Harmony and related studies can build on this foundation to further refine the approach and enhance its educational and inclusive potential.

3. Methodology

Chroma Harmony is a serious game centered on education, color perception, and inclusion. It strives to introduce an innovative concept for games-based learning, utilizing advanced technologies and a fresh approach to teaching color theory and inclusivity, particularly for visually impaired individuals. By offering a comprehensive, engaging experience, Chroma Harmony serves as a model for blending entertainment with meaningful learning, fostering an understanding of color concepts and promoting a sense of community among players of all abilities.

3.1 Concept

This project involves the design and development of an innovative card game, Chroma Harmony, which aims to stimulate color perception and promote the inclusion of visually impaired individuals through the use of the ColorADD system. The game provides an interactive platform for players to assume the role of artists as they recreate and color impressive three-dimensional objects. The process begins with the conceptualization of the game, based on objectives of color perception and inclusion, and drawing inspiration from principles of universal design and inclusive gaming. Throughout the game, the ColorADD system is integrated to assist players with visual impairments in distinguishing and understanding color combinations.

The gameplay centers around players using color cards to combine colors and complete artworks. The game includes basic singular colors and special cards drawn from a randomly generated deck to keep the experience fresh and engaging. As players advance, the game introduces increasingly complex objects and combinations to challenge their color perception and matching skills. This progression is essential for sustained engagement and skill development. A reward system based on the scores achieved in each stage allows players to earn collectible cards showcasing their results, which vary in rarity depending on their performance. The multiplayer mode fosters community building, collaboration, and healthy competition among players.

In terms of user testing and iteration, the project includes collecting feedback from diverse groups, including players with and without visual impairments, to assess the game's inclusivity, playability, and appeal. This feedback is used to refine the game mechanics, ColorADD integration, and overall gameplay to enhance the player's experience and achieve project objectives.

3.2 Objectives

The project focuses on fostering inclusivity and creativity in gaming by introducing Chroma Harmony, a card game that encourages players to explore color combinations while promoting the inclusion of visually impaired individuals. By integrating the ColorADD system, the game becomes accessible and engaging for all players. As players progress, they develop perceptual and strategic decision-making skills, engaging with a diverse cast of characters and rich narratives that foster empathy and artistic expression. Chroma Harmony sets a new standard in the industry by delivering an immersive, inclusive gaming experience that both entertains and educates players on color perception and inclusion. As such, the project aims to:

- Promote understanding of colors and their combinations by enabling players to explore and experiment with a wide range of color combinations and facilitating a deeper understanding of how different colors interact and how these interactions can be applied in creative and real-world contexts.
- Encourage inclusion of visually impaired players by leveraging the ColorADD system to create a game that is accessible and enjoyable for visually impaired players and removing barriers to participation by offering features such as screen readers, customizable color palettes, and tactile feedback.
- Develop perceptual and strategic decision-making skills by encouraging players to analyze, plan, and execute color combinations to achieve artistic goals and fostering critical thinking through the progression of difficulty and variety in the game's challenges.
- Engage players with compelling, authentic characters, by introducing a diverse cast of characters, including visually impaired and sighted artists, to foster empathy and understanding and building character-driven narratives to enhance player engagement and promote inclusion.
- Stimulate creativity and artistic expression by providing a platform for players to express themselves artistically through color and design and encouraging experimentation and personal interpretation in the creation of three-dimensional artworks.

Overall, the project is centered on creating an engaging and inclusive gaming experience that not only entertains but also educates players on the nuanced aspects of color perception and inclusion. By thoughtfully designing

game mechanics and integrating innovative systems like ColorADD, Chroma Harmony sets a new standard for accessible and inclusive gaming in the industry.

4. Game Design and Development

The project centers on the development of a comprehensive card game designed to foster color perception and inclusion for visually impaired individuals through the innovative use of the ColorADD system. The game begins with a homepage displaying the game name and logo, followed by a login page for players to access their data or create an account. Once logged in, players encounter a menu with options such as single-player and multiplayer modes, a tutorial on how to play, an about the game section, and game settings for personalizing aspects like visuals, audio, and accessibility.

The game features both single-player and multiplayer modes. In single-player mode, players are given an unpainted canvas and a set of cards. They must combine color cards to paint sections of the canvas within a time limit, earning scores based on accuracy and completion time. In multiplayer mode, two players take turns painting a shared canvas and must strategically choose whether to paint a clean area, contest an opponent's work, or recolor their own work.

The game incorporates various types of cards, including basic cards (one color), palette cards (choose one color from a selection), prism cards (which combine with any other card to generate the correct color), diluent cards (which clear the canvas), mirror cards (duplicate the last played card), and RNG cards (which generate a card with a randomly chosen color).

Victory in multiplayer mode is determined by the highest score, which is calculated based on the accuracy of color choices in each painted section of the canvas. The game rewards players with collectible cards and character lore, creating an immersive and rewarding experience that emphasizes both creativity and competition.

Table 1: Game actions.

ID	Game mode	Trigger	Object	Action	Result
1	Single player	Puzzle	Player's hand	Level begins	The player receives 5 cards for their hand. The stopwatch is started
2	Single player/Multiplayer	Player	Player's hand	The player selects 1 'basic' card and 1 section	The section is painted with color. The card leaves the player's hand. The score is updated. The player receives 1card for their hand
3	Single player/Multiplayer	Player	Player's hand	The player selects 2-3 'basic' cards and one section	The section is painted by combining the colors of the cards. The cards leave the player's hand. The score is updated. The player receive s 2-3 cards for their hand
4	Single player/Multiplayer	Player	Player's hand	The player chooses a 'palette' car	X colors are presented to the player for them to choose. The card takes the value of the chosen color and goes to the player's hand
5	Single player/Multiplayer	Player	Player's hand	The player combines a 'prism' card with any other card and selects a section	The section is painted with the correct color. The cards leave the player's hand. The score is updated. The player receives 1 card for their hand
6	Single player/Multiplayer	Player	Player's hand	The player selects a 'thinner' card and a section	The object's section loses its assigned color. The card leaves the player's hand. The score is updated. The player receives 1 card for their hand
7	Single player/Multiplayer	Player	Player's hand	The player selects a 'mirror' card	All cards played by the player so far are presented. The player selects an option. The card goes to the player's hand

ID	Game mode	Trigger	Object	Action	Result
8	Single player/Multiplayer	Player	Player's hand	The player selects an 'rng' card and a section	The section is painted with a randomly chosen color. The card leaves the player's hand. The score is updated. The player receives 1 card for their hand
9	Single player	Stopwatch	Stopwatch	The stopwatch reaches the limit	The level ends, and the final score is calculated and assigned
10	Single player	Puzzle	Puzzle	The puzzle is completed	The final score is assigned. Level rewards are assigned and added to the p layer's collection
11	Multiplayer	Puzzle	Player's hand	The game begins	Players receive 5 cards for their hand. The stopwatches for each player are set to 2m30s. The starting player is decided by chance. The starting player's stopwatch starts counting
12	Multiplayer	Chronometer	Chronometer	The player's stopwatch reaches the limit	The player whose stopwatch reaches the limit loses the match. The level ends, and the final score is calculated and assigned

4.1 Dynamic Difficulty Adjustment (DDA)

To better match the difficulty of gameplay with the skills and experience of players, a passive form of Dynamic Difficulty Adjustment (DDA) is intended to be implemented into the game. DDA is a game design approach that dynamically adjusts the level of challenge based on a player's performance, ensuring a balanced and enjoyable experience for all skill levels (Oostendorp, van der Spek, & Linssen, 2014).

In Chroma Harmony, the DDA system will revolve around the use of the Lucky Card, a special card that can transform into any color the player needs. The influence of the Lucky Card on the gameplay will change according to the player's score and the time spent playing.

The DDA is activated as follows: if a player accumulates more than a certain threshold of points, the Lucky Card will revert to a normal card, reducing its influence on the game. Conversely, if the player's score falls below the designated threshold, the Lucky Card retains its original transformative power, helping the player progress. This system ensures that players of varying skill levels can maintain an engaging and balanced experience as they play.

5. Evaluation and Quality Control

Testing is a critical component of modern software development, essential for ensuring the quality and functionality of an application across a range of anticipated scenarios. This project emphasizes user interaction, focusing on usability, playability, stability, and performance.

To assess the project's technical requirements and measure the degree of fulfillment, the development team employs the Quantitative Evaluation Framework (QEF). QEF serves as a foundational tool for evaluating the project's technical aspects, allowing the team to measure the level of fulfillment for each requirement and ensure the game adheres to established quality standards (Escudeiro & Bidarra, 2008; Escudeiro & Escudeiro, 2012, 2013; Escudeiro et al., 2013; Marques et al., 2018).

Through technical testing under QEF, the team conducts an in-depth analysis of the game's capabilities, limitations, and potential performance issues. This methodical approach enables a thorough evaluation of key aspects of the application, such as functionality, adaptability, and usability. By systematically assessing the degree of fulfillment for each technical requirement, the team gains valuable insights into the project's current state and can make informed decisions about necessary adjustments and areas for improvement.

The structured nature of QEF promotes accountability and continuous improvement, providing a clear roadmap for achieving the game's objectives. Additionally, this framework fosters efficient communication among team members, encouraging collaboration and a shared understanding of the project's progress and goals.

To ensure the evaluation was comprehensive and representative, participants for the testing sessions were recruited based on specific criteria. The recruitment targeted a diverse group of users, including both visually impaired individuals. Participants were informed about the nature of the study and provided written consent to participate, ensuring ethical standards were upheld.

The test sessions were conducted in a controlled environment, where participants were asked to perform a series of tasks within the game that assessed their ability to differentiate and combine colours according to the ColorADD system. Observers recorded the participants' performance and feedback, focusing on their interaction with the game interface, ease of use, and overall experience.

The QEF evaluates the project across several dimensions: functionality, adaptability, and usability. Functionality encompasses aspects such as gameplay, collection, and features, measuring how effectively the game fulfills its intended purpose and objectives. Adaptability evaluates the game's flexibility and accessibility, including its capacity for maintenance, versatility, and accommodation of different user needs. Usability focuses on the user interface and experience, assessing elements like menu navigation, content quality, and integrity (Escudeiro & Bidarra, 2008; Escudeiro & Escudeiro, 2012, 2013; Escudeiro et al., 2013).

In the final evaluation, Chroma Harmony achieved the following scores: 93.868% in functionality, reflecting its success in gameplay, collection, and features; 58.333% in adaptability, indicating potential areas for improvement in versatility and accessibility; and 100% in usability, demonstrating excellence in menu navigation, content quality, and integrity.

By using QEF and regularly reviewing the project's progress, the development team can ensure that Chroma Harmony meets high standards of quality and delivers an engaging, accessible, and inclusive gaming experience.

6. Conclusions

In conclusion, the development of Chroma Harmony, an inclusive game designed to promote engagement for people with vision impairments, has been a significant accomplishment. By incorporating the innovative ColorADD system, the game successfully meets the unique needs of individuals with visual impairments, enabling them to enjoy a rewarding and immersive gaming experience.

Significant effort was invested in meeting the outlined objectives, and most of these goals were achieved. Chroma Harmony stands as a testament to dedication to inclusivity and accessibility, offering a platform where all players can explore and appreciate color concepts and combinations. This experience not only enhances players' understanding of color but also fosters a sense of community and healthy competition.

As this phase of the project concludes, the positive impact Chroma Harmony will have on promoting greater inclusivity within the gaming community and beyond is anticipated. The game's focus on accessibility and educational value positions it as a valuable tool for learning, particularly in the realms of color theory and inclusive gaming. Looking forward, Chroma Harmony presents opportunities for expanding inclusivity in digital entertainment and will play a role in shaping a more inclusive future for the gaming industry.

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Work in Progress Papers

Exploring the Relationship Between Challenge and Reward for Game Based Learning

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Abstract: The aim of this research is to investigate how problem-solving challenges affect young people's motivation for learning computer programming. It explores the relationship between difficulty and reward as part of a game-based learning application and evaluates the effectiveness of the ARCS learning model when teaching primary school children. Research in game-based learning is based, in part, on the study of the impact of games on students' learning motivation, engagement and outcomes. The ARCS model, developed by John Keller in 1987, is a widely recognized model for designing effective instruction that motivates and engages learners. The model is a cognitive psychology-based learning model that consists of four main elements: Attention, Relevance, Confidence, and Satisfaction. A pilot study comprising primary school teachers was conducted to evaluate the effectiveness of the ARCS model. Two experiments were conducted: the first an experimental group based on the design of the game focussing on the player's experience and evaluation of the difficulty and reward mechanisms. For this group, the game dynamically changes in terms of difficulty and rewards. This is achieved by adjusting the difficulty and rewards through a dynamic player score to maintain player attention, confidence, and satisfaction. The second experiment involved a control group, where the game adopts a traditional linear learning model where difficulty and reward are fixed. For both experiments, data was collected from a feedback questionnaire. The questionnaire was designed to be closely aligned and mapped to the ARCS learning model's four elements. The scores of the results were based on the Likert scale and t-test to determine the significance of the difference in scores between the experimental and control groups. Results based on data analysis of the user study show that the overall mean score of the experimental group is higher (= 4/5) compared to the control group (= 2.2/5) on all four ARCS elements. Further analysis shows that the most prominent teaching impact is on players' satisfaction.

Keywords: Game-based Learning, ARCS Model of Learning.

1. Background and Research Motivation

Research has shown that people invest more time, energy and are more motivated in areas they have a great interest in (Harackiewicz et al, 2016). This underpins the idea that interest is categorized as an important factor that influences learner motivation and engagement with a subject. Educational digital games have been found to enhance learner motivation towards curriculum engagement and improve their learning outcomes. Studies indicated by (Sabirli and Çoklar, 2020) show that the use of educational games to augment learning beyond the classroom, can enhance players' attention and motivations. Further, students who engage with game-based learning have a higher level of positivity towards learning and have improved their academic performance (Zhan et al, 2022).

The challenge when introducing game-based learning to users is to balance the difficulty and reward elements during game play. Research has shown that the setting of game difficulty needs to match a player's game proficiency and skill level, allowing players to maintain high levels of motivation, participation, and enjoyment during game play (Koskinen et al, 2023) though game difficulty levels need to be reasonably set (Kristan et al, 2020). Equally, rewarding a player during gameplay influences their motivation and engagement. Greipl's study found that the reasonable use of rewards in game-based teaching can improve players' participation and motivation (Greipl, 2021). It was also shown that rewards in game-based learning can increase intrinsic motivation, enabling players to develop their learning and problem-solving in a sustainable way (Ryan, 2000).

2. ARCS Model of Instructional Design and Learning

The framework to assess the effectiveness of our experimental design is the motivational pedagogical model proposed by Keller (1987). This model was originally developed to find more effective methods of understanding the influences on the motivation to engage with a learning environment. Keller (1979 & 1983) applied motivation theories to design theory, behavioural theory, and cognitive psychology. Based on research in these areas, Keller (1979) concluded that motivation involves more than extrinsic factors. Learners are not only affected by extrinsic behaviour factors but also by intrinsic factors (Keller, 1979).



Figure 1: Keller's ARCS model for motivational learning

The first provision of the ARCS model and a prerequisite for learning is *attention*; and gaining attention by a defined methodology (or the use of strategies within a learning application such as difficulty settings in games). Secondly, the learner requires a feeling of perceived *relevance*. This refers to the concept of linking the content to a learner's needs. In this case, this would be in the "in-game" activities and how closely they link to the computing curriculum. The recipient must sense that what has attracted their attention is of benefit to their learning and time. The third element in the ARCS model is *confidence*. Confidence is linked to the "in-game reward" and the relationship between difficulty and reward. Solving a more challenging task will give players greater confidence in their ability to solve the next problem. And finally, *satisfaction* arises from solving problems and receiving a reward, but the relationship between difficulty and reward is linked to game-play balance and flow and their impact on player experience. An easy task can make a player bored, equally a difficult task could create anxiety. The relationship between difficulty and reward and how this dynamically changes is a crucial factor for player satisfaction.

Keller's model was not originally developed for game-based learning. However, literature on the use of the Keller's model has been used as a basis for the design, and integration of ARCS into games as an evaluative method for learning. Cheng and Su (2012) developed a game-based learning system to improve self-efficacy for students' learning for an information systems analysis course. For this research, Keller's ARCS model was used as an evaluation tool to assess students' learning. The results show that the learning motivations of students who used the game application had a significant impact on their learning progression compared with student who adopted the traditional face-to-face teaching method. In a second study Hamza et al (2014), proposed an enhanced ARCS+G model for gamification of learning. This model was utilised to identify the motivational requirements of learners during the gamification process and was later implemented in the development of motivational design for e-learning. Kanoko et al (2015) developed and evaluated a game-based learning environment for library instruction based on the ARCS model. In this research, a user study based on an experimental and control groups was carried out to compare game-based and e-learning performance respectively. Results showed that no significant difference in performance was found between the two groups, however three ARCS components were significantly higher for the experimental group when compared to the control group. Camacho-Sánchez et al (2023) assessed the effects of an educational intervention grounded in game-based learning on attention, relevance, confidence, satisfaction, intrinsic and extrinsic motivation, as well as academic performance, utilizing the ARCS motivational design model. The findings of this study revealed significant disparities in the ARCS dimensions between the intervention and control groups. The experimental groups displayed notably lower scores in attention, relevance, confidence, and satisfaction. The intervention had a significant impact on students' perceptions of intrinsic goals and task value, and it exerted a moderate influence on extrinsic goals. The findings suggest that integrating the gamified digital game-based learning approach with the ARCS model can effectively enhance students' motivation, academic performance, and practical knowledge in higher physical education. Koceska et al (2024) presented work on the design and development of an educational game for children with special educational needs (SENs). The study combined the ARCS motivation model with a game design model to develop a user interface through which learners can control learning objects using their physical movements. The validation of the design was done using the quality assessment instrument called LORI (Learning Object Review Instrument).

3. Research Design

The research conducted for this work-in-progress paper is based on a pilot experimental study. The participants in the experiment are primary school teachers who deliver on the computing curriculum with a teaching experience ranging between one and 15 years. The experiment and questionnaire were conducted online. All participants agreed that the experimental group's game design was more biased towards their preferences, but the aspects they favoured differed. All participants took part in this study on an anonymous basis. The total sample size and number of participants for this study = 10 (N= 10). The number of participants was equally split between the experimental and control groups. The experimental group experienced the game based on the

ARCS learning model, with a focus on exploring the effects of difficulty and reward on players. Here, difficulty and rewards during game-play change dynamically according to the player's "in-game score" as a way of maintaining player attention, confidence, and satisfaction. The control group experienced the traditional linear educational model in which difficulty and rewards are fixed. The evaluation of this study is based on the analysis of data collected from feedback questionnaires. The questionnaire was designed to be closely aligned and mapped to the ARCS learning model's four elements shown in Table 1 below.

Table 1: Questionnaire mapped to Keller's ARCS model of learning.

Keller's motivational model	Questions aligned with Keller's model of learning
Attention	-Your attention was attracted already at the beginning of the game. -The ordering and sequencing of shapes, forms and sounds of the game affects the learning process.
Relevance	-The software allows you to take a break and continue later. - You intend to recommend the application to others.
Confidence	- You use correct terms while referring to the application. - You have the impression (at first sight) that this would be an easy game to play.
Satisfaction	- The procedures of the application motivate the user. - The application is entertaining to the user.

Feedback from both sets of participants were quantified into scores based on Likert scales and t-tests to determine the differences between the experimental and control groups. Details of the attained results and their evaluation are presented in Section 3.

4. Results and Evaluation

The results of this pilot experiment are shown in Figure 2 below. Figure 2 shows that the scores for each of the ARCS model of learning for the experimental group are higher than those experienced by the control group. The overall score of the experimental group was 4 (out of 5) while the overall score of the control group was 2.225 (out of 5). Looking at each element of the ARCS model (Attention, Relevance, Confidence, and Satisfaction), we note that their scores are 4, 3.9, 4.1, and 4 for the experimental group and 2.5, 2, 2.4, and 2 for the control group. Combining the above data and the mean difference shows that the experimental group's scores are higher than the control group on all four ARCS elements. We can deduct from these results that the effect of dynamically changing the in-game difficulty and award based on players' "in-game score" incentivises players to maintain attention, confidence, and satisfaction and overall perform better than the traditional linear education model.

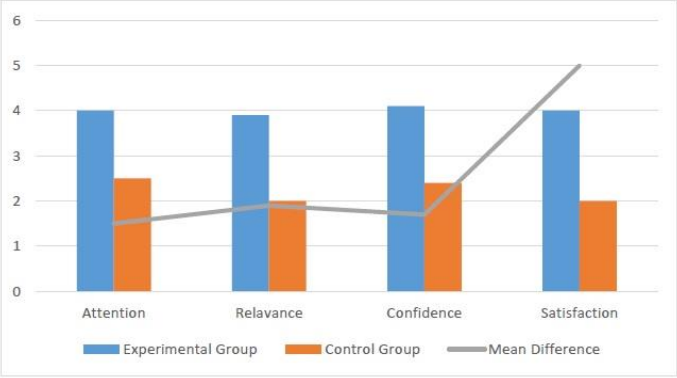


Figure 2: ARCS model mean scores for experimental and control groups

Given the small sample size of our participants, a t-test inferential statistic was implemented to assess whether the differences in the attained results are significant. In turn this enable us to generalise our finding and make inferences about users beyond our data for this pilot study. Equation 1 and Table 2 below show the formula for the t-Test and the t-Distribution table in terms of degrees of freedom according to different α.

Equation 1: t-test calculations formula

$$t = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Table 2: t-Distribution table

t Table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850

Looking at Table 2 and given that the total sample size of the combined group is 10, the degree of freedom in the t-test will be calculated by subtracting one from the total number of participants (N-1 = 9). The experiment is based on one tail, and the chosen significance level α is usually taken as 0.05 or 0.01. For this experiment α = 0.01 was selected because a higher significant difference was desired in the results. When the calculated t-test is greater than the corresponding t-quartile, it indicates a large difference. This can be seen in Figure 3 below.

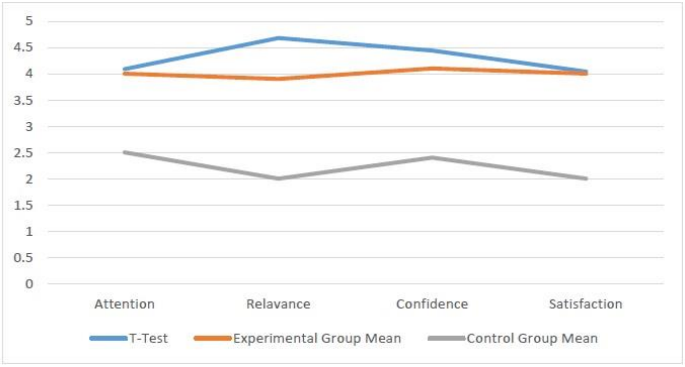


Figure 3: The parameter is a line graph of the t-test values calculated as the mean of the experimental and control groups at α = 0.01 and df = 9.

The t-tests for Attention, Relevance, Confidence, and Satisfaction were calculated to be 4.09, 4.68, 4.44, and 4.04. These figures are all greater than the corresponding t quartiles at α=0.01 and df=9. They indicate that the experimental and control groups have more significant differences in the means for all four components of the ARCS model.

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Educational Gaming and Situational Interest for Higher Education Students

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Abstract: InPraktijk is an educational game developed for first year physical therapy students. The game aims to use playful learning to optimize students' interest in interacting with course content. This project is a first step in achieving a versatile educational game platform optimized for engaging, playful learning that can be applied across multiple educational programmes. The project seeks to improve students' motivation to engage with course materials outside of class time and explore the relationship between playful learning and situational interest. Our research is focused on a deeper understanding of the relationship between situational interest and playful learning. The InPraktijk game, developed in collaboration with Game Tailors, will be used as a tool to test this relationship. Through the game, we will collect quantitative data on time played, drop out location and situational interest using the situational interest scale. This work in progress paper covers the design for study 1 of the InPraktijk project. The study indicates whether the gamified interaction with course content can generate more situational interest compared to traditional content delivery methods. The results will provide insights into the effectiveness of the InPraktijk app in stimulating situational interest. Our findings will guide the direction of follow-up studies on further game optimization and the integration of playful games in educational structures.

Keywords: Serious games, games-based learning, playful learning, situational interest

1. Introduction

In higher education, motivation is a necessary element that stimulates and maintains successful learning (Sogunro, 2015). Game elements focused on harnessing the power of students' intrinsic motivation can help ensure that students stay interested and engaged with their course content (Konetes, 2010). Additionally, playful learning can help generate excitement, enjoyment, and interest in the learning process for higher education students (Rice L. , 2009). Interest is a psychological state that has a positive relation with learning outcomes in the context of educational games (Koskinen, et al., 2022). Through this project, we develop and test a game that intends to stimulate students' situational interest in study-related learning materials. Situational interest can be defined as the motivation to engage (Silvia, 2008), or the motivational state students experience when engaging with a task (Schraw, Flowerday, & Lehman, 2001).

InPraktijk is an educational game that uses playful learning and game elements with the aim of increasing students' situational interest, or motivation to engage with their course materials. InPraktijk is an educational game designed for physical therapy students at the Utrecht University of Applied Sciences (HU) in collaboration with Game Tailors, a serious game development company located in the Netherlands. It focuses on harnessing students' intrinsic motivations to become physical therapy professionals to trigger situational interest in the educational game. Using the InPraktijk game as a tool, this research aims to explore the relationship between situational interest and educational gaming in higher education students. The focus is on providing interactive content that triggers situational interest through playful learning, creating an environment that resembles practical application or "InPraktijk". The goal of this iterative study is to achieve measurable improvements in students' motivation to engage with course material via the InPraktijk game.

The game is a mobile application that simulates a physical therapy practice: students portray the role of a physical therapy intern and have to treat patients by completing patient cases. When entering the app there are patients waiting in the waiting room, students must then begin the medical history conversation with the patient. Students are given multiple choice options for how to continue the conversation, if they choose the wrong option the assistant provides tips as to why this may not be the best choice. Throughout the conversation small exercises may appear, such as organizing the varied factors influencing the patient in the right category (social, cognitive, emotional).

2. Related Work

2.1.1 Situational interest formation

Situational interest can be understood as the appealing effect of an activity on an individual, as opposed to the individual's personal preference for the activity, or their individual interest (Hidi & Anderson, 1992). Situational interest was later defined by Hidi (2001) as a short-term psychological state triggered by something in the immediate environment. According to Schiefele (2009), triggering situational interest can facilitate intrinsic motivation to learn more about a subject. However, according to Rodríguez-Aflecht et.al. (2018), triggering situational interest without maintaining it can actually have negative long-term effects on individual interest. This makes the relationship between situational interest, individual interest, and intrinsic motivation complex.

2.1.2 Situational interest in educational games

Situational interest is a motivational construct that can be related to students' engagement in game-based learning (Kiili et.al., 2021). According to a study by Kosiken et.al. (2022), in the context of educational games, situational interest and learning are positively related. While game-based learning is expected to increase students' situational interest (Plass, Homer, & Kinzer, 2015), a study by Rodríguez-Aflecht et.al., showed that educational gaming environments may only trigger situational interest in students who are already interested in the subject before the game-based intervention (2018). Again, highlighting the complexity of the relationship between situational interest and educational games.

Plass et. al. (2015), reviewed the psychological foundations of game-based learning and noted the additional complexity of intrinsic motivation and situational interest in the context of game-based learning. They discuss how students may be intrinsically motivated to play the game but not to learn the content, therefore, when designing educational games, it is crucial to tightly link learning and game mechanics. Csikszentmihalyi's concept of flow- a state of complete absorption in an activity (1975) can also be used when discussing playful learning or gaming. Flow is a state of peak enjoyment, energetic focus, and creative concentration (Csikszentmihalyi, 1975). According to a study by Kiili et.al., (2021), situational interest and flow share similar components, however, they are independent constructs. For this study we will focus on the concept of situational interest, however; the relevance of Csikszentmihalyi's concept of flow should be mentioned. There is still a lot that is unknown about the relationship of situational interest and intrinsic motivation in the context of educational games. This study attempts to explore this relationship through the use of the InPraktijk game.

3. Study design

The aim of this study is to assess whether the gamified delivery of course content generates more interest compared to traditional methods, such as static cases. To measure this, all first-year physical therapy students at the Utrecht University of Applied Sciences (HU) in academic year 2024-2025 (n=+/-200) will be invited to participate in a study. The InPraktijk game will be introduced to half of the students, and the other half (control group) will interact with the same content/ cases via a static format that does not utilize playful learning. The students will be instructed to participate in the study over the course of the first block of the semester, +/-8 weeks. The study set-up will first be piloted with a group of n=10 UX researchers to optimize the study design and identify any usability issues in the game and n=10 physical therapy teachers to identify any potential content issues.

The following research question is guiding this study; *Does physical therapy students' situational interest in the course content increase when interacting with the InPraktijk game as opposed to a static content delivery method?*

- Is there a difference in situational interest between the control group and InPraktijk app user groups?
- Does the students' level of situational interest correlate with the number of cases they complete?

3.1.1 Methodology

Study 1 consists of two groups, a test group (Students use the InPraktijk app to interact with the patient cases) and a control group (students receive the patient cases in a static online format). Teachers will be instructed on how to introduce students to the cases during class time, they will be given standardized prompts to reduce potential bias amongst classes. Students will be randomly placed in either the control or the test group.

3.1.2 Data collection and analysis

Situational interest is measured using the Situational Interest Scale (Rotgans & Schmidt, 2014). Situational interest will be measured at five points throughout the game, after a designated amount of playtime. Qualitative data on students' interest formation, game-play experience and intrinsic motivation will be collected via semi-

structured interviews after the test period. Quantitative user data is collected on player activity in the following ways:

- *Time played*- A player's activity is measured per second of playtime. If the player closes the app (soft close) this is considered inactivity.
- *Login attempts*- A login attempt is only measured when actual gameplay occurs. If a user logs in and does not complete any tasks, then this is not registered.
- *Drop out location- Captures* the last active location in the app for students who leave the app.
- Shows the last mission played, when it was, and how long they spent on it.
- Shows if a mission has been started and completed.

Students from the test group and control group will be interviewed using semi-structured interviews to uncover qualitative data behind students' motivation and interest regarding the content and content delivery methods. The interviews aim to discover how students interact with the game, what they enjoyed, and whether they are intrinsically motivated to continue playing the game.

Study 1 aims to uncover the following insights using the Situational Interest Scale in combination with InPraktijk player data:

- By conducting a T Test analysis, we will determine if situational interest (measured using the Situational Interest Scale) is higher with the InPraktijk app than with the control group
- Using the Pearson Correlation Coefficient (*r*) we will determine if the students' level of situational interest correlates with the number of cases they complete.
- Using the Pearson Correlation Coefficient (*r*) we will examine if the time students spend in the app correlates with their interest, as measured by the Situational Interest Scale.

4. Conclusion

The results from this study will help uncover insights into the relationship of playful learning and situational interest for higher education students. The study will also determine whether the InPraktijk app adds value by enhancing students' situational interest in comparison to traditional content delivery methods. This information will guide decisions on the potential integration and improvement of the InPraktijk game in educational settings. By leveraging playful learning elements and game mechanics, the project aims to stimulate situational interest, thereby facilitating a deeper connection with course materials. Insights gained from this research will inform the ongoing evolution of educational gaming platforms and holds promise for broader applications across diverse educational programs.

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WeAreEurope SD: A Playful Sustainable Development Education Approach for Primary School Level

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Abstract: Sustainable Development (SD) has been in the EU's political Agenda for the past decades. In 2001, the EU established a SD Strategy and more recently contributed to the UN's 2030 Agenda for SD, reaffirming the political importance it attributes to this pressing matter. Education for Sustainable Development (ESD) plays a vital role in pushing forward the Agenda for SD. The WAE-SD project has been designed so as to offer a variety of complementary learning solutions that use active learning, game-based learning, and storytelling, among others. These solutions have the potential to engage children, address more complex concepts in a comprehensive manner, contribute to the development of other XXI century and basic competencies, like literacy, teamwork, social competences, ICT skills, among others. The WAE-SD project addresses the educational needs of children (6-10 years old) at 3 levels: a) Envision the future: depict what might happen if we don't change our lifestyles, so that they better understand what's at stake, b) What needs to change: learn about the UN's SD Goals, so that they better understand what should be addressed/emended to create a more sustainable world, and c) Call to Action: learn what we can do as individuals and as part of a community to reach the UN's SD Goals, and act. To this purpose, the project delivers three results: a) an eBook to illustrate a future scenario for the Planet if we keep up with our lifestyle, b) A Game Add-on to the pre-existing WeAreEurope Digital Game, to introduce and explore the UN's SD Goals, thus presenting children with what needs to be changed for a more sustainable Planet, and c) an Action Kit, consisting of guidelines for the implementation of SD projects/activities for schools and other settings, thus promoting real change in behaviours and attitudes. This paper focuses on the designed material and the proposed ways of utilizing them in classroom settings

Keywords: Sustainable Development (SD), Digital Games, Primary Education

1. Introduction

As Earth and human development face enormous and increasingly complex challenges such as climate change, global warming, overpopulation, and inequalities, the search for solutions takes the political stage. A widely accepted response to these challenges is the notion of Sustainable Development (SD), referring to a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). SD has been in the EU's political Agenda for the past decades. In 2001, the EU established a SD Strategy and more recently contributed to the UN's 2030 Agenda for SD, reaffirming the political importance it attributes to this pressing matter. Education for Sustainable Development (ESD) plays a vital role in pushing forward the Agenda for SD.

According to the United Nations (UN, 2018), all educational institutions ranging from preschool to tertiary level should consider it their responsibility to address SD and foster the development of key crosscutting competencies related to sustainability. Following this direction, the WAE-SD project offers learning materials that use active learning, game-based learning, and storytelling. These materials have the potential to engage children by addressing more complex concepts in a comprehensive manner, while also cultivating transversal competencies. The project proposes to address SD with children (6-10 years old) at 3 levels: a) Envision the future: depict what might happen if we don't change our lifestyles to better understand what's at stake, b) What needs to change: learn about the UN's SD Goals to better understand what should be addressed/emended to create a more sustainable world, and c) Call to Action: learn what we can do as individuals/community to reach the UN's SD Goals, and act.

To this purpose, the project aims at delivering 3 Results:

- An eBook to illustrate a future scenario for the Planet if humanity keeps up with the current lifestyle
- A digital Game, to introduce and explore the UN's SD Goals, thus presenting children with what needs to be changed for a more sustainable Planet.
- An Action Kit, consisting of guidelines for the implementation of SD projects/activities for schools and other settings, thus promoting real change in behaviours and attitudes.

In the next section, the eBook and the game are presented, as the project is still a work in progress, before the concluding remarks and the future plans.

2. The WAE-SD Approach

Overall the approach was a follow-up of a previous WAE project about European citizenship education (Bratitsis et al., 2016; 2017; Bratitsis, 2018) and thus utilized the same narrative. This concerned 4 children who got lost in time and had to travel back to today. Three main outputs were designed for WAE-SD.

The first output is an eBook which aims to raise children's awareness about SD and the need to take action. Stories have the potential to create engaging narratives and scenarios that can be used to illustrate and explain more complex topics, deconstructing them and levelling them down, making it also more inclusive (Bratitsis, 2017). In the story (Figure 1) the 4 characters travel to the future. There they get a glimpse of the consequences that today's lifestyle might impose to the planet if nothing changes. The aim is to cultivate the children's disposition to the learning process, involving the other outputs.



Figure 1: The frontpage and the main characters of the WAE-SD eBook

The characters visit known places in Europe in their search for parts of a medallion, required to activate a Time Portal for their return. During their adventure they find out that humans have mistreated nature with disastrous consequences. Despite the scientific advances in various areas, they neglected to look after the Planet and failed to create a better society. Thus, the children see the results of such actions which are water acidification, climate change, sea level rise and biodiversity loss (Figure 2).



Figure 2: Pages from the WAE-SD eBook

The eBook is accompanied by an educators' guide to help them explore the story with children in the classroom. It contains questions and lesson plans to explore situations in the story, characters' behaviours, etc. Also, it includes additional contents/explanations to encourage further reflection and class discussion. The lesson plans are pilot tested while this paper was being written. The material is freely available in 5 languages (English, Greek, Portuguese, Polish and Italian) on the project's website (http://wreurope.eu/).

The main project's output, the focus of this paper is the WAE-SD game, which is based on the pre-existing WeAreEurope Game (Bratitsis et al., 2017). The design process followed the same approach (Bratitsis, 2018). It allows a more effective children's engagement, as the provided context and the immersed activities, allow to create a more challenging and yet very inclusive learning environment. The main objective is that children learn

about the UN's SD Goals and required action plan. Moreover, they can experiment in order to understand at what levels to revert, stop or reduce the negative impact of human behaviour on the Planet.

The game can be played individually or in a group setting. Figure 3 depicts the game roadmap and introductory page. A short video introduces the game context. The players would have to navigate within the map of Europe to reach specific checkpoints. There they would have to go through challenges, also allowing them to see some information about the corresponding SDGs.

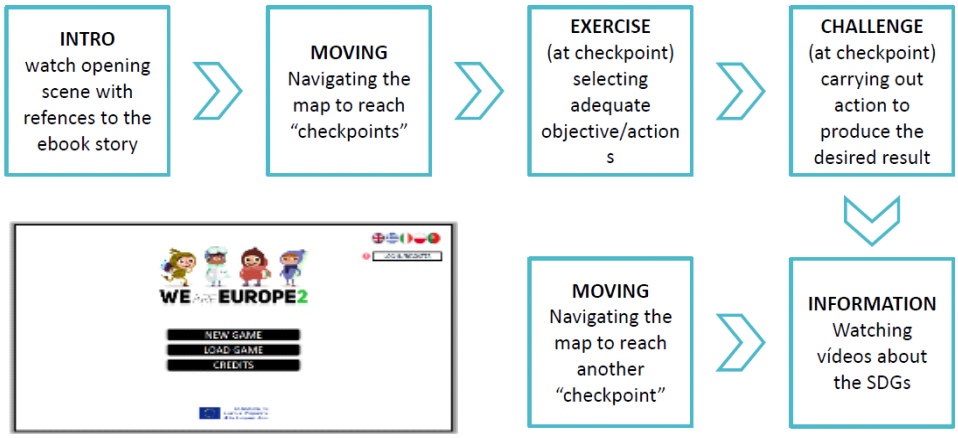


Figure 3: The roadmap and the introduction page of the WAE-SD game

The game pictures a near future where Europe is suffering from the consequences of the lack of response to the Sustainability issues. The characters go through a Time Portal, arriving to the future where they find a different Europe: pollution is hard to bear, extreme climatic phenomena are frequent, economy has depleted, there is a huge unemployment rate, poverty and famine are spreading. Their aim is to uncover the chain of events that led/pushed Europe to a precarious situation and to find their way back to the present where they still can make a difference and prevent that terrible future.



Figure 4: The map of the WAE-SD game

The game starts with a map of Europe (Figure 4), identifying 6 checkpoints which the players must visit. They correspond to places mentioned in the eBook story. In each checkpoint, the players must solve a challenge which will contribute to evade the future problems described in the eBook. The challenge in each checkpoint is connected to SDGs and SD problems as they are described in the eBook. Upon completion, a 7th checkpoint reveals a secret place where another character, David, is being held by the Time Agents and the players will attempt to free him. David was a mentoring character, present also in the first WAE game.

To reach the checkpoints, players must navigate the map using the cursor keys or a mouse. While doing so, players should avoid the Time Agents. These Agents try to catch the players. If they do, players will have to answer correctly to a question to mislead the Time Agents into believing they should be released. The questions are connected to SD topics. Some examples are: "What is ocean acidification?", "Which of the following are examples of cleaner energy", "Give examples of consequences of the global warming".



Figure 5: Checkpoint 1, the hometown mockup

In each checkpoint, different SD aspects are treated. For example, in the first checkpoint (Figure 5) the players see their hometown which has become unrecognizable. The players need to choose from a list of objectives to achieve, following the eBook story. Upon selecting the correct ones, they are asked to complete a challenge. In this case (Figure 5), that is to examine their hometown as it is today and plan its future form through drag-and-drop actions, thus adding buildings and elements of infrastructure in the empty spaces. They may add, for example, wind turbines and replace coal plants, add mass transportation systems, recycling factories, green areas, etc. All these actions result in a more sustainable city, meeting the initially selected objectives. During the challenge they can see 3 indicators: Pollution, Economy and Clean Energy (top left of the screen). The indicators are initially slightly negative and may improve through the players' actions. Tooltips for all main items on the map may provide explanations. The empty map spaces designate the available number of changes to be applied. When players define their plan, they "submit" to get feedback.

Depending on the actions, algorithms have been designed to calculate the value of each indicator. For example, installing solar panels on roofs give +0.25 point for a maximum of 8 panel sets. After the puzzle is solved correctly, the players are presented with information about the specific SDG related to the checkpoint, namely videos from the UNESCO or other sources that explain in more detail what each SDG is all about. The SDG/videos may repeat in checkpoints as some topics are recurrent, but if the repeated video was watched before it will show in faded colour.

The game itself serves mainly the purpose of raising awareness and providing a tangible perspective on the consequences of human activity on the planet. Thus, as an educational resource it should be utilized with the accompanying material, including the eBook. The designed lesson plans address this requirement.

Up to this point, 3 of the 6 checkpoints have been implemented and are being tested with students. The game has been developed in HTML5 and the backoffice relies on PHP5 and MySQL database.

3. Future Plans

Upon completion of the game development, including testing and refinement, a third output is planned, an Action Kit. It consists of a set of proposed SD projects/activities for implementation in schools and other settings. It includes detailed guidelines, examples and, in some cases, demonstration videos and other materials. This learning activity and resource applies active-learning methodologies that are known for their positive impact on the inclusion of the learning process. The projects/activities might include things like (examples): a) preparing and making a campaign in school or in the community for saving water, b) writing and performing a theatre play about the subject of poverty, and c) designing specific measures to promote gender equality in school.

All these projects are being co-created with pupils from the partner schools in order to benefit from children's perspective and imagination and generate immediate impact on those involved, namely by encouraging a real change in behaviours and attitudes.

Upon completion, all the project material will be freely available through the official website.

Acknowledgements

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Gamification for Sustainable Management Education: Prosper Management Edition's Role in South Africa's Climate Policy Engagement

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Abstract: The escalating climate crisis necessitates inventive strategies to engage diverse stakeholders in sustainable management and policy-making, particularly in regions like South Africa. "Prosper Management Edition," developed under the GREAT project, leverages gamification to foster communication between future corporate leaders, citizens, and policy stakeholders. This educational game connects sustainability principles with their practical application in management and policy, focusing on the integration of Sustainable Development Goals (SDGs) into business operations. This paper presents the initial design stages, implementation strategy, expected outcomes, and theoretical underpinnings of the game, aiming to enhance participants' awareness of sustainability and strategic thinking.

1. Introduction

In today's rapidly changing educational landscape, innovative methods that merge entertainment with educational outcomes are increasingly crucial, especially in addressing complex global challenges such as climate change and sustainability. "Prosper Management Edition," developed as part of the GREAT project, represents a pioneering approach in this direction. It utilizes the principles of gamification to transform traditional educational paradigms into dynamic and engaging learning experiences. This game targets university students and young professionals, integrating key sustainability practices into a virtual management and policy-making environment. By doing so, it not only aims to educate but also to deeply engage the players, encouraging them to think critically and apply their knowledge in practical, impactful ways.

The rationale behind integrating gamification with education, particularly in the field of environmental policy and sustainability, is supported by a growing body of research indicating that active learning environments significantly enhance both engagement and retention of complex material. "Prosper Management Edition" is designed to challenge players to navigate the multifaceted issues surrounding sustainable management practices, aligning business operations with the Sustainable Development Goals (SDGs). The research questions guiding the development and implementation of this game include: How effectively does gamification promote understanding and engagement with sustainability practices among university students? Can a well-designed educational game enhance participants' strategic thinking and decision-making skills in the context of climate policy? These questions reflect the game's core objectives: to foster a practical understanding of sustainability issues and to develop capable future leaders in the field of environmental policy and management. This game not only serves as an educational tool but also as a platform for vital research into the effectiveness of gamification in higher education settings, particularly in enhancing learning outcomes related to complex societal challenges.

2. Theoretical Foundations in Game-Based Learning

The integration of game-based learning (GBL) within educational environments leverages the motivational potential of games to facilitate deeper engagement and understanding, particularly in complex subject areas such as sustainability and climate policy. Fundamental to this approach is the application of key educational theories, including constructivism and cognitive engagement theories, which suggest that learners construct knowledge best through active participation rather than passive reception. In "Prosper Management Edition," these theories are operationalized through immersive gameplay that requires players to make strategic decisions that reflect real-world sustainability challenges. By placing players in roles that simulate real-life positions of influence, the game facilitates experiential learning, allowing players to experience the outcomes of their decisions and thereby enhancing their understanding of the principles of sustainable management and policy-making.

Additionally, the game design incorporates elements of intrinsic motivation theory, as outlined by Ryan and Deci in their Self-Determination Theory, which posits that effective learning is driven by intrinsic motivators such as autonomy, competence, and relatedness. "Prosper Management Edition" is crafted to satisfy these motivational needs by providing players with autonomy in decision-making processes, challenging tasks that enhance their sense of competence, and opportunities for social interaction that fulfill their need for relatedness. These elements are crucial for maintaining engagement and promoting a deep, meaningful learning experience that translates beyond the game. The educational efficacy of this gamified approach is anchored in the ability to scaffold learning content, offering progressive challenges that adapt to the player's growing skill set, thus maintaining a balance between skill level and challenge that keeps players in a state of flow, as conceptualized by Csikszentmihalyi. This theoretical framework supports the game's goal to not only educate about sustainability but also to inspire a proactive approach to global environmental challenges.

3. Sustainable Development Goals as a Framework

"Prosper Management Edition" strategically employs the United Nations Sustainable Development Goals (SDGs) as a foundational framework to inform its gameplay mechanics and content. By embedding the SDGs directly into the game's structure, it ensures that each decision and strategy undertaken by the players is anchored to these global objectives. The game features problem cards that each represent a significant global issue related to one or more SDGs, such as climate action, economic inequality, or sustainable cities and communities. Players are then tasked with matching these problem cards with appropriate solution cards, which represent actionable strategies or interventions designed to address the specific issues depicted on the problem cards.

The gameplay is designed to promote collaborative problem-solving and discussion among players. Each solution card must not only be relevant to the problem card but should also be justified and discussed among team members, ensuring that the proposed solutions are understood and agreed upon by all players. This discussion phase is crucial as it encourages players to engage deeply with the SDGs by thinking critically about how best to implement sustainable solutions in various scenarios. The game thus serves as a dynamic educational tool, providing players with a practical understanding of how SDGs can be applied to real-world problems. It emphasizes the complexity and interconnectedness of global challenges and highlights the necessity of teamwork and collective action in achieving sustainable solutions. Through this interactive and cooperative approach, "Prosper Management Edition" not only educates players about the SDGs but also instills essential skills such as strategic thinking, negotiation, and consensus-building, which are vital for fostering global citizenship and achieving sustainable development.

4. Game Design and Implementation

"Prosper Management Edition" employs a thoughtful design that immerses players in real-world scenarios through the strategic use of problem and solution cards, each intricately linked to the Sustainable Development Goals (SDGs). The game design hinges on a unique mechanic where problem cards, depicting global issues such as environmental degradation or social inequality, are presented to the players. These cards require players to apply critical thinking and collaborative decision-making skills to match them with appropriate solution cards. Solution cards offer a range of interventions or strategies that could realistically be implemented to address the problems. This matching process is not only about finding correct answers but also about stimulating discussion and debate among players, fostering a deeper understanding and awareness of complex global challenges.

To enhance the learning experience and ensure that the game mechanics promote active engagement, the game also incorporates a narrative element that contextualizes the challenges within a broader story of global interconnectivity and collective responsibility. Each session of gameplay is designed to build upon previous experiences, gradually increasing in complexity and requiring players to synthesize knowledge from various domains. This progressive complexity helps maintain player engagement and interest throughout the game, while also mirroring the increasing difficulty of addressing global issues in reality. Additionally, the game is designed to be inclusive and accessible, featuring clear, intuitive interfaces and inclusive visuals that reflect a diverse range of cultures and perspectives. This inclusivity ensures that players from different backgrounds feel represented and that the game can be used effectively in a variety of educational settings, from classrooms to informal learning groups. Through its thoughtful design and implementation, "Prosper Management Edition" not only educates about the SDGs but also empowers players to think critically and collaborate effectively to tackle some of the most pressing issues facing the world today.

5. Methodology

The game's rollout involves collaboration with educational institutions and businesses to facilitate pilot testing in South Africa. These implementations are monitored to gather both quantitative and qualitative data on the effectiveness of the game in improving understanding of and engagement with sustainability issues. Methodologies include pre- and post-game surveys to assess knowledge gains and attitudinal changes, focus groups for in-depth feedback, and gameplay analytics to understand player behavior and learning patterns.

6. Expected Results and Impact

We anticipate that the "Prosper Management Edition" will significantly enhance participants' comprehension of sustainability and their ability to engage in meaningful policy discussions. Expected results include improved strategic thinking regarding environmental challenges, heightened awareness of sustainable management practices, and enhanced ability to communicate complex policies effectively. The project also aims to contribute to the broader discourse on the potential of gamification in education, especially in promoting engagement with complex global issues like climate change.

7. Conclusion

"Prosper Management Edition" represents a pioneering approach to combining gamification with serious educational content on climate policy and sustainability. Through strategic gameplay, theoretical rigor, and a focus on SDGs, the game seeks to transform traditional education on sustainability into an engaging, impactful learning experience. This initiative aligns with global educational trends and addresses critical needs in both academic and professional development contexts.

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Viral Sphere: Fostering Healthy Social Media Practice Through Playful Simulation

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Abstract: In this paper, we present the development of a learning game, *Viral Sphere*, aimed at stimulating discussions on the European General Data Protection Regulation (GDPR) among secondary school students and educators. Our game consists of a fictional social media platform, displaying a network diagram to illustrate the spreading of data. Our design aims at promoting informed decision making, through interactive scenario-based learning. Players navigate real-life inspired situations, simulating posting on social media platforms and related consequences, as data spread beyond their immediate network. Data from testing with students, shows that our gameplay can facilitate meaningful conversations about GDPR in a relatable manner.

Keywords: GDPR, Game-based Learning, Social Networks, Social Media.

1. Introduction

As we acknowledge the need to teach young people principles about data protection, we propose a design-concept to foster informed decision-making regarding posting online. We designed a learning game to encourage and catalyze discussions between high school students and teachers on the European General Data Protection Regulation (GDPR), based on various theories of learning and game design. Our project builds upon a larger Erasmus project about GDPR (Marchetti et al., 2024).
Our design leverages a fictional social media platform, integrated with a network diagram, visualizing the spreading of data across multiple nodes, representing an individual posting across her network, and potential consequences.

Our project incorporates interactive scenario-based learning, where players are presented with decisions regarding posting on social media, portraying real-life inspired scenarios as seen on Figure 1. As the students decide about posting within the game, they will witness the potential consequences of their actions. This is demonstrated through the network component, allowing students to observe chats, reactions, and the spreading of data to individuals, beyond their immediate social circles, hence the game name *Viral Sphere*.



Figure 1: The three scenarios from the game.

Our learning game aims at serving as an interactive tool for initiating meaningful conversations about GDPR compliance, leveraging the influence of social media to contextualize abstract concepts in a relatable and accessible manner. Through immersive gameplay and scenario-based challenges, students should engage in interactive experiences and stories that prompt critical thinking and ethical decision-making regarding data privacy issues. Ultimately, the learning game should foster a culture of informed digital decision-making.

2. Theory and Design

Our concept builds on Kolb's Experiential Learning (Kolb, 2015) and network theory (Hogan, 2017). According to Kolb, learning is a continuous process where knowledge is gained by experiencing real life situations, reflecting on them, and then re-forming their knowledge to then repeat the process (see figure 2).

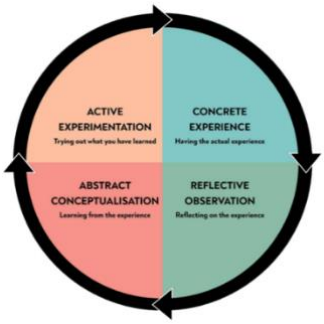


Figure 2: Kolb's Experimental Learning model (Kolb, 2015)

Our game fits into Kolb's model by providing an opportunity to experience firsthand the potential consequences of posting to social media platforms. Students and teachers should use the game during lectures aimed at teaching about GDPR and being safe online. Here the students will play through the game followed by a class discussion, allowing them to reflect on their experience.

Using games in education to make learning processes more fun and effective is encouraged in theories like Playful Learning (Papert & Harel, 1991). This theory argues for the use of games, or other creative learning tools in education, to bring a fun element that can help the students learn, increasing motivation and reflections. Our design concept aims at making learning processes about GDPR fun and, therefore, increasing engagement and willingness to participate in a potentially boring topic. Being a work in progress, we are still investigating existing literature on the topic. Henriksen-Bulmer et al (2023) and Scholl (2018) address motivation and learning of GDPR schools, leveraging analogue board games. DiGioia et al (2019) investigated a non-linear storytelling game (similarly to our game), aiming at clarifying the rules avoiding legal jargon. Tobarra et al (2019) instead adopted a meta-level perspective, providing a cloud game-based educational platform, aimed at hosting games to support learning of cyber-security.

The network diagram of our game is based on a simple level 1 network, defined as the personal network (Hogan, 2017). The term "simple network" refers to a network consisting of nodes and edges illustrating the connection between these nodes. In our social network diagram, individuals are represented as nodes, while the edges depict associations and activities among certain individuals (Fig. 3).

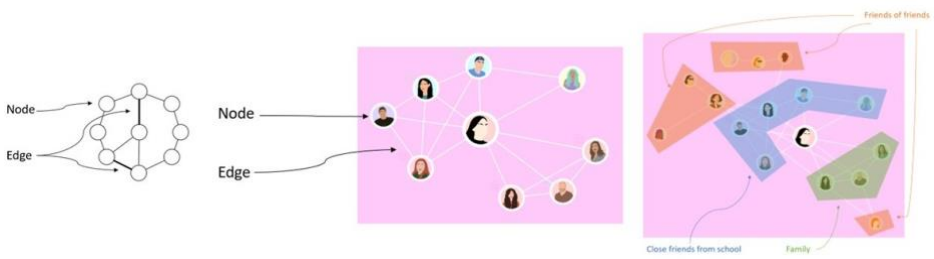


Figure 3: Simple Network (Hogan, 2017), basic and expanded network from Viral Sphere

Level 1 of the simple network is also referred to as "The personal network", which illustrates the personal connections associated with an individual. In our game, this network is small at the start including only the protagonist's immediate family and close friends from high school. As the game advances, the network gradually

expands and more clusters emerge, as data is spread to friends of the protagonist's friends. Through this diagram, we aim at demonstrating how individuals possess clusters of connections within their social network. Furthermore, we seek to illustrate that each person within your own clusters also have their own network, through which your data can spread (Fig. 3).

A main part of our design process was writing the stories represented in the game, in particular we focused on branching narrative (Heussner, 2015), in which players' decisions affect what will happen next, so to provide players with different experiences depending on their own decisions in the game. This is beneficial to create player agency, so the players feel that their actions are meaningful to the story and the game (Heussner, 2015, pp. 111-113). In Viral Sphere we have chosen a simple branching narrative structure, by only allowing two branching paths at a time, which will link up again after every scenario. These branches happen when the player can choose between posting or not posting on social media. This makes the choice of posting become more meaningful to the player which highlights the focus of the game. Thus, it helps direct the focus of the player to the element we want them to think about.

The game is designed to create experiences that will make players reflect on the choices taken by the characters in the game, as well as the choices the players and their friends take in their everyday lives. Using the medium of games for this purpose is appropriate since games are capable of being vehicles of ethical and moral experiences and introspection, as argued by Miguel Sicart in his book Beyond Choices (Sicart, 2013). According to Sicart, a failure in a game which leads to consequences for the non-player characters, can feel like a moral failure on the player themselves. This is accomplished by creating an object (the game) that invites the player to explore and 'play', whilst engaging with their own values (Sicart, 2013, p. 6). This works even when the game is not particularly responsive to the player's actions. A game, like ours, where the players observe the story more than affecting it, can still provide a meaningful experience, enabling players to reflect on the actions of the characters in the game without losing overview on narrative (Sicart, 2013, p. 88).

3. Test and Discussion

We conducted an ethnographic test with 3 classes, for a total of 42 students, from Oerestad Gymnasium, a technical high school in Copenhagen with the support of their informatics teacher. The students were from various ethnical background with a ratio of circa 1/3 females and 2/3 male, are enrolled in their final years of (18-20 years old), with focus on sciences and technology.

We started with an introduction to the project, afterwards the students were given time to play through the game while being observed by the group and teacher. After finishing the game, the students were prompted to fill out a survey regarding their experience of the game. The survey consisted of qualitative, open-ended questions focusing on how the students related to the characters and stories in the game, their answers were afterwards categorized based on the students' recurring statements.

In figure 5 one can see a diagram of the initial response from the users after they had completed the game. The diagram shows that they enjoyed the game, with many being interested in the subject matter and finding it realistic and relatable. However, some students felt that the material was too inconsequential and tame, wanting more dramatic narratives and more influence on the game's outcome.

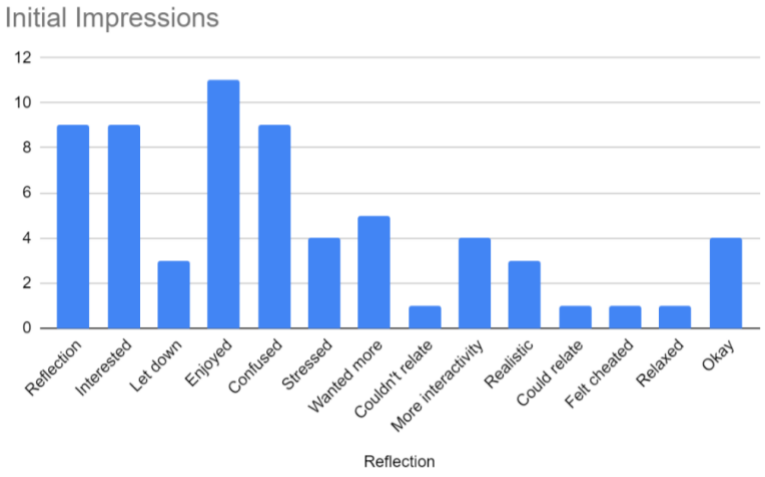


Figure 5: Graph over the users' initial impressions

Students seemed to enjoy discovering what would happen in the narratives, as shown in figure 6, such as being able to choose whether or not to share posts and see the consequences, which are core mechanics in Viral Sphere.

Figure 7 shows a diagram about suggested changes. The most common suggestion was to have more available actions, with many specific suggestions concerning a more interactive chat system. Other frequent suggestions included creating a more personal connection to the player, with wanting to be able to recreate themselves, or making the game easier to follow with more simplified instructions and a clear explanation of the game's purpose at the beginning.

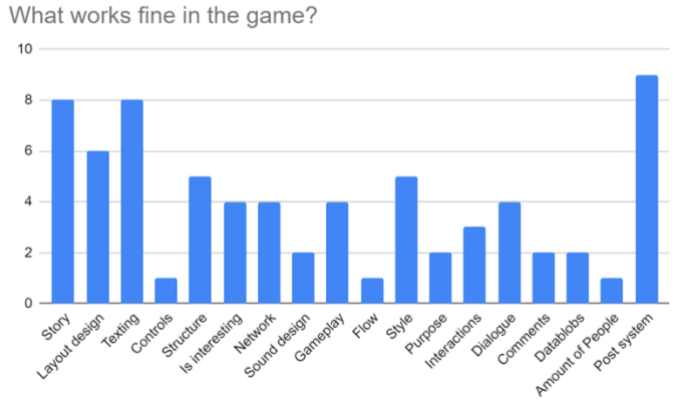


Figure 6: Graph over what the users enjoyed about the game

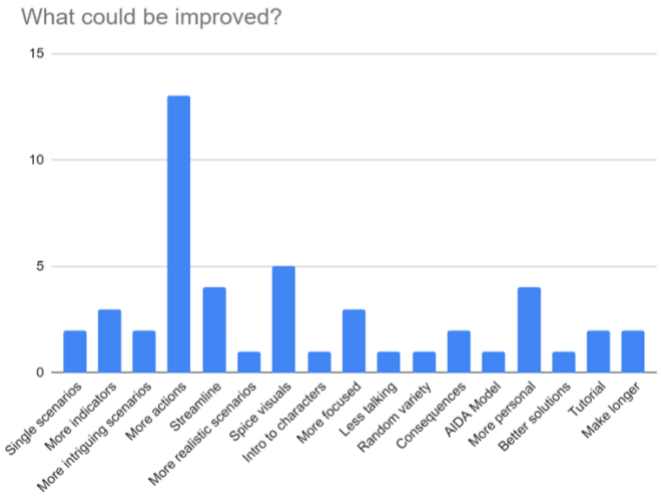


Figure 7: Graph over the users suggested changes

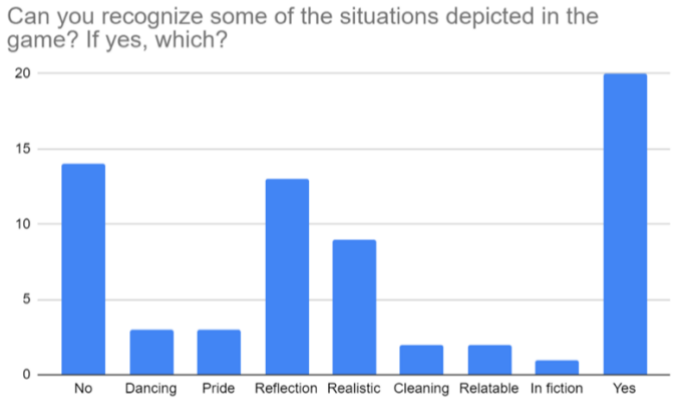


Figure 8: Graph over what, if any, situations in the game the users found recognizable

Some answers contradict each other, as figure 8 shows small difference between people answering yes or no, regarding if the students find the scenarios recognizable. This suggests that it may be difficult to capture the

attention of every user through a narrative based video game, however, our results indicated that a majority enjoyed the experience as it was.

Based on the response from our tests, in a possible future iteration, we should attempt at giving more choices to the players, most likely through the game's chat system. We could explore the concept of *Illusion of Choice* (Brown, 2016), to enhance a sense of agency, hopefully helping the players adverse to reading to feel more engaged. Another aspect that would be prevalent to add is the ability to create oneself at the start of the game, as opposed to being a designated person. However, this aspect would require further testing to verify whether it would help create a stronger connection to the game or make the experience to feel more disconnected. Finally, to appease users who, feel that the game needs to tackle more mature situations, a built-in Scenario Creator would allow each teacher to implement whichever narrative they feel would be fit to discuss, allowing users to explore various kind of scenarios that they feel would fit their intended demographic.

4. Conclusion

By utilizing the power of interactive learning games as tools for dialogue, our project aims at empowering students to become active participants in terms of shaping digital privacy norms and practices. Through collaborative engagement with teachers, students are expected to develop critical thinking skills, ethical reasoning, and a nuanced understanding of their rights and responsibilities in this digital age. Ultimately, the learning game serves as a starting point to fostering a culture of a more informed digital decision-making.

Based on our testing, it can be stated that the learning game is facilitating discussions about GDPR and behavior on social media between the high school students and educators. Feedback from testing sessions indicates a positive reception, with participants appreciating the engaging narratives and interactive elements. However, constructive feedback highlighted the demand for increased interactivity and customization options. Despite varying preferences among users, the majority expressed satisfaction and engagement with the game, affirming its potential as an educational resource.

In conclusion, while further refinement is warranted, our learning game serves as a promising tool for instilling awareness of digital privacy principles and fostering responsible online behavior among high school student, for which these kinds of games can be utilized to make it easier for educators engaged in a dialogue about these kinds of subjects.

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A Virtual 3D Chemistry Escape Room for Exam Preparations

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Abstract: Chemistry can be incredibly captivating. However, learning the theory can often be challenging and less appealing for students. Providing them with hands-on methods in their learning process is beneficial and also helps to lower the barrier for understanding theory. In a gamified approach, the "ChemScape" virtual 3D chemistry escape room, designed as a realistic laboratory with various equipment and hidden chemical tasks, can help solidify chemical knowledge and prepare students for chemistry exams. In 2023, as part of an e-learning project, the foundation of such a chemistry escape room was established, and several chemical questions were incorporated as escape room tasks. The objective is to discover hidden questions within the laboratory, utilize different instruments (such as scales), conduct virtual chemistry experiments, and solve various chemistry questions using theoretical knowledge (such as nomenclature and understanding of pH) in a game-based setting (utilizing multiple-choice, drag and drop, connecting cables, solving color codes, etc.). Typically, a code (comprising numbers, letters, signs, etc.) needs to be obtained for progression. To solve the chemistry tasks, approximately 10 different door-openers have been developed. Initial user tests have been conducted, and adjustments were made based on the feedback received, which was satisfactory and positive. In 2024, the "ChemScape" escape room will evolve from a game with a fixed set of tasks to a dynamic escape room game with a dynamic database that allows for the creation of new questions at the same stations, significantly expanding learning opportunities. A virtual chemistry laboratory rat provides hints if a participant gets stuck and requires assistance. Furthermore, "ChemScape" will be trialed in chemistry lectures and potentially utilized as an additional attraction at events held at the University of Applied Sciences.

Keywords: Chemistry, Elearning, Exam Preparation, Virtual Laboratory, Escape Game

1. Game-based Learning With Escape Room Games

Gamification methods are often a nice change in teaching, helping to increase attention, to activate participants, and to give easy possibilities to memorize theory, before continuing with the next topic. Especially hands-on methods are very helpful as they activate different senses of the participants at the same time. And, although the designing of escape room tasks is challenging – also outlined by Hermanns et al (2018) - they can often be helpful avoiding boredom and frustration.[1] Together with educational games and simulations, Game Based Learning looks especially promising in higher education [2].

Escape room games are a special kind of gamification. They can be carried out in a physical environment (e.g. a room with different task stations) or in digital forms accessible on a webpage or in an application for mobile devices (e.g. you have to solve different questions in a row connected with links). However, these digital forms are usually known for escape room games with different topics for leisure games but not that much for learning purposes – especially not in scientific or technical fields. Educational escape games are defined as “an educational approach which uses a game format in which students participate in a series of activities designed to acquire knowledge or skills, linked to learning objectives, by solving a series of puzzles in a given period of time” [3].

The general goal of escape room games is to solve different tasks (in a given or variable order) to be able to leave the room, respectively the environment, where the game takes place. Sometimes it could also lead to a treasure.

The Cambridge dictionary has the following definition: “Escape rooms are a game where people are locked into a room and have to find a way to escape by finding clues (= signs or information that help you to find the answer to a problem or mystery) in it, and solving puzzles, or a special room where this is done.”[4]

Escape room games are in some cases designed as one player games but in many cases a group of players solves the challenges together.

2. The “ChemScape”

2.1 The Project

In our study, we aim to introduce "ChemScape" - a virtual 3D escape room game. The project commenced in the first quarter of 2023, and since then, the laboratory room itself and numerous tasks have been developed, rendering the game playable. Various chemical questions have been formulated, encompassing topics such as

the periodic table, chemical calculations, knowledge of chemical formulas and nomenclature, and pH. Over the past months, these questions have been integrated into the escape room tasks.

In the "ChemScape" game, players must discover and solve different chemical questions hidden within the laboratory to progress in the game or complete the final task. Throughout gameplay, a digital clock indicates the remaining time.

The escape room game offers diverse applications. Primarily, it serves as a tool for exam preparation. Additionally, it could be utilized within courses as a form of interim assessment or even as a marketing activity.

2.2 The Purpose and the Advantages

The creation of such a game serves multiple purposes: to enhance students' interest in chemistry, to engage them actively, and to provide them with an innovative tool for exam preparation, all in a gamified and motivating manner. Additionally, short games can facilitate knowledge transfer and improve understanding of chemistry, serving as an effective supplement during lectures to help students stay engaged with course content. "ChemScape" aims to reinforce chemical knowledge, introduce new information, and integrate chemical theory in a novel way, including the safe application of chemical experiments.

Playing the virtual chemistry escape room game is expected to lead to improved performance in chemistry exams and to establish a stronger foundation of knowledge for natural science or engineering courses related to chemistry. Digital escape games offer the advantage of easy setup once programmed, without the risks associated with physical chemistry games or the need for chemical materials, making them a safer and more cost-effective option.

Furthermore, such games can mitigate potential aversion to the subject or its theory, presenting the material in a fresh and engaging format that differs from traditional methods. Generally, gamification is recognized as an effective motivator, capable of transforming seemingly dull topics into enjoyable learning experiences that foster genuine interest and a desire for further exploration.

2.3 The Programming of the Game

For the design of the laboratory, photos of inventory in real chemistry laboratories on the campus of the university have been taken and then designed virtually.

The laboratory and all objects are created with “Unity 3D” (https://unity.com/de). At the moment, the game works as an offline application, in future it will also work as a web-application with a website based on php, html5 and javascript. Questions, tips, equipment, and behaviours of the objects will be inserted in a mysql database via a content management system and can be extracted dynamically depending on the respective exam.

2.4 The Laboratory

The “ChemScape” 3D virtual designed chemistry laboratory contains virtual furniture (mainly laboratory benches, cupboards, fume cupboards, sinks and some safety establishment), equipment as cleaning facilities, analytical instruments (e.g. balances) and a big variety of chemical glass ware and paraphernalia. Figure 1 shows one side of the laboratory room. With the arrows on the right and left side, the player can change the section of the laboratory room.



Figure 1: One side of the “ChemScape” 3D virtual chemistry laboratory room

Some measuring instruments, as for example balances are already designed. Their special feature is that their usage is in a realistic way which means that in the case of the balance you have to use a spatula and see the increasing amount of substance on the rising number at the balance display.

2.5 The Methods

2.5.1 The Tasks

The assignment questions are either present at the virtual laboratory working place or will be shown in the game after solving the previous question. Materials (as e.g. vessels with chemical substances), hints (e.g. a colour code) and useful things (e.g. diagrams, periodic table, ..) are present in the laboratory room – sometimes obvious and sometimes hidden (e.g. behind chemical boxes or in the cupboard). The different chemistry tasks cover theoretical knowledge as well as associated laboratory experiments. Theory from the chemistry lecture gets combined with practical experience from chemistry laboratory work in a game-based e-learning setup.

At the moment around 10 different task stations have been thought of, designed and implemented. To make it more realistic (like in a physical game), when solving tasks, objects and instruments (e.g. scales) have to be used.

Figure 2 shows exemplary one riddle in the laboratory where images can be moved around. For this task, the player finds a sheet of paper in front of the pictures with different solutions. With his chemical knowledge it should be clear, that the solutions in the images in front have to be sorted by increasing pH – meaning from sour over neutral to basic. Without chemical theoretical knowledge, the player might be able to solve this task just with trial and error, but it would not be possible to pass all tasks in a given time.



Figure 2: One task in the "ChemScape" 3D virtual chemistry laboratory

Other tasks in the laboratory already designed concern for example questions to atomic models, elements, nomenclature of inorganic chemical compounds, the gas laws, reaction equations and stoichiometric calculations.

In order to move from one task to the other, different door openers have been developed for this escape room game.

2.5.2 The Door-openers

For solving different kinds of chemistry questions, a variety of door-openers has been designed. They include for example multiple choice, drag and drop, codes (colours, numbers, signs, ..) or n:n-connections. Table 1 gives some examples.

Table 1: Door-openers used in the "ChemScape" 3D virtual chemistry laboratory

Number	Door-opener	Example for Usage
1	bring images into a certain order	line up solutions by increasing pH value
2	type a code into a display	a code made with element symbols
3	select a test tube and put in the right slot	name and chemical sum formula

Number	Door-opener	Example for Usage
4	single-choice slot: select the right option in different slots	only one sum formula is correct
5	weigh a certain amount of a substance on a scale	after a stoichometric calculation
6	bring sliders into the right position	for the oxidation number of an element in different compounds
7	get a certain amount of a liquid with a pipette	after a stoichometric calculation
8	n:n cable-connection for assignment	names of acids and their corresponding salts
9	create a certain amount of gas	after a stoichometric calculation
10	drag & drop different objects into different boxes	sort metals and non-metals

2.5.3 User Tests

First user tests (n = 45) have already been performed and evaluated. The individual participants played the game in groups on mobile devices under supervision. Subsequently, comprehensive qualitative feedback was collected. The test participants were asked to the general idea of such a game for learning chemistry, to the design of the laboratory environment, its usability and the didactic value in comparison with traditional learning materials.

The outcome of this evaluation test showed some minor technical problems or didactical ambiguities. This means that the formulation of some questions was not sufficiently clear and had to be clarified. Furthermore, some buttons to click on were too small and some door-openers did not work on an ipad tablet. Directly after the tests the improvements were made according to these results. The feedback about the game itself and the set-up was satisfying and positive.

As can be inferred from these statements, an empirical combination of interviews and actual gameplay was chosen as the method for game optimization.

3. Outlook

In the current version, the game can be played without any problems. But all questions are connected to one set of solutions. In the upcoming months, a database will be programmed which will open the possibility to change questions at the different task stations and to hereby generate a dynamic game. Although the order of the tasks combined with the different door openers stays the same, the choice of the tasks should be possible in a randomized manner or by a selection of the person setting up the learning environment. The learning possibilities will hereby be expanded enormously. It will also be possible to choose whether experiments or answers can be redone (one time or more times) before the results are finally inserted and checked.

Additionally, if players need hints, a laboratory rat will be present in the room which will be able to help along in the game.

In the following semester, the “ChemScape” escape room game will be tried out in chemistry lectures and maybe as well as additional attraction e.g. at events at the University of Applied Sciences.

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The Circular Game: The Impact of Gaming on Sustainable Behaviour

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Abstract: The main objective of this paper is to assess the impact of The Circular Game use on participants' sustainable awareness, learning and behaviour. The Circular Game is a strategy board game to learn about sustainability, improve environmental awareness, apply circular economy strategies, and train to design innovative and circular business models. Researchers will analyse changes in participants' sustainable knowledge, awareness, and behaviour before and after participation in the game with ad hoc questionnaires. The results of this analysis will allow us to test whether the emotions generated during the play-based learning process can condition their environmental awareness, learning and behaviour towards greater sustainability in the future. The game can generate emotions in participants and work teams, promote collaborative and green knowledge acquisition, and help bachelor and master students and employees apply theoretical knowledge to real-world situations. Similarly, companies and entrepreneurs need a relaxed environment to present their ideas and proposals for improvement. This methodology uses game elements in academic or working environments to stimulate and challenge participants to incorporate sustainable business choices. The Circular Game is a game in which participants compete to be the company that applies the most circular economy strategies in its business model. The groups advance through a circular board where, depending on the squares they land on, they can earn money, invest in circular economy strategies, and add or reduce CO2 emissions. The winner will be the one who has completed all the circular economy strategies set out in the game with the minimum of CO2 emissions. The social impact is substantial as it is a methodology that can be applied in any field, educational or business. The impact will be more significant if the game's objective, to be more sustainable, is translated into the participants' real lives.

Keywords: Sustainable behaviour, Game-based learning (GBL), Board games, Environmental Sustainable Education (ESE), Education for Sustainable Development (ESD), Environmental awareness.

1. Introduction

The climate emergency has raised the importance of incorporating knowledge and sustainability awareness. Education for sustainable development has gained attention in higher education, particularly since the Brundtland report in 1987 and the Rio-1992 Conference; both stress the need to integrate sustainable development in business education. Since then, the terms Education for Sustainability (ES), Environmental Sustainable Education (ESE) and Education for Sustainable Development (ESD) have gained international usage (Shrivastava, 2010; Gatti, Ulrich and Seele, 2019).

ESD affects not only the content of education but also its process and outcomes. This requires a new learning culture based on participative processes and new teaching techniques. Among the different methods and techniques, as typologized by Figueiró and Raufflet (2015), action and experiential learning methods offer a promising approach to sustainability teaching. This paper explores a teaching experience based on the action and experiential learning approach, specifically game-based learning (GBL). ESE and ESD can and should be learned and practised at all educational levels, in formal and informal contexts, and even in professional settings. ESE can help change attitudes and behaviours towards environmentally friendly practices (Janakiraman, Watson and Watson, 2018).

This research aims to analyse the impact of using a board game, The Circular Game, in the learning process of teaching sustainability and environmental awareness. The Circular Game is a competitive board game for different environments: secondary education, university education, and professional settings. The expected results of its application aim to find evidence of greater environmental awareness when its concepts are learned and worked on in groups through a game that motivates and encourages more sustainable behaviour among its participants in a competition framework.

2. Theoretical Background

Gamification is applied to encourage behavioural change and promote desired attitudes in different fields such as health, psychology, education, etc. (Almarshedi et al., 2017; King et al., 2013; Chow et al., 2020). Dieleman

and Huisingh (2006) discuss the relevant role of games in all four learning phases (concrete experiences, reflective observation, abstract conceptualisation, active experimentation) of experiential learning (Kolb, 1984).

Hammady and Arnab (2022) review the most adopted theories for designing Behaviour Change Games. There are three: (1) 'Self-Determination Theory' as it is empirically based on human motivation. (2) 'Theory of Planned Behaviour' suggests that desired human social behaviour comes from behavioural, normative, and control beliefs. (3) Social Cognitive Theory (SCT) introduces behaviour change as a function of improved skills and confidence or self-efficiency in performing the new behaviour. These three aspects bring the elements that should have a game designed to change the behaviour concerning sustainability.

Also, according to educational theory, there are two main areas of learning in higher education: cognitive and affective learning. The first domain relates to acquiring knowledge and understanding (cognitive outcomes), while affective learning involves values, attitudes, and behavioural intentions (affective outcomes). Following Shephard (2008), especially in sustainability education, the affective dimension of learning seems to be an essential part of the learning experience because it appears to stimulate critical and creative thought in sustainability, which is one of the most important targets of ESD (Figueiró and Raufflet, 2015).

3. The Circular Game

The Circular Game aims, among other things, to raise awareness of the different circular economy strategies, promote sustainable behaviour, and invite people to reflect on how companies operate and the different possibilities when deciding how to conduct their business. It is a competitive board game for 2 to 6 players. The game elements (boards, cards, dice, and coins) try to reflect different elements of the circular economy in a business context. The game aims to complete two strategies in each product's five life cycle stages with the least CO2 emissions.

Each of the elements of the game has been designed concerning the elements and strategies of the circular economy:

- Central board. The central board is circular and divided into five consecutive sections corresponding to the five phases of the product lifecycle: eco-design, raw materials, production, use and lifetime of the product, and waste management. The starting square is the Eco-design section; players roll dice and progress through all game sections by drawing cards until they complete two circular strategies.
- Player's board. Each player has a board on which they must fill in two strategy cards from each stage of the product lifecycle.
- Strategy squares: Each of the five sections of the central board relating to the five stages of the product lifecycle has two squares where the player can buy a strategy related to that stage (eco-design, raw materials, production, use and lifetime, and waste management). In the strategy squares of the Eco-design section, the player can buy strategies from any part of the cycle.
- Strategy cards. The strategy cards explain different circular economy strategies related to each part of the cycle. Players must complete two strategies from each section on their player's board.
- Action cards. Action cards add a chance and fun component to the game, as they can mean going to jail for committing an environmental crime, not complying with the law, increasing CO2 emissions, or being out of the game for a turn.
- CO2 emission tokens. With the circular economy strategy cards, players accumulate CO2 emissions that limit the chances of winning the game.
- Greencoins. Greencoins are coins that allow the purchase of circular economy strategy cards. Each time the product's lifecycle starts, players accumulate greencoins when they pass through the starting square.
- Dice. The dice is the element of chance that allows you to move around the board.

The player who completes two circular economy strategies from each product lifecycle stage and accumulates the least CO2 emissions wins the game. As players move through the different squares of the game, they relate strategies to the various stages of the product lifecycle, learn the need to address each of these stages sequentially, and become aware of reducing environmental impact through CO2 emission tokens and possible penalties for non-compliance with environmental laws.

4. Research Design

The research methodology is based on collecting information before and immediately after participation in the game. A pre-game and post-game questionnaire will be developed to evaluate it with a sample of 50-60 volunteering undergraduate students enrolled in the 2nd year of Management Degree at Universidad de Burgos, Spain. Questionnaires will be developed to measure students' knowledge and awareness about sustainability and their perceptions of the importance and relevance of the topic in the business field. The "before" questionnaire will be conducted before introducing the game, while the "after" questionnaire will be collected at the end of the debriefing discussion following the game. Both questionnaires were collected in the classroom. The students who play several rounds also do the test before and after each round.

Questionnaires include sociodemographic data (gender, age), questions concerning circular economy concepts and practices, questions regarding sustainable behaviour, and others related to the gamified experience.

In addition, to evaluate gamified experience, we will use the Gamified Game Experience Scale (GAMEX) (Eppmann, Bekk and Klein, 2018), validated in the Spanish population by Parra-González and Segura-Robles (2019). It comprises 27 items grouped through six subscales evaluated through a five-point Likert scale (1 = Strongly disagree; 5 = Strongly agree): Fun, Absorption, Creative thinking, Activation, Negative affect, and Dominance. The GAMEX index has been validated as a valuable resource for measuring gamified learning experience results.

Despite being designed for higher education, The Circular Game can help raise environmental awareness and develop soft skills in secondary education and workplace settings.

5. Conclusion and Future Research Lines

Applying The Circular Game and the research findings from this study could provide insights into the impact of GBL and gamification on sustainability and the circular economy. The results will show whether the application of the game increases environmental awareness, learning about the circular economy, and expected sustainable behaviour. The improvement and the relationship between these items (awareness, learning, and sustainable behaviour) through the game will allow us to know if the design of GBL methodologies is more effective than other environmental awareness and training campaigns.

Analysis of student questionnaire responses will reveal how the game has contributed to knowledge acquisition in the circular economy, environmental awareness enhancement, and sustainable behaviour. Furthermore, the results will indicate undergraduate students' perceptions regarding incorporating dynamic elements in the learning process and whether these techniques enhance motivation for regular courses.

Future research will also explore differences between groups of students from different backgrounds. It could also compare the improvement in environmental awareness following a traditional classroom lesson on circular economy and sustainability versus a gamified experience with The Circular Game. In addition, the game could serve as a tool for companies to foster employee engagement and environmental knowledge and promote integration and teamwork. Therefore, if implemented in corporate settings, the researchers will try to replicate the study among this population and compare the results between educational and professional contexts.

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Boardcraft: Learning the Art of Strategic Decision-Making Card by Card

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Abstract: *Boardcraft*, an interactive, sequential card game, is a powerful tool for teaching Strategic Management in an undergraduate Business Administration Degree. This innovative game provides students with practical experience in strategic analysis, business strategy formulation, and strategic decision-making, addressing one of the main challenges of social science teaching: practical application. The objective of the research to be carried out is to find evidence of a change in students' attitudes towards making strategic decisions. To do this, two questionnaires will be carried out, one before and one after the game's introduction in the classroom, three months apart. The data will tell us if decision-making through a business strategy game changes their perception and attitude towards decision-making by acquiring competencies and skills that prepare them better for decision-making throughout their career and life. This game will streamline the teaching of strategic management in higher education, a subject traditionally based on lectures and case studies. Teaching strategic management is complex since the student is immersed in a context of continuous decision-making that requires the application of an appropriate methodology for proper understanding. Game-based learning (GBL) activities like *Boardcraft* that bring strategic management closer to real-life contexts are desirable. The application of this game will also allow researchers to analyse the effect of experiential learning, the acquisition of interpersonal and conceptual skills, the importance of aesthetics and the introduction of fun elements in game-based learning.

Keywords: Decision-making Teaching, Strategic Management Teaching, Game-based Learning (GBL), Experiential Learning, Card Game, Decision Crafting.

1. Introduction

One of the main challenges in teaching social sciences is the lack of a "laboratory" to apply the theoretical knowledge taught in the subjects to make decisions, and real-life situations do not provide enough practice opportunities (Chernikova et al., 2020). Teaching strategic management is complex as the student is immersed in a continuous decision-making context that requires the application of an appropriate methodology for proper understanding. Game-based learning (GBL) activities that can approximate strategic management to real life are desirable (Stewart and Wang, 2023).

Studies show that the results of a GBL methodology and traditional teaching are similar in knowledge acquisition, but game-based learning was more successful in increasing students' motivation (López-Fernández et al., 2021). Student learning involves acquiring knowledge and developing general and specific competencies, and both types of learning are enhanced by increased motivation. Games can be an appropriate methodology for motivation in developing competencies that are not achieved with the transmission of knowledge in the master class.

This study explores structuring a course as a game parallel to theoretical lectures. The research aims to evidence the change in university students' attitudes towards strategic decision-making and the acquisition of competencies and soft skills by introducing experiential learning through a game in the classroom parallel to the strategic management lecture sessions, which increases engagement and motivation.

2. Theoretical Background

Strategic management requires skills in conceptual and analytical thinking and creative thinking. The most common materials used in teaching the analytical dimensions of business strategy are texts, case studies, and simulations. However, materials that foster creative thinking are scarce (Weick, 2003). Research demonstrates that GBL is a well-founded methodology that can replace and complement traditional learning, providing engagement, motivation, fun, immediate feedback, causality, experiential learning, etc., in acquiring competencies (Tang et al, 2007; Anagnostopoulou, 2017). Literature in games and simulations in management higher education prioritises the beneficial effects of experiential learning (Stewart and Wang, 2023). These kinds of experiential teaching and learning activities, such as games, simulations, and practical activities, are increasingly in demand in management education. Gamification encourages behavioural change and promotes desired attitudes in many fields (Almarshedi et al., 2015). Following Mintzberg (2005:2), “Management is a

practice that has to blend a good deal of craft (experience) with a certain amount of art (insight) and some science (analysis).” In this sense, one of the challenges of teaching strategic management in higher education is introducing this experiential learning into the learning process.

3. *Boardcraft*: Game Description

Boardcraft is a sequential and interactive card-based role-playing game used to teach strategic management in the bachelor’s degree in business administration. It is designed to align with the course description. Students play it in teams throughout the course at the pace of developing the theoretical concepts, combining the practical game sessions with the theoretical lectures.

We named the game “*Boardcraft*” to convey that strategic decision-making within any organisation is an art. The game initiates students into “crafting” decisions as they act as if (role-playing) they were already at Strategic Committee. Their mission? To carry out the company's strategic analysis, formulate the most appropriate strategy according to their objectives and decide on the long-term strategy to present at a simulated General Shareholders' Meeting.

Weekly, each team randomly picks cards related to their company and environment: *Information, Decision, and Breaking News*. What will they do? At the end of the semester, students will be able to understand the process of analysis and formulation of business strategy with an entertaining methodology that challenges and helps them develop, among others, strategic thinking, teamwork, and communication skills.

3.1 Game Elements

The game's elements are a virtual road map of the strategic process, a set of three different card desks, a guide booklet, and a task description.

Boardcraft’s Road Map is a virtual board with a road map of the strategic process. The visual element locates the participants' positions in the decision-making process, the following steps, and the path to the final decision (Figure 1), following two of the strategic management process's main stages: strategic analysis and formulation (Guerras and Navas, 2023).



Figure 1: *Boardcraft*’s Road Map

The cards comprise *Information cards, Decision cards,* and *Breaking News cards.*

Information cards are physical cards with a yellow diamond in the front. There are five themed decks: company’s ownership structure, essence and values, geographical location, sector of activity, and primary resource/capability (Figure 2).



Figure 2: Set of Cards: Information cards

Decision cards and *Breaking News* are virtual cards (Figure 3). *Decision cards* have an orange diamond on the front. These cards are standard to all groups and are sent by the teachers:

- *Decision Card* #1: What is your field of activity within the sector?
- *Decision Card* #2: What is your general strategic positioning?
- *Decision Card* #3: Given three strategies, choose the most appropriate one as the company's next move.

Breaking News cards have a red diamond on the front. During the game, the teachers prepare these cards to choose real news related to the cards picked by the teams.



Figure 3: Set of Cards: Decision cards and Breaking News cards.

The guide “booklet” and task description for the students are digital guides uploaded to the university's virtual platform.

3.2 Game Dynamics

At the beginning of the course, the students form teams and are informed that they have recently joined a company's Strategic Committee. Their mission is to deliver the strategic report, prepare an executive 8-minute presentation for a simulated General Shareholder’s Meeting, and debate and justify their decisions on a given date (the last day of the course).

The game unfolds in three stages, and the teams periodically pick *Information cards* five times:

- First stage: Who are we?

  Information Card #1: Teams pick one card from the “Ownership” deck.

  Information Card #2, #3, #4: Teams pick three cards from the “Essence, Values” deck.

  Information Card #5: Teams pick one card from the “Geographical location” deck.

- Second stage: Strategic Analysis

  Information Card #6: Teams pick one card from the “Sector of activity” deck.

  Decision Card #1: What is your business within the sector?

  Information Card #7: Teams pick one card from the “Resources, Capabilities” deck.

- Third stage: Strategic Choice

  Decision Card #2: What is your general strategic positioning?

  Decision Card #3: Which strategy do you think we should follow, why, and what resources should be required?

- Finish line: A simulated general shareholder's meeting takes place on the last day of the course. Each team has 8 minutes to present their business case and strategic decision and deliver the strategic report for evaluation.

The game has been designed to encourage the spirit of play. The design of the cards is attractive to achieve greater student engagement. Colours, symbology and illustrations try to convey the messages and promote the understanding of the information with a touch of humour. The role of fun elements is to create comfort and increase motivation in a learning process, providing satisfaction without coercion and without feeling bored (Prensky, 2001).

4. Research Design

The research will be carried out in one semester of the academic year. The sample will be between 50 and 60 undergraduate students in the Strategic Management course for the Business Administration Degree. The methodology will be a pretest and post-test before and after the game's introduction in the classroom. The phases of this research are as follows:

1. At the beginning of the semester, an ad hoc questionnaire will be administered to students measuring their motivation and attitude towards decision-making (*I like to make decisions, I prefer to be the one who decides, I prefer others to decide*, etc.), their attitude towards group or individual decision-making work, as well as the personal assessment of other competencies and soft skills. The questionnaire also will include initial demographic questions (gender and age).
2. For three months throughout the semester, the game will be implemented in the teaching methodology in parallel with the development of theoretical lectures.
3. At the end of the course, the students will be questioned again to obtain information on a change in their attitude towards decision-making, and a discussion group will be held with them to obtain qualitative information on the intervention.

4. At the end of the intervention and data collection process, we will have qualitative and quantitative information on the student's attitudes towards strategic decision-making and the acquisition of competencies throughout the course.

Before the research, the game was tested and introduced into the classroom methodology to verify its functioning and its integration into the content of the Strategic Management subject in 2023-2024 academic course. Boardcraft will be integrated into the teaching plan for 2024-2025, incorporating enhancements based on the pilot test conducted in the previous academic year.

The appropriate methodology will be used to treat quantitative and qualitative data, allowing robust conclusions to be reached about the change in students' attitudes towards decision-making and the acquisition of soft skills and competencies such as teamwork, negotiation, collaboration, creativity, decision-making with uncertainty, individual and group responsibility, and oral and written communication.

5. Conclusions

Boardcraft is a learning methodology that balances the practical application of strategic management knowledge with the development of soft skills inherent in people engaged in "the craft of" decision-making and management. The application of *Boardcraft* aims to recapture the principle of "instructing by delighting", used by Horace in the 1st century BC to promote holistic growth of learners (moral, spiritual and intellectual growth) beyond the purely intellectual. The main objective of the research is to demonstrate whether experiential learning through a game increases motivation and changes learners' attitudes towards decision-making. The learner belongs to a group, and the group has to make strategic decisions. The data collected before and after the intervention (application of the game) will allow us to demonstrate whether there is a change in the students' attitudes towards decision-making because motivation increases and, with it, the acquisition of competencies.

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Digitising a Card Game for Teaching Pragmatic Markers

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Abstract: Most language learning applications focus on pronunciation, vocabulary, and grammar of a language. However, learning the pragmatics enables learners to interpret contextual meanings of specific words uttered by native speakers during conversations. An educational card game called *Mind You!* was developed for non-native English-speaking international students in Australia to help them learn English pragmatic markers. The card game was designed to encourage social constructivism and situated learning, where learners construct their own sentences based on their combined interpretations of pragmatic markers, images and scenarios displayed on cards to answer hypothetical questions. A mobile application of the card game is being developed as a supplementary resource when face-to-face or in-person learning is neither possible nor practical. Learners can listen to audios of pragmatic markers in sentences and type or record their own sentences based on their interpretations of the cards and share them online with other learners. This provides a platform for distance collaborative learning between other language learners where they share sentences based on different interpretations of different card combinations. The objective of the mobile application is to train learners in using pragmatic markers for English conversations outside the game. This work-in-progress manuscript outlines how the card game can be digitised into a mobile application.

Keywords: Pragmatics, Card Game, Mobile Application, Language Learning, Constructivism, Situated Learning

1. Introduction

Pragmatic competence is the ability to understand the meaning of an utterance within certain contexts where its meanings can change based on the culture, tendencies, and behaviours of native speakers (Ishihara & Cohen, 2021). A non-digital card game called Mind You! by Marquez et al (2019) was developed based on situated learning (Lave & Wenger, 1991) and social constructivism (Piaget & Cook, 1952), where learners form sentences with pragmatic markers based on their interpretations of scenarios. Examples of pragmatic markers include *well, right, actually,* and *mind you*.

A previous study explored how international nursing students played Mind You! to practise using pragmatic markers in conversations before their mandatory medical placements (Marquez & Penman, 2021; Marquez & Penman, 2023). They reported gaining awareness of the functions of pragmatic markers in improving their linguistic and interpersonal skills and building rapport with peers.

This work-in-progress manuscript outlines how the card game can be digitised into a mobile application, which can act as a supplementary resource when face-to-face learning is not possible. Collaborative mobile learning of pragmatic markers can be facilitated when learners listen to audios of pragmatic markers, type, record, and share their sentences online with others for feedback. Learners can then implement their new knowledge from the mobile application into English language conversations outside the game.

2. Literature Review

2.1 What are Pragmatic Markers?

Pragmatic markers, or *discourse markers,* is a study in pragmatics related to specific words or phrases uttered by speakers to direct listeners to the 'features of the context' within a conversation (Aijmer & Simon-Vandenbergen, 2011). Brinton (2017) listed the most common characteristics of pragmatic markers. Most pragmatics markers such as *right, well,* and *so* have either one or two syllables while others have more than two syllables including *actually, anyway*, or *admittedly*. Many pragmatic markers are adverbs, conjunctions, or interjections, but their only function is to emphasise the meaning of the speaker without modifying the grammar. Pragmatic markers are used to evaluate, judge, share information, and confirm shared knowledge or understanding.

Eslami and Mirzaei (2012) acknowledged that appropriate use of pragmatics is based on tendencies by native speakers. Mahfoodh (2024) emphasised that language learners can achieve pragmatic competence akin to native speakers of the language if they gain enough exposure to the different uses of the language in different situations.

2.2 Mobile Learning

The advantages of non-digital games like cards include facilitating social interaction when players sit physically close to each other, allowing the players to personalise and rearrange their cards. The rules of card games can be modified to suit different situations and players (Rauch, 2017). However, non-digital games may not be ideal for learning when face-to-face learning is not feasible. Learning on mobile devices has demonstrated many advantages as listed by Rizoqulovna (2023).

2.2.1 Interactive and Immersive Practise

Mobile games can allow learners to interact and participate in activities and simulations where audio, visual or audiovisual elements, such as videos, photos, music, and animations make the learning more engaging (Rizoqulovna, Nosirova Dilnoza, 2023). The ability to provide audiovisual aesthetics allows digital applications to provide lifelike scenarios for language learners to immerse themselves in and to practise the target language (Rizoqulovna, Nosirova Dilnoza, 2023).

2.2.2 Accessibility and Flexibility

Mobile learning is cost-effective, portable, convenient, and accessible to a wide range of learners (Garzón, Lampropoulos, & Burgos, 2023). Learners can study at their own pace and have access to learning materials from anywhere at any time (Rizoqulovna, Nosirova Dilnoza, 2023).

2.2.3 Personalised Learning and Immediate Feedback

Learners can learn autonomously at their own pace and develop their own learning strategy to meet their own needs and receive immediate feedback (Kazu & Kuvvetli, 2023). The portability and personalisation of mobile devices can allow learners to practice their skills anywhere at any time and gain instant feedback so they can learn from mistakes, gain self-awareness, identify areas for improvement, set goals and monitor improvements and performances (Garzón, Lampropoulos, & Burgos, 2023).

2.2.1 Community and Collaboration

Mobile devices provide easy access to online communities for learners to practice their language skills with other learners, where they can receive support, learn more about the target language and culture, and feel a sense of belonging (Rizoqulovna, Nosirova Dilnoza, 2023; Garzón, Lampropoulos, & Burgos, 2023). Kukulska-Hulme & Viberg (2018) described how mobile technology can support collaborative language learning by encouraging social constructivism (Piaget & Cook, 1952).

A mobile application would be beneficial for learning pragmatic markers. It can be a platform for language learners to learn collaboratively online by sharing with each other their knowledge on pragmatic markers. They also can practise speaking and/or writing pragmatic markers autonomously outside the language classroom.

3. Proposed Design Process

3.1 About the Game

The card game of Mind You! contains three categories:

3.1.1 Pragmatic Markers Cards



Figure 1: Sample pragmatic marker cards.

Each *pragmatic marker* card (Figure 1) displays one pragmatic marker, which were based on a list of common English pragmatic markers (1996, p. 32). Upon receiving the cards, students immediately identify the individual marker in its full spelling. To demonstrate the different different functions of pragmatics by native speakers (Mahfoodh, 2024), each card includes two example sentences with the pragmatic marker for learners to use as guidance when they construct sentences.

3.1.2 Topic Cards

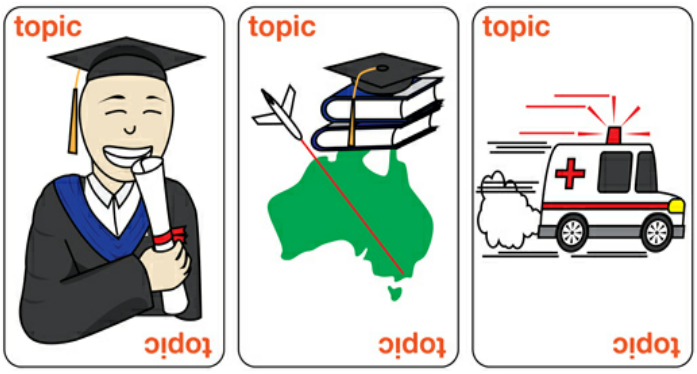


Figure 2: Sample topic cards.

The *topic* cards (Figure 2) portray scenarios using imagery only and no text. The game was originally designed for international students studying in Australia. Learners construct sentences based on their own interpretation of scenarios related to Australian culture, cuisine, sports, and fauna. The card deck also contains situations based on fantasy to make the learning engaging.

3.1.3 Situation Cards

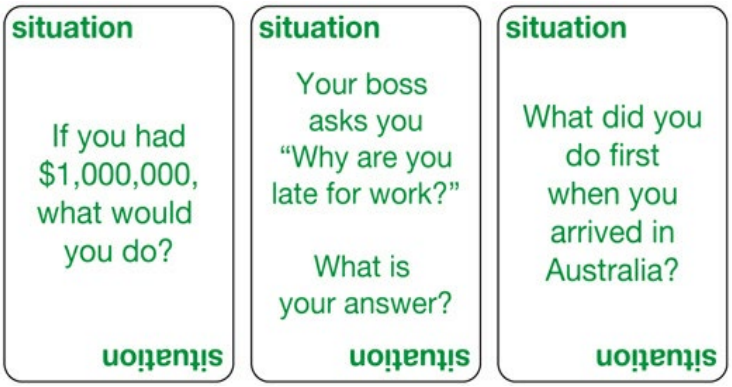


Figure 3: Sample situation cards.

The *situation* card deck (Figure 3) contains hypothetical situations based on both fantasy and life in Australia. At every round of the game, learners must answer the question using their pragmatic marker and topic cards.

3.1.4 Rules

1. Each player is dealt two pragmatic marker cards and two topic cards.
2. At each round, one situation card is drawn from the deck and a hypothetical question is revealed.
3. All players must answer the question by saying one sentence related to one pragmatic marker card and one topic card.
4. After all players have stated their sentences, they must select and vote for one of the other learners' sentences as their favourite. Players cannot vote for their own sentences.
5. The player whose sentence receives the most votes, will receive a score of one point and then a new round of the game commences. The first player to receive 5 points wins.

3.2 From Non-digital to Digital

For the mobile application Mind You!, this manuscript proposes two game modes: *Competitive Game* and *Solo Learning*.

3.2.1 Competitive Game

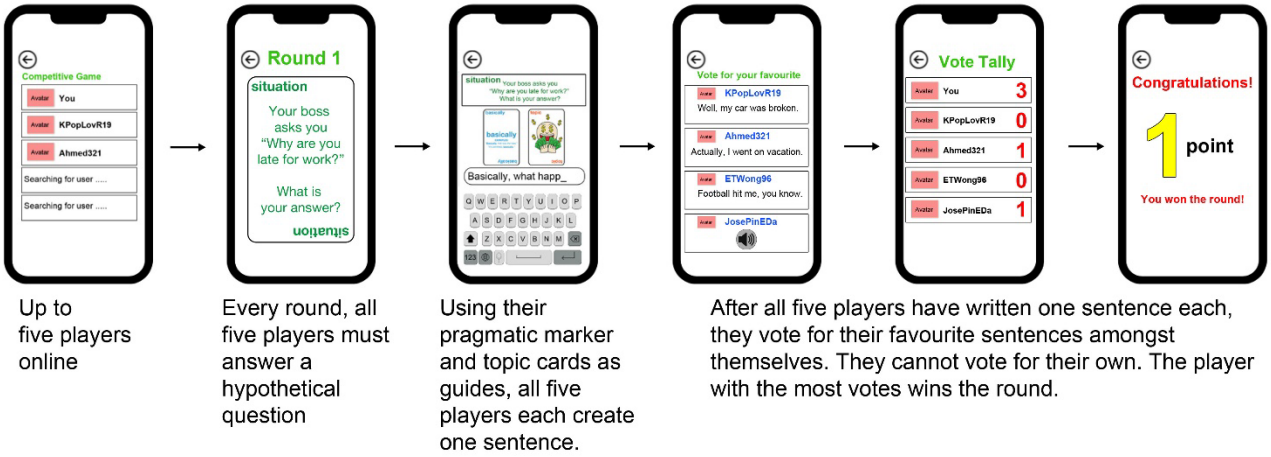


Figure 4: Example gameplay in Competitive Game mode.

Competitive Game closely resembles the game rules of the card game where a maximum of five players can compete against each other online. Figure 4 shows how learners compete online rather than face-to-face by either typing their sentences or recording themselves while stating them.



Figure 5: Pragmatic marker cards and situation cards with buttons to play the pronunciations of the pragmatic markers and example sentences.

The application will offer the ability to play audios of pragmatic markers and their example sentences including their pronunciations, tones, and their functions in the example sentences and then repeating them (Figure 5). The situation cards will also allow learners to listen to audio recordings of the hypothetical questions.

3.2.2 Solo Learning

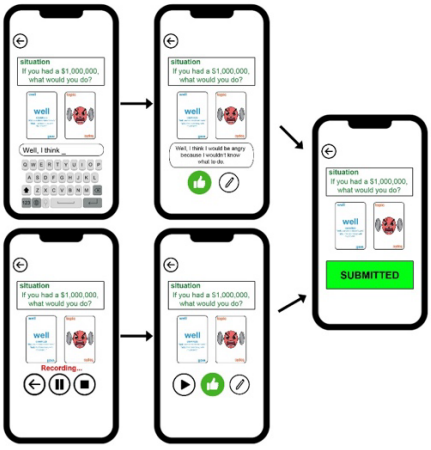


Figure 6: Learners can type or record their sentences before uploading online.

Solo Learning is a game mode where learners practise forming sentences with pragmatic markers using different card combinations autonomously without the pressure of competition. Learners can formulate sentences using one pragmatic marker card, one topic card and a situation card and submit them online (Figure 6).

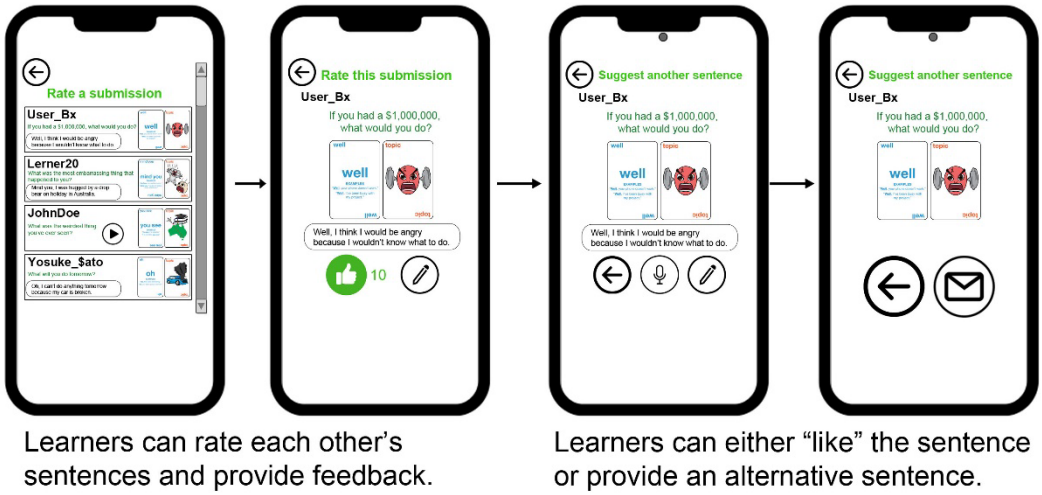


Figure 7: Example of collaborative learning in the application.

Solo Learning will also offer online collaborative learning where learners can provide feedback on each other's sentences (Figure 7). Learners can upload their own sentences and give feedback on other learners' sentences by providing comments or by typing or recording alternative sentences. Not only can grammar and vocabulary be learnt from other learners, but also the different ways pragmatic markers can be used in sentences. When learners record themselves saying their sentences, others can also practise listening to the pronunciations.

4. Future Studies

A non-digital educational card game is effective in encouraging face-to-face interaction among language learners and with native speakers. However, a mobile application of Mind You! can be more accessible by allowing online learning with other learners anywhere and at any time when face-to-face interaction is not possible or practical.

The next step is to develop the Solo Learning mode first before the Competitive Game by using an iterative design process to formulate the base game mechanics for the application. To encourage ongoing use of the application, a reward system including experience points and leader boards will be conceptualised. It is also possible for uploaded sentences to be unanswered or for learners to learn incorrect ways of using pragmatic markers. To reiterate, appropriate use of pragmatics is based on tendencies of native speakers. However, various methods will be further explored to address these situations.

A future study will involve playtesting a fully functioning prototype with current English language learners. The participants will also be interviewed or surveyed on their experience with the developed digital game. They will also be assessed to gauge improvement in their language skills and awareness of the functions of pragmatic markers in communication. The evaluation from these future studies will also be used to further improve the mobile application.

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Reflecting on Current State and Future Research of Empathy Assessment and Development within the Game-Based Learning Community

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Abstract: There are decades of growing interest in social-emotional learning (Muravevskaia, 2023; Hoffman, 2009). According to the founders of the SEL concept, Cherniss, Goleman, et al. (2006), SEL is "the process of acquiring a set of social and emotional skills—self-awareness, self-management, social awareness, relationship skills, and responsible decision-making within the context of a safe, supportive environment." One of the most popular SEL frameworks is CASEL (2003), which includes five aspects: self-awareness, social awareness, self-management, decision-making skills, and relationship skills. The social awareness aspect includes competencies related to empathy: (taking others' perspectives, demonstrating empathy, and showing concern for the feelings of others). Empathy is widely used and mentioned in SEL and other literature across the research fields of game-based learning, design research, social psychology, neuroscience, affective computing, artificial intelligence, educational technologies, and others. Design thinking methodology and user experience research claim empathy is the first step in user research and developing multiple tools and measures (Dorst, 2011; Wright, 2008). Virtual reality is suggested as an "empathy machine" and promoted as a good tool for empathy development (Ventura, 2020). Affective computing works on modeling and measuring empathy in artificial agents to create systems that would scaffold the learning experience using SEL components (Gebhard, 2021). Empathy games are emerging as a new separate sub-domain (Muravevskaia,2023). Such situation multiplies many different definitions, methodologies, and measures for empathy. Such an active and divided interest in empathy across different domains can cause potential research confusion and challenges for educational technology and game-based research communities. We invite the GBL Research community to gather together as an interdisciplinary community to be able to discuss what empathy means for our community, how we define it and which methods use, which role it plays in the GBL, and which emerging future research in this area we envision together.

Keywords: Empathy, Social-emotional Learning, Empathy Development, Empathy Games, Affective Computing

1. Introduction and Background

Psychology research describes empathy as social and emotional competence, which "measures the ability to understand, process, manage, and express social and emotional aspects of our lives" (Cohen; 2001, p. 220) and "may be considered as a basic human characteristic related to social adaptation" (Borke, 1973, p. 102). Cotton, during his study in 1992, suggests that empathy mainly comprises affective and cognitive components, whereas Reid (2013) defines three aspects of empathy: affective, cognitive, and behavioral (Reid; 2013). There are two major lines of definitions:

1. Some researchers (De Waal, Reid, Bayne) suggest that empathy is a general term (or even an umbrella of terms) that identifies the ability of one to identify and understand others' feelings and emotions and includes several aspects (i.e., affective, cognitive, and behavioral).
2. Other researchers (Bloom, Preckel) identify empathy as a state or a feeling of what another person feels. They highlight that this state might not be helpful and that a person who experiences empathy towards another person cannot even act prosocially sometimes due to personal distress. In contrast, they identify compassion as a solution when a person can stay distantly emotional and act prosocially according to the situation. The first group of researchers talks about these two concepts as aspects of empathy and names them affective empathy and cognitive empathy accordingly.

Besides these two big general chains of thought, there are many others that can also be identified. In particular, Cuff (2014) identified 43 more or less distinct definitions of empathy. The way empathy has been defined affects: 1) how the relationships between empathy and other similar concepts (compassion, sympathy, theory of mind, etc.) can be identified; 2) how it can be measured; and 3) which methods to use for its development.

Empathy games are still new research area, which is in its infancy. Scherier (2021) conducted a systematic review of "empathy" and "games," which aimed to establish a common foundation for the new research area of empathy games. She found that the word empathy is now used or defined very loosely across the papers, which focused on the empathy games domain. Interest in empathy games is increasing nowadays, in particular, in game-based learning field of research. For example, only in 2024 year there 61 papers published that mentioned the words "game-based learning" and "empathy" at least once (Google Scholar). This interest is timely and

reasonable as it has a potential to address several current issues with decline of empathy and social skills among young people. Early childhood development research supports role-play activities as very important practices for social-emotional learning, and in particular, for empathy development (Cotton, 1991; Vygotsky, 1978). Moreover, modern technologies (e.g., VR, AR, AI) bring opportunities for the systematic development of educational empathy games, such as: 1) opportunity to collect and analyse behavioural and biometrics data, 2) real-time scaffolding of player's educational and emotional needs during the game flow, and 3) providing feedback and conducting assessment as a result of the player's activity. However, It is still underexplored how to systematically approach these opportunities in order to design educational empathy games.

Up to date, there were several studies which tap on some of these opportunities. For example, there were several projects addressed SEL and included assessing emotions. For example, "InsideOut" (Kralicek, 2018) environment aimed to support SEL by visualization of emotions for a teacher and students in the classroom. There were multiple data collected (i.e., brain waves, heart rate, and skin resistance noninvasive sensors) and presented as emotion avatars based on five basic emotions: joy, anger, sadness, fear, disgust. "EmotoTent" (Antle, 2019) also used noninvasive sensors to measure brain and heart activity to generate and visualize children's emotions and projected them as a 3D holographic image on the top of the tent. Antle (2019) suggested that such visualization can lead to a discussion of how to express prosocial actions, contributing to the development of empathy. Antle (2019) also suggested emotions guessing games using such holographic images as a tool to support emotional recognition skills. Both papers contribute new tools for emotions' representation and suggested activities on how to use it for developing emotion recognition and perspective-taking skills. However, none of them provided further specific recommendations for game activities. Another research by López-Faican (2021) proposed a circular iterative empathy development model for analyzing gamification strategies. This model is proposed to be useful for the design of interactive systems for the development of empathy. This model uses pedagogical strategies in which users are exposed to affective, cognitive, reflective, and social experiences that encourage the expression of behaviors of a prosocial nature. The model presented by Lopez-Faican (2021) is based on Davis's empathy research and aligns with PAM empathy model from psychology field (Preston, 2007), that suggest developing affective empathy proceeds to cognitive empathy and that behavioral empathy is built on affective and cognitive empathy (Reid, 2013). The further work by Lopez-Faican builds on this model and explores ways to develop empathy via AR games, however, does not provide clarity on whether such games can build empathy in the educational contexts. It opens a number of further research avenues.

2. Current Opportunities

We suggest the following opportunities be explored so that the GBL community can consistently move empathy research forward: 1) establishing the vocabulary for the new empathy games field; 2) interdisciplinary collaboration.

2.1 Establishing the Vocabulary

While researchers in human-centred computing, game design, and educational technologies refer to some of the psychology or medicine literature in order to be able to ground their empathy research, a lack of training in this area might lead to confusion about which definition and from which psychology research school they shall build their research. This is illustrated by the initial systematic survey by Karen Scherier on empathy and games (Scherier, 2021), which lists 18 different definitions and aspects of empathy used in different research papers from different fields of study related to empathy games studies. Scherier highlights that many papers use the definitions very loosely and/or create their own variations of empathy aspects/sub-aspects, which leads to adding new definitions that are potentially not well grounded in psychology research. Such a situation might lead to more confusion if, for example, other researchers refer to newly generated definitions without deep exploration of the topic. Such dynamics might undermine the quality and consistency of the further empathy research in GBL. Therefore, we need to make sure we have a common ground and unified terminology for every concept we use (i.e., empathy, compassion, sympathy).

2.2 Interdisciplinary Collaboration

GBL is a very interdisciplinary community, which includes researchers and practitioners from education, computer science, HCI, games, psychology, and others. Confusion with empathy definitions might make interdisciplinary projects challenging because different definitions might represent different learning traditions

(e.g., social constructivism, cognitivism, etc.) as well as utilize different methodologies. Therefore, it is a need for more collaborative interdisciplinary projects among these domains.

3. Future Research Opportunities

This sub-section lists potential interdisciplinary research avenues on empathy research that might interest the GBL community.

1. A systematic literature review on how game-based learning can address empathy assessment and development. We consider it a first step, which would establish a systematic foundation of definitions, learning theories, and methods to be used in this area (Schrier, 2017).
2. Research on how tools and methods from affective computing and mixed reality fields can be used to incorporate biofeedback and immersive environments into learning games in order to scaffold the learning process as well as create empathic experiences for the players (Muravevskaia, 2023).
3. Research on further establishing game design frameworks for empathy games, which would create empathic experiences in players and provide learners with an opportunity to explore, interpret, and address the emotions of others (Muravevskaia, 2023).
4. Research incorporating artificial intelligence into games to explore ways to design game characters that model the player's empathic behavior as well as address their emotional changes.

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Indie Games for Ethical and Socioemotional Development in Secondary Education

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Abstract: Video games, particularly those developed in the independent scene, are a form of media with great educational possibilities. This work in progress will be completed in three years and it aims to improve teachers video game literacy and help them implementing activities for ethical and socioemotional development (European key competencies 5 and 6) through indie games. Therefore, through design-based research and mixed-method designs, it aims to achieve three goals: (O1) identify the perception and meaning-making processes that teachers and students have about videogames and learning through video games; (O2) design a measurable training program for teachers around the educational possibilities of indie games and help them implement activities for ethical and socioemotional development; and (O3) evaluate the programs impact based on the indicators of key competencies 5 and 6. The project is in its first phases and it will be developed in the next three years. First, representative samples of each agent will be accessed to analyze their beliefs, types of knowledge, and practical experience in the field. Subsequently, four independent video games that promote key competencies 5 and 6 will be selected, and classroom activities will be designed for each of them. Next, teachers from four high schools in Spain (Cantabria, Baleares, Andalucía and Catalonia) will be trained in the use of the educational resources, and they will be accompanied in its implementation with students. Finally, the programs impact on students will be evaluated based on various psychological variables associated with key competences 5 and 6 (e.g., empathy, emotional identification, civic skills, etc.) as well as the participants perceptions of the experience, enabling the generation of design principles for future iterations and for the programs scalability.

Keywords: Videoludic Literacy, Media Literacy, Video Games, Game-based learning, Civic Competence, Personal and Social Competence

1. Introduction

Reluctance has lingered when it comes to introducing commercial games into classrooms and their inclusion often is replaced by simple game-based learning or gamification practices that elicit questionable educational benefits (Raessens, 2014; Oceja, 2019). However, in recent years, sociocultural approaches led by James Paul Gee (2014) have highlighted non-explicitly educational games' possibilities when used to generate relevant conversations from dialogical perspectives. These possibilities increase when working with games designed by small studios with high levels of autonomy and creative freedom, leading to so-called *indie games* (Juul, 2019). This scenario, in our view, is the optimal framework for working with most key competences in the European context, particularly with the personal, social, and learning to learn competence (Competence 5) and citizenship competence (Competence 6).

The European Commission (2004) defined key competences as follows:

> Key competences represent a transferable, multifunctional package of knowledge, skills and attitudes that all individuals need for personal fulfillment and development, inclusion and employment (p. 6).

Since then, the regulatory framework has modified the names and number of competences. The Council Recommendation of May 22, 2018, established eight key competences that must be addressed in the context of lifelong learning, especially in the curricular development of member states. In particular, Competence 5 is defined as:

> The ability to reflect on oneself, manage time and information effectively, collaborate constructively with others, maintain resilience, and manage one's own learning and career. It includes the ability to cope with uncertainty and complexity, learn to learn, contribute to one's own physical and emotional well-being, preserve physical and mental health, and be able to lead a healthy and future-oriented life, express empathy, and manage conflicts in an inclusive and supportive context (p. 10).

Competence 6 is described as:

> The ability to act as responsible citizens and participate fully in social and civic life based on an understanding of social, economic, legal, and political concepts and structures, as well as sustainability and global events (p. 10).

As various studies have demonstrated (Gil-Olarte et al., 2006; Palomera et al., 2012), explicit work around these variables with secondary education students is complex, but can make a decisive impact on their lives and improve school climate.

This project will help generate knowledge by (O1) providing information on teachers and students' perceptions and meaning-making processes about learning through video games; (O2) generating a scalable and evaluable training program that educates teachers in the educational use of independent games and allows for implementation of classroom activities for development of ethical and socioemotional competences; and (O3) evaluating its impact on students based on the indicators in which Competences 5 and 6 are manifested, thereby also generating design principles that will be useful in the future.

2. Methods

This project will first focus on students and teachers' practices and meaning-making processes regarding video games to design an educational program that provides teachers with meaningful activities for the classroom.

O1 will be reached through a mixed-methods design, combining questionnaires and focus groups with teachers and students. O2 will be achieved by deploying design-based research (DBR) phases as presented in the following section, and O3 will be achieved through mixed-methods approaches that combine qualitative elements with the application of validated psychometric tests that measure the program's impact on students in relation to the development of Competences 5 and 6. To a certain extent, the entire project also can be interpreted as large-scale DBR. Furthermore, as it combines qualitative techniques with quantitative ones, it also can be interpreted as a sequential exploratory mixed-methods design, in which qualitative work precedes quantitative work.

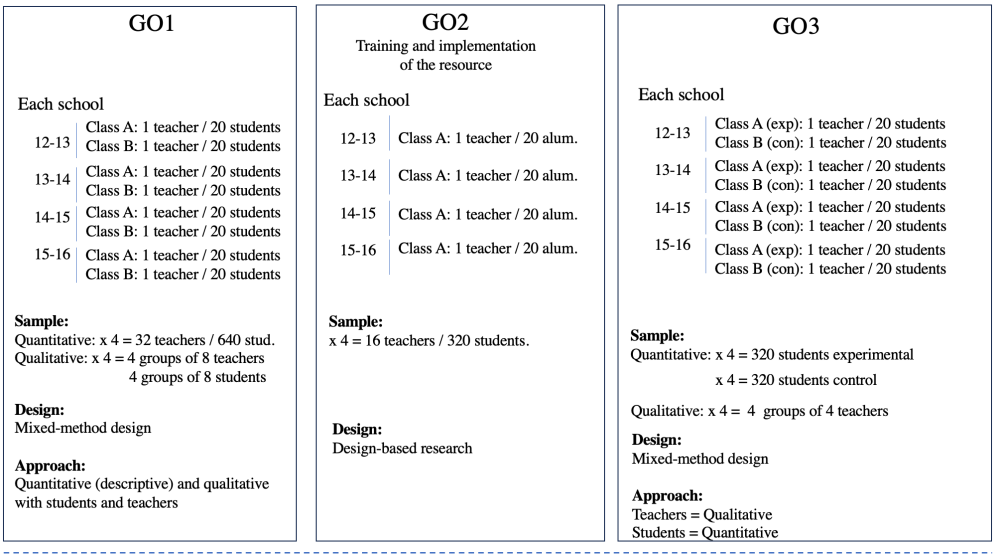


Figure 1: Design-based research

The sample will comprise teachers and students from four schools in Spain. Teachers will implement five activities designed for each of the four games, which will be selected by the research team throughout the first year. Similar activities have been designed and implemented in several Spanish schools in previous years through various funded projects, using games such as *Braid* by Jonathan Blow and *Gris* by Nómada Studio.

The selection of games is a critical element of the project and will take into consideration several factors, including: (1) artistic and creative value, (2) the extent to which they allow explicit work with competencies 5 and 6, (3) the possibilities they offer for dialogical and sociocultural learning, (4) PEGI ratings, (5) price, and (6) accessibility.

Sample selection will consider the centers' sociocultural and socioeconomic diversity; therefore, sampling will be accidental/casual and nonprobabilistic, as the team has access to schools in these various territories. Each

school will participate through their four courses of compulsory secondary education (12 to 16 years old). We will gather information from two classes (a and b) in each course with each school guaranteeing gender representativeness in all cases. This will result in a total teacher sample of n = 32. Calculating an average of 20 students per classroom, we will have n = 640 students during this first phase. All of them will complete descriptive questionnaires and then representative subsamples of teachers and students will be chosen for the qualitative focus groups. Subsequently, teachers who wish to participate in the training and implementation of the educational resource will be given the opportunity. In this case, it will be required that at least one line from each center and course act as an experimental group and at least another line from the same center and course act as a control group. This will result in n = 16 teachers and n = 320 students who will apply the resource, with corresponding numbers acting as a control.

2.1 Analysis Strategies and Implementation

For achieving O1, student and teachers' qualitative information will be gathered thorugh focus groups and analyzed using Atlas.ti software. The process will be inductive primarily, with contributions and categories emerging from the data themselves using analytical induction and grounded theory and constant comparison methods.

Regarding O2, agreements with the Education Departments and Teacher Training Centers in the various locations will be forged to implement a training modality called *work groups*, allowing teachers to be trained at their schools throughout the year by a researcher while they implement various activities. This training will comprise six two-hour sessions interspersed with implementation of classroom activities.

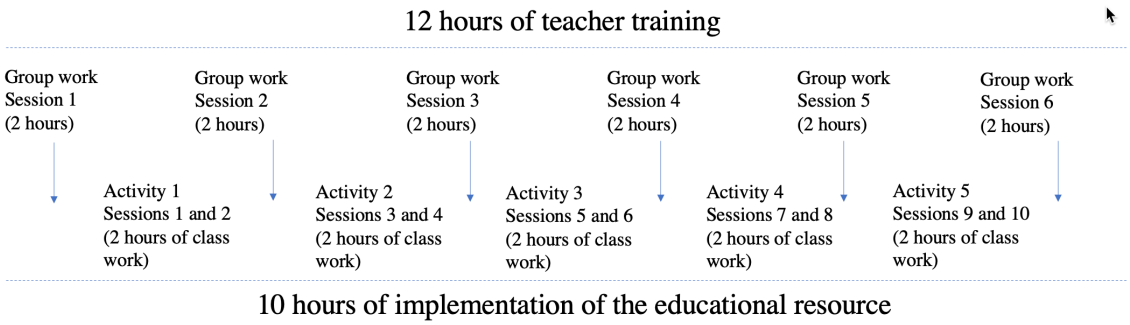


Figure 2

At the end of the process, Department of Education credentials will be given to all teachers who complete the training. The educational resource itself comprises five activities that require about 10 hours of work, so implementation in the class will comprise 10 one-hour sessions.

O3 will be pursued once training and classroom activities have been implemented. First, qualitative data from teachers who implement the resource will help us analyze their perceptions of the program and to what extent it has impacted their game literacy and games' educational possibilities. Data will be gathered and analyzed by following the same strategies as those used with O1.

Finally the program's impact on the students competence level will be assessed through a quasi-experimental quantitative methodology with a control (n = 320) and experimental group (n =320), pretest, and posttest.

Although literature reviews will be conducted to confirm the most relevant instruments, the team already has considered the use of some validated psychometric tests. To measure Competence 5's impact, use of the *Bar-On Emotional Quotient Inventory: Youth Version* will be considered. For Competence 6, instruments such as the *Child and Adolescent Scale of Participation (CASP)* or *Deliberative Process Perceived Quality Scale (DPPQS)* will be used. Data will be analyzed through a general linear model analysis of repeated measures using SPSS data, considering gender in the analyses as a control variable.

3. Expected Results and Applicability

The most evident impact will be linked to improvement of Key Competences 5 and 6 among the students.

Beyond explicit improvement, we expect to observe enriched video game literacy among the teaching staff.

While educational projects might not generate an immediate social and economic return, some extant research indicates that ethical and socioemotional competences are significant predictors of adjusted functioning and individual well-being. For example, improvements related to a lower index of maladaptive behaviors, such as disruptive and aggressive behaviors or risk behaviors that include drug use, have been identified (González-Yubero, et al., 2020). Above all, relationships have been found with greater adapted behavior, such as higher-quality social relationships, higher retention in the educational system, increased prosocial behaviors, better academic performance, better mental and physical health, greater life satisfaction, and increased altruistic behaviors (Gil-Olarte, et al., 2006).

In the same line, various meta-analyses have found that these programs generate improvements in attitudes toward school, a decrease in disruptive and aggressive behaviors, fewer affective problems, and improved academic grades (Durlak et al., 2011).

Therefore, we expect more than just short-term improvement in teachers' video game literacy and students' strength in Key Competences 5 and 6, but above all, an impact on digital critical literacy in schools and, by extension, society as a whole. We advocate for a real critical digital literacy. By helping educators and students recognize games' cultural and artistic value, we envision a learning environment in which digital tools are utilized judiciously and based on pedagogical objectives. Our approach encourages informed decision-making regarding integration of digital resources while ensuring that educational goals remain the most important element.

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Bridging Theory and Practice in Military Education through Advanced Technologies

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Abstract: This study presents a comprehensive examination of the developmental trajectory and operational advancement of a pioneering military simulation apparatus explicitly engineered to facilitate the seamless integration of joint fire support principles within the ambit of military education, with a specific focus on artillery students. The Virtual Reality (VR) and Augmented Reality (AR) technology provided by industry leaders such as Microsoft and Meta present solutions for interdisciplinary pursuits situated at the confluence of emergent technologies and contemporary military instructional methodologies. Central to the efficacy of this endeavour is the incorporation of meticulously crafted virtual and augmented reality models of authentic military equipment to imbue the simulation experience with unparalleled realism and fidelity to the principles of artillery fires. Collaborative ventures with private enterprises have facilitated the production of a simulator characterized by its gamification elements and unparalleled verisimilitude, enhancing its efficacy as an educational tool. Augmented by spatial intelligence gleaned from Unmanned Aerial Vehicle (UAV) sensors, the simulation framework can be further enriched by integrating true-to-life topographic representations meticulously synthesized by amalgamating laser scanning methodologies. Positioned as an indispensable cornerstone within the academic purview of the esteemed Department of Fire Support at the University of Defence, this initiative aspires to impart foundational knowledge and cultivate a proactive ethos of inquiry and engagement amongst the students. Furthermore, the simulator is a pivotal instrument for military training, offering a risk-free environment devoid of the hazards associated with live artillery fire exercises. By mitigating financial burdens and other logistical constraints inherent in conventional training methodologies, this innovative simulation apparatus represents a paradigm shift in contemporary military education and training practices.

Keywords: Simulation, Artillery, Training, VR, AR

1. Introduction

Artillery live fire training is indispensable for fire-observing units due to its unparalleled benefits (Blaha, Potužák, Šustr, *et al.* 2021). It provides soldiers with a realistic environment, enabling them to experience and respond to combat scenarios and improving their decision-making skills. Providing joint fire support to maneuvering forces involves coordinating diverse elements such as artillery, close air support, and naval forces, all operating under stringent principles of precision and synchronization, while assessing the effects on the target, see Fig. 1. However, live fire training also presents challenges such as safety risks, logistical complexities, and environmental impacts, which can be mitigated through simulation technologies (Foltin, Vlkovský, Mazal, *et al.* 2018).

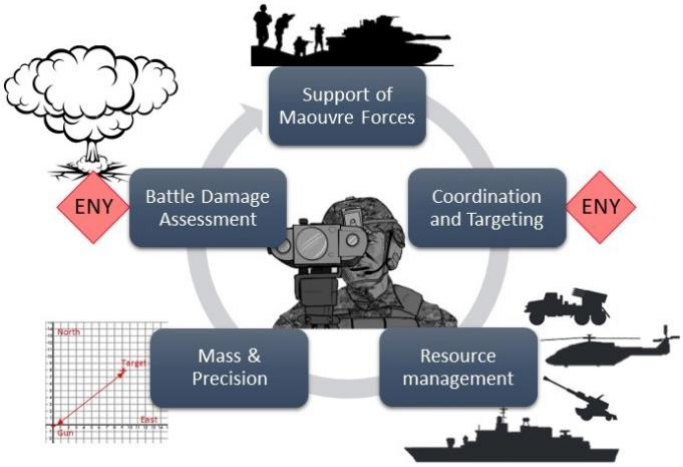


Figure 1 Complexity and principles of Joint Fire Support

However, simulation-based training may lack the realism and sensory immersion crucial for accurately replicating real-world combat situations, potentially impacting soldier's readiness (Mazal, Zezula, Procházka, *et al.* 2022). Acknowledging these limitations, collaborations between institutions like the University of Defence and the YORD company leverage Virtual Reality (VR) and Augmented Reality (AR) technologies. These efforts aim to develop immersive training environments that bridge theoretical education with practical applications, enhancing training effectiveness and engagement.

This paper introduces the architecture of the simulator software suite and discusses key developmental challenges encountered.

2. Architecture

The simulator suite comprises two main applications (Control and Field) and two additional modules for supporting functionality. This design simplifies application architecture, enables independent updates, reduces code complexity, and facilitates the reuse of common functions.

The control module is a standalone application designed for personal computers running Microsoft Windows. It allows access to local files via the system-native file picker dialogue. The application's main functions are to load scenarios from the backend, modify area and target definitions, and display field users' real-time locations. Users can save scenarios locally for future use. The control application utilizes *Mapbox's Unity plugin* to provide three-dimensional map data with multiple terrain layers (Mapbox 2024).

Unity's glTFast plugin loads 3D models in gltf/glb format at runtime to display three-dimensional targets and area ground models, reducing application size and enabling independent model distribution (Unity Technologies 2024e). Draco compression via the *DracoUnity plugin* minimizes network bandwidth, which is crucial for areas with limited mobile network throughput where the Field application may operate (Atteneder 2019). *Unity's Universal Rendering Pipeline* (URP) supports scalable graphical tools and PBR materials from glTF files, enhancing visual quality and realism in the simulation (Unity Technologies 2024f).

The field module allows users on compatible mobile phones and VR headsets to view targets in a designated area. Users navigate the area using the mobile phone version and can then switch to augmented reality (AR) mode on either the mobile phone or a connected VR headset. In addition to various plugins and libraries mentioned earlier, we utilize *Apple's ARKit plugin* (via AR Foundation) and Meta's Core SDK plugins for positional tracking on iPhones and Quest headsets, respectively (Unity Technologies 2024a).

The simulator's backend module facilitates communication between multiple instances of field and control applications running simultaneously. It leverages *Express.js*, a *Node.js* backend framework, for this purpose and for storing target and ground model files (StrongLoop, IBM 2017; OpenJS Foundation, 2024). The backend also provides API endpoints for file listing and timestamps, manages structures for model destroy rules, and pairs mobile phones to headsets.

The networking module contains definitions of structures shared between the field and control applications. It also allows for two-way communication by utilizing APIs exposed by the backend. Communication is facilitated using *Socket.IO*, which allows for real-time messaging between connected peers (itisnajim 2022).

In addition to APIs provided by our backend modules, *Mapbox's Raster Tiles API* is used to obtain elevation information for accurately placing targets and areas. We discuss the reasoning behind this decision in a further section. The workflow consists of downloading a specific tile texture and analyzing the colour value of a specific point (MapBox 2024). The RGB channels are then decoded to obtain the accurate altitude. In order to save on network bandwidth, we have created a file synchronization system. Since 3D models used within the applications can potentially reach hundreds of megabytes in size, we download them once and then store them in the local storage on the device. Each time the model is requested, we ask the server to provide us with a timestamp of the remote file, and if said timestamp is older than the timestamp of the local file, we skip redownloading the model. Created models of enemy air units and models of terrain are shown in Figure 1 (Cimr, Tomaskova, Cimler, *et al.* 2018).

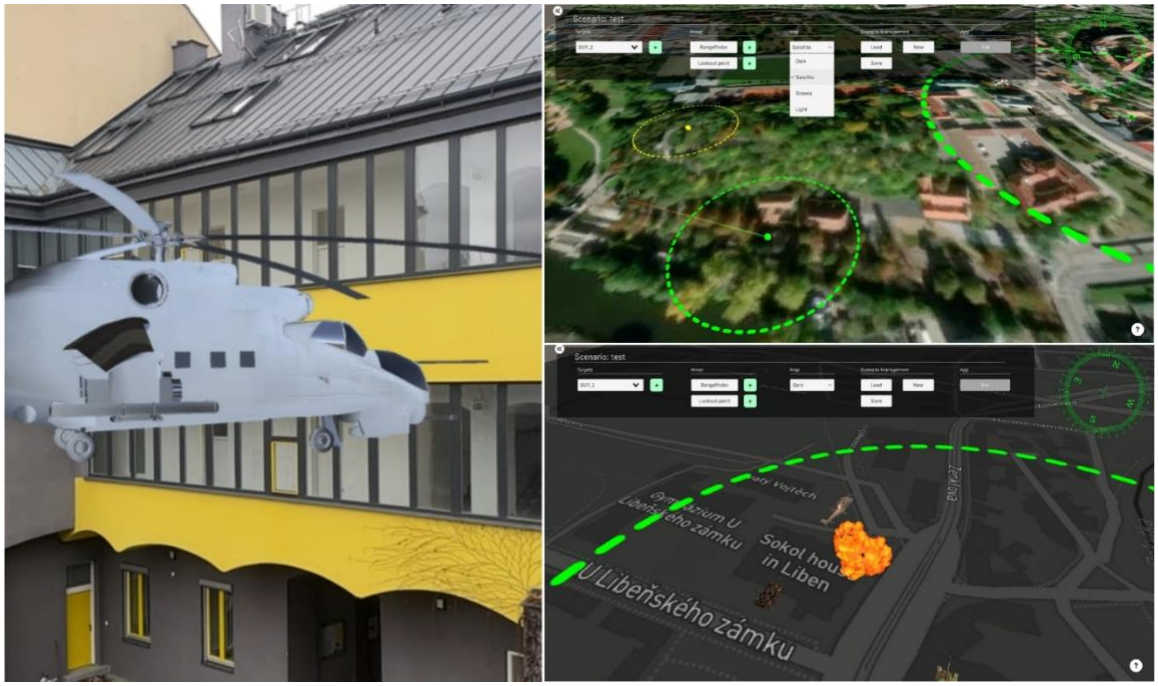


Figure 2: Display of models created within the terrain [authors]

3. Encountered Issues

During the development of the simulation, several challenges were encountered and addressed. These included issues related to GPS and vertical inaccuracy, the absence of a compass on the Quest 3 headset, communication and pairing between devices, implementation of the rangefinder functionality, and UAV terrain modelling. Strategies such as leveraging alternative orientation methods, optimizing communication protocols, and refining data acquisition techniques were employed to mitigate these challenges effectively, ensuring the accuracy and reliability of the simulation system. These experiences highlight the importance of adaptive problem-solving and innovative approaches in overcoming technical hurdles during simulation development.

3.1 GPS and Vertical Inaccuracy

Utilizing GPS-enabled mobile phones for user location presents challenges due to inherent inaccuracies and noise in location data, especially in varying environments. While employing specialized GPS receivers could improve accuracy, it adds complexity to the system architecture. Inaccurate GPS measurements affect user experiences in control and field applications, leading to position "jumping" and drift effects in rendered models.

To address these issues, we adopted a strategy of taking location measurements only upon entering AR mode, reducing drift effects. Additionally, we leverage Unity's Location API's horizontal accuracy property for enhanced location precision in real-time reporting to control users (Unity Technologies 2024c).

Elevation data accuracy posed a significant challenge, with errors exceeding 10 meters using Unity's altitude property—an interim solution using *Mapbox's UnityTile.QueryHeightData* method provided relative elevation but lacked absolute accuracy. We improved accuracy by leveraging Mapbox's Raster Tile API, which provides exact elevation data encoded in RGB channels, offering accurate measurements down to centimetres (MapBox 2024).

3.2 Missing Compass on Quest 3

Initially, we expected GPS data to be provided by the mobile device since the Quest 3 lacks a GPS module. We assumed the device would have a compass module accessible via Unity's Compass API. However, despite numerous modifications to the AndroidManifest, we needed help getting the compass working on the Quest 3. As a result, we devised a solution where the user runs the application simultaneously on both the headset and the mobile phone. They orient the devices to face the same direction and then align themselves with the north direction. Once in AR mode, users can stow away their mobile phones, continuing to use the application on the headset. Users must recalibrate the orientation if the headset goes into sleep mode (Unity Technologies 2024b).

3.3 Device Communication and Pairing

Initially, our system relied on local network connections between mobile phones and headsets to minimize network latency during critical operations like heading updates in calibration. The mobile phone acted as an intermediary between the backend and headsets, especially for headsets lacking direct mobile data access. We utilized *Mirror* for local networking but faced challenges with peer discovery when headsets were connected via mobile hotspots, requiring additional hardware like an external network access point. We shifted all data communication to the backend to address these issues, albeit introducing slight delays in heading updates during calibration (UNET 2024).

We sought automatic linking between individual mobile phones and headsets to seamlessly support multiple field users without requiring a headset-side input interface. For this purpose, we leveraged Unity's SystemInfo API, specifically the *deviceUniqueIdentifier* property. However, we encountered issues as this identifier can change under specific conditions, such as app updates on both iOS and Android. To mitigate this, we store the initial identifier value and reference it for consistency (Unity Technologies 2024d).

3.4 Rangefinder Implementation

To replicate the real hardware experience, we designed the rangefinder functionality in our system to closely resemble actual rangefinder operations. Using Unity's RenderTexture feature, we create a monoscopic view from a Camera, simulating the rangefinder's view in front of the user. The zoom level adjustment mimics natural optical settings by changing the camera's focal length, enhancing realism. For ease of zoom control on headsets, we utilize the volume buttons as accessible physical controls, although this triggers the system UI for volume adjustment, which cannot be suppressed.

Upon loading the rangefinder view, users encounter a ground model (if available), although discrepancies between the model and actual terrain may exist. To mitigate this, we automatically adjust target heights to align with the ground model's geometry, assuming all targets are positioned on the ground level for consistency (Unity Technologies 2018).

4. Terrain Modeling

In our endeavour to create a terrain model for AR/VR simulation using terrain data acquired by the DJI M300 RTK UAV and Zenmuse L1 LiDAR (Light Detection and Ranging) sensor, we encountered challenges primarily related to data processing and the realism of tree representations. Integrating data from laser scanning provided detailed 3D point cloud true-coloured data for constructing an accurate terrain model. However, issues arose with representing trees realistically in the simulation, as the initial models appeared unnatural and lacked lifelike features, as shown in Figure 2. Addressing these challenges involved refining data processing algorithms and enhancing tree modelling techniques to improve visual fidelity and create a more immersive virtual environment for AR/VR simulations (Ivan, Sustr, Pekar, *et al.* 2022).

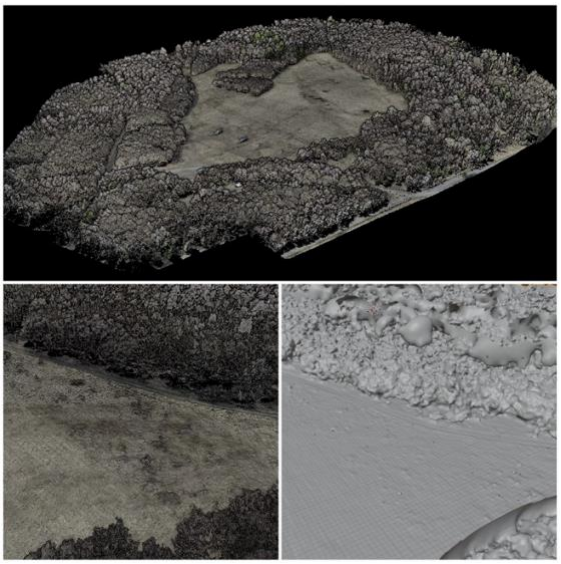


Figure 3: Acquired point cloud data and model terrain derived [authors]

5. Conclusion

The development of the simulator suite marks a significant advancement in military education and training methodologies, particularly in the context of fire support principles for artillery students. Our comprehensive approach, integrating Virtual and Augmented Reality (VR/AR) and prospects of unmanned aerial vehicle (UAV) sensors, results in a robust simulation framework capable of delivering unparalleled realism and fidelity to artillery fire principles. Despite the challenges, these experiences underscore the importance of leveraging emergent technologies and interdisciplinary collaboration to overcome technical hurdles and advance military education and training practices. The ongoing refinement of data processing algorithms and tree modelling techniques reflects our commitment to continuous improvement and delivering an immersive and compelling training environment for military personnel.

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Young Gamers Outside Education, Employment or Training: Translating Computer Gaming Skills to Job Relevant Competencies

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Abstract: 9.5 per cent of people aged between 15 and 29 in Norway are 'not in education, employment or training' (NEET) (Statistisk sentralbyrå, 2022). NEET status is generally associated with several negative factors, such as lack of social mobility, poverty, negative socioeconomic status and persistent exclusion from education and work life (Wrigley, 2017). Work exclusion represents a significant challenge on both a macroeconomic level and for the individuals who experience work exclusion. The perspective of computer games as learning tools has resulted in an increased interest in how games can generate positive changes in the player (Gee, 2007; McGonigal, 2012). From the perspective of career guidance, it is central to look at whether the positive changes and the learning such change implies can be used to develop career competencies and skills that are attractive for the world of work. This paper reports on a project to develop, conduct, study and evaluate an occupational training program for 15 young gamers between the ages of 18 and 30 classified as NEET. The research question for the project is how participants in a work preparation course experience computer gaming as an arena for developing career competencies and skills and how these skills and competencies may contribute to the participants' employability

Keywords: Computer games, NEET, Occupational Training Program, Competence Development, Employment

1. Introduction

Persons not in employment, education and training (NEET) represents a heterogeneous group (Fyhn, Radlick & Sveinsdottir, 2021). NEET is generally associated with a number of negative factors such as lack of social mobility, poverty, low socio-economic status and consistent exclusion from education and work (Wrigley, 2017).

Norway has seen a rise in demand concerning innovation directed towards programs aimed at reducing unemployment (Meld- ST 32, (2020-2021). Given that young people are large consumers of computer games with as many as 47 percent of those aged between 16 and 24, and 32 percent of those aged 25 to 44 reporting daily engagement in digital games in Norway, implementing computer games and gamification into occupational training programs is one potential approach to assist people in transitioning from NEET into permanent employment or education. Occupational training programs, referred to as AFT in Norwegian, are designed to evaluate a person's ability to work, assessing their work-related competencies and offering them work related activities (NAV, 2023).

In recent years there has been a shift in discourses concerning gaming from viewing it as problem behaviour to focusing on the beneficial outcomes that engagement in computer games might have for the player (Gee, 2007; McGonigal, 2012). The shift towards exploring how computer games enhance skills, reflective abilities, cooperation, and ethical decision-making has sparked increased research interest (Kelly, Magor & Wright, 2021; Snodgrass et al., 2018; Nuyens, Lopez-Fernandez & Griffiths, 2019; Alonso-Díaz, Yuste-Tosina, & Mendo-Lázaro.; 2019: O'Connor & Menaker, 2008) and the use of computer games in career guidance have become more common because of its potential to create positive changes in the player (Gee, 2007; McGonigal, 2012)

The purpose of career guidance is to generate career competence, which means providing persons with skills and competencies needed to navigate through life, learning and work (Bakke et al, 2020). Applying computer games as a means to increase work and education-related competencies has according to O'Connor & Menaker (2008) and Perkins (2011) shown promise. However more research is needed in order to generate knowledge on how computer games can be used as a concrete approach in occupational training.

2. Games as Learning Machines

Video games have historically been seen as just another form of entertainment, primarily for kids, and with little real-life value. Since the inception of game studies in 2001 and the growing omnipresence of video games in

everyday culture, the focus has shifted to recognising that video games have value, not just as a cultural product but also as an art form (Aarseth, 2001). Additionally, they can function as powerful learning machines that are useful in teaching, training, and learning (Gee, 2003, 2005a, 2005b, 2007). This is particularly important for young people outside of education, employment or training, as video games can represent an informal but practical learning arena (Pallavicini et al., 2018; Pereira et al., 2019). Through engagement in video games, players can develop a range of competencies and skills that are relevant and sought after in the job market such as creativity, strategical and critical thinking, planning and problem-solving skills, collaboration, communication, teamwork, leadership, decision-making and more (Barr, 2017, 2018; Oei & Patterson, 2013; Adipat et al., 2021; Glass et al., 2013; Isabela et al., 2014). Through playing video games, players also often develop advanced technical skills and a high level of digital literacy (Tinmaz et al., 2022; Turner et al., 2017). Game environments are also dynamic and often unpredictable, requiring players to adapt to new situations and overcome challenges quickly. This continuous adaptation builds resilience and the ability to handle stress, which are valuable traits in a job market characterised by rapid technological changes and frequent disruptions (Pallavicini et al., 2018; Wang et al., 2023).

Video-games can also represent a unique opportunity to acquire relevant skills to facilitate the workforce transition for young people outside of education, employment, or training. However, understanding what players have learned from playing requires an active translation process.

The need for active translation of qualifications between contexts is referred to in learning psychology literature as 'the transfer problem' (Illeris, 2012). Qualifications are only part of learners' competence to the extent of their ability to apply them practically. The transfer problem presents itself mainly when learners try to apply qualifications they have obtained in a school setting to a workplace context. The transfer problem can, however, be overcome by helping learners restructure already established mental schemas through the process of accommodative learning, a 'transcendent' or transformative form of learning that fundamentally shifts people's understanding of the world. Players' abilities to translate learning outcomes from playing to valuable competence in the labour market can be seen as a form of career competence, and this project allows exploring how gamers can develop this competence.

3. Career Learning Through Games and Guidance

The field of career development is often seen as a transdisciplinary field that draws on psychology, pedagogy, sociology, economy and philosophy. The aim of career guidance and education is to facilitate career learning that enables clients to build career competence that helps them navigate through life, learning and work.

Gaming generally promotes a kind of learning that is internally motivated and problem-focused. Young adult gamers then enter new learning processes with many experiences from gaming and other life domains. The occupational training program that we explore in this project aims to meet the gamers on their turf, scaffolding their learning with a range of different and integrated career learning activities that give them a context and an opportunity to share and discuss their often tacit knowledge and understandings from their previous experiences.

This pedagogical approach to career education aligns well with McIlveen's (2012) proposal to build on andragogy and transformative learning to promote transformative career development learning, which can help gamers learn to translate their gaming experiences to competence transferable to the labour market. The practical approach to the program aligns with integrated guidance, which is a method of building learning activities through instructional design to scaffold career learning (Bakke & Hooley, 2022). The program then allows for the exploration of both pedagogical and practical approaches to career education for young gamers.

4. Method

In this project, we followed 15 young adults (NEETs aged 18 to 32) who participated in an occupational training program focussing on enabling and supporting the transition to work or education on commission from the Norwegian welfare administration. The program consisted of various activities, such as seminars and workshops, cooperative gaming, individual counselling in-game, job interview training in VR and traditional occupational training activities such as job search, writing applications, developing a CV and more.

The methodological approach was action research and ethnography (Fangen, 2010; McNiff & Whitehead, 2006). The data was collected over nine months. The action research framework called for participants to actively participate in developing the activities in the program, and interviews and interactions with the participants

throughout the project period focused on evaluating and adapting the activities in the program. The fieldwork was conducted using participant observation, focus group interviews and individual interviews with the participants in the project, both in real life (IRL) and in a virtual in-game environment.

The analysis will employ a thematic approach within an experience-based narrative methodology (Gubrium and Holstein, 2008; Mishler, 2006; Phoenix, 2013).

5. Preliminary Findings

Since this is a work-in-progress paper, we have not yet begun the thematic analysis. However, to state something about what this project has found, we applied AI as a tool to do a preliminary screening of the data-material and identified the following themes.

- Problem-solving skills
- Critical thinking
- Strategic planning
- Team-work skills
- Language skills
- Logistics management skills
- Systematic organisation
- Ability to handle complex systems
- Increased social skills

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Late Submissions

Didactic and psychological Principles of Successful Design of serious Games

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Abstract: In this paper, a systematic, evidence-based overview of didactic and psychological design principles is provided, which have a significant impact on the learning success of Serious Games. Design criteria are described that relate to the structure of games, the principle of learning through play, interaction regarding usability and playability, as well as motivation with the necessary game incentives. Furthermore, perspectives on the future development of Serious Games are outlined, focusing particularly on the implementation of concepts of adaptive e-learning and AI-supported learning.

Keywords: Serios Games, Game Design, Principles of Learning Through Play, Learning Success

1. Introduction

Today, adept handling of digital technologies and technical assistance systems in everyday work is becoming increasingly important. New job profiles emerge, demanding corresponding competencies (Lehmann et al., 2021; Zinke, 2019). The imparting of so-called Future Skills, such as the ability to work in digital networks or proficiency in handling digital data (data literacy), is gaining significance (Spiegel et al., 2021; Ehlers, 2020). Digitalization not only alters the work environment but also impacts the education sector (Bohlinger et al., 2022; Schumann et al., 2022). Educational approaches and methods are continuously becoming more digital. Innovative learning concepts, such as Serious Games, are gaining increasing importance.

Serious Games are digital learning games designed to support individual learning processes, having an entertainment purpose but also serving to convey learning content and develop and train competencies, skills, and abilities (Becker and Metz, 2022; Dörner et al., 2018; Strahinger and Leyh, 2017). They aim to make learning more engaging and effective. Knowledge and skills are imparted in an entertaining manner, creating a high diversity of perspectives. Learning content can simultaneously encompass various subject areas such as competency building, health management, communication, or teamwork.

The unique aspect of the learning concept of Serious Games lies in integrating learning content and tasks into a gaming environment. They enable individualized learning with numerous opportunities for reflection and facilitate the internalization of knowledge and the retrieval of learning content, which can then be transferred not only into the virtual world but also into Real-life-situations. To achieve this, it is important to consider didactic and psychological design principles in the development of Serious Games. Didactic criteria pertain to the learning objectives pursued with Serious Games, the structure of the game, the game design, and the method of conveying learning content. Psychological design criteria focus on the motivation of the player, emotional, and behavioral aspects. A successful Serious Game should motivate players to engage, experience positive emotions, and change their behavior. By considering these criteria, the design of Serious Games can be made more effective and engaging.

This paper describes design criteria related to game structure, the principle of learning through play, interaction regarding usability and playability, as well as motivation with the necessary game incentives. Prior to that, it delves into pedagogical foundations that delineate the conceptual framework of Serious Games.

2. Pedagogical Framework of Serious Games

Serious Games are based on the potentials of playing and self-directed learning (Jeske, 2022; Wouters and Oostendorp 2017; Breuer, 2010). In contrast to purely entertainment games, Serious Games pursue specific learning objectives to promote skills or behaviors, as well as to continuously motivate and activate players in the learning process. This includes adapting to the individual needs and abilities of players and integrating feedback mechanisms. It is important for Serious Games to be flexible enough to address the diversity of players and their needs, enabling a personalized learning experience.

From a pedagogical perspective, the game structure in Serious Games should allow players to take on the role of active agents. Players must make decisions, solve problems, and complete tasks to progress in the game

(Brauner and Ziefle, 2022; Schutz and Schutz, 2022). The underlying game design should not be immediately apparent, and the challenges should be engaging and solvable to enable and promote immersion. Immersion is the process or state in which a person fully engages in an experience and loses themselves in it, forgetting the environment around them. In an immersive gaming world with authentic scenarios and lifelike characters, whose identity learners actively assume, learning should be perceived as natural rather than strenuous and tedious. Through additional media, players can be further integrated into the setting. For example, players can be multimedia integrated into the game world beyond the learning environment through emails in a regular account or via SMS on their mobile phones.

Playing is a voluntary and intrinsically motivated activity pursued for its own sake and not specifically aimed at achieving certain teaching-learning goals (Huizinga, 2006; Oerter, 1999). Learning occurs conceptually on different levels. Serious Games support the analysis of decision-making processes and appropriate behavior with the concept of situational learning. Furthermore, players' own competencies become experientially accessible and can thus unfold. This enables competency activation and growth. The offered learning paths, depending on the game setting, can contribute not only to the promotion of professional and methodological competence but also to an increase in learners' self and social competence. Competencies for successfully navigating Serious Games can be incidentally acquired – that is, without direct learning intention (Kerres, 2013, 2001). Since Serious Games can be used very flexibly and tailored to players, they are granted a high degree of learning autonomy, which is further reinforced by the self-control contained within the game. This fosters specific action competencies such as self-directed learning. Other content can be acquired in explicit learning mode, for example, when specific tasks or missions need to be solved, such as strategic thinking and problem-solving skills, strategic, analytical, and combinatorial abilities, concentration, persistence, or frustration tolerance.

Social complexity, problem control and resolution, and self-regulation are also important factors in the pedagogical concept of Serious Games. Different learning aids can be incorporated to support the learning process (Bopp, 2005), such as tutorials explaining the basics of game mechanics as didactic learning aids, and forums where hints for coping with certain game situations can be found or other players can be asked for help.

Klimmt (2005) distinguishes between exploratory and problem-solving actions in the game. Exploratory action is used when additional information or objects are needed to solve specific problems (missions, etc.). The state of problem-solving, on the other hand, involves immersion in the game world. As long as the person subjectively moves through the game world, implicit or incidental learning takes place in the game cycle. Only when the person gets stuck, they are more likely to switch to explicit learning, and only for as long as necessary to immerse themselves back into the game world and apply the new knowledge to solve problems. A game world should offer both phases alternately, with explicit learning phases being rather short. Learning processes in Serious Games can be situated on four levels (Hofinger, 2003):

- Level of content-related problem constellations: Understanding problems, taking action, bringing about solutions.
- Level of individual thinking processes: Thinking strategies, aspects of motivation (including motivation balance, motivation goal), emotions (e.g., dealing with frustration), biographical characteristics (e.g., age).
- Level of problem-solving process control: Goal setting, decision-making process, implementing action plans (action organizations), and work organization (observing the further situation, controlling the effects of the measures taken, and critical reflection as well as background control, e.g., hazard cognition).
- Level of social processes: Dealing with social complexity, balancing teamwork, assessing the respective consequences of actions, analyzing the effects of decisions on the environment and in detail, etc.

In complex game worlds, it is not only about applying previously named rules, i.e., transferring declarative knowledge into procedural knowledge. It is also about generating procedural knowledge in interaction with the game system. Learning the game can be promoted through a didactic-immersive game design. Case-based and action-oriented learning creates a learning experience that motivates learners to understand the underlying theories and concepts. This means that play comes first, experiences are gathered, and then knowledge and theories are conveyed. This contributes to a relaxed learning atmosphere with a positive and motivated context for change.

3. Consideration of Didactic and Psychological Aspects in the Design of Serious Games

Embedded within the outlined pedagogical framework, the success and effectiveness of a Serious Game depend on the extent to which it manages to align the game structure, gameplay, and progression with didactic and psychological principles (Becker and Metz, 2022; Breiner and Kolibius, 2019; Gee, 2007). Didactic design principles refer to learning-promoting elements integrated into game development to create an effective learning environment. These include aspects such as clear definition of learning objectives, feedback mechanisms, opportunities for adaptation to player characteristics, and integration of real problem-solving situations. These principles are intended to ensure that Serious Games are not only entertaining but also achieve a sustainable learning effect.

Psychological design principles of Serious Games involve the integration of insights from psychology into game development to influence players' behavior, motivation, and learning. This includes aspects such as the application of motivational reinforcement mechanisms, consideration of players' cognitive abilities, and the creation of emotionally appealing and stimulating game worlds. These principles are aimed at ensuring that Serious Games are not only effective learning tools but also promote the well-being and engagement of players.

From didactic and psychological perspectives, Serious Games should simulate situations and challenges in a gameplay that learners may encounter in their professional or personal lives. Game mechanics and interactions should therefore be designed to allow players to acquire the desired knowledge and required skills or competencies. Serious Games should cater to individual learning needs in addition to content. Skills or competencies can thus be trained in the safe environment of Serious Games and assessed within a space for reflection. Players thereby have the opportunity to learn from their actions, decisions, and mistakes.

In Serious Games, patterns of action, thought, and communication are observable. The underlying experiences and mental models, values and goals, or behavioral rules can be made consciously, discussable, and understandable in an evaluation and reflection phase, thereby also being subject to change. For the transfer from the gaming situation to the learning and work context, it is less about factual knowledge than about one's own learning competencies, approach to knowledge acquisition, and assistance in retrieving knowledge. Therefore, debriefing is very important, whether as a discussion afterwards or as reflection with other learners or with a coach or teacher (Peters and Vissers, 2004). The role of the teacher is to guide through the stimulating learning environment and deliberately encourage reflection. Learning is thus sustainably accompanied by a coaching-based process of reflection, and learning effects can be reinforced through this didactic structuring of self-observation and self-reflection (Helm and Theis, 2009). Furthermore, in a simulation, behavior can be tried out and adjusted multiple times, as often as necessary. In particular, new behavioral patterns emerge by consciously developing and practicing action strategies. Serious Games thus enable the tracking of learning progress.

The context of the game and its appropriate use are further influencing factors on the effectiveness of Serious Games. Contextual factors consider the place of use, technical support, and the learning environment (Ravyse et al, 2017). For the success of Serious Games, it is crucial that quality and functionality are ensured and an appealing design is present. Speed and immediate recognition are also important. The game content must be engaging and have a trial-and-error character, meaning that tasks must be assigned and goals set, points awarded for actions, and players should be able to compare themselves.

In conjunction with the described didactic and psychological design criteria, the usability of Serious Games in terms of usability, user-friendliness, or playability also plays an important role (Becker, 2022; Shneiderman and Plaisant, 2018). The game setting should relate to a captivating theme, an exciting plot, and an entertaining environment and have a playability to maintain the player's interest or level of attention. It should be ensured that the functionalities of a digital learning game and their usability are designed as accurately as possible with the specific requirements of the target groups or user base. Serious Games can unfold the intended learning effects when the game design is user-oriented and the interaction between the virtual learning medium and the players – the user interface – is characterized by high usability (Jeske, 2022; Marcus, 2011). If players can cope with the game structure and gameplay, they often experience a sense of control, which promotes the acceptance of Serious Games. With increasing usability, the learning success of digital learning games increases.

For successful Serious Games design, playful motivational mechanisms such as feedback, reward, fun, etc., are important. Through the playful character and the integration of reward systems, learners are motivated, their engagement is promoted, and they are involved in the learning process. An immersive gameplay ensures a sense of success and enhances motivation. It should not be too easy, but also not too difficult, should never bore, but

also not permanently overwhelm. The challenges and difficulty level of the game should be adjustable according to performance and progress to maintain learning motivation and flow continuously and promote the player's learning progress. The flow state describes a mental state of complete immersion and concentration in an activity and unity with the task (Csíkszentmihályi, 1975). It represents an optimal balance between the demands of an activity and the individual's abilities. In a flow state, people feel particularly motivated, engaged, creative, and fulfilled. The difficulty level should be gradually increased, and progress should be continuously experienced. Level design sets certain stages of increasing difficulty that must be completed before reaching the next, more difficult level. In this regard, the motivational psychological "principle of fit" (Heckhausen, 1989), "Mastery-Learning" (Bloom, 1971), or "Scaffolding" (Vygotsky, 1978) come into play. Learners are gently guided into increasingly challenging situations, thereby developing more competencies. Serious Games should therefore be able to adapt to the level of the players to lead to experiences of success. From a learning psychological perspective, repetitions, referred to as the Game Loop, are characteristic. Through repetitions, acquired knowledge can be practiced, reinforced, and internalized. Depending on the competency-related goals associated with Serious Games, the requirements should be increased in the course of the game or from level to level (spiral didactic principle). Coping with the increasing demands on the players also has a positive effect on motivation and the experience of flow. From a cognitive psychology perspective, attention lapses, comprehension difficulties, or feeling overwhelmed should be avoided and addressed through different learning paths.

Another important design element of Serious Games that also provides enjoyment is the ability to experiment. In the game setting, activities and processes should be embedded according to an experimental or problem-based educational approach (Boud and Feletti, 1991). The player does not need to know everything in the digital gaming world; they can try out certain moves and receive feedback from the system. Through repeated rounds, the player acquires knowledge. Repetitive patterns are implicitly learned, leading to improvement, increased speed, and task accomplishment. The knowledge acquired by the player in such game worlds is a collection of scripts or patterns (Schank and Abelson, 1977). In a script, knowledge is stored on how to handle a specific type of situation, what to consider, and the typical sequence of actions. This knowledge becomes routinized through repeated application and automatically activates when a situation is assigned to a specific script. Expertise is characterized by learners having a set of elaborated scripts available and highly routinized. This increasing game competence triggers a feeling of joy and efficacy. The uplifting feeling of increasing competence is another significant source of motivation (Behr et al, 2008).

Learning in a safe, manageable, and realistic environment is an important framework factor for the sustainability of this form of learning and thus a crucial advantage of Serious Games. The learned material is integrated sustainably through the realistic game situation – the experience – and reflective engagement, which can then unfold not only in the virtual world but also be applied in real situations. Teachers or trainers can observe the progress of learners and provide situational feedback to enhance the learning experience. Players, on the other hand, have the opportunity to directly experience their decisions and actions in the game and learn from the consequences of their actions – even in retrospect. This leads to a deeper understanding of oneself. Players are also motivated to question and optimize their own actions.

4. Future Perspectives of Serious Games

Against the backdrop of increasing demand for digital teaching and learning formats as a result of rapid technological progress and societal transformations, it can be expected that the need for Serious Games will continue to grow in the future. This is facilitated by the increasing dissolution of the perceived separation between entertainment and learning elements, thereby increasing the acceptance of formats of game-based learning. Also, digital selection tests (recruitment) and opportunities for personal development give digital learning games more significance for the identification and development of professional competencies and skills (Jansen et al., 2023; Gensicke et al., 2021).

The assessment that the importance of Serious Games will increase in the future can also be supported by figures on the previous use of Serious Games in vocational education. In the Weiterbildungsmonitor 2021, questions were asked about the use of digital formats and media in teaching/learning processes. The proportion of further education institutions that reported using Game-Based Learning or Serious Games in Germany increased by 2 % from 2019 (11 %) to 2021 (14 %) (Koscheck et al., 2022: 24). Although this percentage refers to the circle of providers of further education measures, it can serve as a guideline for the dissemination of digitized learning games in the entire field of vocational education. Accordingly, there are significant potentials for expansion in the use and deployment of Serious Games.

It is important that existing media pedagogical and media didactic game concepts are adapted and further developed to the structural changes of the necessary professional competencies in the workplace. The intention should be to increase the willingness to learn among users of digital learning games and to achieve sustainable learning success. What distinguishes Serious Games, namely learning by doing, is a particularly effective form of adaptation and internalization of learning content. Simulations mimic real situations to practice without risk and acquire skills that are important and useful for professional life. The combination of physical action and mental concentration stimulates complex cognitive processes. Especially in recognizing, understanding, and comprehending in a digital learning environment, attention, spatial vision, cognitive, and social development are promoted.

In the future, the increased use of Serious Games will play a special role because learning environments are created that enable creativity, cooperation, and agility, especially to promote qualifications for solving new tasks and problems. In such learning formats, Future Skills can be learned and trained in decentralized and digital structures in a special way (Stifterverband für die Deutsche Wissenschaft, 2020; Rapp et al., 2019). Essentially, it is about the task-related combination of digital competencies (digital literacy, agile working, etc.) and classical skills such as problem-solving ability, creativity, adaptability, etc.

The potentials of Serious Games should be used more strongly than before because digital games are an important everyday medium for younger generations. Learning content can be prepared in a target group-specific manner and be made motivating for learners who do not have access to it in everyday life. Therefore, in the future, it is particularly important to involve the respective (even heterogeneous) user group participatively in the development and further development of digital learning games and to enable learning and thus qualification in the sense of participation.

5. Discussion

The previous discussions aimed to provide a systematic and literature-based overview of didactic and psychological principles for the successful design of Serious Games. The relevant design principles pertain to the game structure, the concept of learning through play, interaction regarding usability and playability, and motivation with the necessary game incentives.

The benefit of this systematic compilation lies in offering a framework for the development and practical application of digital educational games. Considering didactic and psychological principles increases the likelihood that the intended learning objectives of a Serious Game can be comprehensively achieved. However, it should be noted that knowledge or skills learned within a game are not automatically transferred to real-life situations. This transfer of learning to practice should be part of the didactic concept and included in the reflection framework.

The use of Serious Games should not occur in isolation but should be embedded in appropriately designed learning architectures depending on the user group, learning objectives, and content, incorporating analog learning forms. This underscores the special significance of educators as learning coaches and mentors. As previously stated, educators should guide learners through the playfully designed learning environment and support the learning process through coaching-based reflection processes. Through didactically structured self-observation and self-reflection, learning effects can be enhanced, and individual learner development can be effectively supported and promoted. It is essential that educators have access to appropriate guidelines and instructions. These materials serve to facilitate the entry into digital learning games and motivate practical use of Serious Games.

A particular aspect of learning with Serious Games is their adaptability to the individual needs of learners, allowing learning in various locations and times. By offering personalized learning experiences tailored to the individual learning style and needs, Serious Games provide an effective way to actively engage learners in the learning process. Additionally, Serious Games can confront learners with complex situations and challenges in a practical manner. By creating simulated environments where learners can make decisions and experience their consequences directly, critical thinking and problem-solving skills are developed and strengthened in a realistic way. Another aspect is the social component of digital learning games, which promotes collaboration and collective learning, developing skills for effective teamwork in a digital environment.

Considering the described didactic and psychological principles allows the potential of Serious Games to be fully exploited, especially in connection with Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI). However, this should not overshadow the limitations of Serious Games. The acceptance, access, and use of

digital learning games, and thus their success, depend heavily on intervening variables such as age, gender, educational level, competence level, social class, etc., of the players. This must be considered when developing and using appropriate Serious Games.

The described didactic and psychological principles can also serve as criteria for assessing the quality of digital games in a broader application context. A systematic and methodologically sound evaluation by independent experts in a peer-review process, focusing on game design and associated player experiences such as attractiveness, motivation, flow experience, involvement, and usability, as well as learning success in terms of effectiveness and efficiency, offers the possibility of certifying Serious Games (Bruder et al, 2012; Caeserman et al, 2020; Certifications, such as the RAL quality seal awarded in Germany, can sustainably ensure the quality of Serious Games and promote it through "Best Practices" (Gütergemeinschaft Serious Games, 2024; SG-IV, 2023).

6. Summary

Serious Games integrate learning content and tasks into a gaming environment that is meaningful for achieving goals and fits the user context and other learning measures. Digital learning games promote active learning. Various scenarios can be played out, and the learner can experiment with alternative problem-solving approaches. The game structure of Serious Games should be designed so that players take on the role of active agents. The underlying game design should not be immediately recognizable, and the challenges should be engaging and solvable to unfold important didactic and psychological principles such as motivation, enjoyment of playing, sense of achievement, flow, and immersion optimally. Additionally, there should be sufficient space for review, reflection, and introspection.

It is expected that the use of Serious Games will continue to increase in the future. An important development path lies in the development of AI-supported learning programs, which enable Serious Games to be flexibly adapted to players with different learning prerequisites. Significant impulses for the further development and optimization of digital learning games can also be expected from an intensification of scientific accompanying research. The spectrum ranges from questions of the acceptance of game-based learning depending on the professional competence field, the expectations, and experiences of players differentiated by age, gender, competence level, to the changing roles of educators in learning support. On the other hand, investigations are needed on the influence of usability on the sustainable learning effects of Serious Games and on the change in learning culture through smart tools and learning algorithms. Helpful here are research and development concepts characterized by interdisciplinary collaboration between game developers, educators, psychologists, and the recipients or users of Serious Games.

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Serious Games in EDI Education: A Preliminary Discursive Literature Review

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Abstract: In Higher Education Institutions Equality, Diversity, and Inclusion (EDI) training sometimes has great variability and may lack sensitivity. As a result, the process often lacks depth and does not provide the ability to make mistakes in a more risk free/simulated practice environment in a simulated practice way. EDI can often encompass and touch on rather uncomfortable subjects that people would much prefer to avoid such as racism, discrimination, sexuality, religion, disabilities, marginalisation, lack of representation, unconscious bias and micro-aggressions, professional dilemmas, and ambivalence. People tend to avoid having difficult conversations and asking questions to enhance understanding. Serious games can offer a vehicle to explore some of these issues in a simulated, risk free, immersive environment with no real world consequences. They are a legitimate academic discipline used in a number of diverse fields such as business, mathematics, and soft skills. This paper will perform a preliminary discursive review of the use of games-based learning and serious games in EDI education and associated terms to produce valuable empirical evidence. The study will review developmental, evaluation and development frameworks for developing serious games for potentially difficult contexts in line with EDI i.e. resistance, ambivalence, and challenging confrontational discussions.

Keywords: Serious Games, Equality, Diversity, Inclusion, Preliminary Discursive Literature Review

1. Introduction

Dedicated educators strive to enhance the educational experience for their learners. This can entail methodological approaches or the integration of innovative technological learning, teaching, assessment, and evaluation tools to provide a more effective and immersive educational experience at all educational levels. Serious games offer a platform to increase motivation, engagement, immersion and provide, risk free, experiential simulated learning (Connolly et al., 2012; Boyle et al., 2016). Not only must educators attempt to utilise and take cognisance of potential innovative teaching approaches, but they must also take time to reflect on their own practice (Djumagulov, 2019). This means additional CPD, keeping up with modern practice and filling in the gaps in knowledge for self-improvement. Serious games can also be utilised tools for educators to enhance their own teaching and learning practice in a simulated class room environment where teachers can learn and make mistakes with decreased risk and without potential insensitivity. Educators at all levels may find themselves in front of a diverse group of students which requires empathy, understanding, sensitivity, respect, and adaptability on their part. This entails educating learners from different cultures, race, social backgrounds where they are expected to adapt to identifying pronouns learners that are disabled or from the LGBTQIA+ community. In his chapter which is an excerpt of his book available at (https://www.academia.edu/9878443/DIVERSITY_IN_EDUCATION, p.3), Johnson (2014) citing Johnson (2010) states that diversity in an educational setting includes: "*social economic status (SES), ethnicity, religion, gender, sexual orientation, cultures and abilities, exceptionalities and language*."

Serious games have been used in a variety of incredibly diverse areas including culture, health and wellness, education, support, professional learning, and training and for social skills (Din, Baig, & Khan, 2023; Boyle et al., 2016; Connolly et al., 2012). The development of serious games which incorporate appropriate pedagogical content and marrying fun and engagement to the educational learning outcomes is a complex, intricate, and challenging process. This is exacerbated when the learning content can be of a potentially sensitive and complex nature. This study will also perform a preliminary review of evaluation and developmental frameworks in the field of games-based learning and serious games to ascertain if any particularly take into account EDI aspects or have been utilised to integrate content of a potentially sensitive nature. The study will be a first step to a larger

study to create a serious game for some aspect of EDI education or training. It will also be a first step to attempt to synthesise some of the literature in serious games for EDI and evaluation/developmental and pedagogical content integration frameworks for subjects of a potentially sensitive nature.

2. Equality, Diversity, and Inclusion

Definitions of 'equality', 'diversity' and 'inclusion' are exceptionally varied and therefore it is difficult to establish a definitional consensus and theorise the concepts. The Scottish Government defines **Equality** as "*making sure every individual has an equal opportunity to make the most of their lives and talents. It is also the belief that no one should have poorer life choices because of where, what or whom they were born or because of other characteristics.*" Capaldi (2002) points out that the concept of equality is both descriptive and normative. In the descriptive sense meaning that entities are in some respect identical and in a normative sense that all humans are in some special respect equal where the reality is that to achieve this equality that special treatment may be required to achieve the descriptive state. The Scottish Government (2024) defines **Diversity** as "*an acceptance that everyone is different and that those differences are to be recognised, respected, valued, promoted, and celebrated. They may include but are not limited to differences protected by equalities law.*" Diversity is a multi-layered concept with many frameworks proposed in the literature. One comprehensive framework/model by Gardenswartz and Rowe (1994) was proposed for application in healthcare sector organisations. In 2003 it was enhanced and defines the dimensions of diversity into four layers including personality, internal dimensions, and external dimensions. Leicht-Scholten (2012) transferred those four layers to the context of a university i.e. Higher Education organisation. This dimensional layers for an organisation and for a university are displayed in Table 1. Differing attributes of the dimensions are displayed in bold. It is interesting to not that these attributes are more frequent at the organisational level.

Table 1: Dimensions of diversity

Level	Organisational Description (Gardenswartz and Rowe, 2003)	University Description (Leicht-Scholten, 2012)
1. **Personality**	which can be broken down into the big 5 personality traits i.e. openness to experience (inventive/curios vs. consistent/cautious), conscientiousness (efficient/organised vs. extravagant/careless), extraversion (outgoing/energetic vs. solitary/reserved), agreeableness (friendly/compassionate vs. critical/judgmental) and neuroticism (sensitive/nervous vs. resilient/confident) (McCrae and Costa (1987).	
2. **Internal Dimensions**	ethnicity, race, age, gender, sexual orientation, mental and physical ability.	age, colour of skin, **educational background**, **migration background/experience, nationality (intern students),** gender, sexual orientation, mental and physical abilities.
3. **External Dimensions**	Income, personal habits, recreational habits, religion, educational background, work experience, appearance, parental status, marital status, and geographic location.	Geographic location, **caring responsibilities**, religion/philosophy, **social-economic status**, **professional experience,** recreational habits, personal habits, **admission to university.**
4. **Organisational Dimensions**	Work content field, division/department/unit/group, seniority, work location, union affiliation, management status, functional level/classification.	**Degree, doctorate, combination of subjects, study programme, student employment (tutor/mentor/student assistant), module, focus of studies, phase of studies, University/subject-specific semester, department/institute/academic centre/faculty, guest auditor/part-time studies**.

The Scottish Government (2024) defines **inclusion** as "*where everyone feels valued at work. It is about providing equal access to opportunities and resources for people who might otherwise be excluded or marginalised.*" Winters (2013) citing Tapia (2009, p. 12) when distinguishing between diversity and inclusion states that "*Diversity is the mix. Inclusion is making the mix work*" Winters (2013) points out that others have defined the distinction as "*diversity is about counting heads; inclusion is about making heads count*" and personally defines inclusion as "*creating an environment that acknowledges, welcomes, and accepts different approaches, styles, perspectives, and experiences, so as to allow all to reach their potential and result in enhanced organizational success.*" The Quality Assurance Agency in partnership with the University of Hull, University of Derby,

Staffordshire University, York St John University and Keele University generated a cross institutional Inclusive Higher Education Framework (https://www.inclusiveeducationframework.info/#Framework). Hubbard and Gawthorpe (2023) provided detailed documentation on the Inclusive Higher Education Framework highlighting five areas of activity:

- Structures and Processes
- Curriculum Design and Delivery
- Assessment and Feedback
- Community and Belonging
- Pathways to Success

And six key principles or ways of working:

- Clear, consistent language and communication
- Leadership, responsibility, and accountability
- Wellbeing, empathy, and authenticity
- Development and training to empower individuals and teams
- Partnership working across an institution
- Evidence, reflection, and evaluation

Each area of activity in the framework document presents an individual teaching practice checklist, a programme team checklist, and a senior leader checklist. E.g. the Design and Delivery Activity Checklist for personal teaching practice includes some of the following:

- "*I embed inclusive education practices within my teaching and assessment planning, design and delivery, with support from the programme team*"
- "*My teaching highlights diverse figures within the discipline to students (e.g. LGBTQIA+/Black/Asian/Disabled researchers, authors, or policy makers)*"
- "*My teaching adopts an active and authentic learning approach, not being overly reliant on didactic lecturing, and designed to be accessible to all students (considering e.g. disability, international students, those with limited financial resources)*"

'EDI' (Equality, Diversity, and Inclusion) or 'DEI' (Diversity, Equality, and Inclusion) are often used as flippant, buzz acronyms but in reality are a set of immensely intricate, interconnected terms The relationship between Equality, Equity, Diversity, and Inclusion is complex and nuanced with the Equity being the how, the Diversity being the who and the Inclusion being the what in relation to organisations (Davis, 2022). Figure 1 shows the concept of Diversity, Equity & Inclusion, and the interconnected/related terms. It should be noted that this diagram is not exhaustive.

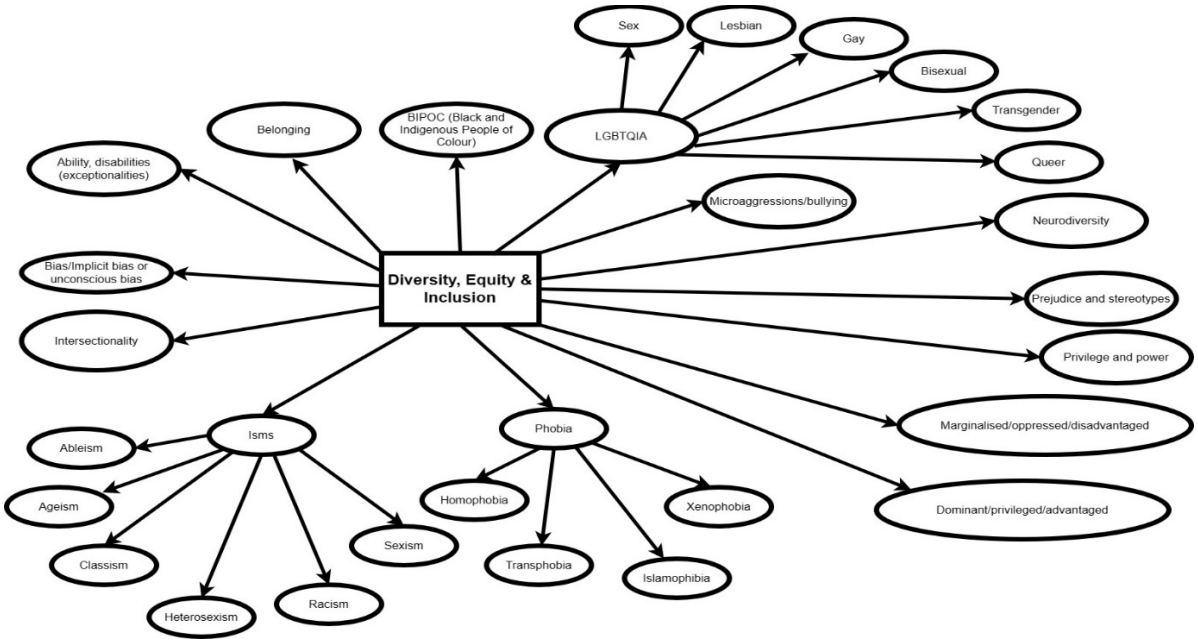


Figure 1: The concepts associated with Diversity, Equity & Inclusion

3. Serious Games/GBL/Commercial Game Examples in EDI related Subjects

3.1 Gender Equality

Yañez, Alonso-Fernández & Fernandez-Manjon (2020) conducted a study to review the work on the use of serious games to educate on gender equality. The paper identified 31 games to educate on a number of different topics such as: consent, teen dating violence, teen dating abuse, bystanders, gaslighting, gender equality, gender violence, women empowerment, destigmatisation of menstruation, LGBT and women trafficking. The study also produced a prototype serious game that is available to attempt to educate about sexism divided into four chapters with the main character being a female and attempting to get a career in computer science which is a male dominated career path. The study also highlighted the following interesting points: firstly, that education about sexism is better introduced as early as possible to displace stereotypes, secondly some of the games that were discovered in the study were not available to play and therefore this greatly decreased their overall impact.

3.2 Bullying

Calvo-Morata et al., (2020) conducted a review of serious games to detect bullying and cyberbullying where they discovered 33 resources where 20 were videogames, 7 were simulations, 2 were virtual environments and 1 was an app. The main criteria were firstly the game, simulation, application, or virtual world was available to play and was also supported by an academic publication. 4 simulations focused on the problem of bullying, 1 cyberbullying, 1 bullying/drugs and eating disorders and 1 bullying/drugs and mental disorders. 2 simulations focussed on detection where the rest focused on prevention.

Lievense et al., (2019) developed a game called “Stop bullying now!” to allow teachers working with disabled individuals to increase their own self-efficacy and enhance their autonomy promoting strategies. The game intervention was approximately 20 minutes long and was evaluated in a Randomized Controlled Trial utilising 150 participants with an experimental and two control groups. The experimental group had 62 participants who played the serious game for 20 minutes. One active control group with 41 participants read a digital information pack about bullying and another passive control group with 47 participants read a digital information pack that was not bullying related. The learning outcomes were measured pre/post intervention and then at 4-6 weeks follow up. Utilising parametric tests (repeated measures ANOVA) the serious game intervention yielded a statistically significant positive result in relation to autonomy in promoting strategies however there was no significant results in relation to self-efficacy across the three conditions.

3.3 Neurodivergence

Azadboni et al., (2024) performed a systematic review of serious games for training social skills to autistic individuals which highlighted that serious games have tremendous promise in this area. The study discovered 25 games within 25 studies where 104 pieces of criteria were assessed with 57 of these criterion showing significant improvement in the participants. 22 of the studies showed significant enhancement in at least one piece of measured criterion and 13 significant improvement in all assessed outcomes. Targeted skills included: social interaction, communication skills, collaboration, recognising facial expressions, emotional understanding, emotional management, empathy, and social functioning. Some of the games found in the studies were: Guess Who? GOLIAH, Join-In, No-Problem, The Junior Detective Training Program (JDTP), Secret Agent Society, ECHOES, CVLE 3D empathy system, Mario & Sonic at the Olympic Games, FindMe, WUBees, VR-SCT, Zirkus Empatico (ZE), Social Tutor, CoASD, MEBoo and ShopAut 2.0. For comprehensive article coverage the study performed a backward snowball literature search and found 8 related works consisting of systematic reviews, meta-analysis and scoping reviews of the literature associated with serious games, social skills, and autism.

Derks, Willemen and Starkenburg (2022) performed a meta-analysis of Randomised Controlled Trials (RCTs) of the effect of serious games for improving adaptive and cognitive skills of children with Intellectual Disability (ID) or Autism Spectrum Disorder (ASD). The study involved 11 RCTs with a total of 654 participants and the findings indicated that serious games can be linked to improvements in adaptability and cognitive skills. It should be noted however that more research is required as this is not a straightforward association.

3.4 Transgender Representation/Trans and Gender Diverse Attitudes to GBL

Stauss et al., (2019) performed a qualitative study to ascertain young trans and gender diverse (TGD) people’s attitudes to digital games-based learning mental health interventions. The study utilised 14 TGD people aged

11 – 18 for a focus group and utilised a general inductive thematic analysis approach. The study indicated that using games-based mental health interventions for the improvement in mental health of TGD individuals was feasible with the implications being that games need to be of high quality and recommended by health professionals and/or peers. Games should also be inclusive of sexuality and diverse genders and be preferably preventative rather than treatment focussed with the games being discretely about mental health. Given that TGD you people are at a very high risk of mental health difficulties further empirical evidence is required in this field and mental health interventions should address clinical and subclinical symptoms.

As a result of sexual minorities having a higher frequency of mental health issues in comparison to the heterosexual peers Iacovides *et al*., (2017) conducted a study utilising three focus groups with sexual minority youths in the UK ages 15 to 22. Ten participants identified as male, four female, three transgender (1MTF, 2 FTM), three were gender diverse or queer or non-binary. One participant responded as "N/A". The focus groups were 1.5 hours where each participant had the opportunity to play Module 1 of the game Rainbow SPARX (Smart, Positive, Active, Realistic, X-factor thoughts). The findings showed that there was a low level of acceptability for the game (i.e. only 38% of participants suggested they would use Rainbow SPARX themselves) as it was dated. This highlighted useful aspects to be considered when designing games in this area i.e. the serious game or games-based learning application should be indicative of the times.

In relation to the production of the commercial game *Tell Me Why*, trans/non-binary and gender non-conformant staff at *Xbox* and *Dontnod Entertainment* made countless creative contributions to including character design, narrative, and dialogue to provide inclusive online spaces. This was to ensure that Tyler's character would resonate with the wide and diverse audience of trans people (Eurogamer, 2021).

The literature review indicates that any serious game developed for these purposes of EDI related, sensitive topics must be: indicative of the times and utilise high fidelity graphics (Iacovides *et al*., 2017), where possible utilise creative, real life, subject matter experts to appeal to the intended audience (Eurogamer, 2021). It is also beneficial to introduce games to displace stigmatisms as early as possible (Yañez, Alonso-Fernández & Fernandez-Manjon, 2020)

4. Serious Games Development Frameworks

For the purposes of developing a serious game for EDI education and training it was considered appropriate to review developmental and evaluation frameworks for games-based learning and serious games to attempt to begin to synthesis the literature. Pistono, Arnaldo and Baptista (2022) performed a study to qualitatively analyse serious games frameworks where the findings were that there was twice the tendency to use a game approach rather than a pedagogical one. That although learning outcomes are mentioned in a few frameworks that they are no examples of them being dimensions within frameworks. This work is based on previous research by Pistono, Arnaldo and Baptista (2021) which performed a literature review identifying 11 serious games frameworks. The frameworks identified were very much a mixture between developmental and evaluation frameworks. 5 were development frameworks, 3 were evaluation frameworks and 3 were categorised as both developmental and evaluation frameworks. The study also highlighted two particular frameworks that referenced a flow state and also focussed on identifying the gaps in relation to planned adaptation of serious games. Some of the future research directions within the context of professional training included: looking at the relationships between game elements and learning outcomes, the relationship between learning outcomes and professional competencies and designing and developing models and frameworks for the adaptation of serious games. The study identified the following frameworks which we looked at in more depth:

- The four dimensional framework (de, Freitas and Oliver, 2006) taking into account the following dimensions: context, learner of learning group, internal representation, and pedagogic considerations.
- The serious game design assessment framework (Mitgutsch and Alvarado, 2012) taking into account: mechanics, framing, content information, purpose, aesthetics/graphics, and fiction/narrative.
- A framework of mission based scenario generation (Luo et al., 2013). Allows direction of the scenario generation process in the context of a virtual training application.
- The framework for cognitive load and empathy in serious games (Huang and Tettegah, 2010) taking into account: environments, characters, and activities in serious games.
- The flow framework to analyse the quality of educational games (Kiili, Lainema, De Freitas and Arnab, 2014) taking int account the antecedents of flow (clear goals, playability, sense of control, feedback, and challenge), factors effecting a flow state (context, representation of context, learning objectives,

learning characteristics and pedagogy) and five mind lenses (sensing, processing, integrating, relating, and transferring).

- The serious game evaluation framework for evaluation driven design (Emmerich and Bockholt, 2015). This takes into account the preparation phase which is vital to the planning of every serious game which is relevant to this study as it may potentially concern minority groups or specialised groups. There is also an iterative process of games design and evaluation where the measurements of the effect of the game have to be operationalised, the experiment has to be design, conducted, and interpreted. This particular study also interestingly highlights stakeholders and their advantages to a serious games evaluation such as: games developers and marketing, game researchers, intermediaries, and users.
- The framework for evaluating serious games (Wilson et al., 2016) taking into account theoretical, technical, empirical, and external grounding.
- A framework to conceive, design, and evaluate immersive and collaborative serious games in cultural heritage (FRACH) (Andreaoli *et al*., 2017). This takes into account the full developmental process in terms of preliminary, conceptual, developmental and evaluation phases.
- The interpretive framework for serious game mechanics (Ulrich & Helms, 2017) which takes the following considerations into account: pedagogic, knowledge, sociotechnological and design. It also takes the following mechanics into account: learning, social, game and immersive mechanics.
- The LEAGUE conceptual framework for evaluation (Tahi & Wang, 2020). The framework takes into account the following dimensions: learning/pedagogical, game factors, affective cognition reactions, usability, user, and the environment.
- Conceptual framework for Student-Centred Digital Games-Based Learning (Coleman and Money, 2020). This framework takes into account: player engagement (single, mixed, and multi-player), intervention type (setting (level and situation), study type (data type, study design)), game design (platform, development style), educational factors (gaming principles (understanding, problem solving and learner empowerment) and student centred learning (learner independent, mutual respect, reflexive attitude to learning, active learning, deep learning, increased responsibility, and sense of autonomy)).

Connolly, Stansfield and Hainey (2009) developed an evaluation framework for games-based learning where the study identified a number of previous frameworks and models including:

- The Four Dimensional Framework (de Freitas & OIiver, 2006),
- The SIG-Glue quality criteria framework (Dondi and Moretti, 2007)
- The CREST model of learning (Baker and Mayer, 1999)
- Kirkpatricks's four level of evaluating training (Kirkpatrick, 1994)
- The GOM and GOM II models (Amory et al., 1999 and Amory 2006)

Hainey, Connolly and Boyle (2010) expanded on this research to produce a refined evaluation framework for games-based learning which found additional frameworks including the theoretical model of game consumption (Lee and LaRose, 2007). It should be noted that some of these frameworks/models are duplicated.

5. Conclusions

The preliminary review has indicated that serious games and sometimes even commercial games have been used for education and training in relation to EDI related subjects. It should be noted that it is necessary to drill down into these individual subjects and that using search terms such as "serious games" coupled with the terms "equity", "diversity" and "inclusion" yields very little in relation to results where academic databases are concerned. Serious games were discovered in the following EDI related fields: gender equality, bullying, neurodivergence and transgender representations. Bullying and gender equality have been synthesised in systematic literature reviews (Calvo-Morata et al., 2020; Yañez, Alonso-Fernández & Fernandez-Manjon, 2020) suggesting that there is scope for many systematic literature reviews to be conducted in EDI related subjects.

One of the key challenges for performing a systematic literature review in these areas was that the literature on both serious games and EDI is extremely extensive. Although it will be possible to perform this in a comprehensive fashion it will not be possible to find all sources. A major challenge will be using interconnected related terminology and adopting a snowballing approach to thoroughly search for literature. This could involve backward and forward snowballing. Backward being where the reference list is used to identify new papers and forward being where new papers are identified which cite the paper of interest. If such an approach is adopted then it is necessary to be cognisant of the guidelines (Wohlin, 2014).

The preliminary review included investigating development and evaluation frameworks for serious games and games-based learning to ascertain if any of these frameworks significantly took Diversity, Equity and Inclusion into account or had been utilised to develop a game with sensitive content. The results seemed to indicate that there were few developmental frameworks that particularly took the integration of sensitive pedagogical content into account (Pistono, Arnaldo and Baptista, 2022; Pistono, Arnaldo and Baptista, 2021). Although some mention the particular user and empathy for characters which is highlight important in relation to immersion and empathising with characters/situations in games.

In relation to future research directions, we wish to expand the literature search to ascertain if serious games have been utilised in any other EDI related concepts. While there have been a number of developmental/evaluation frameworks and models identified from this preliminary overview, this is by no means exhaustive, and we wish to formulate a comprehensive synthesis of games-based learning and serious game frameworks in the first instance. One potential future research direction is to take a previously developed evaluation framework and enhance it to be a developmental framework for serious games to train/teach/educate about EDI related subjects taking into account sensitive nature of topics and the fact that creative subject matter experts with real life experience may be required (Connolly, Stansfield & Hainey, 2009). We will work very closely with a serious games developer in this regard who has had extensive experience of developing serious games for industrial/corporate practice. We believe that serious games lie in between the development of traditional functional software and games development and that when serious games are developed for the purposes of corporate training that user requirements should be considered and that a developmental framework should take traditional software requirements and learning outcomes into account.

Future work will entail a synthesis of serious game EDI literature and development of a serious game developmental framework for potentially sensitive topics requiring mixed methods requirements capture.

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From Boring Tests to Engaging Adventures: A Game-Based Learning Approach in LMS

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Abstract: The paper explores a game-based approach to language placement tests within Learning Management Systems (LMS), addressing issues of incorrect course placement and student disengagement. By gamifying assessments, the initiative aims to create a motivational and playful environment that accurately estimates students' language skills. The game design is guided by player type models and motivational frameworks, ensuring an engaging experience that caters to diverse player motivations. The game, "Journey to Mars," is set in a science fiction environment and uses multimedia elements and interactive modules to integrate educational content seamlessly. Methods for game analysis were adopted to create a gamified placement test in three steps. First, we adopted the basic game structure from the goals of the placement test. Second, we created plot points and settings and derived certain style and interface elements to create a coherent gaming environment. Third, we enriched the gaming experience with additional elements like badges and secret elements. The development process involved utilizing the ILIAS LMS tools, generative AI for content creation, and implementing progressive difficulty and feedback systems to enhance the educational value. Initial feedback indicates positive engagement and motivation among students.

Keywords: Game-Based Learning, Language Placement Tests, Design Principles, Player Motivations, Self-Determination Theory, ILIAS LMS

1. Introduction

In the realm of educational technology, the challenge of maintaining student engagement and accurately assessing competencies is ever-present. This paper presents an innovative approach to addressing these issues through gamification within Learning Management Systems (LMS). The primary objective of the project, "Journey to Mars," was to transform the mundane process of language placement tests into an engaging and motivational experience. The goal of the language center at Wismar University and the author was to create a game-based environment that not only accurately assesses students' language skills but also enhances their intrinsic motivation to participate. Initially, students were often enrolled in incorrect courses, lacking the necessary skills to succeed. To address this, we aimed to ensure that students were placed in appropriate courses and motivated to participate in an assessment that accurately estimated their language skills, leading to the idea of gamifying the assessment process. Our initiative also prompted us to explore practical methods for assessing competencies. We focused on the player experience, ensuring that every game element enhanced engagement and motivation. But at first, there was a simple and important question: *How can we build a good game?*

2. Players & Motivations as Starting Point to Create the Game

To design an engaging game, we first needed to understand the various types of players and their motivations. We drew from established player type models to guide our design decisions. Bartle's model identifies four distinct player types:

- *Achievers*: These players are driven by the need to achieve and succeed within the game. They enjoy earning points, completing tasks, and collecting rewards.
- *Explorers*: These players are motivated by the desire to explore the game world. They take pleasure in discovering new areas, uncovering secrets, and learning about the game's mechanics.
- *Socializers*: These players thrive on interaction with other players. They enjoy forming relationships, collaborating, and engaging in social activities within the game.
- *Killers*: These players seek competition and dominance over others. They find satisfaction in defeating opponents and asserting their superiority (Bartle 1996).

In addition to Bartle's model, Aarseth introduced the concept of the Cheater, a player who finds ways to bend or break the game's rules to their advantage (Aarseth, 2003). This concept is essential for understanding how to design a game that is both engaging and fair. Yee's framework provides a more extended understanding of player motivations by categorizing them into three main areas: Achievement, Social, and Immersion (Yee 2007). *Achievement* encompasses players who are driven by a desire for progression and success within the game. These players are motivated by several factors:

- **Advancement**: These players seek to improve their character's power, capabilities, and status, constantly striving to reach new levels and milestones.
- **Mechanics**: They enjoy understanding and mastering the game's systems and rules. These players take pleasure in figuring out the underlying mechanics and optimizing their strategies to succeed.
- **Competition**: Driven by a desire to compete and excel against others, these players thrive in competitive environments where they can measure their skills against those of other players (Yee 2007, 5).

Social motivations focus on the interaction and relationships formed within the game. This category includes players who:

- **Socializing**: Value the social aspect of games, enjoying interactions and conversations with other players. These players often engage in the game to meet new people and form connections.
- **Relationship**: Seek to develop meaningful connections with other players. They are motivated by building friendships and alliances, finding deeper personal fulfillment through these relationships.
- **Teamwork**: Enjoy working collaboratively to achieve common goals. These players find satisfaction in being part of a team, working together to overcome challenges and succeed collectively (Yee 2007, 6).

Immersion involves players who seek to become deeply engrossed in the game world and narrative. This category includes players who:

- **Discovery**: Love exploring the game world and uncovering its secrets. These players are motivated by the thrill of finding new areas, hidden items, and understanding the game's lore.
- **Role-Playing**: Enjoy creating and inhabiting characters within the game's narrative. They immerse themselves in their roles, crafting detailed backstories and personalities for their characters.
- **Customization**: Seek to personalize their gaming experience, tailoring characters and environments to their preferences. These players take pleasure in customizing every aspect of their gameplay to reflect their individuality.
- **Escapism**: Use the game as a way to escape from real life, immersing themselves in an alternate reality. They find solace and enjoyment in being able to step away from everyday stresses and into the game world (Yee 2007, 6).

By leveraging Yee's comprehensive framework, we were able to design a game that catered to a wide range of player motivations. This approach ensured that our game could engage and motivate players through various avenues, enhancing both the educational and entertainment value of the placement tests.

Secondly, we examined the basic motivational needs for humans to effectively link the gaming experience to our primary didactical goal: the placement tests. To achieve this, we grounded our design in the Self-Determination Theory (Ryan and Deci, 2000), which outlines three fundamental psychological needs.

- **Autonomy:** Players are given the freedom to explore and uncover secrets within the game's open spaces. This freedom empowers players to make choices and take control of their gaming experience, fostering a sense of independence and personal agency.
- **Competence:** To solve in-game mysteries and progress, players must demonstrate mastery of the English language. This requirement ensures that players feel a sense of accomplishment and efficacy as they overcome challenges and achieve their goals within the game.
- **Relatedness:** The inclusion of videos and AI-generated voices adds authenticity to characters, creating a solo experience enriched with parasocial interactions. These interactions help players feel connected to the game world and its characters, fulfilling the need for social connection and belonging.

There is a clear connection between player types and the motivational needs outlined in Self-Determination Theory. Players driven by Achievement are satisfied by demonstrating their skills and progressing in the game, fulfilling their need for competence. Those who seek Immersion enjoy exploring and making choices, meeting their need for autonomy. Players motivated by social interactions find a sense of Relatedness through the game's parasocial interactions and character-driven narratives, addressing their social needs.

Combining these insights with the goals of a language-oriented placement test, we integrated several key elements into our game design:

- Difficulty Levels: Adjust the game's difficulty based on player performance to keep challenges stimulating yet not frustrating. This ensures a balanced experience that matches the player's abilities,

following the Flow Concept (Kahyaoğlu Erdoğmuş & Kurt 2023, 4; Pan & Ke 2023, 463). It also matches the design of the placement tests with progressive difficulty levels.
- Story-Driven Quests: Require players to use their language skills to progress, seamlessly integrating educational goals and mechanisms with game mechanics that enable a sense of gamefulness (Gui et al. 2023, 6)
- Feedback: Provide detailed feedback on player performance and opportunities for reflection, helping players understand their progress and areas for improvement (Kahyaoğlu Erdoğmuş & Kurt 2023, 3)

By incorporating these elements, we aimed to create a game that is both engaging and educational, motivating players to enhance their language skills through an immersive and interactive experience.

3. Design Principles for Creating the Game

Aarseth (2007) identifies three key components of game design that informed our approach: gameplay, game structure, and the game world. *Gameplay* includes the players' actions, strategies, and motives within the game, shaping their overall experience. *Game structure* involves the rules of the game, including the simulation rules, ensuring consistency and fairness in the game mechanics. The *game world* encompasses the fictional content, topology/level design, textures, and overall aesthetics of the game, creating the immersive environment where the gameplay takes place. We've also included the conception of five levels of game design elements, which include similar elements like game design patterns and mechanics, game interface patterns and game design principles and heuristics (Deterding et al. 2011). To create a game, we've adapted these models that were designed for analysis. These were used to create basic design principles for the gaming environment.

3.1 From Goals to Basic Game Structures

Due to the limitations imposed by the ILIAS platform, our development process began with establishing the game structure. The starting point was the existing assessments and their associated goals, which provided a foundational framework for our game design. Creating the underlying structure of the game involved the use of game design patterns and mechanics. These elements dictate how the game operates, including its rules, challenges, and player interactions. Given the constraints of the ILIAS LMS, we focused on implementing simple yet effective mechanics that could be supported by the available tools.

To create prototype structures, we utilized several key elements within the Learning Management System to support a gameful design. These elements were integral to the development of our game, "Journey to Mars," providing a structured yet flexible framework for implementing engaging and educational content. By leveraging the existing features of ILIAS, we were able to craft a game environment that not only met our educational objectives but also provided an immersive and enjoyable experience for the players.

- *Learning modules* were an obvious choice for segmenting the chapters and sections of the game. They allowed us to organize content systematically, ensuring a coherent flow of information. These modules support the inclusion of various multimedia and interactive elements, enhancing the immersive experience. We leveraged the ability to link different learning modules to create multiple paths in the game, offering players a sense of autonomy and choice. Additionally, applying a consistent visual style across all modules helped maintain a coherent gaming experience, making the game visually appealing and engaging.
- To establish a distinct style and bring the game world to life, we implemented *text, pictures, audio, and videos*. These multimedia components supported our story-based approach, turning the game into a visually rich narrative. In its initial version, this approach gave the game the feel of a visual novel, providing a strong foundation for the evolving game design.
- To incorporate point-and-click game mechanics, we used *interactive pictures*. This choice was crucial for creating an engaging gaming environment. Interactive pictures served as a main element, reminiscent of classic point-and-click adventures. Players could click on objects to open boxes with additional information, media, and links to placement tests.
- *Tests* were used to evaluate the competencies of the students and track their learning progress. These tests provided automated control and immediate feedback to students, enhancing their learning experience. We also incorporated generated audio files to assess listening and comprehension skills, adding another dimension to the language evaluation process.
- *Badges* were implemented as rewards for certain achievements in the game, motivating students to engage and perform well. We differentiated between performance-based badges, which required

students to accomplish specific tests, and more gameful badges that rewarded exploration of game secrets. This system was inspired by popular games with similar rewarding mechanisms. The badges were designed in the reddish Martian style of the learning modules, ensuring visual coherence.

By limiting ourselves to these fundamental elements, we were able to create a feasible and engaging game: a point-and-click adventure where players encounter various situations requiring a certain level of language skills. This approach allowed us to focus on enhancing the learning experience through game-based elements, effectively integrating educational objectives with engaging gameplay.

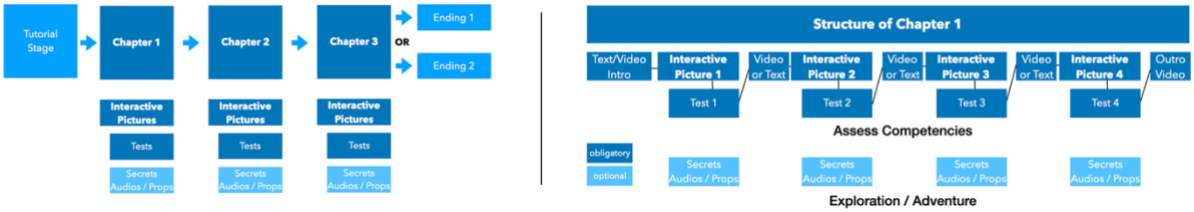


Figure 1: Left side: Structure of the whole game. Right side: Structure of chapter 1 and its elements

3.2 From Structure to Style

Next, we focused on the game world and the overall style of the game. Inspired by the title "Journey to Mars," we chose a science fiction setting. This decision allowed us to incorporate futuristic elements into the plot, such as robots, super intelligence, and routine space tours to Mars. These thematic choices not only shaped the storyline but also influenced the design of the user interface. Game interface design patterns involve the visual and interactive elements that players interact with directly. In the context of ILIAS LMS, this meant utilizing existing interface components to create a cohesive and engaging user interface that mimicked traditional game interfaces. The interface needed to be intuitive and appealing, enhancing the immersive experience of the game.

To align with the Martian setting, we designed interactive elements in a reddish-orange color scheme through the theming options of ILIAS LMS. This color choice not only evoked the iconic Martian landscape but also served a functional purpose as a highlighting element. These interaction indicators were strategically used to guide players through the game, making it easier for them to navigate and interact with the game world (Fromme & Könitz 2014; Könitz 2022).

3.3 Using Useful Addons to Deepen the Gaming Experience

To further enhance player engagement and motivation, we incorporated several additional design elements. Reward systems, such as badges and in-game secrets, were implemented to recognize and celebrate player achievements, drawing on the principles of gamification and the positive effects of rewarding systems in gaming experiences. This also potentially leads to a reduction of cognitive load (Kahyaoğlu Erdoğmuş & Kurt 2023, 5).

By integrating these design principles and frameworks, we were able to navigate the limitations of the ILIAS LMS and create a game that effectively engaged students and enhanced their learning experience. It turned out that the LMS was the most limiting factor for the game creation process. To accelerate the creation process, we adopted a pragmatic approach:

- **Keeping it Simple**: By focusing on simplicity, we were able to create a functional and engaging game without overcomplicating the design. This approach ensured that we could work within the constraints of the ILIAS LMS.
- **Using Common ILIAS Tools**: We made the most of the existing tools and features available within the ILIAS LMS. This included leveraging learning modules, interactive pictures, and multimedia elements to create a rich gaming experience.
- **Utilizing Generative AI:** Wherever possible, we used generative AI to enhance our content. This included creating images, dialogues, and voiceovers, which significantly streamlined the content creation process.

4. Creating the Game

We set a time limit of two weeks for the development of the first prototype. This tight timeframe forced us to prioritize essential features and make quick decisions, leading to a focused and efficient development process.

The result was a prototype that, despite the limitations of the LMS, offered a compelling and engaging game-based learning experience. To realize this prototype we've used a three step approach.

The development of our game followed a three-step approach:

1. *Creating a Story-Based Environment*: We transformed existing English assessments into engaging plot points, using ChatGPT to craft immersive dialogues.
2. *Extending the Experience*: We enriched the game with multimedia elements, including AI-generated images and voiceovers, to enhance the narrative.
3. *Incorporating Freedom and Playfulness*: We added interactive backstories and alternative endings to strengthen player autonomy and replayability.

4.1 First Step: Creating a Story-Based Environment Using ILIAS Learning Modules

We began our journey by transforming an existing English assessment into engaging plot points for our story. Therefore, the resulting game is a relatively pure game of progression (Juul 2005). Leveraging the capabilities of ChatGPT, we crafted the first chapter with coherent and immersive dialogues. The narrative was designed to be relatable and engaging: a man on Earth wants to visit his childhood girlfriend on Mars, but it seems that his memories are being manipulated by an AI named Aurora, which is controlled by a secret syndicate.

The game's structure was aligned with the three achievable competence levels of the placement tests from the language center. Consequently, the game was divided into three chapters, each incorporating four tests. These chapters were set in three main environments: the first chapter at the Spaceport, the second chapter aboard a spaceship, and the third chapter upon arrival on Mars. To transform an existing English test into an engaging game, we converted test questions and content into plot points. Using ChatGPT, we developed coherent dialogues that seamlessly integrated educational content into the storyline. This approach ensured that the educational objectives were met while maintaining an engaging narrative. With this in mind, this type of game can be classified as an educational game. It seeks to balance playful accessibility with a didactic goal (Wechselberger 2012).

Next, we addressed the technical constraints of the ILIAS LMS, which lacks explicit game elements. To navigate these limitations, we used learning modules for navigation and effortlessly integrated text, picture and audio elements. The interactive picture tool was crucial in allowing free exploration, a staple of point-and-click adventure games. This tool enabled players to click on objects within pictures to reveal additional information, media, and links to assessments, thus creating an interactive and engaging environment.

The basic structure of the game was consistent across all chapters, each containing four situations to explore. These situations included an introductory sequence that familiarized the player with the new setting, providing context and setting the stage for the challenges ahead. Each chapter had four explorable areas accessible through interactive pictures. These areas led to smaller assessments, and object descriptions for certain elements, enriching the gameplay experience.

4.2 Second Step: Extending the Experience Through Interactive Multimedia Elements

To give the game more personality, we infused the main protagonist with a distinct character by inserting ironic options about certain objects in the game. This element drew inspiration from classic point-and-click adventures that our team had played, demonstrating that personal gaming experiences and genre knowledge can be valuable starting points for enhancing the gaming experience. We extended the multimedia content by using various AI tools and creative methods. ChatGPT was employed to further outline the story, ensuring coherent and engaging dialogues. DALL-E was used to generate images that visually enriched the game environment, while ElevenLabs provided diverse voiceovers to add depth to the characters. Videos were produced by combining these generated images and sounds, resulting in immersive multimedia content.

In this second phase, we also revised the initial questions to better align with the storyline. The questions were integrated seamlessly into the plot, enhancing the educational aspect of the game without disrupting the narrative flow. The heavy use of generative AI allowed us to implement AI-generated audio files for these questions, assessing listening and comprehension skills in an engaging manner.

4.3 Third Step: Including More Freedom and Playfulness

Our goal was to strengthen the players' sense of autonomy and exploration. To achieve this, we used generative AI to create a backstory hidden within the interactive pictures. Embedded audio files were chosen to further immerse the players and to enhance their listening and comprehension skills. This approach not only made the game more engaging but also provided additional layers of narrative depth.

We leveraged the concept of Ludoliteracy (Zagal 2011) to create a more immersive game world. Ludoliteracy refers to the ability to understand and appreciate games as complex, rule-based systems. By applying this concept, we aimed to design a game that not only entertained but also educated players on how games function and how to engage with them meaningfully. The third stage of development was heavily influenced by our collective knowledge and experience with games. We recognized that visual novels can be highly immersive. For example, the game "Steins;Gate" demonstrated how a simple gameplay structure with minimal gaming elements could still offer a deeply engaging experience. Inspired by this, we initially created a visual novel using generative AI, which allowed us to produce the game content quickly and efficiently. As the development progressed, we integrated more playful elements familiar from classic LucasArts adventures and the Broken Sword series. The main character was given an ironic perspective on the game world, which helped to strengthen the player's relatability and immersion. This ironic viewpoint provided humor and depth, making the game world feel more alive and engaging. Ultimately, we implemented an alternative ending, a feature known from adventure games like "Blade Runner," offering players choices in how the adventure concludes. This addition not only increased the replayability of the game but also allowed players to feel a greater sense of control over their gaming experience. By providing multiple potential outcomes, we encouraged players to explore different paths and decisions, thereby enhancing their engagement and investment in the game.

Through these efforts, we aimed to create a game that was not only educational but also enjoyable and immersive. By incorporating elements of autonomy, exploration, and player choice, we developed a rich gaming environment that effectively motivated students and enriched their learning experience.

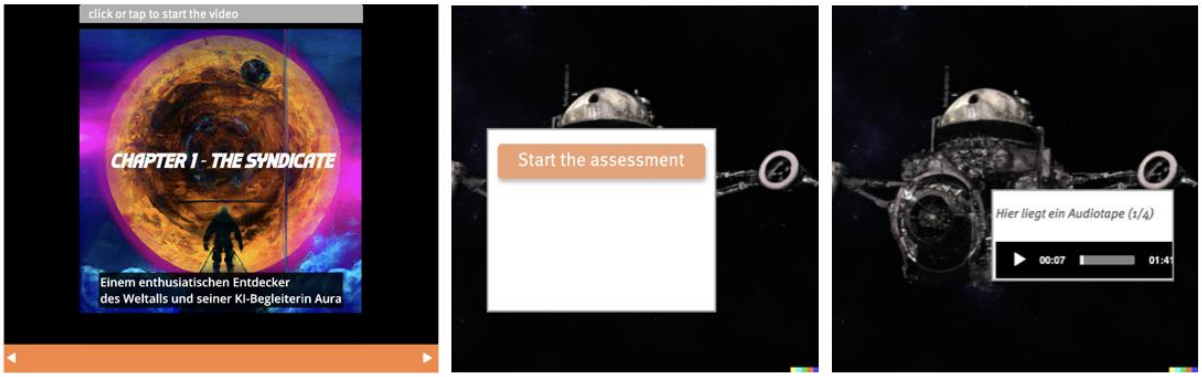


Figure 2: Left side: An English-speaking video with German subtitles in an ILIAS learning module. Middle & right side: An interactive scene with a link to an assessment and a hidden audio-file.

5. Conclusion and Outlook

Our project successfully integrated game-based elements into the ILIAS LMS, demonstrating a positive impact on student engagement and learning motivation. Initial feedback from a small group of students who tested the first version of the game was largely positive. They found the setting relatable and engaging, which validated our narrative and design choices. However, we encountered technical issues, particularly with varying screen sizes, which affected the user experience. Additionally, the login process for ILIAS proved to be a technical barrier for some students, highlighting an area for improvement in future iterations.

Looking ahead, we plan to build on this foundation by developing further chapters and expanding the content. This expansion will not only cover more advanced topics within the current subject but also extend to other subjects and tests, making the game a versatile tool across different areas of study. We recognize the need for a more adaptive design to overcome the current limitations of the ILIAS platform. Future versions of the game will incorporate better adaptive features, ensuring a seamless and flexible user experience regardless of the device or screen size. Accessibility options are also a priority. We aim to ensure the game is accessible to players with diverse needs and preferences, including adjustable difficulty levels and customizable controls. This will make

the game more inclusive, allowing a wider range of students to benefit from its educational content. By providing these options, we can cater to different learning styles and abilities, making the educational experience as effective and enjoyable as possible for all students.



Figure 3: Left side: AI generated picture of the main protagonist in the game. Middle & right side: reworked images of the future character selection to implement light RPG-elements.

Enhancing dynamic storytelling is another key focus. We plan to create a narrative path system that adapts to the player's choices, making each playthrough unique and personalized. This could involve integrating light RPG elements, such as character choices, which would deepen the engagement and personalization of the gaming experience. By allowing players to influence the storyline and outcomes, we can increase their investment in the game and their motivation to continue playing and learning. Additionally, personalized learning paths will be further developed. These paths will allow players to choose their own challenges and directions based on their interests and proficiency levels. This approach enhances their sense of autonomy and competence, key motivational factors that contribute to a deeper engagement with the learning material. Personalized learning paths ensure that each student can progress at their own pace and focus on areas where they need the most improvement, leading to a more effective and satisfying learning experience. A broader rollout of the game to all students is essential for gathering more comprehensive data through quantitative analysis. This will help us refine the game based on a larger dataset, ensuring it meets the needs and preferences of a wider student audience. Finally, we intend to connect the game with the competency management system implemented in ILIAS. This integration will allow us to track student progress more effectively, aligning the game outcomes with academic performance metrics and providing a more holistic view of student development.

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Virtual Simulation Games in Entrepreneurship Education: Status Quo and Prospects

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Abstract: This study reviews the current status and future perspectives of virtual simulation games in entrepreneurship education in higher education institutions. Virtual simulation games act as digital twins to replicate real-world scenarios, which can be integrated as a part of online learning in entrepreneurship courses or digital learning resources in entrepreneurship education in higher education institutions. Virtual simulation game-based learning effectively enhances student engagement and entrepreneurial competencies in entrepreneurial learning to improve student learning outcomes in entrepreneurship education in higher education institutions. Virtual simulation games as digital tools for specific learning tasks or active teaching methods engage students with virtual simulation learning experiences to generate improved student learning in immersive and interactive environments through the use of extended reality (XR) including virtual reality (VR), augmented reality (AR), and mixed reality (MR) in a virtual or blended learning environment. This study indicates the promising development of AI and XR applications in virtual simulation games in entrepreneurship education. It provokes discussions on the technological, pedagogical, and content design of virtual simulation games and their integration into hybrid and online models of entrepreneurship education, which has significant implications for the digital transformation and innovation of entrepreneurship education in higher education institutions. It draws attention to digital well-being and digital inclusion in virtual simulation game-based learning in entrepreneurship education in higher education institutions.

Keywords: Virtual Simulation Games, Digital Game-based Learning, Serious Games, Entrepreneurship Education, Higher Education Institutions

1. Introduction

With the development of ICTs and the digitalization of higher education, digital game-based learning is increasingly used in teaching and learning in higher education institutions such as virtual simulation games in entrepreneurship education. Digital game-based learning, virtual simulation game-based learning, online gamification, and other gamification applications in entrepreneurship education have gained popularity with the development of online learning and technological advancement in teaching and learning in entrepreneurship education. Virtual simulation game learning in entrepreneurship education aims to engage students in online learning to improve their learning experience within the virtual environment including virtual teamwork experience and self-efficacy (Chen et al., 2021). Virtual simulation games in entrepreneurship education as interactive learning tools replicate real-world business scenarios in a risk-free virtual environment to allow students to engage in decision-making, problem-solving, and resource management, mirroring the experiences of actual entrepreneurs, which are designed to enhance students' entrepreneurial skills and engagement by providing practical, hands-on experiences to complement theoretical knowledge and bridge the gap between classroom learning and real-life business challenges for more effective entrepreneurship education (Yasin et al., 2022). Virtual simulation games function as digital twins, an integrated part of online learning, or digital learning resources in entrepreneurship education. Virtual simulation games can generate improved immersive and interactive experiences in students' entrepreneurial learning by using extended reality (XR) technologies including virtual reality (VR), augmented reality (AR), and mixed reality (MR) and virtual interactive environments to deliver engaging, simulated, and real-world learning experiences. In virtual simulation games, "students take the roles of business managers and make sequences of managerial decisions to understand the obstacles and consequences of running a company, and the interdependencies among the different areas of business" (Gawel et al., 2022, p. 5). Virtual simulation game learning in entrepreneurship education provides an innovative way of using immersive learning technologies to foster students' engagement and entrepreneurial skill development, which has significant implications for teachers to select and/or develop virtual simulation games to enhance students' engagement and learning outcomes (Yang et al., 2022, p. 1).

Three objectives of entrepreneurship education focus on education "about" entrepreneurship to increase awareness about entrepreneurship, "for" entrepreneurship to enhance students' intentions to be entrepreneurs, and "through" entrepreneurship to develop entrepreneurial competencies in new venture creation (Kyrö, 2005). Four programs suitable for entrepreneurship education include "entrepreneurship awareness education about the development of the know-how on the subject; education for individuals with background on the subject and the need for gaining a practical understanding of how to set up start-ups;

education for entrepreneurial dynamism programs can be delivered" (Liñán, 2004). Entrepreneurship education should transit business scenarios to deliver effective learning modules to support developing students' entrepreneurial skills and mindset (Maaravi et al., 2020). Virtual simulation game-based learning fits these purposes to achieve the objectives of entrepreneurship education in blended or digital learning settings. This study aims to answer the following question: What are the current status and future perspectives of virtual simulation games in entrepreneurship education in higher education institutions?

2. Literature Review

Studies have discussed overlapped concepts of gamification, serious games, simulation games, virtual simulation games, online games, virtual games, digital games, and business simulation games in entrepreneurship education. "Game-based learning effectively enhances students' entrepreneurial competence, e.g., generating ideas, managing resources and taking action, and boosting self-efficacy but didn't significantly impact entrepreneurial intentions" (Daniel et al., 2024). Gamification as a learning process can enhance learners' motivation and engagement in entrepreneurial learning. Content and structural gamification can create a more engaging and effective learning experience (Kapp et al., 2013). Online games as mutual interactive learning are useful tools to enhance learning outcomes (Takemoto & Oe, 2021). Serious games and simulations often overlap with similar features. Simulations feature students' active interaction with real-life complex situations (Thavikulwat, 2004). Serious games as computer-based learning simulations engage players in realistic activities to increase knowledge; improve skills; and enable positive learning outcomes (Prensky, 2001; Fox et al., 2018, p. 63). The main difference between virtual simulation games and traditional simulation games lies in the level of immersion and the technology used. "Mobile business simulation games improve entrepreneurial attitudes and self-efficacy, but cannot change entrepreneurial intentions" (Chen et al., 2023). Simulation games positively influence students' entrepreneurial intentions (Bhullar & Aggarwal, 2022) and foster experiential learning (Fox et al., 2018). Business simulation games positively enhance students' skills, attitudes, and practical knowledge, ultimately impacting their intention to become entrepreneurs (Shabbir et al., 2024). "Simulations, serious games, and virtual worlds provide immersive three-dimensional spaces to embed major learning principles" (Marques & Martins, 2013, p. 29). Educators can use serious games, mobile business simulation games, and virtual simulations to create a holistic learning experience in blended or digital learning environments and incorporate game-based learning into teaching and learning in entrepreneurship education (Chen et al, 2023).

Methods used in entrepreneurship education include "action learning, new venture role plays, serious games, the development of actual ventures, skills-based courses, video role plays, experiential learning, and mentoring" (Fox et al., 2018, p. 63). Game-based learning in entrepreneurship education focuses on experiential learning via serious games. Game-based learning activities help students gain the necessary skills to tackle everyday obstacles on their entrepreneurial pathways (Grivokostopoulou et al., 2019, p. 1). Simulation-based learning uses immersive learning simulation technologies to foster realism for effective learning (Yasin et al., 2022, p. 26) through learners' observation to learn or understand the simulation being an illustration of the contents or through experiential learning induced by direct interactions with the simulation (Frasson & Blanchard, 2012, p. 2). "Simulation games represent players with simulations of a mimicking real-life scenario for educational purposes to facilitate 'learning' (e.g., acquiring or enhancing knowledge and skills) and 'simulation' (e.g., facilitating learning primarily or supporting learning indirectly)" (Frasson & Blanchard, 2012, p. 2). Business simulation games involve humans and learning practices for (teams of) students to act as if they were in charge of a real business (Frasson & Blanchard, 2012, p. 2). Several features of simulations (e.g., realization, fidelity, interactivity, immersiveness, and intelligence) influence simulation-based learning opportunities (Frasson & Blanchard, 2012, pp. 3-4). Interactive games with different scenarios keep students motivated and immersed in the learning process during online teaching to enhance the learning effectiveness of entrepreneurship education (Takemoto & Oe, 2021, p. 28).

Digital game-based learning, coined by Prensky (2001), is the fusion of knowledge dissemination and gameplay from computer and video games, aiming to leverage digital games' learning and motivational potential to acquire real-world knowledge to support players to engage with educational content while enjoying the game. Digital game-based learning as an effective learning medium is "a competitive activity in which students are set educational goals intended to promote knowledge acquisition" (Erhel & Jamet, 2013). Digital simulations are computer-based versions of high-fidelity simulations. Virtual simulation game-based learning integrates educational content into game formats to enhance learning. "The ideal game can capture critical aspects of the entrepreneurial process, but sufficiently simple to minimize the danger of confounding factors" (Low et al., 1994, p. 384), which highlights the importance of entrepreneurship simulations to assist learners in avoiding some of

the most painful life lessons one might encounter in a real company (Fox et al., 2018, p. 64). Fox et al. (2018) conducted an in-depth assessment of the impact of simulation games in enterprise education, considering "the level of fidelity (i.e., the amount of realism), verification (the quality of the game's technical design), and validation (the game's adherence with the tasks that are being attempted to be simulated)" (Fox et al., 2018; Yasin et al., 2022, p. 31).

A broader definition of virtual reality as a three-dimensional interactive computer-generated environment incorporates a first-person perspective including immersive and non-immersive (screen-based) forms of VR (Brey, 2008, p. 2). "Augmented reality (AR) as a special type of VR in simulated virtual worlds is blended with the real world experienced through normal vision or a video link, usually through transparent glasses on which computer graphics or data are overlaid" (Brey, 2008, p. 3). Four essential elements in virtual reality include a virtual world, immersion, sensory feedback, and interactivity (Sherman & Craig, 2003). "The 3D virtual reality educational environment utilizes pedagogical approaches based on gamification principles for students' immersive game-based learning activities on real challenges in business environments" (Grivokostopoulou et al., 2019, p. 1). VR applications in education increase student engagement; provide authentic experiences to impact student identity; allow for new perspective-taking and empathy; and support creativity and the ability to visualize difficult models (Hu-Au & Lee, 2017, p. 222). Digital game-based learning focuses on integrating game elements into the learning process, while virtual simulation game learning provides realistic practice scenarios in a virtual environment. Both approaches enhance engagement and skill development but differ in formats and emphasis. Many studies have discussed adopting serious games and game simulation in entrepreneurship education. However, it is vital to integrate virtual simulation games into entrepreneurship courses for educational innovation rather than adoption and application.

"Studies on the effect of virtual simulation game courses on students' entrepreneurial learning are generally based on the planned behavior theory, the technology acceptance model, and flow theory" (Yang et al., 2022). Yang et al. (2022) explored the influence mechanism of virtual simulation game learning experience on students' engagement and entrepreneurial skill development including game design, teamwork, and self-efficacy based on Biggs' (1993) 3P model (presage-process-product). "Virtual simulation games based on the experiential learning theory (Kolb, 1983), combined with the organization theory and the game theory to design rules and algorithms are widely used in business education" (Yang et al., 2022, p. 3). Constructivist learning theory focuses on the active role of learners in constructing new knowledge, inferring meaning to concepts through experience, active learning, and social interaction as a factor in the knowledge construction process (Kayii & Akpomi, 2022, p. 33). Based on these theories, this study views the status quo and prospects of virtual simulation games in entrepreneurship education.

3. Methods

This study conducts a status quo and prospects analysis of virtual simulation games in entrepreneurship education. It uses online website search through Google and Google Scholar search engines with key phrases for the search engines including "digital simulation games", "online simulation games", "virtual simulation games", "simulation games", "business simulation games", "(virtual) simulation game-based learning", "(virtual) simulation game learning", "serious games", and "(virtual) simulation games in entrepreneurship education". The samples of (virtual) simulation games are presented in Table 1.

4. Current Status of Virtual Simulation Games in Entrepreneurship Education

Virtual simulation games have emerged as an effective teaching method for entrepreneurship education, which can be integrated as a key part of online learning into entrepreneurship courses or digital learning resources. Virtual simulation games in entrepreneurship education aim to engage students in online learning to improve their learning experience and entrepreneurial skills development, self-efficacy, and virtual teamwork experience within the virtual environment. Virtual simulation games as an effective teaching method for online entrepreneurship education directly or indirectly affect entrepreneurial skills development through students' learning engagement to improve students' participation, learning outcomes, teamwork experience, and general self-efficacy (Yang et al., 2022, p. 1), while students' general self-efficacy affects entrepreneurial skills development and students' engagement (Yang et al., 2022, p. 9). Virtual simulation games have been used to generate improved interactive student learning experiences and create immersive environments where players interact with digital elements. Virtual simulation games play an important role in supporting learners' entrepreneurial learning in a virtual and risk-free environment to develop students' professional and decision-

making skills to cope with unexpected market changes in a multifaceted environment, which overcome the constraints of conventional teaching methods and techniques in teaching entrepreneurship education through lectures and case studies and the lack of real-world experiences and practices. "Learning entrepreneurial skills through real-life simulations can prevent and reduce potential risks, harms, the costs of acquiring entrepreneurial skills and abilities" (Chen et al., 2021, p. 213). "In a simulation game course, students' general skills (e.g., decision-making, communication, teamwork, information processing ability, entrepreneurial ability, and new application skills) have positive impacts on learning outcomes" (Hernández-Lara et al., 2019).

An e-learning model using virtual simulation games is designed to build a virtual learning space to foster learners' entrepreneurial mindsets and entrepreneurship through virtual experiential learning. An e-learning framework in entrepreneurship integrates three main components identifying business opportunities, developing business scenarios, and risk analysis (Bodea et al., 2015). "In business simulation game courses, students' generic skills (e.g., decision-making, communication, teamwork, information processing ability, entrepreneurial ability, and new technology application ability) could have a significant positive impact on learning outcomes" (Hernández-Lara et al., 2019).

Business simulation games simulate real-life business scenarios to support learners in acquiring entrepreneurial skills and competencies while avoiding real-life risks and damages and reducing cost and uncertainty (Chen et al., 2021, p. 213); allow learners to run virtual companies including making financial decisions and competing in markets; and make the learning process attractive and fun (Chen et al., 2021, p. 219). "Business simulation games are a practical way of learning about business challenges and how to overcome those challenges in a risk-free environment to enhance critical experimental thinking and learning, time management, teamwork, and collaborative learning and significantly increase students' investment and acceptance of entrepreneurship courses to improve students' entrepreneurial intention and learning performance" (Zulfiqar et al., 2021, p. 3). Business simulation games integrate business concepts into realistic business scenarios for users to practice business concepts in lifelike scenarios and make decisions based on visualized data diagrams, tables, and charts such as Harvard Business Simulations (Chu et al., 2023). Startup simulation allows students to create and manage a virtual startup including scaling and making decisions on product development, pricing, and market entry. Simulation games for startups can significantly improve students' business management knowledge and business planning skills (Kriz & Auchter, 2016). Marketplace simulation simulates a competitive market where students run their businesses and compete against each other. Supply chain simulation explores supply chain dynamics, inventory management, and logistics. Serious games (e.g., SimVenture) offer student experiments in a virtual environment and simulate real-world entrepreneurial challenges without risks.

Good game design has the following features: "a clear overall vision, a constant focus on players' experience, strong character and structures, useful interfaces, and dynamic range; the ability to store development, progress, exploration, and discovery; highly adaptive and interactive; easy to learn but hard to master; staying within the 'flow state'; and providing mutual assistance and frequent rewards instead of punishments" (Prensky, 2001, p. 23). The good user-centered game design of virtual simulation games should have clear learning objectives and goals, diverse authentic scenarios, feedback mechanisms, balanced complexity, intensive interactivity, high replayability, and storytelling with a compelling narrative around the simulation. Active learning game design should support "students' learning journey with a cyclic approach in deepening students' critical thinking and application of theories in entrepreneurship learning" (Takemoto & Oe, 2021, p. 31).

The integration and innovation of virtual simulation games in the hybrid and online model of entrepreneurship education in higher education institutions should consider the compatibility of virtual simulation in entrepreneurship courses: "whether they meet the teaching objectives, whether the game establishes clear performance evaluation standards and provides rich and clear learning materials, and whether it can provide clear feedback to students" (Yang et al., 2022, p. 8). Educators must ensure that the adoption of virtual simulation games fits the curricula of entrepreneurship courses including the technological, pedagogical, and content design of virtual simulation games and their compatibility and deep integration in alignment with the course goals to fit the purposes of entrepreneurship courses to improve student learning and entrepreneurial skills. Virtual simulation games should integrate their technological, pedagogical, and content design into the teaching practice compatible with deep learning and game-based learning in teaching and learning in entrepreneurship education in higher education institutions. Meanwhile, virtual simulation game-based learning needs to draw attention to digital well-being and digital inclusion in virtual simulation game learning in entrepreneurship education in higher education institutions.

Simulation games advertise them with their special characters (See Table 1): "*GoVenture World is the most authentic business management and entrepreneur training experience ever created*" (https://goventureworld.com); "*The most advanced business game online about company management and economics*"(https://virtonomics.com); and "*The most realistic small business startup and operations simulation in the world*" (https://www.goventure.net/products). "The Startup Game, GoVenture: Entrepreneur, GoVenture World, Hipster CEO, Innovative Dutch, Interpretive solutions: Entrepreneur, SimVenture, Venture blocks, Venture Strategy, and VSL simulations have been used in teaching related to the area of entrepreneurship in higher education" (Yasin et al., 2022, p. 32). However, whether simulation games fit the curricula of entrepreneurship education and the ongoing courses still need evidence-based studies. The case of Aarhus University provides evidence of the successful integration of game-based learning into entrepreneurship education.

"*Gamification plays a special role in entrepreneurship teaching at Aarhus University and in the EIT Food Master's program in Food Systems. An entrepreneurship professor from Aarhus University has been using physical and digital games for targeted purposes in several courses. Three games played an important role in online teaching during the COVID-19 pandemic: LeapInTime (https://leapintime.grendelgames.com) is a patent game developed specifically during the pandemic to tackle online team learning about intellectual property. Savvygoat (www.savvygoat.com) requires teams to fulfill tasks for climbing a mountain, training students in collaboration, and internal team and project management. ESHIP: NavigatingUncertainty (https://biosymfonix.com/Biosymfonix/Eship.html) is a multiplayer cooperative board game that teaches student teams to decide cooperatively under uncertainty. Available evidence indicates a positive effect on students. Serious games tend to enhance their technical understanding related to entrepreneurial processes such as intellectual property protection and acting under market uncertainty. However, the effect of digital games on improving teamwork skills was found to be limited."* (HEI Innovate, 2023)

Table 1: Samples of (virtual) simulation games in entrepreneurship education

Games	Websites	Descriptions on the Websites
Conscious Capitalism-Bikes	https://www.marketplace-simulation.com/compare-our-business-simulations/conscious-capitalism-bikes/	Conscious Entrepreneurship explores the costs and benefits of corporate social responsibility within a startup.
ENTRExplorer	www.entrexplorer.com/projecto.php	ENTRExplorer "Serious Game for Immersive Entrepreneurs" aims to develop an online serious game related to entrepreneurship themes where learners have access to learning content to acquire entrepreneurial skills necessary to manage their businesses in the future.
GoVenture Entrepreneur	https://www.goventure.net/en	GoVenture Entrepreneur, the most realistic small business startup and operations simulation in the world, offers the fastest and most experiential way to teach and learn business with the most realistic small business startup and operations simulation ever created.
GoVenture World	https://goventureworld.com	Players run virtual businesses while competing and collaborating with players (virtual entrepreneurs) in a global massively multiplayer online role-playing game (MMORPG).
Harvard Business Simulations	https://hbsp.harvard.edu/simulations/?ab=browse%7Csimulations	Marketplace Simulations: Conscious Capitalism - Bikes (Play against classmates); Entrepreneurship Simulation: The Startup Game, etc.
Interpretive simulations: Entrepreneur	https://www.interpretive.com/business-simulations/retail-entrepreneurship-simulation/	Retail entrepreneurship simulation provides students hands-on experience running a clothing shop and making key decisions on inventory, pricing, and staffing.
SimVenture	www.simventure.com	SimVenture business simulations and online entrepreneurship learning tools with advanced business learning software support educators to provide learners with meaningful and authentic business experiences in a safe digital learning environment, ranging from a Windows-based small business simulation to an advanced online business simulation and an online startup ideas platform.
Startup Wars	www.startupwars.com	It brings education to life with immersive tailored simulations for students to explore business & entrepreneurship to enhance student engagement with immersive business simulations and bridge the theoretical learning and practical application gap.

Games	Websites	Descriptions on the Websites
The Startup Company	https://www.startupcompanygame.com	A business simulation sandbox game where the player is the CEO of a new company to build a website and compete against the largest tech giants.
The Startup Game	https://interactive.wharton.upenn.edu/academic/the-startup-game/	Each player takes on the role of either a founder, an investor, or a key early employee to secure the right combination of funding and talent to make their startup a success. Players actively move around the room, competing and cooperating to fund, join, and grow startups. The game introduces students to the latest academic findings that support real-world lessons about key startup concepts such as hiring, equity, salary, and funding considerations.
Venture blocks	https://ventureblocks.com/	Simulation + AI teaches students to interview customers and identify needs.
Venture Strategy	https://www.marketplace-simulation.com/compare-our-business-simulations/venture-strategy-bikes/	The Venture Strategy simulation provides students with a safe virtual environment to experience being an entrepreneur as they start up a new business.
Virtonomics	https://virtonomics.com	Business games and company management simulation games encourage entrepreneurship through realistic models of markets, industries, and businesses.

5. Future Perspectives of Virtual Simulation Games in Entrepreneurship Education

Serious games and virtual simulation games offer dynamic ways of teaching entrepreneurship that combine entertainment, learning, and practical applications, contributing to effective entrepreneurship education for different learning needs and preferences. Serious games are powerful tools to facilitate deeper learning through entertainment (Martins et al., 2023). Serious games often incorporate virtual simulation elements for educational purposes to eliminate the fear of failure and enable students to learn by doing. Integrating serious games into entrepreneurship education is important "to nurture key entrepreneurial competencies essential for students' career development" (Daniel et al., 2024). Virtual serious games combine the principles of serious games with VR or AR in immersive environments to enhance the learning experience by allowing users to interact with digital content. Serious games combine learning with entertainment on broader educational content while virtual simulation games specifically target skill development and decision-making in entrepreneurship, providing practical experiences in a safe environment. Combining a digital twin with game-based learning in entrepreneurship education can create an innovative and engaging approach for students. Digital twin provides business processes' visual representations and tangible abstract concepts and simulates entrepreneurial scenarios (e.g., market dynamics, supply chains, and financial management, allowing students to explore business concepts, decision-making, and problem-solving) (Sepasgozar, 2020, p. 1). Augmented reality (AR) and virtual reality (VR) allow students to model and interact with digital twins and immersive learning experiences. "AI can improve entrepreneurial attitude in business simulation games in various ways such as simulating competitors, providing targeted feedback for failures, and improving game experience" (Sepasgozar, 2020, p. 1). AI is increasingly used to improve virtual simulation games in entrepreneurship education. AI and XR applications in virtual simulation games in entrepreneurship education are promising.

6. Conclusion

Virtual simulation games as an effective approach to entrepreneurship education can enhance students' immersive and interactive entrepreneurial learning experience to inspire them with positive intentions toward entrepreneurial learning. Virtual simulation game-based learning can increase student engagement to mitigate the challenges of lacking student engagement in traditional teaching methods in entrepreneurship education, allowing students to construct knowledge from meaningful experiences to explore solutions and collaborations. Virtual simulation games as an effective teaching method can affect students' learning engagement, entrepreneurial learning experiences, and learning outcomes, which can be integrated as digital twins, online entrepreneurship courses, or digital learning resources of entrepreneurship education in higher education institutions. Virtual simulation games need proper technological, pedagogical, and content design to fit the specific teaching goals of entrepreneurship courses and integrate into entrepreneurship curricula to innovate entrepreneurship education in higher education institutions. The technological, pedagogical, and content design of virtual simulation games and their integration of hybrid and online entrepreneurship education has significant implications for promoting digital innovation of entrepreneurship education by using virtual simulation games

to enhance student learning outcomes and entrepreneurial competencies as well as the effectiveness and the quality of entrepreneurship education in higher education institutions.

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Towards AI-assisted Board Game-based Learning: Assessing LLMs in Game Personalisation

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Abstract: Board games are used in different educational settings to promote acquisition of disciplinary content, soft skills, foster engagement towards learning content, and sustain motivation. However, designing and conducting effective educational activities with board games requires instructional design skills, knowledge of games, as well as the ability to align the player's internal goals with the learning objectives. Board game-based learning (bGBL) design includes choosing appropriate games and personalising them to better fit with the educational setting and the students' individual needs. This complexity, coupled with a general lack of teacher familiarity with games and game culture, is likely a reason for the relatively low use of board games in formal instructional settings such as schools. Artificial Intelligence (AI) has long been used in education, but the recent diffusion of user-friendly tools for large language models (LLM) opens a new range of possibilities to assist teachers and educators in instructional design: This includes the design and implementation of bGBL. In a preliminary study, we explored the ability of a well-known chatbot, ChatGPT, to select board games and suggest modifications to better align with the classroom context and personal student needs. However, this study was limited to a sample learning unit and was based on a posteriori evaluation by experts. In this contribution, we develop a new testing protocol to assess the reliability, effectiveness, and context sensitivity of several LLMs to adapt given board games to different classroom scenarios. The methodology features blind comparison of AI and human experts. The results suggest that general-purpose AI tools such as Copilot, Claude, and ChatGPT can provide quality and context-sensitive board game modification suggestions, to the point of slightly overperforming human experts in aligning personalisation suggestions to instructional goals. This study represents a first foray in the use of general Artificial Intelligence to assist the modding, or personalisation, of board game-based learning activities and, despite its limitations as a pilot experiment, might pave the way for successful integration of assistive technologies in game-based learning and facilitating its integration in the school curriculum.

Keywords: Artificial Intelligence, Instructional Design, Board Games, Personalisation, Modding.

1. Introduction

1.1 Board Game-Based Learning

(bGBL) is an educational methodology that exploits board, or tabletop, game mechanisms (Engelstein and Shalev, 2019) to provide students with an engaging, motivating, and social learning environment (Bayeck, 2020). Board games have long been used as a learning tool in human societies (Parlett, 1999; Donovan, 2017), but they also meet the needs of new generations of learners due to their specific properties. First, they promote collaboration and healthy competition among students. Collaboration favours the exchange of knowledge, negotiation of solutions, and the development of communication and teamwork skills (Berland and Lee, 2011). At the same time, healthy competition can motivate students to do their best, encouraging the pursuit of excellence and the development of problem solving skills in a challenging and fun context (Plass *et al.*, 2013). Second, playing around a table generates a sense of sharing a common experience, or "togetherness" (Calleja, 2022), which is a catalyst of spontaneous engagement towards the activities, allowing a positive disposition towards self-expression and risk-taking (DeKoven, 1978; Suits, 2014). Third, board games are "transparent systems" as their rules and the way they interact in gameplay are visible and enacted by players. This allows them to explore nonlinear systems in ways no other media allows (Berland and Duncan, 2016; Zeijlemaker *et al.*, 2022). Fourth, board games can be easily modified, or personalised, to align with learning goals and

standards, promote inclusion, and achieve different educational and instructional goals (Castronova and Knowles, 2015; Sardone and Devlin-Scherer, 2016; Abbott, 2019; Sousa, 2021; Sardone, 2022).

1.2 In-game and Around-game Personalisation

To achieve effective alignment between learning goals and game goals (de Freitas and Oliver, 2006), teachers and educators must not only select a game that suits their educational and ludic needs, but must also be able to modify, or personalise, them, according to the specific educational context. The customisation (or personalisation) of the game experience is a key steps in bGBL (Abbott, 2019; Sousa, 2021; Sardone, 2022; Andreoletti and Tinterri, 2023); first, it is unlikely to find games that perfectly fit the learning goals of the activity (Van and Freitas, 2011; Arnab *et al.*, 2015); second, the specificities of the learning context often require specific measures to promote inclusion to allow participation of all students (Davis-Temple, Jung and Sainato, 2014; Heron *et al.*, 2018; Westwood, 2018). Targeted approaches and effective strategies are essential to ensure an optimal learning experience (Nicholson, 2011; Denham, 2016; Weitze, 2016; Sousa, 2023). Customising existing games makes the best use of already available resources by making targeted modifications to suit games to the specific needs of students. The possibilities for customisation are numerous and include modifying game parameters, such as adjusting the difficulty or varying the modes of interaction; adding instructional elements, such as quiz questions or informational resources; and integrating specific educational content, such as instructional materials related to the topics covered. Based on the work of Ejsing-Duun and Hanghøj (2019), the authors defined two main strategies for game personalisation (Andreoletti and Tinterri, 2023):

- In-game: changes that modify game mechanics; examples include modifying game components to better align with subject matter (Sardone, 2022), changing game objectives (Castronova and Knowles, 2015), etc.
- Around game: changes to the game experience that does not require modifying the physical components or the mechanisms of the game; examples include playing in couples, introducing moments for self-reflection (Abbott, 2019), etc.

According to the desired goals and the teacher's familiarity with game design principles, in-game and around-game personalisation provide non-exclusive opportunities to customise games to achieve better constructive alignment (Biggs, 1996; Andreoletti and Tinterri, 2023). However, modifying the game experience can be a daunting task for teachers, who generally possess little knowledge of games and game design principles and have trouble in exploiting the educational potential of games beside its motivational value or as an exercise tool (Allsop and Jessel, 2015; Loperfido, Dipace and Scarinci, 2019; Persico *et al.*, 2019).

1.3 General Artificial Intelligence in Board-game Based Learning

Artificial Intelligence (AI) has the potential to revolutionise education (Adiguzel, Kaya and Cansu, 2023; Baidoo-Anu and Owusu Ansah, 2023) by enhancing the quality of teaching and learning practices, promoting personalised learning, automating routine tasks and allowing smart management of classes and resources. AI-assisted education is not a new concept, as machine learning has been used for years to assist educational tasks (Southgate *et al.*, 2019); however, the recent mass availability of AI models based on large-language models (LLMs), or "general" AI, represented a turning point: The user-friendly conversational interface of tools such as OpenAI ChatGPT, Anthropic Claude, Microsoft Copilot, and others, allowed non-AI experts to explore the potential of AI In assisting a growing range of instructional practices (Ch'ng, 2023). While these tools present significant ethical (Yan *et al.*, 2023) and literacy (Ng *et al.*, 2021) challenges, they could represent an invaluable tool to assist the design of bGBL, helping teachers bridge gaps in game knowledge and design by providing suggestions for game choice and personalisation. In a previous pilot study, we explored the potential of general Artificial Intelligence (AI) tools to assist teachers in the choice and personalisation of board games for learning (Tinterri *et al.*, 2024); in a follow-up study, we extensively assessed the reliability, accuracy and context-sensitivity of ChatGPT in choosing board games for specific learning contexts and observed that, while the model is not entirely reliable, its choices are generally in line with those of human experts and sensible to the educational context (Tinterri *et al.*, in press). In this study, we explore whether different AI tools can provide personalisation suggestions, both in-game and around-game, that are of sufficient quality to be realistically integrated in bGBL practice. Thus, the research questions of this study are:

RQ1: Are there any differences in performance for the different AI tools examined?

RQ2: Are general AI models able to provide helpful (i.e. comparable to human experts) suggestions for the personalisation of board games for learning?

2. Methods

The experiment has been carried out in four steps: first, we defined the pedagogical and instructional bGBL framework to construct the tasks for AI and human evaluators. Second, we built instructions for evaluators and the prompts for AI models. The third phase was divided in two subphases: first, we collected the suggestions for game personalisation from AI models and human experts; subsequently, we asked human evaluators to blind rate the personalisation suggestions from their peers and AI. In the fourth phase, we collected and analysed the data.

2.1 Instructional Framework and Experimental Protocol

Designing meaningful and impactful bGBL experiences requires the intentional alignment of various critical components. These components include disciplines, dimensions of competence, the infusion of engaging and immersive playful scenarios, and the careful selection of pedagogical approaches (Biggs, 1996; Nicholson, 2011; Torrente *et al.*, 2011; Catalano, Luccini and Mortara, 2014; Sardone and Devlin-Scherer, 2016; Weitze, 2016; Salen, 2017; Parrish, 2020; Erdoğan, Atasay Sunay and Eryılmaz Çevirgen, 2022; Andreoletti and Tinterri, 2023; Cantoia, Clegg and Tinterri, 2023; Sousa, 2023). This alignment is the keystone upon which the effectiveness of educational interventions is built (Lyon, 2016). For this study, we used the GDBL ID model (Andreoletti and Tinterri, 2023; Tinterri *et al.*, *in press*) for bGBL design, based on the well-known ADDIE instructional model.

The educational framework for the two sample activities that were provided to AI and human experts included:

1. A description of the level of instruction (primary or secondary school) and classroom context, including demographic information, general assessment of the cognitive, motivational, and socioemotional characteristics of the students, and indications of the presence of students with special learning needs.
2. The learning objectives of the activity, structured in a learning goal and observable evidence.
3. The game scenario. Hanghøj (2013) uses this term to refer to the "dynamic, future-oriented models for possible actions" (*ibid*., p.2) that are embedded in gameplay. Game scenarios "can be used to explore and experiment with the construction, deconstruction, and reconstruction of knowledge" (*ibid*., pp.2-3). Scenarios for the activity has been based on the mapping of 15 game scenarios by (Andreoletti and Tinterri, 2023; Tinterri and Andreoletti, *in press*), which expanded on the work of Salen and colleagues (2010).
4. The game goals of the activity. They define the learning processes that activate spontaneously through and during gameplay and are made visible by the actions of the players. Game goals for the activity have been selected based upon a preliminary categorisation made by the authors for each game scenario (Tinterri *et al.*, submitted).
5. The games selected for the activity. An advanced research had been performed on *BoardGameGeek* (www.boardgamegeek.com), indicating as parameters: 1) publication between 2000 and 2024, as recent games usually present more streamlined rules and more accessible components; 2) user rating between 5 and 10 with a minimum of 20 ratings, to exclude prototypes, unpublished or self-published games; 3) complexity rating between 0 and 2.5, to exclude excessively complex games; 4) indicating as categories: Educational+Math for the first activity, Medieval+Civilisation for the second. The query resulted in 26 titles for the first search and 5 for the second. Putative titles have been individually parsed by the researchers to identify games that fit the learning objective and game goals according to five criteria: accessibility, setting, content, learning curve, and opportunities for assessment (Tinterri *et al.*, in press) . The resulting activities are described in Table 1.

Table 1: Characteristics of the Learning Activities used for personalisation suggestions.

	Activity 1	Activity 2
Target	Primary School	Secondary School
Classroom context (summary)	20 students (11 boys and 9 girls), lively, dynamic, and inclusive; cultural and linguistic diversity.	22 students (11 boys and 11 girls), a welcoming and challenging environment. Special educational needs: Marco (motor disability, 12 hours of support weekly), Sofia (learning difficulties, 10 hours of support weekly), and Alessio (autism spectrum disorder, 15 hours of support weekly).
Learning	Develop competencies in basic calculus.	Understand and analyse historical events.

	Activity 1	Activity 2
goals		
Acceptable evidence	[The student]: correctly executes additions and subtractions up to 100; uses such operations to solve simple problems; uses concrete materials, such as cubes, or counters, to aid calculations.	[The student]: identifies and describes the main events and historical periods of Middle Age; analyses causes and consequences of historical events, connecting past, present, and future. uses primary and secondary sources to interpret historical events of the Middle Age.
Game scenario	Exercise	Documentation
Game goals	1c. Interpret and respond to sensory stimuli present in the game (visual, auditory, and/or tactile). 16e. Choose paths and levels of challenge according to one's own skills and abilities. 16f. Self-assess the understanding of specific concepts through quizzes or activities in the game. 24g. Incrementally integrate new concepts during the game.	10d. Celebrate personal success and achievement obtained during gameplay. 16h. Use the components of the game, such as cards, tiles, or characters, to create unique and personal scenarios.
Game	Secret Code 13+4.	Era: The Medieval Age

2.2 Prompt Building and Execution

The instructions summarised in Table 2 were provided to human experts and four general AI models: OpenAI ChatGPT, in both GPT-4 and GPT-4o versions, Microsoft Copilot, and Anthropic Claude. Prompts were built according to the principles described in (Tinterri *et al.*, 2024). Shortly, a series of successive prompts were given to instruct the AI. Instruction specified the persona ("You are an instructional designer of learning activities that use board games. Your task is to propose personalisation (modding) opportunities for the game activity according to the context and the goals that will be given to you [...]"). Further prompts described a) the task, including criteria for game personalisation evaluation and definition of key terms b) examples of in-game and around-game personalisation c) the classroom context d) the learning goals of the activity e) the scenario and game goals f) the rules of the game, uploaded as pdf in models that allow this function (ChatGPT and Claude) and summarised as text input in Copilot. Afterwards, the script was run in the four AI tools examined and results were collected using Google Sheets.

2.3 Expert Evaluation

The three experts recruited for the study have specific experience in bGBL and work as educators or teachers in primary or secondary school. They were given the same instruction as AI models and asked to propose an in-game and an around-game personalisation for each activity. Their suggestions were collected via Google Sheets. ChatGPT was used to rewrite all personalisation suggestions (both AI- expert-generated) to prevent identification of AI-proposed suggestions by means of stylistic cues. Then, suggestions were randomised, and each expert rated each personalisation suggestion (except their own) on a scale of 1 to 5 based on three factors: constructive alignment (how much the suggestion reduced the distance between learning goals and the game internal goals), feasibility (how easily the modification could be implemented) and inclusivity (how much the suggestion facilitates access to learning, according to individual characteristics) and were asked to provide a short motivation for their ratings.

2.4 Data Analysis

Data was analysed using Jamovi software (Şahin and Aybek, 2020). Statistical testing used nonparametric analysis (Mann-Whitney U test and Kruskal-Wallis test).

3. Results

For each activity, we obtained 14 personalisation suggestions: 6 from human experts (3 in-game and 3 around-game) and 8 from AI software (4 in-game and 4 around-game). Human-generated suggestions were averaged based on the two rankings received by the other two experts and AI-generated suggestions based on all three experts' scores. Table 2 shows an example of the rankings obtained for in-game personalisation in Activity 1.

Table 2: Short description and median ranking for in-game personalisation for Activity 1.

Author	Content (synthesis)	Alignment	Feasibility	Inclusion	Total
Claude	Instead of target numbers, the "barrier" tokens represent additions, subtractions, or multiplications to be solved using the available dice.	5	4	4	13
ChatGPT (GPT-4)	Introduce "challenge cards" that require more complex mathematical operations and increase rewards.	4	4	4	12
Expert 3	The choice of mathematical operations which can be used for each barrier is restricted (only sum-subtraction or multiplication-division).	4	4	4	12
ChatGPT (GPT-4o)	Cooperative instead of competitive gameplay.	4	4	4	12
Copilot	Add a special dice with +, -, × and ÷ symbols. If the result matches the required operation, it can be spent instead of using numbered dice.	4	5	2	11
Expert 1	Extra points for using more difficult operations.	3,5	4,5	2	10
Expert 2	Increase numbers up to 100, with a d10 for units and a d10 for tens.	3	3,5	2	8.5

3.1 Comparison of AI Tools Personalisation Suggestions

We first checked whether human experts could distinguish AI suggestions from those of their human peers, by asking them to indicate, for each suggestion, if they thought it came from humans or AI. Overall, the expert evaluators, all of whom have previous experience with general AI tools, did a poor job of identifying personalisation suggestions as human or machine generated (38%, 45%, and 38% success rate, respectively). This indicates that the results observed were likely not biased by conscious or subconscious preconceptions towards AI. We also checked that the scores of personalisation's proposed by human experts do not significantly differ between them, also considering the different contexts (primary and secondary) and in-game and around-game personalisation (Mann-Whitney U, data not shown). This confirms that the experts have comparable bGBL skills and experience. To answer RQ1, we compared performance by the different AI tools that have been used in the study. We did not observe any significant difference (Kruskal-Wallis, 3df, X^2=1.69, p=0.64) when comparing the overall rankings achieved by the suggestions by different AI tools (Table 3); the same is true when considering only individual dimensions (Constructive alignment, Feasibility, and Inclusion; data not shown).

Table 3: Average aggregate score of personalisation suggestion by the AI tools examined in the study. Personalisation concerning Activity 1 and 2 and in-game and around-game modalities are pooled together in the analysis.

Software	N	Mean	Median	St. Dev	Min value	Max Value
ChatGPT (GPT-4)	4	11.00	11.50	7.54	9.00	12.00
ChatGPT (GPT-4o)	4	12.15	12.00	8.20	11.00	12.00
Claude	4	11.50	11.50	5.51	10.00	13.00
Copilot	4	11.00	11.00	13.36	10.00	12.00

3.2 Comparison of AI-generated and Human-generated Personalisation Suggestions

To answer RQ2 and compare the quality of AI-generated and human-generated suggestions, we pooled personalisation suggestions for the two activities and compared the performance of AI and humans. Nonparametric Mann-Whitney U test shows that the overall median score achieved by AI tools for in-game personalisation does not differ significantly from median score of human-suggested personalisation (Table 4). Conversely, AI-generated suggestions received significantly better scores than human-generated ones for constructive alignment in in-game personalisation. The scores achieved by AI and human experts are similar also for around-game personalisation, , suggesting that AI tools can provide game personalisation's of comparable quality to that of human experts.

Table 4: Comparison of median rankings for in-game and around-game personalisation suggested by human experts (experts) and AI tools (AI). Table compares aggregated scores for the three dimensions evaluated by experts (constructive alignment, feasibility, and inclusion) as well as the overall score obtained by their sum.

	Group	N	In-game				Around-game			
			Mean	Median	SD	M-W U (p-value)	Mean	Median	SD	M-W U (p-value)
Constructive Alignment	Experts	6	3.42	3.50	0.376	2.50 (0.004*)	3.25	3.50	0.689	16.0 (0.305)
	AI	8	4.38	4.00	0.518		3.63	4.00	0.518	
Feasibility	Experts	6	3.83	3.75	0.606	24 (1.00)	4.17	4.50	0.876	20.0 (0.626)
	AI	8	3.75	4.00	0.886		4.25	4.00	0.463	
Inclusion	Experts	6	2.83	2.75	0.816	21.50 (0.778)	3.50	3.50	0.447	20.0 (0.620)
	AI	8	3.00	3.00	0.926		3.63	4.00	0.518	
Overall	Experts	6	10.08	9.75	1.393	13.00 (0.168)	10.92	11.00	1.281	18.0 (0.449)
	AI	8	11.13	11.50	1.356		11.50	11.50	0.535	

4. Discussion

In this exploratory study, we tested the ability of different general AI tools to provide personalisation suggestions for board game-based learning (bGBL) activities. The methodology of choice used a two-step protocol that saw AI tools and human experts provide personalisation suggestions for specific bGBL activities in parallel, followed by blind evaluation of the suggestions by the same experts. In this way, we were able to avoid scoring bias. We observed that the AI tools included in the study were similarly effective in providing quality and context-sensitive personalisation suggestions, achieving similar scores to those of human experts or slightly overperforming them in specific categories (Table 4). This preliminary finding suggests that, when provided clear and comprehensive instruction, current state-of-the-art general AI models can be a useful tool to assist the complex task of personalising games for bGBL instructional design, as they are able to provide personalisation suggestions in line with those of human experts for alignment with subject matter, feasibility, and inclusivity. Furthermore, this seems to be true for different school contexts as well as for modifications that involve changes to game mechanisms (in-game personalisation) as well as those that do not, suggesting that these tools can fine-tune their suggestions according to the needs of the teacher/designer. However, this experimental study has a few limitations. The first is numerosity: the study only involved three human experts and a total of 28 personalisation suggestions from two sample activities. While the collected data is enough to identify significant tendencies, the involvement of more experts would ensure that an expert's personal preference or inclinations would have a marginal influence on results, and the use of more contextual scenarios and games would help generalise the

results obtained. Second, there is considerable evidence in AI literature that the quality of prompts plays a key role in the quality of answers from AI tools (Bozkurt and Sharma, 2023; Liu, 2023). The prompts used in this study use currently known best practices, such as providing a persona, clear progressive instructions, and limiting word count; still, research on prompting techniques is still in its infancy, and different prompting strategies have not been addressed in this study. Third, European policies towards ethical use of AI in education stress the importance of explainability and transparency in AI models (European Parliament, 2024); however, the tools used in this study, such as ChatGPT, work as "black boxes", meaning that it is impossible to know what information has been used to compute answers and how they have been obtained. This is a significant limitation that suggests the adoption of different, less controversial tools in the future. Fourth, bGBL currently lacks established, evidence-supported pedagogical and instructional frameworks. In building the experimental framework for this study, we used the GDBL ID model developed by the authors, which is based on state-of-the art literature and currently being empirically tested. Still, this being a work in progress, it would be beneficial to compare the results obtained with different bGBL models.

5. Conclusion

Taken together, this study represents a first foray in the use of general Artificial Intelligence to assist the modding, or personalisation, of board game-based learning activities. Despite the limitations due to its pilot nature, this work indicates that common AI tools can help personalisation of games by providing quality suggestions to modify board games gameplay to promote personalisation of learning and constructive alignment. This represents a potential breakthrough for the field of game-based learning, wherein mounting evidence concerning the effectiveness of games as a powerful learning environment is contrasted by limited adoption by teachers and educators, in no small part due to lack of game knowledge and game design skills. By providing context-sensitive and accurate suggestions for game personalisation, AI tools can help teachers in experimenting with bGBL and thus highlight the unique and largely unexplored educational potential of boardgames.

Author Contributions

Conceptualisation, A.T.; introduction and theoretical framework, A.T. and F.Pe..; methodology, A.T.; data acquisition, A.T.; data analysis, A.T., game evaluation G.V., F.Pa. and F.Pe; writing—original draft preparation, A.T. and M. di P..; writing—review and editing, A.T., M. di P., F.Pa., F.Pe., G.V.; supervision, A.T. All authors have read and agreed to the published version of the manuscript.

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Utilizing a Digital Escape Room to Improve Students' Grasp and Understanding of Qualitative Research Methods

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Abstract: Utilizing the potential in game mechanisms for learning purposes is not new. This version of gaming for learning is about developing a Digital Escape Room (DER) revolving around a specific subject: qualitative research methods. Qualitative research methods have proved to be a difficult topic for many UG and PG students. It is thus important to develop tasks that will enable these students to obtain a deep learning experience. The significance of this project lies in that both qualitative and quantitative research methods seem to be difficult to learn for students. It seems to be a curriculum that the students need to invest more time learning than they expect and are willing to spend. Hence, seeking to utilize the potential that lies in immersive gaming. One of the aims of this project is to investigate if and how the DER approach will suit the step-by-step approach that is often used in qualitative research methods courses. Will this approach of solving puzzle-by-puzzle, and then combining answers in order to unlock the next level enable an emergence of more understandings of what the qualitative research is about? In this theoretical paper (work-in-progress), we will look at the DER literature and describe how the different components of the DER will contribute to pedagogical support regarding learning outcomes. In this next phase of this project, we are planning to develop our DER based on the current literature and previous evaluations of DERs, we will also conduct more semi-structure interviews, and further investigation is underway.

Keywords: Digital Escape Room, Pedagogical Support, Games-based Learning, Higher Education, Research Methods.

1. Introduction

Teaching scientific research methods have proved to be difficult and there have been different approaches to making students learn how to do research in an ethical, reliable and valid manner (Boger and Tufte, 2009). Students seem not to understand the importance of learning about research methods until they have to utilize this in their bachelor or master's degree theses. In our experience, students attend the first day of the course and then turn up for the last lecture summing up the curriculum, with a few exceptions. Hence, several students fail the course every semester. Many efforts have been made to make students understand the value of working on the different approaches within the area of scientific research methods, even the use of games (Haave and Vold, 2018; Slyman, 2018, 2019, 2022).

Gamification has, however, seemed to make students become motivated and engaged. Recent studies have focussed on a particular type of games that has had a short history: Escape Rooms.

The potential that lies in this way of playing for learning has gained popularity and momentum. In the last few years, the number of scientific experiments have increased significantly (See Taraldsen et al., 2022). For example Slyman, (2022) and Taraldsen et al. (2022) recognize the invaluable impact of this on motivation and 21st-century skills.

As we have a large cohort of students who are studying online, we would like to develop a digital version of an escape room. This will also serve as an additional learning resource for our on-campus students

Hence, our aim is to develop a digital escape room that motivates students to engage with the curriculum and also support the learning outcomes of the course in qualitative research methods.

This paper will firstly present the theory that has enlightened our study, and then suggest guidelines for a proposed digital escape room.

2. Theoretical Foundations

Gamification has proved to be supporting learning in several different areas of education (Dittman et al., 2021, Hellerstedt and Mozelius, 2019; Shaffer et al., 2005; Prensky, 2003). According to Plass et al. (2015) gamification trigger cognitive, affective, behavioural and sociocultural engagement, hence supporting an immersive learning experience as well as making the learning more comprehensive.

In the last 10 years escape rooms have become increasingly popular (Fotaris and Mastoras, 2019). What is recognized as the first escape room is "Behind Closed Doors" developed by John Wilson in 1988 (Ascalon, 2021). This was a text-based game with a player trapped in a room. In 2004 the "Crimson Room" was developed by Toshimitsu Takagi, a Japanese game creator (Ascalon, 2021). The Crimson Room is a free digital escape room. The first physical escape room opened in 2007 and was created by Takao Kato (Ascalon, 2021). The most well-documented escape room is, however, The ''Real Escape Game developed' by SCRAP. Since then, several escape rooms have emerged in most major cities (Nicholson, 2015).

Nicholson (2015) has defined an escape room as a: "live-action team-based game where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal (usually escaping from the room) in a limited amount of time" (p.1). This coheres with Salen and Zimmermann's (2004) definition of a game as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (p.80).

The majority of the HE research studies on the use of escape rooms have emphasised its significant beneficial role for education (Taraldsen et al., 2022). For instance, we find research on, for example, language education (Bellés-Calvera and Martínez-Hernández, 2022), teaching mathematics (Slyman, 2022; Stohlmann, 2023; Pg Abu Bakar et al., 2023) and health science (Cruaud, 2023).

The social cognitive theory suggests that human functioning, such as the construction of knowledge, emerges from a dynamic causal relationship between three key determinants: behavioural, environmental, and personal (Bandura, 2012, Bandura, 1997). Behavioural determinants involve the human tendency to participate in activities and collaborate with others (Bandura, 2012). Personal determinants encompass affective, biological, and cognitive factors, including motivation, genetic makeup, thinking, and communication skills. Environmental determinants, on the other hand, can be imposed, selected, or constructed by individuals (Bandura, 2012, Bandura, 1997).

In one of the pioneering books on the psychology of video games, Loftus and Loftus (1983) and Gee (2007, 2011) delved into players' motivations, examining what makes video games enjoyable. Drawing heavily on behaviourist theories, they noted that video games often provide rewards or successes intermittently, aligning with an intermittent reinforcement schedule, which is known to produce the highest response rate. They also highlighted that effective games strike a balance: they are neither too easy, which can bore players and lead them to stop playing, nor too difficult which can frustrate players and cause them to quit. Instead, good games find the "sweet spot," where players can achieve success but only with some effort, creating a state of "flow" (Csikszentmihalyi, 1990). In the context of learning, well-designed games aim to be within a player's zone of proximal development.

Adapting the concept of games to the educational context has proven challenging. Researchers in education debate whether games should be used to teach specific subject matter concepts and facts or to support the overall learning process (Prensky, 2003, Chee, 2016). The former approach is known as game-to-teach, while the latter is referred to as game-to-learn (Chee, 2016). In the game-to-teach paradigm, game-based learning is defined as the integration of educational content with computer games. The idea is that combining video games with educational material can achieve results equal to or better than traditional learning methods (p. 145–146). This approach focuses on engaging students with games to achieve learning outcomes.

Conversely, the game-to-learn paradigm involves designing games as scaffolds to guide students through an inquiry process (Chee, 2016). This method includes multiple layers of activities, such as reformulating problems in contextually appropriate ways to construct meaning. While the debate between these two paradigms may not be resolved here, it is important to note that game-based learning aims to leverage the potential of games to enhance the teaching and learning process.

As games and related digital media have become more complex and intentionally instructional, efforts have been made to incorporate the natural scaffolding that occurs during play into the digital environment to support learning. The concept of scaffolding was first introduced by Wood et al. (1976) to describe how an adult or expert helps someone less skilled solve a problem or complete a task. Scaffolding occurs when an expert manages parts of a task that are beyond the learner's abilities, enabling the learner to accomplish something they couldn't do alone. Although Wood et al. did not explicitly connect scaffolding to Vygotsky's zone of proximal development, it is clear that effective scaffolding requires the task or problem to be within the learner's zone of proximal development (Bruner, 1985).

Modern entertainment games excel at guiding new players through the learning process. Typically, these games begin with a tutorial level where players' actions and outcomes are closely monitored. Players receive targeted feedback and support in areas where they struggle, providing dynamic feedback to facilitate learning. As players progress and succeed in the tutorial, the provided extra-support is gradually removed, effectively fading the scaffolding. While this scaffolding process is relatively straightforward and effective in entertainment games, it has been more challenging to implement successfully in educational games. This is partly due to the increased complexity of conducting the dynamic assessments required for learning-focused games (Plass et al., 2015).

When viewed from a sociocultural perspective, game-based learning recognizes that learning is socially constructed and motivated (Wenger, 1998; Bandura, 2002; Slyman, 2018; Slyman, 2022). Games offer opportunities for social engagement and create environments where peer interactions can enhance learning (Squire and Gee, 2011; Squire, 2006). Learning designs emphasize that social and cultural aspects focus on how learners can work in groups, leverage collective knowledge to achieve goals, connect learning to cultural norms and identities, and use social and cultural influences as motivators. These features are integrated into both immediate and broader gameplay contexts.

Cruaud (2023) has analyzed the interactions in three escape room games. The outcome of the research shows that it may be difficult to steer the discussions, and unless the game provides feedback or there is a game master that can provide clues, participants may go astray and become uncertain about what to do next and whether they have the correct answers. Hence, the importance of game testing and a game master to be present for the time of the gaming, making sure there is adequate and good feedback provided to the participants.

Videnovic et al. (2022) have suggested a design thinking approach to develop educational digital escape games. This implies five phases: the first phases are "empathize" and "define" which is about identifying and understanding the problem from a student's perspective, then the "Ideate" follows which is about determining what the game should be about, lastly there are the phases of "prototyping" and "testing".

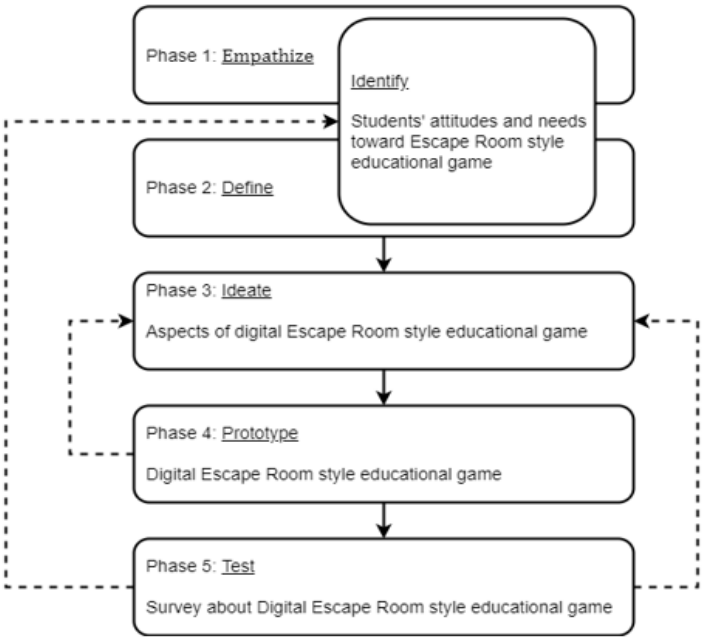


Figure 1 Design thinking methodology used in the development of a digital escape room (Videnovik et al., 2022)

According to Veldkamp et al. (2020), the goal for the game should differ from the goal of the education. Also, in an examination of the impact of the gameful experience done by Vigerdor (2021) in a digital escape room on motivation, Vigerdor found a significant effect driven by intrinsic motivation. Students viewed the digital escape room as a learning incentive, engaging with it purely for the enjoyment of playing and learning, without any external pressure. They also experienced immersion in the game which boosted their motivation and sense of playfulness. Research supports the link between intrinsic motivation and gameful experiences, indicating that intrinsic motivation arises from enjoyment, the excitement of the game, or the desire to improve skills (Vidergor, 2021). While students associated collaboration with the gameful experience, particularly group efficacy, they did not see collaboration as mediating the relationship between gameful experience and motivation. Teamwork helps in mastering challenges and enhances feelings of competence. Belief in group's capabilities and supports, known as group efficacy, could contribute positively to students' confidence in handling assignments (Vidergor, 2021).

3. Research Questions

This paper describes how the different components of the DER will contribute to pedagogical support regarding learning outcomes. One of the aims of this project is to investigate if and how the DER approach will suit the step-by-step methodology that is often used in qualitative research methods courses. Will this approach of solving puzzle by puzzle and then combining answers in order to unlock the next level enable an emergence of the understanding of what qualitative research is about? To develop the DER we will look at development methods and follow up on previous evaluations of DER's. Our research questions, based on the gaming literature review, are as follows:

How does DER approach fit the step-by-step methodology that is often used in qualitative research methods courses.***?***

Will the DER approach enable an emergence of a greater understanding of what qualitative research is about (i.e. help students to understand qualitative research method)***?***

In the following, we will present our method of inquiry, our initial findings from the literature, and discuss briefly the next phase of our future research.

4. Method of Inquiry

We will use the proposed design thinking methodology (As discussed above) as a point of departure. Hence, thorough investigations as to understanding what the problem with learning qualitative research methods is about.

The data is from interviews with the main respondent, conducted both in person and via zoom. The zoom-meeting was recorded and transcribed. The respondent has agreed to the recording. The coding was done manually using categories and sub-categories. We will thus interview students using a semi-structured interview guide (Dalen, 2011). In addition, we will investigate their attitudes and needs towards the DER. Furthermore, there is a need for inviting the students to the development process for developing and testing the prototype for the DER.

5. Initial Findings and Future Research

5.1 Developing the Digital Escape Room for Qualitative Research Methods Course

As seen above, a typical Digital Escape Room generally starts with an introduction and an explanation of the rules. This may either be a game master, a video or a written message (Taraldsen et al., 2022).

One important feature of the game will be to follow the suggestion of separating the goal of the game with the goal of the education (Veldkamp et al., 2020). It will, however, have to be balanced so that they do learn what we aim for. Although fun and engagement are important, it is equally important that they actually learn the intended learning objectives and that they experience not only motivation but are able to utilize what they have learned & applied it posterior to the gaming. Furthermore, we will have to be vigilant regarding the caution made by Cruaud (2023) about the need for input, tips and hints. We will therefore provide feedback on all of

students' answers, especially when they are wrong, so that they get appropriate hints and tips to proceed in the game. We might also explore whether we can establish an AI solution that are able to understand and cater for the students' needs during the gameplay. In the preliminary stages we might have to monitor and personally supply the students with hints and tips when needed. If we fail to provide appropriate feedback, the students may become disconnected from the gaming, loose interest and hence break the *flow* (Csikszentmihalyi, 1990).

The participants need to work together as a team to solve problems within a constrained time limit. In this next phase of our research, we will use the proposed design thinking methodology (As discussed above) as a point of departure. Hence, thorough investigations as to understanding what the problem with learning qualitative research methods is about. We will thus interview students using a semi-structured interview guide (Dalen, 2011). In addition, we will investigate their attitudes and needs towards the DER. Furthermore, there is a need for inviting the students to the development process for developing and testing the prototype for the DER.

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There's More than One Way to Skin a Game: Templating Game-Based Learning

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Abstract: This work in progress paper documents our experiences in academic game development as we shifted from custom-built game designs to a templating approach that could more economically adapt our games to meet the needs of different disciplines. We assess our previous games content and structure for its suitability to fit such an approach and start developing a framework for our future work within our specific constraints.

Keywords: Academic Game Development, Educational Games, Edutainment, Game Development Process, Game-Based Learning

1. Introduction

Making educational games within academia is an effort to meet the needs of educators and students while working with far less resources than found in the commercial sector, amplifying the typical game development constraints relating to time, money and skill (Morrell et al. 2022). While the utilisation of commercial off-the-shelf games in education is a valid economic compromise (Van Eck 2006), it has only grown more difficult to adapt such products as their technologies continue to advance across lines antithetical to modding accessibility.

The intentions of our in-house development team, situated within the Aalto Online Learning-Online Hybrid Lab and serving the staff of Aalto University as our clients, was to avoid work reliant on existent commercial properties and instead aim to create original designs grounded both in research on education and game design. Our work now focuses on developing suitably resourced, realistically produced, game *templates* that can be modified quickly and with minimal friction to meet the needs of educators across disparate disciplines.

Our process is to develop an approach of modular and adaptable game development, with the individual mechanics and combined genres of games being developed distinct from the specific educational material provided by clients. This approach would ideally compile any delivered learning content with the structural template of a game, whose operation could then be rapidly evaluated as either a disposable disarray of elements or ideally, working with enough harmonious synergy to provide some foundation for further iterative development.

This templating approach aims for genre conventionality over any *sui generis* of a game, focused on building moddable elements within a standardised framework to potentially accommodate a variety of educational content. Through this assembly of atomised game elements, from game mechanics to *game design patterns* (Björk & Holopainen 2005) we would aim to attach enough hooks to hang any pedagogy as prescribed, benefiting those educators uncertain or unable to commit to more bespoke design solutions.

This paper documents how our template approach has developed from the knowledge gained during our previous work with educational games. We specifically discuss how our perspectives on design have adjusted within the constraints of academic game making and although important to reflect on later, the related educational model and learning outcomes do not fit within the scope of this paper. In the next section we first discuss how we approached re-utilising assets from our previous educational game work. The section following explores attempts to similarly reutilise the structural and educational components and the issues that emerged in that process. Finally, we briefly discuss how we expect our process to continue, in the pursuit of more efficient and feasible educational game development.

2. The Birth of a City

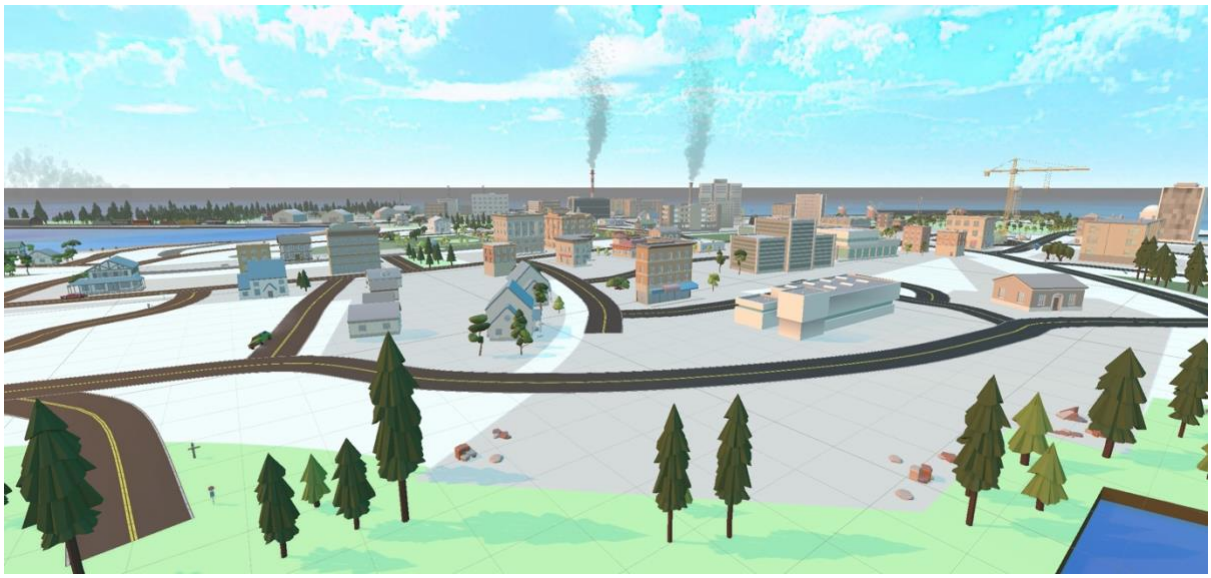


Figure 1: In-Engine Screenshot of the City Environment

One of our long-standing aims working with games has been to combine learning with technology in forms that can be easily modified and reused beyond their initial development. Our 'Playable Concepts' project exemplified this idea, interpreting themes such as burn out or leadership with singular game mechanics and simple 2D art, released alongside their source code and a Creative Commons licence (Kultima et al. 2020). Our following 'Promotypes' (*promo*tional-proto*types*) project moved beyond isolated game mechanics to produce several short but more involved games, demonstrating some of the styles of play we thought most relevant to educators - such as problem-solving, spatial navigation and the application of knowledge (Morrell et al. 2023). The development process of 'Promotypes' was challenging as multiple games with distinct art styles were being developed in tandem by our sole game developer. As the development process ran overlong, our overarching goal of having these games being reusable became secondary to having the original games released in a completed state.

Our experiments in 'Promotypes' included short games in the text adventure, 2D platformer and 3D exploration game genres, all being serviceable if lacking in educational content beyond the addition of text providing historical context about their genre precedents in commercial games. A significant amount of development time was focused on one 'Promotype' game titled 'Cost Driver' that more directly integrated course material from an introductory accounting course. The scope of this game quickly escalated once our theme was established - the player would learn about key accounting terms and concepts from different characters while working as a delivery driver over the day, culminating in an accounting exam. This led to the development of a large three-dimensional city environment, complete with various traffic AI systems and vehicle mechanics. Despite utilising pre-made building and prop assets, significant design work was associated with first sourcing and then assembling these assets together across a large game area with a sense of aesthetic coherence and geographical accuracy (loosely following the road layout of a real town). Our initial conclusions following the release of 'Cost Driver' were that we had to avoid developing such extensive 3D environments in the future, considering both the development time cost and the complexity involved with modifying it further. After some more distance from release, we revisited these conclusions.

Our context of academic game making (Gómez-Maureira et al, 2022) allows us to more visibly reuse artistic and technical assets across multiple games as they target discrete audiences of learners. The development time involved with creating the city environment was at too large a scale to be modified for multiple games. However, when we considered the environment as a relatable setting to act as a canvas for other educational games to be built upon, the value of the existing work grew. While not suitable for every use case, we still felt the city could be utilised across multiple game genres compatible with educational games, justifying further development, for example, on graphical optimisation and improved AI systems. More relevant to our local clients, the city environment could, over time, be transformed to replace the stock individual buildings and props for custom built assets matching the Finnish aesthetic and architecture, adding more regional flavour and cultural relevance, values that can often be integral to games funded in the academic setting.

3. Structural Integrity

With 'Cost Driver', we worked with an educator to adapt key vocabulary from their course material into a narrative themed game, with examples of the terminology emerging through branching dialogues around the city. The mechanics of navigating the city in a vehicle, making deliveries on time and recording the learnt information were implemented in a functional way, while the educational content was largely integrated through an extensive script that attempted to naturally explain these specific concepts through dialogue scenarios.

The simultaneous development of the script, environment and game mechanics were the work of a single developer whose process wouldn't form a cohesive whole until late in the process. While a more playcentric design process (Fullerton 2014) could have helped us to identify issues with the game design earlier, until the script was complete, we felt it was not possible to assess how well the players would be learning the content. Concerns from our designer were reinforced in the later testing, that the slower paced 'visual novel' style story elements were too abrupt a shift in pace to the much faster 'driving game' sections that connected them. The gameplay mechanics of driving and conversation felt incompatible, and this was difficult to rectify. Solutions such as editing the script further or moving more of the example scenarios into the world through props rather than through script alone were not enough to resolve the game's inner friction.

Our first efforts towards the concept of templating were in reverse engineering 'Cost Driver' to assess what mechanical assets were salvageable and what educational content could be replaced or reskinned within the framework. As demonstrated in the frame game concept (Thiagarajan & Stolovitch 1979) there is a dichotomy between a game's content and structure that allows for untrained users to modify a games content while having it remain functional within a predefined structure of rules and procedures (Bekebrede & Champlin 2022). This concept is complementary to our ambitions with templating games, with one additional distinction - between educational content that would ideally be swapped out alongside our partners and supporting content that helps connect this with a structure supporting specific learning objectives. With 'Cost Driver', the parallel development of narrative and mechanics resulted in the educational content, the supporting content, and the structure being interwoven in a way that made them difficult to examine separately.

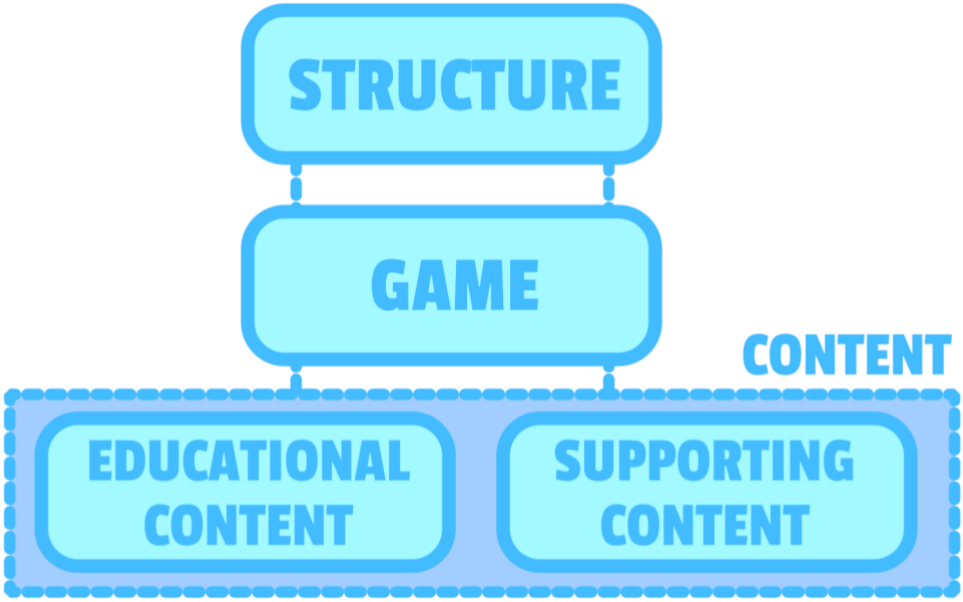


Figure 2: Expanding on the Frame Game Concept (Thiagarajan & Stolovitch 1979)

We had envisioned that the script used in 'Cost Driver', teaching accounting concepts through light comedic dialogues, could be swapped out easily for another script based on entirely different educational content. While this would be the main differentiator, several other assets could be modified to reinforce a new theme, from the in-car audio files to the imagery of billboard advertising. Still, replacing the script did not resolve the issues found within this clash of fast and slow game genres with the original structure. Another approach was to separate the extensive piece of written content, the dialogue script, and present it in a more complimentary structure such as the text-based game engine *Twine*. However, owing to the dialogic nature of the script being absent any descriptive prose, the process of engaging with it by text alone felt incomplete. The genre

incompatibility in the structure, alongside the tightly integrated educational and supporting content left us with a bespoke game that was costly and limited in future application. Our future work would plan for a game's structure and content to be better distinguished and operate in some form independently, before combining them, ideally forming the templating approach.

4. Future Expansion

The benefits of developing a city environment more customised to our locale is to provide a relatable background that could incorporate a variety of genres relevant to learning objectives. The literature has listed genres as diverse as Shooters, Action/Adventure, Fantasy/Role-Playing, Sports, Simulation, Puzzle and Quiz/Trivia games being relatable to specific learning techniques and activities (Rapeepisarn 2008, Silva 2020). A focus on the structure of genres with a standardised set of expectations will provide a more adaptable frame for incorporating content. Our previous development work has produced a variety of content that is reusable and understood in-house, such as the vehicle control system, and it is from systems like this that we can extract further value from our time. In isolation the driving games are not directly compatible with learning techniques as above but would still constitute an expected part of a broader educational game in the Action/Adventure genre. We continue to develop a first-person 'escape room' puzzle game using parts of the city as a thematic and lively backdrop, and development continues to envision a third genre, Simulation, that would have the player act as a city planner while viewing the environment from a bird's-eye perspective.

Going forward, we are still to finalise the templating approach, but we are taking steps to understand it better. We know that much of the difficulty emerged in our shift from 2D to 3D game design and it has required us to better focus our finite resources towards developing those assets which have the highest likelihood to be reusable across varying contexts. Before we can proceed with templating, we need solid games that demonstrate a more harmonious combination of contents and structure, working together to meet learning goals. To achieve this, we aim to build more traditional structures with an adherence to genre convention, while following a more manageable scope. If multiple genres can be constructed in this fashion, and validated through testing with learners, we could experiment in combining genres again and perhaps discover more original game designs. Until then, we will continue building dependable structures, forming recognisable genres, and working with a variety of educational content until we find that winning combination to act as our exemplar game template.

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A Serious Game for the Digital Transformation of Organizations

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Abstract: To aid human resource management professionals design a configuration of human resource management practices that facilitates the employee behaviour needed for the digital transformation, a serious game was created. The serious game challenges human resource management professionals to combine and design human resource management practices that align to the organizational strategy and optimize employee digital transformation behaviour over multiple simulated years. In this paper, the underlying rationale, design, and outcomes of the first test rounds of the game are presented. Organizational change shaped by the diffusion of technology is labelled the digital transformation (Hanelt *et al.,* 2021). Employees can accelerate or slow down the digital transformation. Hence, organizations are looking to facilitate digital transformation enhancing employee behaviours: adaptive performance and proactive agility behaviour (Collou and Bruinsma, 2022). Aligned human resource management configurations (i.e., combination of human resource management practices such as recruitment, selection, and job design) can shape that employee behaviour (Gratton and Truss, 2003; Delery and Doty, 1996). Designing such a human resource management configuration however is challenging. There are many human resource management practices that need to be designed over multiple years and effects on employee behaviour vary. Serious games are well suited tools to enhance understanding of challenges such as strategic human resource management design. They allow professionals to experiment with choices and gauge the outcomes of their selection without the need to test these decisions in real life. Prior work (Collou and Bruinsma, 2022, 2019) illustrated that a serious game can aid human resource management professionals in their quest to design human resource management configurations that align to the organizational strategy. In the current game an additional challenge was added: shaping digital transformation behaviour. Tested in multiple rounds the game shows great promise for professionals and students to experiment with human resource management configuration design. First evaluations illustrate that responders are positive in terms of their learning experience. Balancing the need to align the human resource management configuration and affecting the employee behaviour simultaneously has proven to be challenging for players of the game. Future steps are focused on this balance and empirically validating the serious game.

Key words: Strategic HRM, Digital Transformation, Serious Game

1. Introduction

In the current paper, the underlying rationale, design, and outcomes of the first test rounds of a serious game on shaping the digital transformation through human resource management (HRM) is presented. A serious game is a game in which education is the goal, rather than entertainment (Michael and Chen, 2006). How and why HRM is pivotal in shaping the digital transformation is detailed first. The building blocks of the serious game DTInLine are presented secondly. Thirdly, the flow and actual design of DTInLine, including evaluation and testing, are presented. The paper is concluded by elaborating upon the current state and future steps of DTInLine.

Organizations increasingly combine innovative technologies such as artificial intelligence (AI), augmented reality (AR), and far-reaching robotization. These technologies significantly affect the way these companies operate (Vial, 2019). The organizational changes shaped by the diffusion of these technologies is labelled the digital transformation (DT) (Hanelt *et al.,* 2021). The DT deviates from other organizational change due to (1) the malleable and combinatorial characteristics of the technologies; (2) the open technical infrastructure; and (3) the potential for changes of value propositions (Hanelt *et al.,* 2021). As organizations set out to reap the benefits of the DT however, significant challenges emerge.

One of the most important challenges that organizations face is shaping the employee behaviour needed to truly benefit from the DT. Employees can accelerate or slow down the DT trough their behaviour. Employees can, on the one hand for example, embrace new technology and shape it so the technology aids employees in their work towards organizational goals. On the other hand, employees can resist innovation and refuse to use specific technologies hindering the DT progress made within an organization. Shaping specific employee behaviour is a daunting task. HRM, defined as all management decisions and actions that affect the nature of the relationship between the organization and employees (Beer *et al.,* 1984), is the organizational domain that is concerned with shaping employee behaviour. If HRM is designed and implemented effectively, the employee behaviour needed

to truly reap the benefits of the DT is shaped and facilitated. Hence, HRM is the domain that managers call upon to shape the employee behaviour needed for the DT.

While a vast body of research demonstrates a positive relationship between HRM and organizational performance though affecting employee behaviour (Schuler and Jackson, 1987, Jiang *et al.,* 2012), the specific details of how HRM can be designed to shape particular employee behaviour is lacking. According to literature, employee behaviour is shaped through the design and implementation of a set of HR-practices (i.e., HR-configuration). However, designing an effective HR-configuration to shape the specific employee behaviour needed is a challenge. First, the HR-practices that make up an HR-configuration ought to exactly reflect the organizational strategy (Gratton and Truss, 2003). In particular, an HR-configuration should deviate from the 'ideal type' HR-configuration (i.e., theoretically effective HR configuration given a specific strategy) exactly proportional to the extent to which the organizations' strategy deviates from the ideal type strategy (Delery and Doty, 1996). Secondly, there is no consensus on which specific HR-practices need to be combined (Boon, Den Hartog, and Lepak, 2019). Thirdly, how to design those HR-practices to achieve synergistic effects is unclear (Chadwick, 2010). Fourthly, equifinality is said to occur; the same employee behaviour may be reached from different initial conditions (Delery and Doty, 1996) using different combinations of HR-practices. As a result, HR-professionals and managers are left empty handed in their quest to design a HR-configuration that effectively shapes DT employee behaviour.

Prior work on the design and validation of the serious game InLine (Collou, 2020) has illustrated that the creation and use of a serious game has great potential to address the above-mentioned HR-configuration challenges and truly aid HR-professionals in their quest to design employee behaviour shaping HR. Not only does a serious game enable the specification of the dynamics of HR-configuration design, the element of fun inherent to games is used to challenge and invite HR-professionals to experiment with HR-decisions and gauge their outcomes. While prior work on the serious game InLine has proven to be fruitful, it does not address how to shape the specific employee behaviour needed for the DT, which has become increasingly important. As organizations are looking to reap the benefits of the DT, and the DT gives rise to the need for particular employee behaviours, creating a serious game tailored to the DT is increasingly opportune and valuable.

In the following we detail the specific buildings blocks that enable the design of DTInLine, a serious game on shaping the digital transformation through HRM. After detailing the building blocks, the design and flow of the game are presented. The paper is concluded by detailing how DTInLine is evaluated, and a description of the subsequent research steps.

2. DTInLine: Building Blocks for a Serious Game

The building blocks of a serious game compromise the most important (theoretical) elements that are included in the game. Here, the building blocks are the specific employee behaviour needed, shaping that behaviour through aligned HR-practices, and the dynamics with which it does (theoretical game model).

2.1 DT Employee Behaviour

The initial building block delineates the requisite employee behaviours for the DT. Organizations seek to cultivate these behaviours to fully leverage the benefits of DT. Derived from the perspectives of owners, managers, and employees in organizations undergoing DT, specific behaviours were identified. Findings indicate a focus on fostering adaptive performance and proactive agility among employees (Collou and Bruinsma, 2022). Employees need to maintain and even increase performance as DT technologies are combined. Through adaptive performance behaviour (Koopmans *et al.,* 2012), they can. Adaptivity involves flexibility, keeping job skills up to date, coping with uncertainty and adjusting to changes (Park and Park, 2019). In addition, organizations need employees to perceive opportunities and enact changes. By showing proactive agile behaviour (Doeze Jager, Born and van der Molen, 2021), they can. Proactive agile behaviours revolve around employees actively looking for new opportunities and following up on them, anticipating problems, and acting before they happen. Hence, adaptive performance and proactive agility behaviour are what (HR) professionals are looking to increase while playing DTInLine. They are labelled employee DT behaviour.

2.1.1 Strategy, HR-configuration and DT Behaviour: Alignment

The second building block details the alignment between the HR-configuration and the organizational strategy. A substantial body of literature suggests that such alignment significantly influences employee behaviour (Gratton and Truss, 2003; Delery and Doty, 1996; Schuler and Jackson, 1987). Therefore, alignment is an

important building block for the serious game at hand. This vertical alignment refers to the extent to which an HRM configuration is derived from and reflects the organizational strategy (Bowen and Ostroff, 2004; Macduffie, 1995). If it does, consistent messages are communicated increasing the clarity towards employees in terms of which behaviours are desired within the organization. To create DTInLine, this vertical alignment needs to be specified. A valid method with which organizational strategy can be assessed is the competing values framework (Cameron and Quinn, 2006; Collou, van Riemsdijk, and Bruinsma, 2018). Accordingly, the strategy of an organization can be assessed using four strategic quadrants: cooperative (strategic focus on teamwork), market (strategic focus om competition), mechanistic (strategic focus on efficiency), adhocratic (strategic focus on innovation). Similarly, the focus of an HR-configuration can be assessed using the same four strategic quadrants. Both the organizational strategy and the HR configuration at hand are provided with scores (0-100) on all four competing values strategy quadrants. The strategy score can be provided using the organizational culture assessment index (OCAI) questionnaire or using a fictive score for the game. The HR-configuration is gauged empirically, as detailed below.

A HR configuration is made up from individual HR-practices. For DTInLine, HR-practices were selected that are relevant for all organizations: recruitment, selection, job design, appraisal, compensation, development, and leadership. For these HR-practices, several design options are relevant. Development can, for example be focused on teamwork, or on individual innovativeness. To assess the extent to which these HR-practices and their individual designs align to the four strategic quadrants we use the outcomes of a prior study (Collou, Bruinsma, and van Riemsdijk, 2019); each HR-practice is assigned a score (0-100) on all four strategic quadrants by the HR-professionals. This score illustrates the extent to which that specific HR-practices aligns to the four strategic quadrants. To capture the variety in design possibilities within one HR-practice and allow for the assessment between the HR-practices and the organizational strategic quadrants, four possible designs for each HR-practice are defined. Hence, a total of (7 x 4) 28 HR-practices are used in the serious game DT-InLine. One example of the four designs options of an HR-practice: selection of new employees can be based on either (1) attraction of new customers which aligns to the market strategy, or (2) their versatility which aligns to the cooperative strategy, or (3) their innovative capabilities which aligns to the adhocratic strategy, or (4) their accuracy which aligns to the mechanistic strategy. The four designs of every individual HR-practice, that in turn all have an individual score on every strategic quadrant, allows the assessment of alignment between the HR-configuration (using the average of those HR-practices selected by players) and the strategy (see table 1).

Table 1: Vertical alignment example scores.

	Cooperative	Market	Mechanistic	Adhocratic
Strategy	30	30	30	10
HR configuration	50	20	10	20
Difference	20	10	20	10
Alignment score	(20+10+20+10) = 60			

However, as DTInLine challenges (HR) professionals to increase the DT-behaviour an additional score is needed; the extent to which the specific HR-practice designs affect the DT behaviour. Again, the solidified knowledge of (HR) professionals was collected to detail these scores. These DT behaviour scores are based on a survey distributed amongst (HR) professionals (N=47). Specifically, HR-professionals were asked to assign a 1 (low) to 5 (high) score illustrating the effect of all 28 HR-practices on DT employee behaviour. Table 2 illustrates one HR-practice and the scores used for both strategy and DT behaviour.

Table 2: HR-practice including quadrant and DT behaviour scores.

	Cooperative	Market	Mechanistic	Adhocratic	DT Behaviour
The most important characteristic of job design is that employees need to solve complex problems	23,46	43,56	23,08	9,00	3,87

2.1.2 Effects of the HR-configuration on Employee Behaviour: Theoretical Model

As the needed employee DT behaviour and methods with which (i.e., HR-practices) to facilitate that behaviour is depicted, the dynamics of how DT behaviour comes about needs to be specified. A theoretical model is needed that details how the effects of (changing) HR-practices on the behaviour of employees plays out. Hence, the final building block of the serious game DTInLine is the theoretical model that details how employee DT behaviour is achieved through HR. The theoretical model used for DTInLine describes how changes in the selected HR-practices affects the employee behaviour through alignment. The variables in the model are employee DT behaviour, the organizational strategy, the HR-configuration, and the vertical alignment between the latter two. In the figure, all these variables are defined at two points in time (T0, T1) to illustrate the changes over time. The variable 'redesign of the HR-configuration' (selecting and implementing new HR-practices to affect the employee behaviour), which explains the differences between T0 and T1, and the dynamics that detail the order in which it does, are included in the model. See figure 1.

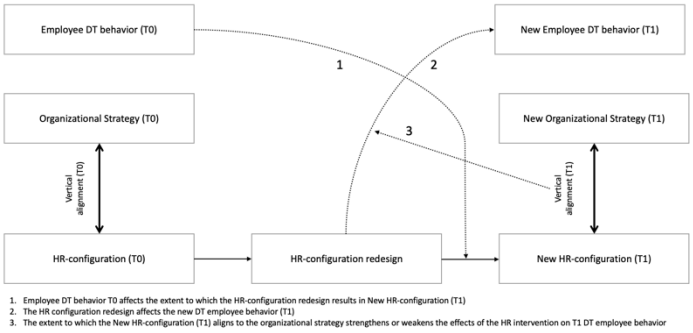


Figure 1: Theoretical model serious game DT-InLine

The following steps are depicted by the theoretical model: a T0 level of employee DT behaviour, current organizational strategy, and current HR-configuration are presented. To subsequently optimize the employee DT behaviour, a HR-configuration redesign is initiated. Professionals redesign the HR-configuration (T0) aiming to shape employee DT behaviour and optimize vertical alignment. The HR-configuration redesign results in a new HR-configuration (T1). The extent to which the redesign is effective (T1) is affected by the DT behaviour (T0). If employees are adaptative and proactive (DT employee behaviour), the redesign is more effective; employees are open to change. If the employee DT behaviour (T0) is low, employees are more resistant to change and dampen the redesign (*arrow 1*). Subsequently, the extent to which the new HR-configuration (T1) and the organizational strategy (T1) align is depicted. In turn, the HR-configuration redesign has direct effects on employee DT behaviour (T1), *arrow 2*. This is affected by the new vertical alignment (T1), *arrow 3*: If the new HR-configuration aligns to the organizational strategy (T1) employees will perceive the redesign as consistent and accept the change. Finally, the new (T1) variables serve as starting point for detailing T2; the model can be applied to continuously illustrate the effects of HR-configuration redesign (T0, T1, T2, T3…).

The building blocks described above allow the creation of DTInLine. The actual design, flow and evaluation of the game is presented below.

2.2 DTInLine: Design and Flow of the Game

The gameboard, HR-practice cards and HR manual used during the game are presented first after which the flow of the game, and how the game is evaluated, is depicted.

2.2.1 Gameboard, HR-practice Cards, HR Manual

At the start of a DTInLine session players are introduced to the organization for which they will design an HR configuration, striving to enhance the DT employee behaviour. The gameboard (figure 2) provides players with the information they need to play the game. First, the organizational strategy to which their HR configuration ought to align is depicted on the gameboard in the top right corner ('organizational strategy). Second, below the organizational strategy, is a designated area ('HR configuration') for players to lay down their HR-configuration (selection of cards to be implemented during the year). All optional HR practice cards are presented on the left side of the gameboard ('HR categories'), players can go through these options and select those HR-practices they want to see implemented. The centre of the board represents the two goals that players strive for: the

current FIT score, which is the vertical alignment score, and the DT employee behaviour score. After each round, players adjust these scores illustrating the current FIT and DT employee behaviour.

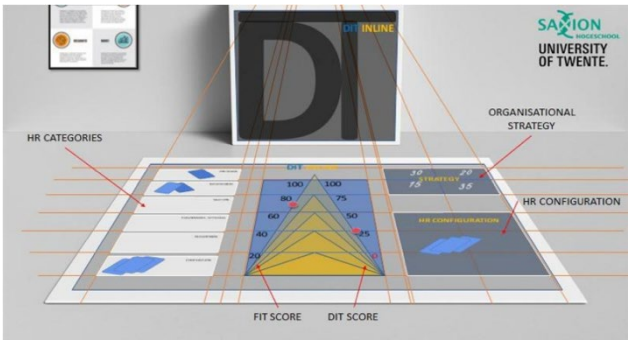


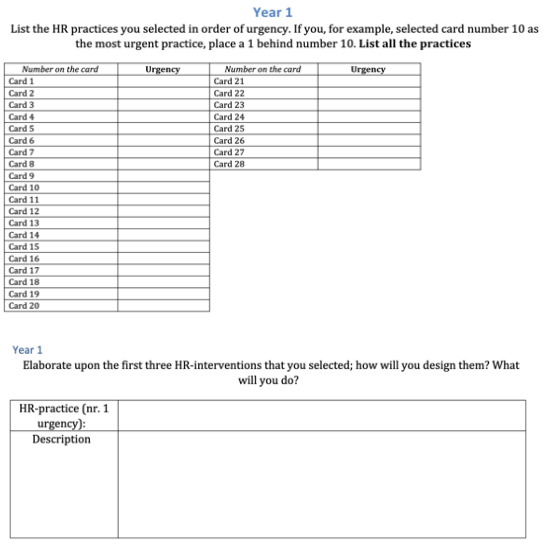
Figure 2: DTInLine gameboard

The HR-practices that players can select are presented to player by the means of play cards. Figure 3 depicts a sample of the play cards used for DTInLine. During the game sessions players shift through these cards selecting those they deem effective in terms of alignment to the organizational strategy and enhancing DT employee behaviour.



Figure 3: Sample play cards.

Finally, as players make their selection of HR-practices they document and detail the HR-practices selected in a HR manual. The manual is made up by two tables. One allows players to select and prioritize HR-practices, one allows players to detail the HR-practices selected. See figure 4.



Year 1

List the HR practices you selected in order of urgency. If you, for example, selected card number 10 as the most urgent practice, place a 1 behind number 10. **List all the practices**

Number on the card	**Urgency**	*Number on the card*	**Urgency**
Card 1		Card 21	
Card 2		Card 22	
Card 3		Card 23	
Card 4		Card 24	
Card 5		Card 25	
Card 6		Card 26	
Card 7		Card 27	
Card 8		Card 28	
Card 9			
Card 10			
Card 11			
Card 12			
Card 13			
Card 14			
Card 15			
Card 16			
Card 17			
Card 18			
Card 19			
Card 20			

Year 1

Elaborate upon the first three HR-interventions that you selected; how will you design them? What will you do?

HR-practice (nr. 1 urgency):	
Description	

Figure 4: HR-manual: HR-practices selection (left) and specification of HR-practices (right)

2.2.2 Flow of the Game

DTInLine represents the key mechanisms relevant for professionals that set out to align the HR practices to the organizational strategy and affect DT behaviours, without being challenged by too much detail (Tsjernikova, 2009). Players are divided into teams of up to six professionals and play two to three rounds (e.g., years) of DTInLine sitting around the gameboard. During a game session players go through the following steps.

1. **Step 0:** players are introduced to the organization that they need to select and design HR practices for. This introduction includes a specification of the competing values strategy of the organization that the HR activities need to be aligned to, and an introduction of the CEO in which the need for DT behaviour is made explicit and urgent.
2. **Step 1:** Once the players are familiar with the organization they start selecting HR practices out of the list of 28 HR practices as a team.
3. **Step 2:** After discussing and comparing the selection made between groups plenary, supervised by a game host, players are challenged to prioritize their list of HR practices.
4. **Step 3:** Subsequently players are challenged to specify to a practical level of detail what they will start doing in terms of the selected HR practices.
5. **Step 4:** The final step in a round constitutes the evaluation of their HR practice selection based on the outcomes in terms of DT behaviours and alignment. See figure 5.

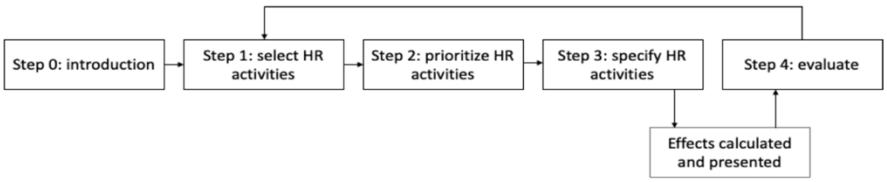


Figure 5: steps (flow) of a DTInLine game session.

Game sessions are finalized by reflecting on the HR practices selected during the years, how these practices changed and a reflection of the systematic manner with which players focused on attaining an increase in DIT and alignment scores, all hosted by a game master.

2.2.3 Evaluations of the Serious Game DTInLine

As players interact with DTInLine, their experiences provide valuable input to improve the serious game. Furthermore, setting out to create a serious game that allows (HR) professionals to experiment and gauge the effects of HR decisions necessitates an evaluation to assess if the serious game actually does. Hence, the game DTInLine evaluated. The focus of DTInline is creating a learning experiment, the extent to which players value their learning experience is therefore vital. Hence, a quantitative approach is used to evaluate DTInLine. At the end of gaming sessions, players are asked to fill out a questionnaire.

The questionnaire consists of a total of items on the topics perceived learning effectiveness, functional fidelity, and satisfaction of the learners. Learning outcomes revolve around the extent to which respondents perceive that they learn by playing DTInLine and the extent to which that learning is effective (perceived learning effectiveness). Functional fidelity refers to the degree of realism within the level of content and functional mechanics and inner workings (Hays and Singer, 1989) of, in this case, DTInLine. Satisfaction of learners (Chou and Liu, 2005) relates to the extent to which learners are satisfied with the learning experience that DTInLine provides. See appendix 1 for the complete questionnaire.

Preliminary outcomes of the first test workshops done with students business administration and HRM (n=37, 3 workshops) illustrate that students evaluated DTInline positively. On the learning outcomes items (for example *I have learned in terms of selecting HR-practices that fir the strategy*, or *by practicing with DT-InLine I discovered errors that I was previously unaware of*) scores ranged between neutral and agree (or learned somewhat and learned quite a lot) with an average score of 3.31 (scale 1 – 5). In terms of satisfaction with the learning experience (for example *I am satisfied with the learning experience I gained from DT-InLine*) the average score of students was between neutral and agree with an average score of 3.98. In addition to the survey students were asked to prove feedback on the game after the session. Students described the DTInLine as fun, an intuitive and quick way to discuss HR content, and as a competitive enjoyable game. When asked what the most significant challenge was students stated that the time taken during the workshop for an introduction in the OCAI framework was limited, similarly students would like more time to select HR-practices during a workshop. Furthermore, the effects of their decisions on HR alignment and employee DT behaviour were perceived as small in the first year. Finally, some students stated that it was a challenge to focus both on selecting HR-practices that match the organizational strategy and increase DT behaviour.

3. Conclusion & Discussion: Evaluations and Future Research

The design and first tests of the serious game DTInLine were presented in this paper. Now, concluding remarks are presented including opportunities for HR practice, research, and education. The paper is concluded by detailing the next steps in the development of DTInLine.

3.1 Concluding Remarks

Similar to prior work on the design and validation of the serious game InLine (Collou, 2020), DTInLine has the potential to enable HR-professionals to experiment with HR decisions and gauge their effects on employee behaviour. By focussing on DT employee behaviour, DTInLine is tailored to those organizations that aim to embrace the opportunities of the DT. Facilitating specific employee behaviour, however, is a complex challenge in which multiple variables can affect the outcomes. DTInLine is designed with a focus on functional fidelity; the fundamental choices and underlying mechanics of how HR-practices contribute to the shaping of employee behaviour is depicted in the serious game. By playing, (HR) professionals are invited to learn which and how HR-practices shape employee behaviour without being overloaded with all details that come into play when shaping employee behaviour.

As such, DTInLine holds great educational potential. InLine allows players to directly witness the consequences of their decisions in relation to alignment and DT behaviour, empowering them to infer the real-world operational dynamics and thereby preparing them for real-world HR challenges. Thus, it holds promise as a valuable resource for educational purposes in configurational HRM at multiple educational levels.

Furthermore, DTInLine facilitates the study of configurational HRM. Firstly, by requiring HR professionals to evaluate the alignment of individual HR practices with four distinct strategies DTInLine adds a layer of detail and specification that enriches the examination of configurational HRM. Analysing whether a set of HR practices theoretically aligned with a particular organizational strategy is indeed aligned according to HR professionals allows for an initial test of configurational HRM. Secondly, DTInLine serves as a valuable tool for scrutinizing decision-making processes and observing player (HR-professionals) behaviour. By documenting the decisions made by HR professionals over multiple iterations, we can evaluate the practical applicability of configurational HRM.

3.2 Future Steps

DTInLine shows promise both as a research tool for studying configurational HRM and DT, and as a learning tool for HRM design. DTInline allows players to engage in hands-on experimentation with HRM concepts in a fun and interactive way. Next important steps in the development of DTInLine revolve around balancing, optimizing and validating DTnLine. During the test rounds, players have expressed that they were challenged by their focus needed on both HR alignment to strategy and employee DT behaviour, and the extent to which their decisions affected both. Hence, in follow up workshops the underlying (theoretical model) mechanics will be rearranged to allow for a somewhat more significant impact from the selected HR-practices on both the alignment and the employee DT behaviour score. This will provide a more wholesome reward for players selecting effective HR-practices and incentives a thorough selection in the next years. In addition, given the feedback collected thus far, more time will be allocated during the DTInLine game sessions for a elaboration on the OCAI framework.

Finally, as DTInLine is optimized through redesign based upon the feedback provided during the game sessions, validation needs to be undertaken in practice. DTInline provides specific outcomes in terms of HR and strategy alignment, and employee DT behaviour, over multiple years. These outcomes can be validated empirically by assessing changes in alignment and employee DT behaviour in practice. Based on this validation the simulation model can be specified. Furthermore, the actual transfer of knowledge and skills from DT-InLine to a real-world setting can be assessed. The extent to which the transfer of alignment and employee DT behaviour knowledge from the game to actual organization specific HRM design takes place, has not been verified yet.

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Appendix 1. Evaluation survey

	I have learned in term of...	**Learned nothing**	**Learned a little**	**Learned somewhat**	**Learned quite a lot**	**Learned a tremendous amount**
4	Selecting HR practices that fit the strategy					
5	Selecting HR practices that improve employee DT behavior					
6	Combining HR practices that fit together					
7	Detailing HR practices					
8	The multi-year design of HR practices					
9	Reflecting on the outcomes of HR practices					
10	Adjusting HR practices					

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
11	During DT-InLine it was possible for me to connect new knowledge and insights with my previously acquired knowledge and insights					
12	By practicing with DT-InLine I discovered errors that I was previously unaware of					
13	Practicing with DT-InLine makes it easier for me to perform my job (not for students)					
14	I find DT-InLine useful for my performance as a professional in my work (not for students)					
15	Using DT-InLine allows me to work more effectively in the real world					
16	Thanks to DT-InLine, I am better able to understand the dynamics between HR and the digital transformation					

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
17	The decisions I make during the DT-InLine workshop correspond with the practice of HR (not for students)					
18	The complexity of aligning HR with the company's strategy and the desired DT behavior of employees is represented by DT-InLine (not for students)					
19	The results presented during DT-InLine are realistic (not for students)					

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
20	DT-InLine is fun					
21	I am satisfied with the learning experience I gained from DT-InLine					
22	Overall, I think DT-InLine is good for practice					

Exploring Mars: An Immersive Survival Game for Planetary Education

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Abstract: Designing educational games can be challenging as fostering academic engagement requires the learning outcomes to be encoded in the game mechanic. Many games that are intended to be educational do not successfully provide this integration and the resulting product can be boring, fail to deliver the learning outcomes, or present the user with periodic interruptions in flow. The aim of this work was to investigate how to design an engaging and effective educational game that teaches the player about planets and their environments. 'Exploring Mars' was designed and built to harbour a player's intrinsic motivation to engage in enquiry-based learning through storytelling in a graphically rich environment with an Artificial Intelligence Non-Player Character (AI NPC). The aim of the NPC is to lead the player through a series of challenges, the solutions to which require them to investigate the planetary environment. In the game, the player assumes the role of an astronaut who has been inadvertently left behind on Mars by their crew following a severe dust storm. The objectives of the game are for the player to navigate the Martian terrain and discover and use essentials —oxygen, food, and energy sources— required for them to survive the Martian environment. The game environment was crafted using Unreal Engine 5 and provides an immersive, visually compelling representation of Mars which is rich in information content. Accompanying sound effects and audio dialogue with the NPC aims to further enhance engagement. The game was evaluated qualitatively through observations and interviews with adult players. Results confirmed that the game's intrinsic gameplay mechanics and immersive environment were successful in imparting the game's learning objectives. Areas for improvement were identified, but the game successfully demonstrates how enquiry-based learning can be fostered through a rich graphical environment that provides the setting for a compelling storyline, with learning scaffolded by AI. The success of the game suggests it could be extended to other planets and used by learners of different ages.

Keywords: Educational game, AI Supported Learning, Enquiry-based Learning, AI Scaffolding, Learning Through Storytelling

1. Introduction

Planetary exploration, and Mars in particular, have fascinated people for hundreds of years and many video games have taken advantage of this, including Surviving Mars, The Technomancer, and Tharsis (Valve, 2024). All of these, however, are designed primarily for entertainment, neglecting the potential to provide an educational experience. A key challenge of educational game development is ensuring that the game is as interesting and engaging as possible whilst effectively integrating its educational components. A high level of engagement by the learner is necessary to provide an effective learning environment (Kalmpourtzis, 2018, p.31) and many do not offer an entertainment experience comparable to that of conventional entertainment video games (Dele-Ajayi et al., 2016). The aim of this work was to create a gamified depiction of Mars, in an educational context, allowing players to experience and learn about the challenges of surviving on the red planet.

2. Background

Intrinsic motivation to learn utilises a player's inherent interest in engaging with the learning activity. It is enhanced through feeling a sense of *autonomy*, *relatedness*, and *competence* (Ryan and Deci, 2000). Autonomy concerns a sense of volition when doing a task; relatedness refers to a player's sense of connection with others and competence relates to feeling capable and effective.

Many game elements can fulfil these factors (Ryan, Rigby and Przybylski, 2006). Open worlds that feel real and aesthetically pleasing facilitate presence (Ryan and Deci, 2017). The incorporation of life-like elements can stimulate enquiry, further developing qualitative understanding (Wang et al., 2018) thus promoting autonomy. Relatedness can be experienced through interactions with others in the game world and advancements in AI now provide for non-playable characters (NPCs) which can participate in meaningful dialogue and display complex emotional reactions (Karaca, Derias and Sarsar, 2024). Ryan and Deci (2017) argue that interactions with NPCs, can promote relatedness, with higher interactivity corresponding to increased relatedness. Competence is enhanced through intuitive controls and environments that provide a balance of challenges that align with the player's growing abilities, enabling a feeling of accomplishment and control (Ryan, Rigby and Przybylski, 2006).

Providing a player with the optimal level of challenge for their skills can lead to flow (Csikszentmihalyi, 1990). Flow motivates individuals to carry out further (learning) activities and increases performance (Engeser and Rheinberg, 2008; Habgood and Ainsworth, 2011). The addition of narrative can further enhance immersion for learners (Jemmali et al., 2018) and motivate learners to initiate and persist in game play, whilst providing scaffolding for problem solving during the game (Adams et al., 2012). However, whilst games can inherently promote flow, traditional educational software often uses games as extrinsic motivators (Habgood and Ainsworth, 2011), where gameplay (and thus flow) is halted, requiring the answer to an educational question before proceeding (Kafai, 1996).

Designing serious games is therefore challenging as it requires integration of the learning outcomes with the game mechanic, with the latter driving intrinsic motivation to play the game (Al-Washmi et al., 2015). Consequently, many serious games fail to deliver their intended learning outcomes (Al-Washmi et al., 2014). Few studies have investigated the pedagogical effectiveness of serious games for planetary exploration and those that have, typically struggled to integrate educational content in a non-disruptive way.

3. Aims and Objectives

The aim of this work was to design, build, and evaluate an immersive and engaging game to teach about planetary exploration using narrative to facilitate enquiry-based learning. The aim was to incorporate constructivist learning, i.e., actively involving learners in constructing knowledge through a "learning-by-doing" situation (Youngblut, 1998). The primary learning objectives are shown in Table 1.

Table 1: Learning Objectives

LO1:	Describe the environment of Mars, namely its climate, terrain, and weather.
LO2:	Understand the hazards and difficulties associated with living on Mars and how these can be managed.
LO3:	Describe prominent technologies used for Mars Exploration.

The game was intended to be an open-world, survival game set on Mars, embodying learning content within the game mechanic to foster intrinsic motivation. Alone on the red planet, players must test their skills of survival and adaptability in a hostile and unforgiving environment. The key game objectives are shown in Table 2.

Table 2: Game Objectives

GO1:	*Exploration*	Allow the player to explore, gather information, and learn about the planet.
GO2:	*Martain Weather*	Simulate the harsh weather conditions of the red planet. The player will have to brave this desert world, its extreme temperatures, and sandstorms.
GO3:	*Health*	Allow the player to manage their oxygen levels, food, water, and body temperature.
GO4:	*Missions*	Provide the players with missions and the ability to conduct scientific research.

Players will construct knowledge through enquiry-based problem solving in the game. With this constructivist approach, players formulate hypotheses and test them through observation and experimentation (Pedaste et al., 2015). An AI-powered NPC, 'Cosmo', will act as a robotic helper, offering guided assistance and scaffolding to players throughout the game. This character, integral to the narrative, will engage players in direct conversation, providing instructions, posing story-driven questions and offering a channel for players to inquire and learn.

4. Methodology

A faithful Mars environment, with special consideration to its properties, atmosphere, and visual aesthetics was designed to naturally encourage players to assimilate information about the planet. The game was developed through Unreal Engine 5 (UE5), chiefly due to its exceptional graphical capabilities including photorealistic rendering (Pokorný and Zapletal, 2021).

The game was designed for players to progress via interconnected missions, with successful completion of one unlocking the next. The game was primarily programmed with Unreal Engine's Blueprint visual scripting language, as it allowed for faster prototyping and iteration, although some elements were coded with C++. In-game terrain was derived from high-resolution Mars satellite data (The University of Arizona, 2022). An AI NPC (Cosmo) was developed through a combination of technologies used to simulate conversational interactions

with the player. Dialogue generation and interaction capabilities were powered by the GPT API Turbo 3.5 model (OpenAI, 2023), enabling contextually appropriate and dynamic responses with minimal latency. Azure's Text-to-Speech (TTS) service (Microsoft, 2024) was employed to synthesize Cosmo's voice, with further UE5 processing applied in-game, and speech recognition is based on a high-performance inference of OpenAI's Whisper model (OpenAI, 2022; Treshchev, 2023), running locally.

The game was evaluated through player observations and interviews to determine gameplay experience, engagement and changes in knowledge from playing the game.

5. Game Design

5.1 Landscape Design

Creating the in-game terrain was an iterative process that involved experimenting with several methods. The initial landscape design used Unreal's Landmass plugin but proved too uniform. Terrain software, TerreSculptor was subsequently used to generate more complex and procedurally generated terrains. However, these failed to capture the geography of Mars. Therefore, the final landscape design was created through Digital Terrain Models (DTMs) produced through HiRISE (University of Arizona, 2022), a high-resolution camera orbiting Mars. Elevation data from three distinct Martian regions—'Landforms in Utopia Planitia', 'Youthful Crater and Ejecta', and the 'Grand Canyon of Gale Crater'—were amalgamated into a single, expansive heightmap. This composite heightmap was imported into UE5 and further refined including sculpting cliffs around the perimeter to serve as natural barriers, delineating clear boundaries for players to navigate within (Figure 1a). Following this, the sky, materials, 3D assets, and post-processes were configured, resulting in a visually immersive environment (Figure 1b).

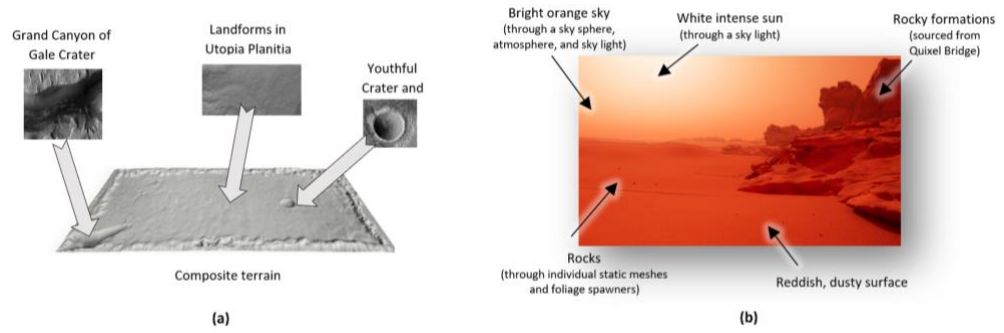


Figure 1: (a) Composite terrain produced through DTMs, (b) in-game perspective on the surface of the terrain

5.2 Character Design

Players can control their in-game astronaut character, through a first-person or third-person perspective. The game's controls are mapped to familiar schemes for either keyboard/mouse or controller input to ensure intuitive control, thus increasing the sense of *competence*. Careful consideration was given to seamlessly integrating the character into the world to create a 'learning-by-being-there' experience, promoting active learning through interaction, uncertainty and choice in the environment (Dengel and Mägdefrau, 2019, p.1). Environmental presentation and interaction (Figure 2) contribute to this. Haptic feedback through the controller aimed to enhance immersion and awareness of in-game surroundings (Söderström et al., 2022) and audio effects such as footsteps added to this. Fluid animations were implemented to convey the low gravity on Mars.

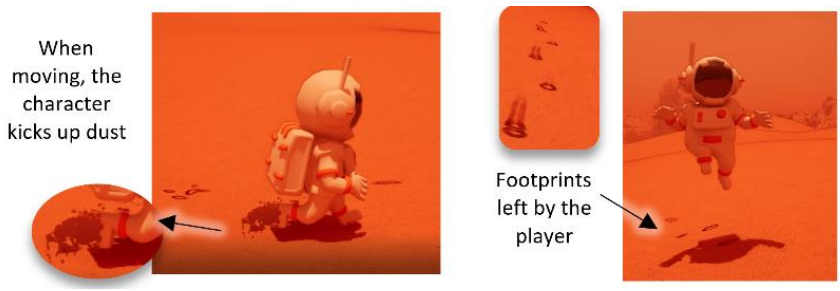


Figure 2: Player character and environmental interaction

5.3 Cosmo NPC Design

Cosmo is a form of chatbot aimed to foster a sense of *relatedness*. The educational benefits of chatbots are many, including keeping learners motivated, engaged and being able to provide immediate assistance and tailored information (Okonkwo and Ade-Ibijola, 2021). However, their use as an NPC in this context has only been briefly explored (Hollister, 2024).

Players communicate with Cosmo via their microphone or keyboard and can form a connection through personalised dialogue, effectively building a para-social relationship with the AI (Namburi and Hopkins, 2023). This can elicit emotion in the player which is key for engagement and learning (Gallego-Durán et al., 2019). Cosmo exhibits a range of facial expressions aimed to make it appear more 'life-like' and relatable, and thus more likely to create the illusion that the NPC is 'alive' in some sense (Lim et al., 2012). Moreover, providing the player with volition to dictate their dialogue to Cosmo enhances their sense of *autonomy*, as they can direct the conversation according to their interests, shaping their own learning experience. Cosmo is also equipped with hard-coded responses that are triggered by specific events within the game, ensuring that essential narrative elements are delivered. For instance, Figure 3 illustrates Cosmo's programmed response through a custom Blueprint Node after a dust storm, querying the player's experience upon re-entering the base.

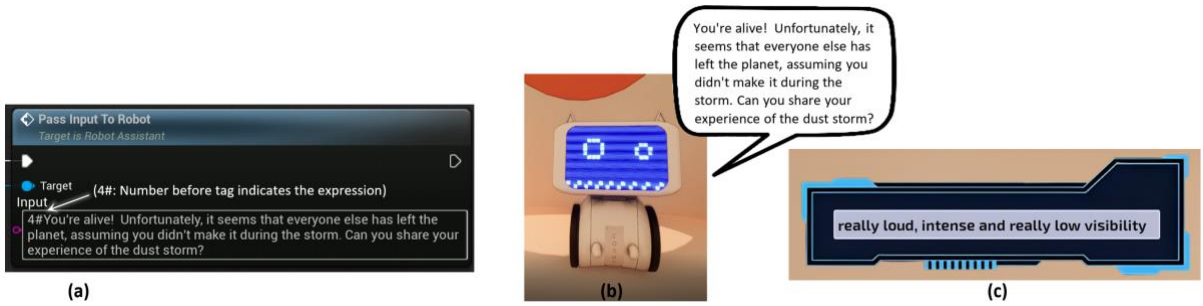


Figure 3: (a) Passing input to robot when the player reaches the base (custom text input, Fig 5), (b) robot talking to the player (with surprised expression) (c) exemplar player response through their keyboard in the chat box

Importantly, Cosmo provides feedback to the user (Gallego-Durán et al., 2019) indicating when an input is being processed, ensuring visibility of system status (Nielsen, 1994). Figure 4 provides a high-level flowchart of Cosmo's communication.

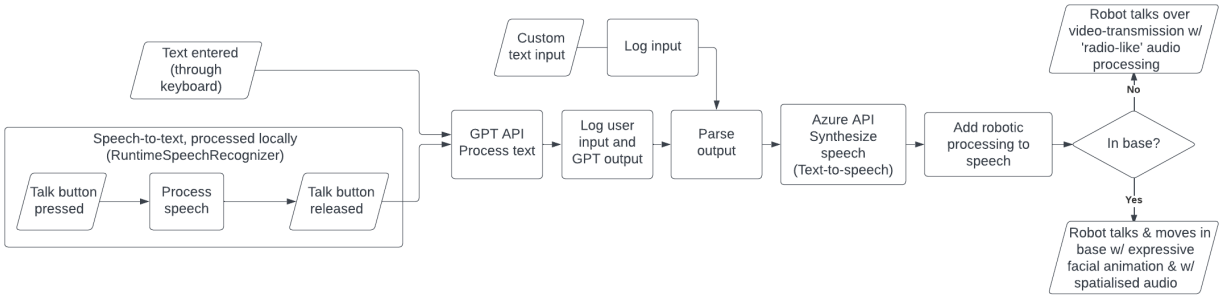


Figure 4: High-level flowchart detailing input/output for Cosmo

6. Gameplay Implementation

6.1 Prelude

A four-minute prelude creates the narrative for why the player is stranded on Mars. The player finds themselves caught in a dust storm, with an approaching dust cloud, including depictions of reduced sunlight, limited visibility, dust particles, and powerful winds. This serves as an attention-grabbing introduction to the game and introduces some of the game mechanics (Figure 5).



Figure 5: Annotated gameplay from the game prelude

The player is introduced to the 'scanner', which allows players to investigate and gather information about the environment. They are then directed to navigate through the storm and regroup with their crew who communicate to the player through synthesized audio 'voice-acting' generated through Replica Studios (2023). Drawing inspiration from the film 'The Martian' (2015), once the player nears the crew, a scripted event is triggered where a satellite dish rips free and hits the protagonist. Chatter can then be heard over the radio about the decision to leave the player behind, who witnesses the rocket taking off and leaving the planet. The screen fades to black as the dust storm has passed and the character picks themself up from the ground (Figure 6).

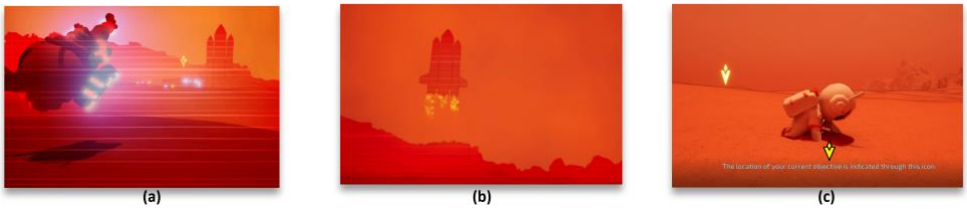


Figure 6: (a) Player's character colliding with a satellite dish and being "rag-dolled" backwards (visual, haptic and audio effects featured) (b) rocket leaving the player behind (c) character recovering after the storm

6.2 Stage One—Dust Storm and Oxygen

Given their low oxygen levels, the player needs to return to base (Figure 7) where they are greeted by Cosmo, who explains the character's in-game situation and asks about their experience during the storm. Cosmo discusses the environment, guiding the player to replenish their oxygen supply so that they may venture outside.

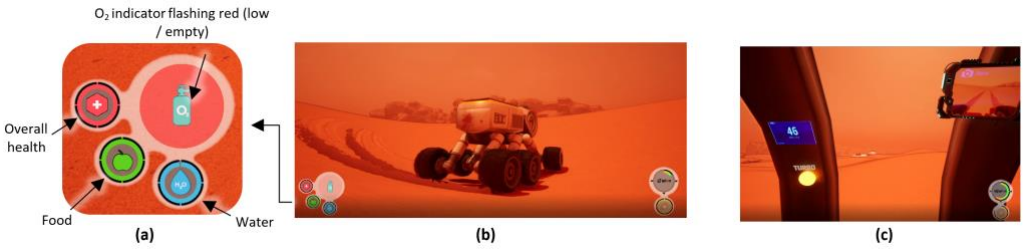


Figure 7: (a) Survival Essentials UI (b) third-person gameplay of the rover (c) first-person gameplay of the rover

6.3 Stage Two—Food

The game moves towards the topic of acquiring food through a structured enquiry-based learning activity (Zion and Mendelovici, 2012). The player is posed with an initial question: "You need food, what do you think would happen if we tried to grow plants outside in the Martian soil?" Following a discussion, the player utilises the scanner to investigate the composition of the soil, before reaching a conclusion (Figure 8). Cosmo then suggests checking inside the base for remaining food brought from Earth.

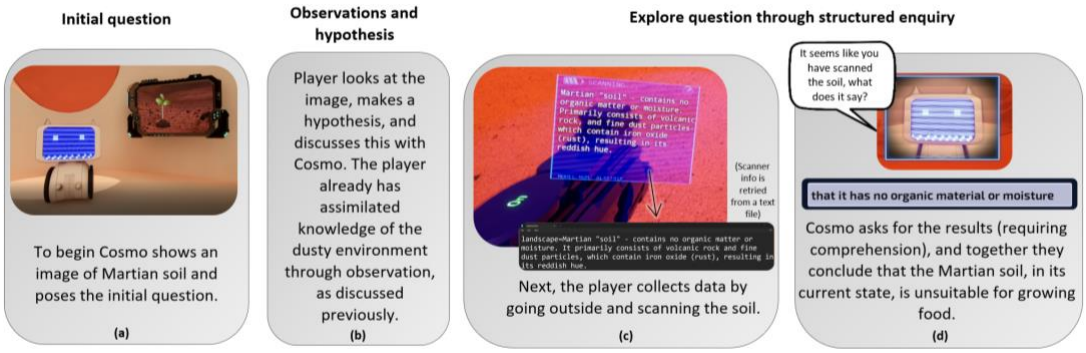


Figure 8 (a)-(d) Player following a structured enquiry

Pointing the scanner at objects predominantly relies upon a 'line-trace' to determine which object is being pointed at, and then retrieves the relevant information in a modular approach by reading it from a text file as shown in Figure 8(c). The scanner enables game progression, but it also empowers players to quell their curiosity and actively seek knowledge; encouraging self-driven exploration and discovery. Players are also encouraged to talk with Cosmo for any potential learning enquiries.

6.4 Stage Three—Energy

In attempting to access a room to check for food the player discovers a problem with the power source (Figure 9a). Cosmo prompts the user to consider where power is obtained on Mars, nudging the player's focus to recent events: "remember the dust storm and all those sand particles blowing around? Do you think they might have interfered with the solar panels?" This creates a meaningful connection to the player's earlier experience of the storm, setting up a logical bridge towards the dusty condition of the panels. The player now needs to locate the panels, determine the issue (the dust storm has covered the panels – Figure 9b), and report back to Cosmo.

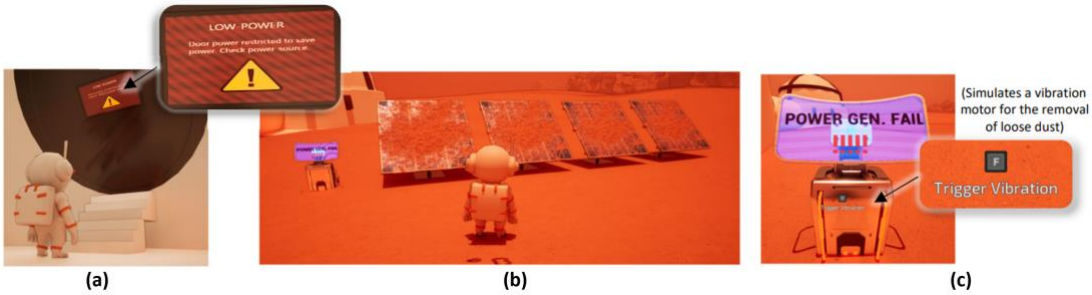


Figure 9: (a) Player encounters power-restricted area, (b) dust-covered solar panels, (c) control box displaying power generation problems

Once reported, Cosmo informs the player on how to clean the panels (Figure 9c) resulting in power generation visibly returning to normal. This scenario aims to result in 'meaningful play'; making relationships between actions and their outcomes discernible and integrated into the larger narrative of the game (Salen and Zimmerman, 2004, p.47). In this instance, the need to restore power connects directly to the survival of the player, thereby effectively integrating the learning process into the gameplay. The player is now able to access the room to replenish their food levels.

6.5 Stage Four—Underground Cave

The game narrative shifts towards exploration where the player is encouraged to venture into the underground cave with an open-ended and 'non-controlling instruction' to explore (Figure 10), capitalising on the player's desire for *autonomy*. Strategically positioned triggers activate Cosmo's communication over video transmissions. For example, on reaching the cave entrance, Cosmo informs players about the origins of the cave formations—products of ancient lava flows; serving not just as an informational tool, but as a companion in the cave, enhancing the player's sense of *relatedness*.

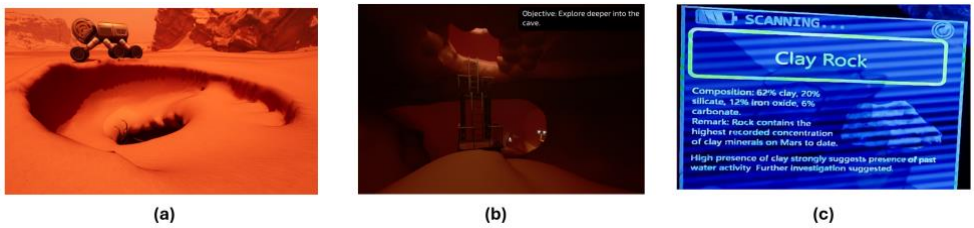


Figure 10: (a) The rover parked next to the crater leading to the cave, (b) the underground cave entrance, (c) example mineral being scanned by player

Eventually, as the player ventures deeper into the cave, Cosmo prompts the user to observe their environment and use a laser drill to 'dig' underground (Figure 11b). The discovery of an expansive subterranean deposit of frozen carbon dioxide and water ice leads to a discussion of the implications this might have for further colonisation efforts.

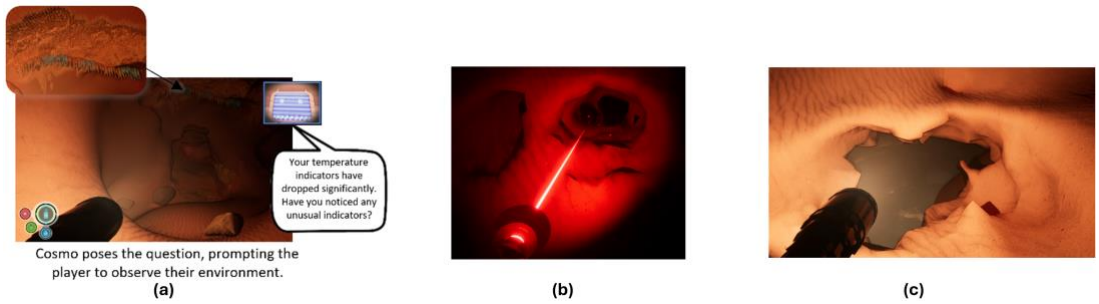


Figure 11: (a) Player's handheld torch illuminating the cave, (b) player's laser drill carving deeper into the ground, (c) hole created by the laser revealing water ice

7. Evaluation

Four Computer Science third-year undergraduates, all aged in their early 20s, were recruited using convenience sampling, for a preliminary evaluation (online and in-person) in October 2023. Players were observed playing the game. Pre- and post-interviews (10 minutes each) were conducted which asked participants questions related to each of the game's learning outcomes (LO1-3). Specifically, the interviews focused on participants' knowledge of the landscape, climate, terrain, gravity, potential hazards and technologies that have been used on Mars. Gameplay was recorded to observe player behaviour and understand levels of engagement with the game outcomes (GO1-4). Table 3 shows the findings in relation to learning outcomes.

Table 3: Degree to which the game Learning Objectives (LO) were met

Player	Pre-gameplay Knowledge	Observations	Post-gameplay Knowledge
A	Substantial understanding, able to correctly answer all pre-gameplay questions, covering each LO (1-3).	Played for 20 minutes. Complimented visual effects, and value of the game as an interactive learning tool for younger players or those less familiar with Mars. Found Cosmo entertaining.	Acknowledged discovering new information about Mars' terrain and atmosphere (LO1).
B	Some prior knowledge, some misconceptions for each LO.	Played for 40 minutes. Approved of visual effects. Stated the game helped correct/expand knowledge of Mars.	Knowledge around LO1 and LO2 greatly improved, less with LO3.
C	No prior knowledge of any LOs.	Played for 60 minutes. Described game as more engaging than reading about Mars, found Cosmo fascinating.	Increased knowledge around all LOs.
D	Many misconceptions about Mars (all LOs).	Played for 30 minutes before their system crashed.	Volunteered extensive feedback on what they had learned, indicating all LOs had been met.

7.1 Observations

Participants A, B and D showed approval of the game's visual presentation. Participant A complimented the game's atmosphere remarking on 'cool effects and lighting'. He 'liked the terrain backdrop', stating it was 'a bit bare' but that it 'reflects Mars well' (LO1). Participant D reported, 'I learned that there are lots of hilly surfaces as depicted […] I noticed this especially when walking at the beginning up lots of hills and it was a slow trek' (LO1), making reference to the game's prelude, but also suggesting a level of immersion. He noted to grow food, 'they may have to use something called hydroponics', but that he was 'not sure what that is' (LO2).

Participant A highlighted the experience with Cosmo as particularly entertaining and 'an engaging way to learn', with the Martian environment and graphics acting as a catalyst to stimulate enquiry, and Cosmo being reported as 'useful for answering questions about the environment' (LO1). The participant observed, 'no games really use that [AI NPC]', 'it'd be sick [sic] in games because it means expanded dialogue and storylines', highlighting the technology's potential benefits in increasing *relatedness.* Participant B commented, 'I was genuinely impressed by the Cosmo part and it works well with the educational aspect of the game'. He praised the relevancy and contextual nature of Cosmo's responses. He had much fun talking to Cosmo (Figure 12), humorously noting, 'I learnt that you can't get a TV signal on Mars' following a discussion on what astronauts can do for entertainment on Mars. He often asked whimsical questions about aliens and other topics, seemingly entertained by Cosmo's engaging (yet educational) responses.

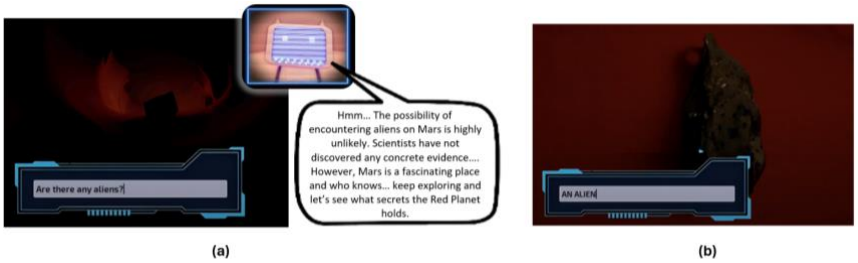


Figure 12: (a) The player enquiring if there are any aliens in the cave accompanied by Cosmo's response, (b) the player humorously claiming to have discovered an alien while examining an intriguing rock

It is evident Participant B also felt a sense of connection to Cosmo, often imbuing it with human-like qualities with phrases such as 'I'm coming' when heading back to base and bidding Cosmo farewell upon leaving. These underscored the player's immersion within the game but also suggested that the game effectively engaged the player's intrinsic need for *relatedness*. However, the participant's recall of educational content still had gaps; when questioned on the Mars InSight lander explained by Cosmo through the screen inside the base, he responded, 'I probably zoned out for that bit' (LO3). He added, 'the screen isn't really used for anything gameplay-wise so you don't look at it a whole lot', suggesting a lack of engagement with this element as it wasn't integrated directly into any mechanic or central narrative of the game. He did, however, praise the integrated learning content, 'I liked how it implemented the hunger/oxygen/water systems into what was actually needed to survive on Mars' (LO2) and he liked the scanning task with its conveyance of knowledge.

Participant C found Cosmo fascinating, impressive and repeatedly asked how it worked. He would have liked subtitles for Cosmo's dialogue to help him absorb information more effectively and minimise in-game distractions. Notably, at the end, he spent a considerable duration simply conversing with Cosmo; however, as the interactions progressed, he veered off topic, broaching topics extraneous to the Martian context, such as queries pertaining to Egypt. This highlights the need for refining Cosmo's design, introducing mechanisms to confine its responses within the game's thematic boundaries.

7.2 Summary

The learning outcomes were met to different extents by different participants. All demonstrated greater knowledge after the gameplay with respect to LO1, including participant A who had considerable prior knowledge. Participant B had increased knowledge around LO1/2, but less so with LO3 having 'zoned out'. Participants C and D both demonstrated increased knowledge around all LOs, post-gameplay. LOs were met not solely from explicitly designed educational components, but predominantly through engagement with the game's visual presentation and interaction with the game's environment. Players described their experiences with enthusiasm and conveyed details in a manner that suggested Mars was somewhere they had 'visited'.

8. Discussion

Exploring Mars provided an immersive, interactive, graphically-rich environment with an AI NPC that guided the players through a narrative motivating them to explore (GO1) and engage in missions (GO4) where they were able to gain knowledge about the Martian weather (GO2) and managing their own health needs (GO3).

During the evaluation, all participants provided evidence that the primary learning objectives of the game had been met, albeit to different extents, with detailed recollections of the environment, its challenges and their problem-solving experiences. Some had expressed surprise at the Martian environment with many preconceptions corrected through the gameplay (LO1). There were several comments regarding the hazards and difficulties of living on Mars and how these could be managed (LO2). There were also comments on technologies for Mars exploration (LO3), but less knowledge was gleaned about some of these such as the Mars InSight lander.

Designing for discovery is difficult. New content needs to scaffold onto already discovered content at a rate that keeps the player in a state of flow (Gallego-Durán et al., 2019). Intrinsic motivation to explore and engage with the learning outcomes was fostered by the AI NPC which engaged the players, imparting information to them and guiding them through the environment and narrative. *Relatedness* with this character was strong, with one player joking with the NPC and another moving on to ask about unrelated topics, which also demonstrated that player's sense of *autonomy*. Dialogue with the NPC was meaningful (Karaca, Derias and Sarsar, 2024), with players recalling situations and interactions with Cosmo, evidencing their feeling of *relatedness*. Players engaged with exploration of the Martian environment for a considerable period. One player stated they knew a lot about Mars, but still explored for 20 minutes. The others explored for longer, demonstrating their sense of *autonomy*. Players were scaffolded by Cosmo to solve problems. They overcame challenges demonstrating a sense of achievement and *competence*, having understood the reason behind challenges and how to overcome them. Their *competence* was enhanced further by the activities they were engaged in such as scanning and digging.

The graphically realistic environment with its audio and haptic feedback enhanced immersion. The addition of a game narrative and AI NPC which promoted constructivist, enquiry-based learning meant that players were intrinsically motivated to engage with the gameplay and hence the encoded learning outcomes. Their sense of *autonomy*, *competence* and *relatedness* was apparent from their reactions to the game and their comments regarding the knowledge they had gained demonstrated that the game had successfully imparted the learning outcomes. Intrinsic motivation had also maintained their state of flow while playing, which was particularly evident from one player who spent a considerable amount of time conversing with Cosmo.

9. Conclusion and Future Work

Overall, the game conveyed a realistic, immersive Martian environment which met the intended learning outcomes. Narrative, problem-solving and contextual enquiry were key to this. The use of an AI NPC significantly enhanced the narrative and engaged the player through relatedness whilst scaffolding their ability to gain competence and autonomy. The game intrinsically motivated players to engage in the learning content.

Future developments include extending the game to other planets and providing subtitles for Cosmo's dialogue to help players to focus and absorb information, enhancing inclusivity. A more comprehensive evaluation, including with children, needs to be done, but restricting Cosmo to relevant discussion topics would be important for safeguarding. The evaluation, whilst preliminary, has already shown a valuable contribution to the area of games-based learning through the development of an intrinsically motivating educational game. The aim of promoting constructivist, enquiry-based learning through narrative and scaffolding, utilising intrinsic motivation has been successfully met.

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Design of a Conversational Adventure app to Promote Argumentation in Science

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Abstract: Currently, the use of energy has become a socio-scientific issue characterized by its complexity, controversy, and direct impact on society, where science and technology play a crucial role. Such open-ended problems, without definitive answers, require active citizen participation in making informed decisions, respecting the values and rights of all individuals in society. In this context, schools must assume a social commitment. With the aim of promoting argumentation skills in science education regarding socio-scientific issues, a research project focused on the creation of video games is being carried out. This work presents the design of the conversational adventure 'Energy Island', conceived as a mobile application intended to enhance these skills. This video game transports participants to a fictional island, where they encounter various scenarios, such as a school, a town hall, a scientific research center, a market, a bank, and a recycling point. In each scenario, players must solve different challenges through interaction with various characters. These challenges range from actions for water conservation to decisions about building a nuclear power plant, recycling components of a photovoltaic panel, or finding a cure for respiratory problems derived from pollution. The ultimate goal of the game is for participants to make an informed decision about the most suitable energy source for the island, considering options such as wind, solar, nuclear, hydroelectric, biomass, or natural gas energy. In an initial testing phase, the video game was implemented with preservice secondary teachers at the University of Malaga (Spain) to identify the strengths and weaknesses of the application. These participants completed a satisfaction and usability questionnaire, evaluating aspects such as ease of gameplay, potential drawbacks, need for prior explanations, complexity, motivation, accessibility, and encountered difficulties, using a 5-point Likert scale (from "strongly disagree" to "strongly agree"). The application was generally well-received by the participants, who found it easy to use and did not perceive significant performance issues. However, it is suggested to provide additional resources to improve the user experience and maximize pedagogical use.

Keywords: Video Game, Conversational Adventure, Socio-scientific Issue, Energy, Argumentation, Decision-making.

1. Introduction

The relationship between science, technology, and society is undeniable, as scientific knowledge has significantly contributed to improving various aspects of daily life. This improvement is reflected in fields such as health, nutrition, or the development of new materials (Lusher et al, 2017; Van Heuvelen et al, 2020). This social dimension of science can begin to be addressed from an early age by presenting students with some socio-scientific issues (López-Fernández et al, 2021), that is, social problems with a strong scientific and technological foundation. These are open, complex, controversial, real, citizen-centric, unresolved, and without defined answers, which can be approached from different perspectives (Simonneaux, 2001; Zohar & Nemet, 2002; Sadler & Zeidler, 2005) and require active citizen participation to make reasoned decisions that respect the values and rights of all individuals in society (España & Prieto, 2009; Franco-Mariscal, 2024). Some examples of socio-scientific issues are related to the use of nuclear energy (Cruz-Lorite et al, 2023), the use of plastics (López-Fernández et al, 2022), or genetically modified foods (España-Ramos & Rueda, 2023).

In this context, the proposal of socio-scientific issues in the classroom plays a fundamental role in improving scientific and technological literacy and in the formation of citizens capable of making informed decisions that benefit society (Rahayu, 2019; Ke et al, 2021). Thus, students also learn to question, discuss aspects of science and technology, or make decisions, all of which can affect their lives and society in general (López-Fernández et al, 2021). The importance of scientific education is increasingly significant within a more democratic, informed, and empowered society, facing the major challenges that the technological world brings to new generations (Harlen, 2015; Forsthuber et al, 2012; Níston et al, 2019; Rocard et al, 2007; Tavares & Almeida, 2015).

Currently, energy and resource use have become a socio-scientific issue that is gaining increasing attention from citizens. Some examples include electricity prices, dependence on Russian gas caused by the war in Ukraine, or the European Union's recommendation to consider nuclear energy as clean energy. Another evidence is that the United Nations (2015) includes this issue as part of Sustainable Development Goal 7, which aims to ensure access to affordable, reliable, sustainable, and modern energy for all citizens. There is no doubt that the energy,

recognized as a core and unifying concept across all science disciplines and grade levels (Park & Liu, 2016), is of great educational interest as it promotes argumentation and informed decision-making, essential skills in critical thinking (Franco-Mariscal, 2024). Science education must raise awareness among new generations about the social and environmental problems associated with the generation and consumption of energy, encouraging the search for sustainable solutions to ensure a better future for our planet (Feinstein & Kirchgasler, 2015).

On the other hand, the use of educational video games has proven to be an effective tool for promoting critical thinking skills such as argumentation in science (Franco-Mariscal, 2024) and facilitating learning in subjects such as biology, physics, and chemistry. These video games provide an interactive and motivating environment that encourages active student participation in their own learning process. According to Tavares (2021), digital educational resources can contribute to learning in science education through the use of animations, games, simulations, or quizzes.

The growing demand and accessibility of mobile devices have led to an increase in the popularity of educational mobile applications worldwide, creating new opportunities for students to exploit the possibilities of these technologies (Chang et al, 2018; Kearney et al, 2020). Thus, most teachers use mobile applications with their students, not only to promote scientific knowledge but also to foster student guidance and engagement in the learning process, to (re)present scientific information, or to develop scientific attitudes (Tavares, 2021).

Educational research on the benefits of using mobile applications for science teaching has substantially proliferated in recent years (Kearney et al, 2020), leading to a growing number of projects dedicated to developing such applications for science learning purposes (Bano et al, 2018; Kyza & Georgiou, 2019).

One format of interest is the conversational adventure, a genre of video games in which the description of the situation in which the player finds themselves comes mainly from text. Interactive adventure games can facilitate vocabulary learning and the development of various language skills such as argumentation (Krashen, 2004). Additionally, they are well-received by students, maintaining positive attitudes towards this type of video game. Story-based conversational adventures also present significant benefits in science education. Humanizing science through the use of a story makes the subject more appealing to many students, promoting interest and motivation (Matthews, 2015; Klassen & Klassen 2014). Moreover, it has also been shown that conversational adventures have a positive effect on the acquisition of new science knowledge (Flynn & Hardman, 2019). Conversational adventure games, which include mini-games, enrich the experience. A single mini-game alone is not a sufficient experience to contextualize the student. A series of different mini-games incorporating various game modes and mechanics on a learning theme helps students assimilate new knowledge and mental models (Frazer et al, 2007).

This study presents the design of the *Energy Island* mobile application in conversational adventure format to develop argumentation skills in science teaching, as well as the evaluations carried out in a testing study by preservice secondary teachers at the University of Malaga (Spain).

2. Methodology

2.1 Conversational Adventure Design

Energy Island is an application designed for Android mobile devices and has been developed with the participation of a team consisting of researchers in science education (the authors of this work), a programmer, and a graphic designer. In the initial phase, the video game was developed as a prototype, i.e., without sound or animations, which would require the use of specialized tools for such tasks.

The game development engine (Game Engine) used was Unity, created by Unity Technology, which uses OpenGL for the Windows operating system, chosen for its versatility and ease of use. Unity allows for the creation of both 2D and 3D video games and requires basic programming knowledge.

The development environment for programming its components, functionalities, and mechanics incorporated into the video game was done using the C# programming language and PHP for connecting to the database that stores the learning outcomes of the participants. The images used were created by a graphic designer using the Sketchbook program. The target audience of the application, available for single-player use, includes future secondary school teachers and students at this educational level, as well as anyone interested in science and technology. The video game is set on an island that includes various scenarios such as a school, the town hall, a technological research center, the commercial zone, a bank, and a recycling point (Figure 1).



Figure 1: Game Setting of *Energy Island*

In each scenario, players must solve different challenges by interacting with various characters (Figure 2) or by solving mini-games (Figure 3). These challenges range from actions for water conservation to decisions about building a nuclear power plant, recycling components of a photovoltaic panel, or searching for a cure for respiratory problems derived from air pollution.



Figura 2. Conversation with the operator of the recycling point centre on *Energy Island*.

The final goal of the video game is for participants to make an informed decision about the most suitable energy source for the island, considering options such as wind energy, solar energy, nuclear energy, hydroelectric power, biomass energy, or natural gas.

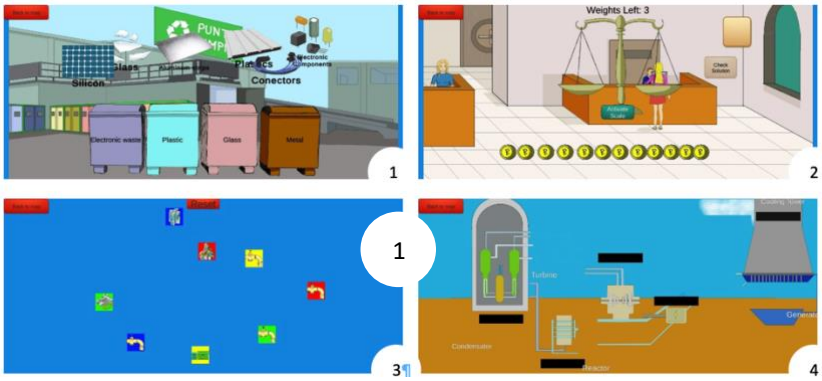


Figure 3: Some mini-games in Energy Island: 1: Mini-game about recycling components of a solar panel; 2: Mini-game about measuring the masses of different coins; 3: Mini-game about the geographical distribution of oil pipelines; 4: Mini-game about building a nuclear power plant.

2.2 Participants

This application is currently in the testing phase. The participants in the study were 29 preservice secondary teachers (82.8 % male, 13.8 % female, and 3.4 % preferred not to indicate) enrolled in the Master's Degree in

Secondary Education Teaching at the University of Malaga (Malaga, Spain) specializing in Technology, Computer Science, and Industrial Processes. Among them, based on their background training, there were industrial engineers, computer engineers, forestry engineers, chemical engineers, and architects. 44.8 % of the participants had used educational apps recommended by a teacher, 41.4 % had never used educational apps, 10.3 % had used them for leisure, and 3.5 % had used them with their teacher and also for leisure.

2.3 Implementation Plan

The Energy Island application is designed to be integrated into the curriculum of preservice teachers. The goal is to incorporate it into several class sessions over the course of a semester, complementing both theoretical and practical content of the subjects. This implementation will allow students to explore and apply scientific and didactic concepts in an interactive and dynamic environment, reinforcing their learning and fostering a deep understanding of the topics covered. At the beginning of the semester, the preservice secondary teachers were informed about the importance of argumentation in science education and received instruction in argumentation. Subsequently, various types of resources for science teaching were worked on in the classroom. Afterward, the students were introduced to the application and the socio-scientific issue presented. The preservice teachers had two weeks to use the application. Towards the end of the semester, participants engaged in a reflection session to discuss their experiences with the game. At the end of the semester, they completed the data collection instruments.

2.4 Data Collection Instruments

The data collection instrument was a questionnaire designed to assess the usability and satisfaction level of the video game by initial training teachers. This instrument was administered at the end of the game session, which lasted for 30 minutes, and consisted of 26 items (15 usability items and 11 satisfaction items) (Cebrián-Robles, 2015, p.101), which the student had to rate on a Likert scale from 1 to 5 points (1: strongly disagree, 2: somewhat disagree, 3: indifferent, 4: somewhat agree, and 5: strongly agree).

The validation of the questionnaire showed a reliability of 0.889, acceptably high, for evaluating educational platforms (Serrano-Angulo and Cebrián-Robles, 2014). The questionnaire was designed to be brief, avoiding the tendency to respond quickly to the items by presenting statements formulated in both positive and negative forms. Additionally, this questionnaire included a rating of the video game from 0 to 10 points and an optional open-ended question for making comments about aspects not included in the instrument.

For this study, the following items were selected:

- The mobile application was easy to use.
- It was exhausting to use the application.
- I needed little time to handle the application.
- I needed help to access the video game.
- At some point, I felt panicked.
- The video game requires help from an expert.
- The given responses are difficult to understand.
- The response time in interaction is slow.
- The aids to understand the application were helpful.

The results regarding the assessment of the application and the degree of satisfaction were analyzed quantitatively by counting the ratings given for each item. The responses given in the open-ended question were analyzed qualitatively by categorizing the responses into the addressed themes. For each category, the frequencies and percentages of response were calculated.

3. Results

This section presents the findings obtained from the questionnaire. Regarding the evaluation of the application, 62 % of the preservice teachers rated it between five and eight points (Figure 4). The average rating of 4.79 out of 10 points suggests that there is scope for improvement in the mobile application.

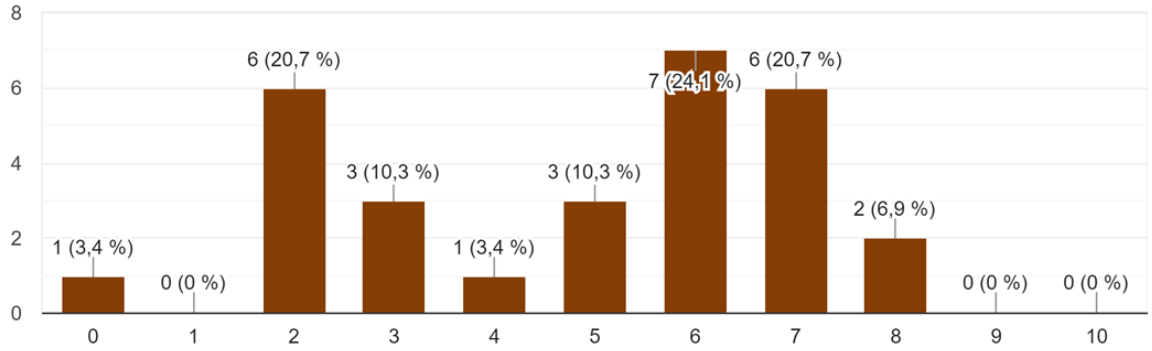


Figure 4: Evaluation of the *Energy Island* application.

The majority of participants (37.9%) were indifferent to the statement "The mobile application was easy to use" (Figure 5). Several initial training teachers indicated being somewhat disagree or somewhat agree with the statement (24.1% for both options). Only 3 out of 29 subjects (10.3%) strongly disagreed with this item.

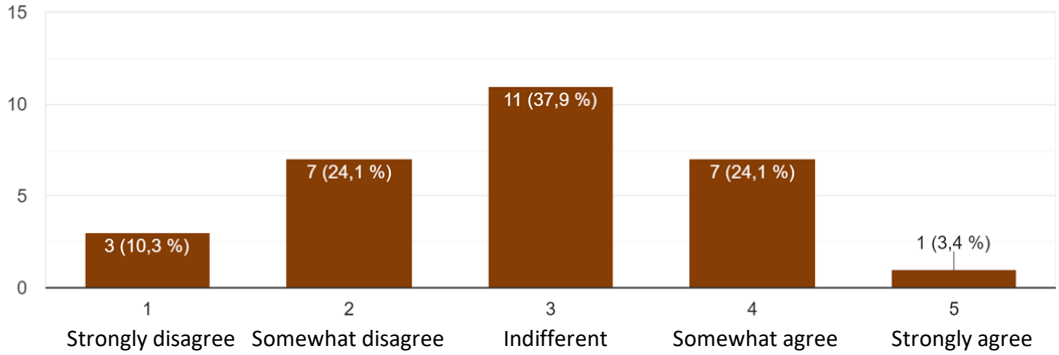


Figure 5: Degree of agreement/disagreement for the item *The mobile application was easy to use*.

37.9 % of the participants were indifferent to the item "It was exhausting to use the application." Only 10.3 % strongly agreed, and 20.7 % somewhat agreed (Figure 6).

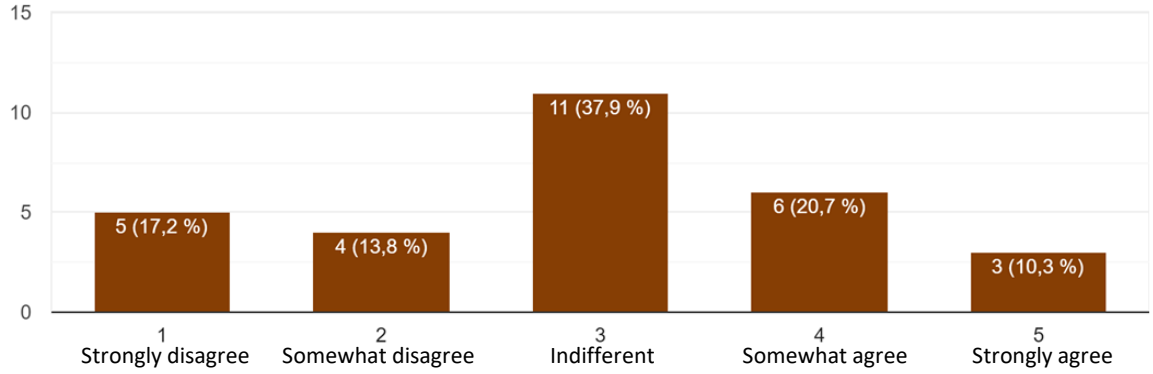


Figure 6: Degree of agreement/disagreement for the item *It was exhausting to use the application*.

The majority of initial training teachers (58.6 %, 17/29) were somewhat or strongly in agreement with the item "I needed little time to handle the application" (Figure 7). 34.5 % (10/29) were indifferent, indicating that it is possible to understand its operation in a short time.

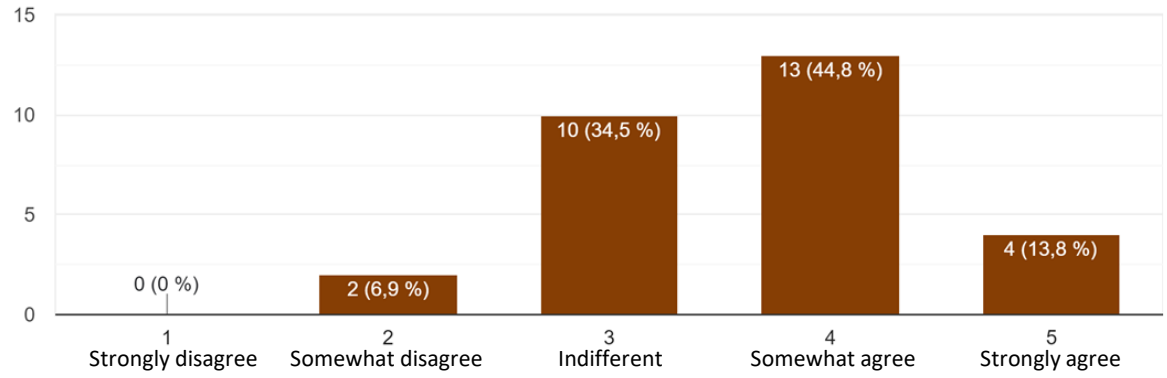


Figure 7: Degree of agreement/disagreement for the item *I needed little time to handle the application*.

The rating given to the item "I needed help to access" offered controversial responses (Figure 8). On one hand, 34.5 % of the participants strongly disagreed because they did not encounter difficulties in accessing. On the other hand, another 34. 5% indicated that they somewhat agreed with the item due to some difficulties in accessing the application.

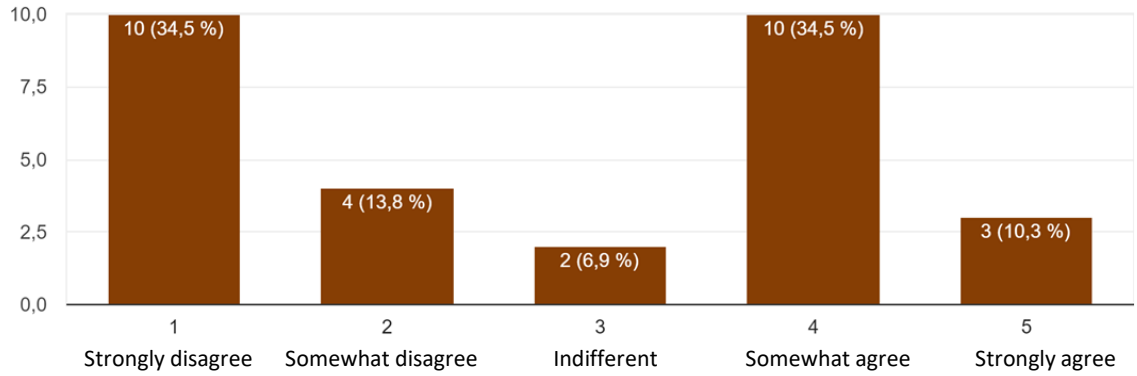


Figure 8: Degree of agreement/disagreement for the item *I needed help to access*.

A significant number of participants (58.6 %) disagreed strongly with the item "At some point, I felt panicked" (Figure 9).

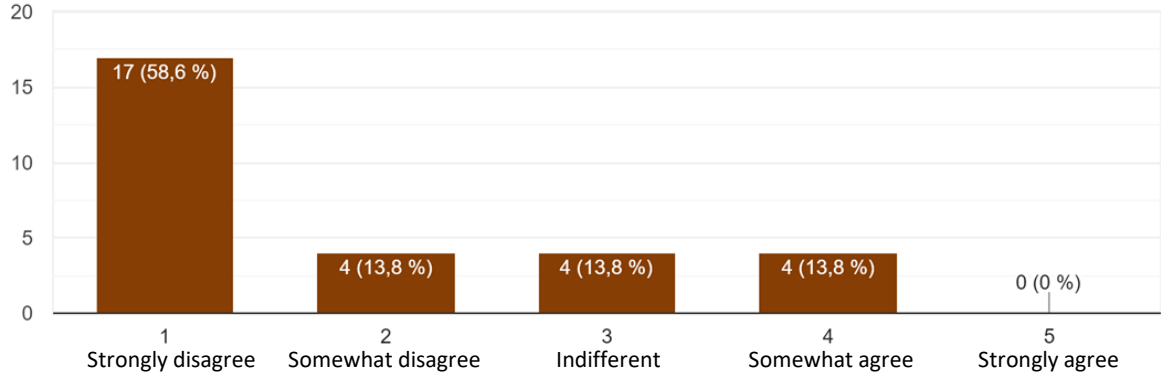


Figure 9: Degree of agreement/disagreement for the item *At some point, I felt panicked.*

Likewise, 79.3% of preservice teachers expressed being strongly disagree, disagree, or indifferent to the item "The video game requires help from an expert" (Figure 10). Only a few marked the options somewhat agree (17.2%) or strongly agree (3.4%).

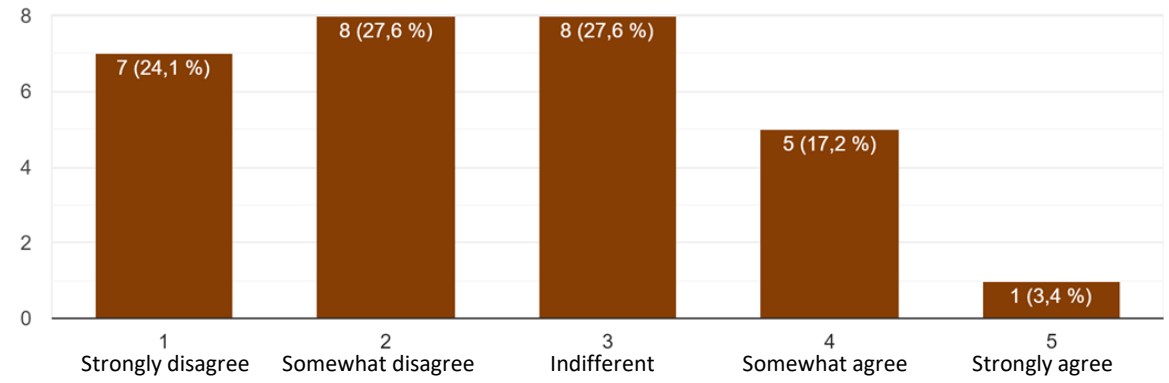


Figure 10: Degree of agreement/disagreement for the item *The video game requires help from an expert.*

Similarly, the responses given in the application were straightforward and easy to understand, as nearly half of the participants (48.3%) expressed being indifferent to the statement "The given responses are difficult to understand" (Figure 11). However, 27.8% disagreed somewhat with this item, and no participant indicated being strongly agree with it.

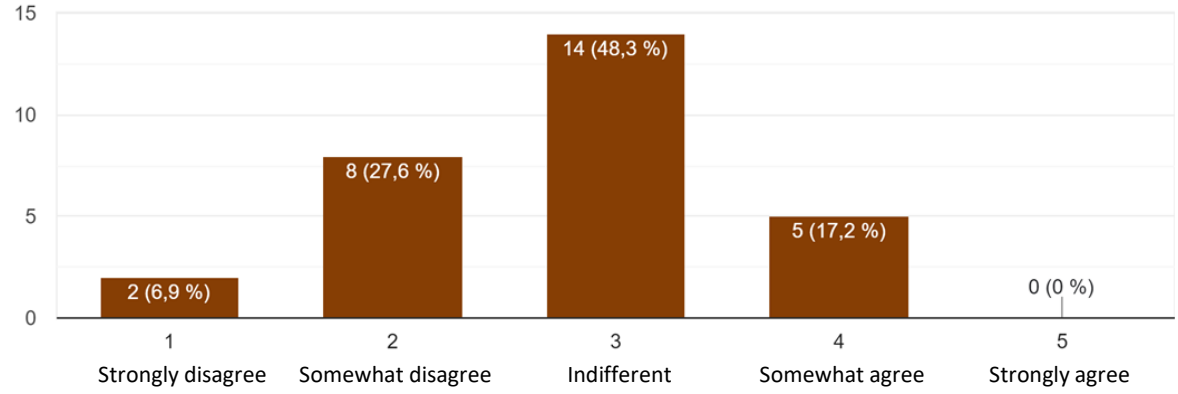


Figure 11: Degree of agreement/disagreement for the item *The given responses are difficult to understand*.

Regarding the item "The response time in interaction is slow" (Figure 12), the findings seem to indicate that the application's response is smooth. Many of the participants were indifferent (44. 8%) or somewhat disagree (27.6 %).

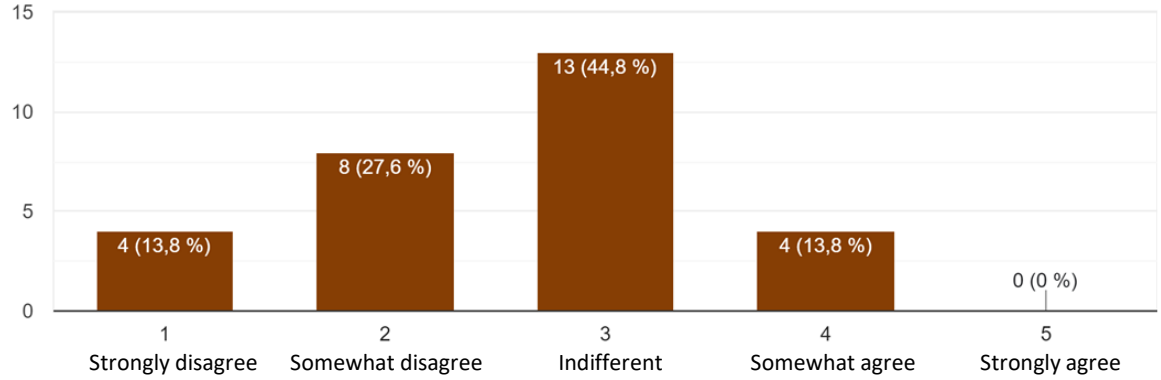


Figure 12: Degree of agreement/disagreement for the item *The response time in interaction is slow.*

On the other hand, not all subjects needed help to understand the application (Figure 13). For this reason, 37.9 % were indifferent to the item "The aids to understand the application were helpful." Of those who needed help, one-third (34.5 %) stated they were strongly or somewhat agree.

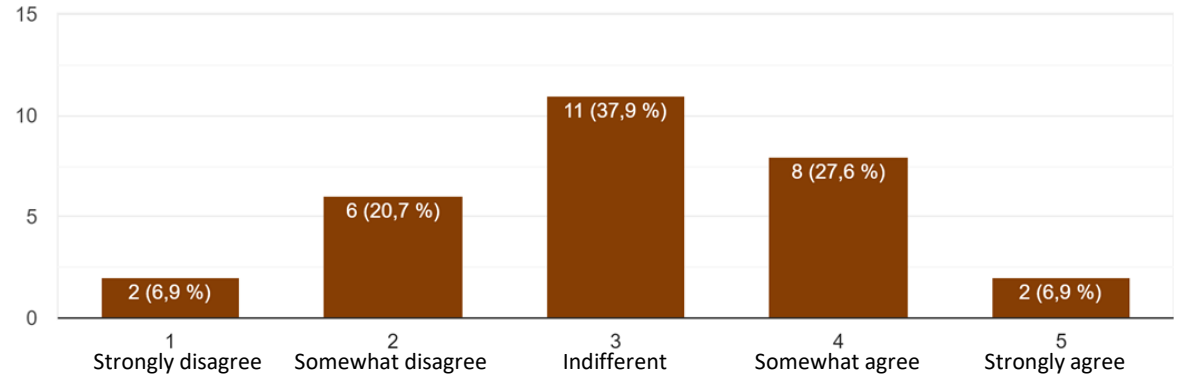


Figure 13: Degree of agreement/disagreement for the item *The aids to understand the application were helpful*.

Table 1 summarizes the response categories found in the open-ended question. Most of the observations referred to the design and interface of the mobile application, suggesting improvements regarding font size, menus, or buttons. Other observations related to the scientific content regarding energy addressed by the application, indicating that its level of difficulty was low. Finally, some preservice teachers provided comments regarding access to the application or the aids to solve the mini-games.

Table 1: Response categories in the open-ended question

Response Category	Percentage (%)	Example
Design and interface	46.67	*The font is too small to read the texts.* *The text size is small, and some are quite lengthy.*
Scientific content	40.00	*I didn't rate some topics highly because I find them trivial. Perhaps they would be interesting to a teenager.*
Access or assistance to solve mini-games	13.33	*I don't see the registration as necessary.* *The mini-game with the scales should be able to be restarted. There are few clues or aids for finding the materials in the mini-game with the photovoltaic panels.*

4. Conclusions

The evaluation of the *Energy Island* mobile application by preservice teachers specializing in technology in the Master's Degree in Secondary Education Teaching after participating in a testing study reveals several significant findings.

Firstly, the application was not perceived as exhausting by the majority of participants, which is positive as it suggests that the user experience is not overly demanding, thus facilitating its integration into the educational environment. Additionally, most participants found that the time needed to become familiar with the application was brief, indicating a relatively fast learning. However, it is important to consider that some users may need more guidance to fully utilize all the features of the application. In this regard, providing additional support resources, such as hints to solve the proposed challenges, an aspect that was demanded by the participants, could enhance the user experience and the effectiveness of the application for pedagogical use. On the other hand, most participants did not experience issues with response speed during interaction with the application, suggesting a smooth performance and contributing to a more satisfactory user experience. It is also important to note that the content of the mobile application was designed for secondary school students, so some participants may have found it too simple.

Another fundamental aspect is to continue monitoring and optimizing the technical performance of the application to ensure its optimal operation in different environments and devices. As a next line of research, the learning outcomes related to energy achieved by the sample of preserve teachers using the application will be analyzed. These results will allow for improvements to be made to the application before conducting studies with secondary school students.

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Serious Games for Education and Training in the Humanitarian Sector: State of the Art

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Abstract: Serious games and game-based learning have seen slow and stymied adoption in the humanitarian sector, despite their general efficacy as training tools. We looked at over 120 games released between 1990 and 2023 that dealt with topics relevant to the humanitarian sector such as disaster risk management, conflict mitigation, human rights and sustainability, and applied the following filters - serious games, games for education and training, and non-commercial games - to obtain a list of 89 serious games that were designed for awareness, education or training in the humanitarian sector. We then noted their accessibility and investigated the following information for each - year of release, developer, format, platforms, context, purpose, target audience, NGOs involved and related research papers - to understand the trends, challenges and future potential of games as a research and pedagogical tool in this field. Of particular interest to us was the subset of 31 training games aimed at professionals, policy makers and stakeholders. We noted concerning trends regarding the accessibility and longevity of games in this field, and tracked recurrent issues facing the development and dissemination of these games, such as the need for a trained facilitator, the difficulty of adapting the content to new settings, a lack of scientific frameworks to guide their design and a lack of long-term impact metrics. However qualitative surveys conducted by the game designers and some third-party researchers indicate that these games remain a valuable addition to traditional forms of education and training and help enliven a difficult topic through experiential learning. We thus propose that involving professional game designers, embracing digital formats, and investing in archiving and long-term impact studies will greatly benefit the development and accessibility of games for humanitarian education and training.

Keywords: Humanitarian Games, Aid Workers, Humanitarian Crisis, Serious Games, Disaster Risk Management, State of the Art

1. Introduction

Serious games have been defined as “games that do not have entertainment, enjoyment, or fun as their primary purpose” (Michael and Chen, 2005) or as "games with a purpose beyond play" (Sawyer and Smith, 2008) or as "an application with three components: experience, entertainment, and multimedia" that combine game elements like challenges, rewards, and immersion with learning strategies and knowledge (Laamarti, Eid and El Saddik, 2014).

There is a growing body of literature arguing for the efficacy of serious games and game-based learning for education and training. Games are useful as cooperative learning tools (Fonseca *et al.*, 2023) and have been found to be "particularly effective in promoting skill acquisition, knowledge retention, attitudinal change, supporting understanding of new concepts and ideas, shaping behaviour, and improving context-based problem solving" (Stevens *et al.*, 2020). The "capacity to safely fail in serious games" has also been found to be a "key component of their value as a learning tool" (Stevens *et al.*, 2020). This is because ‘productive failure’ in educational games has been identified as leading to greater learning gains (Anderson *et al.*, 2018).

A 2020 report by Save the Children NGO on the potential applicability of serious games and games-based learning to the humanitarian sector notes that despite serious games being increasingly adopted as training tools in other fields, they have seen slow adoption in the humanitarian sector (Stevens *et al.*, 2020) (Brynen and Milante, 2012). This could be because of the particular challenges faced by serious games in this field. One such issue is that serious games attempting to more faithfully capture real challenges are hard to make interesting because “increasing system realism allows you to communicate a deeper message but typically makes for a less accessible, less fun play experience” (Chris, 2007). The genre is also plagued by a lack of scientific impact analyses. A 2018 study published in the International Journal of Disaster Risk Reduction notes the scarcity of quantitative and qualitative research into the effectiveness of serious games addressing issues relating to Disaster Risk Management (Solinska-Nowak *et al.*, 2018). However, others note the value games add to the field, be it as useful tools for fundraising and creating awareness (Stokes, Seggerman and Rejeski, 2006), for researching humanitarian logistics (Lukosch and Comes, 2019) or to enhance learning and dialogue on humanitarian work (Harteveld and Suarez, 2015) though they all note the need for more research in this fledgling field.

Thus, to understand the rate of adoption of serious games for education and training in the humanitarian sector and the challenges faced by this field, we undertook a state-of-the-art study to discover games released over the past two decades that would fall into this category. We looked at their year of release, developers, stated purpose, target audience, format, availability (accessibility), and research on their efficacy (if available) to understand the challenges of this sector as well as potential for future growth.

2. Methodology

We began by using web search engines with the keywords - 'games' + 'humanitarian', 'games' + 'human rights', 'games' + 'disasters' and 'serious games' + 'conflict' - to discover a few dozen titles that fell within this category according to their descriptions. We then combed through the database of the Games4Sustainability website aided by search keywords 'humanitarian', 'disaster', 'conflict' and 'human rights' to add more titles that were not included in our previous list.

We combed through the database of ResearchGate and ScienceDirect with combinations of the search words 'serious games', 'games', 'humanitarian', 'disaster', 'conflict', 'human rights', 'education' and 'training' to find research papers referencing games that would fit our criteria and added those titles to the list.

We then excluded the titles that were commercially produced and intended primarily for entertainment that nevertheless dealt with related topics. We also excluded games intended for a very young audience (primary school students or younger).

We also excluded some interactive training modules that were not intended as 'games', and which also lacked public information since they were used for internal training by their organisations. Examples include the International Committee of the Red Cross (ICRC)'s *Disaster Response Training In VR* and World Food Programme's *Logistics Response Team (LRT)* training.

Finally, we compiled our filtered list of games into a spreadsheet and searched for the following information for each of them - name, availability, format, year of release, developer, publisher, purpose, target audience, context, scope, number of players, estimated duration, NGOs involved, link to game or game materials, and related research papers or reports.

In their 2008 paper on the taxonomy of 'Serious Games', Ben Sawyer (co-founder of Serious Games) and Peter Smith used two different axes - "Audience" and "Purpose" to differentiate serious games. Audiences included Government & NGO, Defence, Healthcare, Education, Corporate, Marketing & Communications, etc. while Purposes included Games for Health, Advertisement Games, Games for Education, Games for Training, Games for Work, etc. (Sawyer and Smith, 2008)

However, this taxonomy does not account for the context or scope of serious games; it does not for example distinguish between games training policy makers to deal with an external or unexpected crisis and games training policy makers to conduct their day-to-day work. These two additional categories were used by us to selectively identify serious games relevant to the humanitarian sector.

3. Findings

We found 89 serious games that had been developed between 1990 and 2023 to aid education and training in the humanitarian field. Of these, 18 games had no information about their original release date, but they can be assumed to have been developed between 1990 and 2023, since our study was conducted in 2023 and the technology used to make these games or research papers referencing them were dated well past 1990. We also noted details of 21 separate commercial games made for entertainment that dealt with humanitarian crises to compare their availability metrics.

The Serious Games were found to be either Unavailable (their software, website or physical game materials being no longer accessible), or Restricted (the game software or physical materials and rulebook could only be obtained by contacting the developers directly and requesting their personal copy (in case of a researcher) or by requesting a workshop (in case of an organization)), or Available (the game software or rulebook and materials were publicly available to download or access either freely or by purchasing).

We also differentiated the Serious Games according to their purpose - Awareness (communicating humanitarian issues to a lay audience), Education (teaching topics relevant to the humanitarian field to school or university

students), and Professional Training (training games for professionals, policy makers and stakeholders in the humanitarian sector).

Out of the 89 games, 49 were intended to spread awareness, either about humanitarian issues such as the plight of refugees (e.g., *Path Out*, *Darfur is Dying*, etc.), conflict zones (e.g., *Pax Warrior*, *Mission Zhobia*, etc.), resource sustainability (e.g., *Food Force*), gender inequality (e.g., *Half the Sky Movement: The Game*) or about disaster risk and mitigation for communities in disaster prone areas (e.g., *Ready!*, *Hazagora*, *Act to Adapt*, etc.)

Of these, 19 were no longer available, 3 had restricted access and 27 were still publicly accessible.

Similarly, of the 9 games that were intended as classroom tools to teach school or university students, 2 were unavailable, 1 had restricted access (though it could be accessed via a free sign-up process) and 6 were publicly available.

Finally, the purpose and target group of specific interest to us - training games for professionals and stakeholders in the humanitarian field - had 31 games in total, 11 of which were no longer available, 10 had restricted access (needed to contact the developers to gain access), and 10 were publicly available. **(Figure 1; Figure 2)**

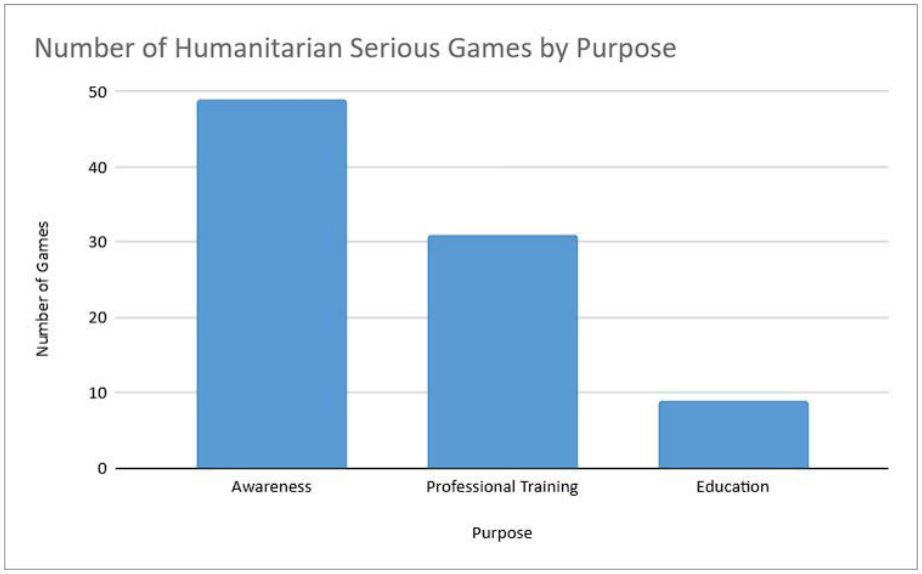


Figure 1: Number of Humanitarian Serious Games by Purpose

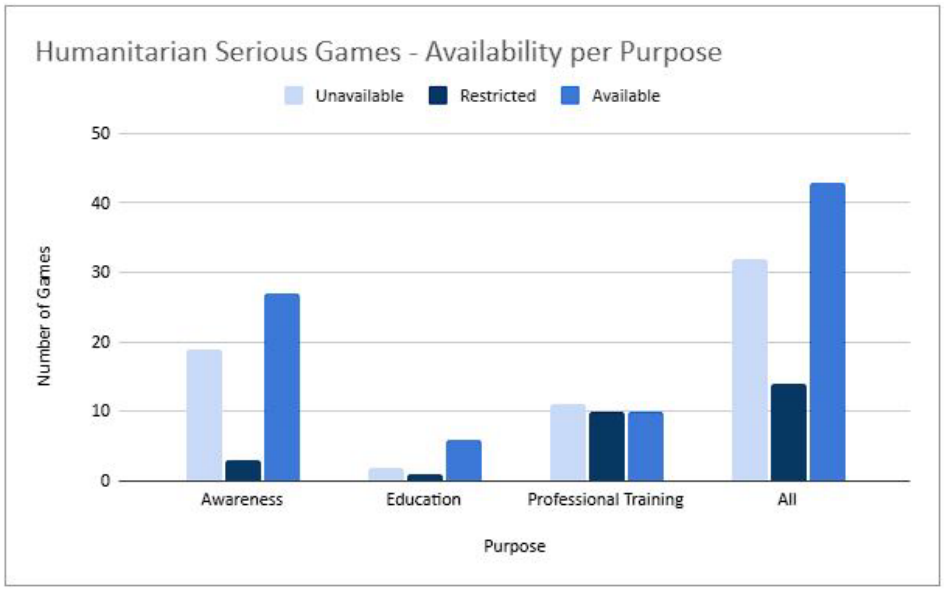


Figure 2: Humanitarian Serious Games – Availability per Purpose

All three types of serious games were found to have much lower availability compared to commercial games or games made for entertainment that dealt with related topics, which retained 100% availability. Even older commercial games no longer maintained by their developers such as the 1990 digital game *Conflict: Middle East Political Simulator*, the 2003 board game *Terra*, or the 2010 digital game *Cart Life* remained available via third party abandonware websites, second hand stores, and public archives, which was not the case for even relatively recent Serious Games that were not maintained by their developers.

We also differentiated the serious games based on their format - analog games (which were all face-to-face multiplayer) and digital games (95% of which were single player games). Games made for Awareness were largely digital, as were games made for Education. On the other hand, games made for Professional Training were mostly analog, multiplayer, and required a trained facilitator (20 analog games and 11 digital). **(Figure 3)** Moreover all 3 multiplayer digital games in our entire sample size of 89 games were intended for Professional Training. There were more digital games in total than analog games, but they also had a greater percentage of titles that were now unavailable. **(Figure 4)**

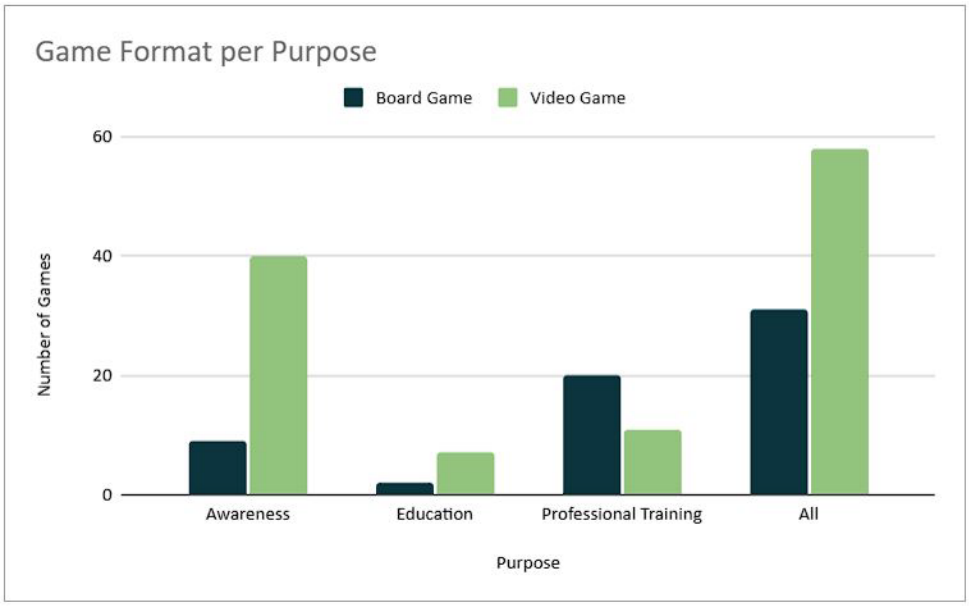


Figure 3: Number of Game Formats per Purpose

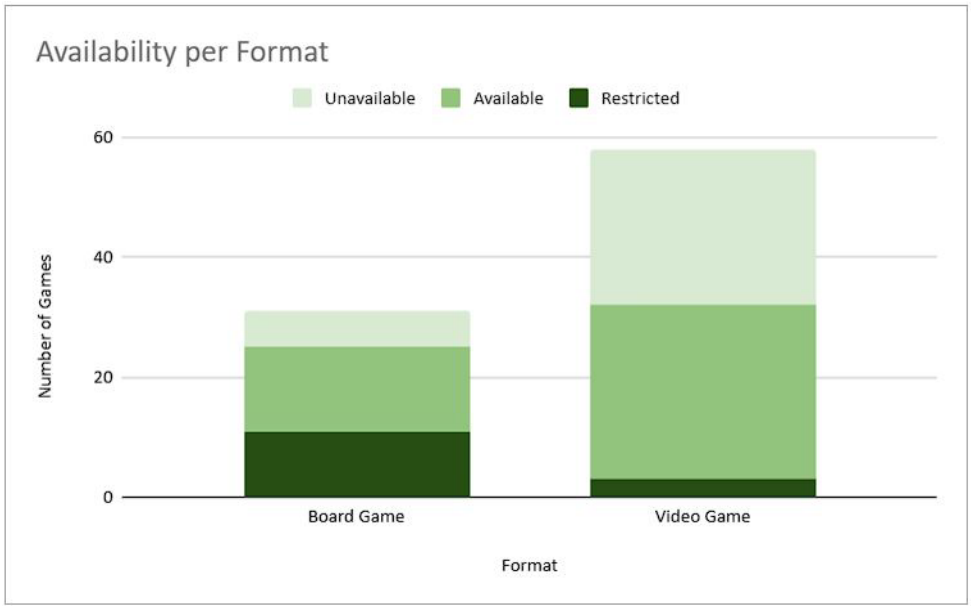


Figure 4: Availability per Format

In terms of NGO involvement in their development, 30 of the 89 games were developed closely with the help of an NGO, 16 of which were digital games and 14 analog games. 7 out of these 30 games were unavailable, and 5

had restricted access, the rest were publicly available. 17 out of the 30 games were for Awareness, 3 were for Education in classrooms and 10 were for Professional Training.

In terms of the research available on their design, efficacy, content or impact, we found 62 of the 89 titles had been mentioned in some form in a research paper, while 27 had no mention. 17 of the 62 games were all mentioned in a single research paper that looked at an overview of serious games specifically about Disaster Risk Management to consider their prospects and limitations, which was published in 2018. (Solinska-Nowak *et al.*, 2018)

4. Analyses

Our special focus was on the 31 Serious Games intended for professionals and stakeholders in the humanitarian field. 20 games out of these 31 were analog and 11 were digital. All the analog games and 3 out of the 11 digital games were multiplayer games, indicating a strong preference for multiplayer games over single player in games for professionals and stakeholders in the humanitarian field. This trend was reversed in games for general awareness.

We noticed three major issues that appeared to be hampering the development, widespread adoption and easy availability of training games for professionals, policy makers and stakeholders in the humanitarian field:

4.1 Need for Facilitators to Drive Learning Goals

The analog games were all multiplayer games requiring face-to-face interactions with other players in the presence of a trained facilitator to explain the context, guide the gameplay and conduct the post-game debriefing, all crucial to driving the learning goals. Debriefing in particular is noted to be an essential part of any effective simulation game. (Fanning and Gaba, 2007)

Rex Brynen, researcher and designer of two serious games for professional training - *Aftershock: A Humanitarian Crisis Game* and *Isis Crisis* notes that "game moderators need to tactfully keep the game on track without heavy-handed intervention. Rules must be enforced, and players who are deviating from their roles nudged back into more appropriate behaviours [...] it should not be assumed that all participants have learned the same things from their experiences [...] The debriefing provides an opportunity to draw out from the experience key insights for the participants, and address any misconceptions that may have arisen. It also provides an opportunity to link the experience to other course materials or parallel, real-world events." (Brynen, 2015)

The researchers who designed the serious game *DisCoord: The Disaster Coordination Game* for local policymakers in the landslide and flood prone Rwenzori region of South-West Uganda, also identified facilitators as one of the three core actors in the knowledge co-creation process, the other two being the game designers and the game players (target group). (Delima *et al.*, 2021)

Similarly, 4 of the 6 professional training games developed by the Centre for System Solutions could only be accessed via a workshop organised and facilitated by the organization. Of the two remaining, one was unavailable, and one provided downloadable instructions for the game moderator.

Thus, this need for expert facilitators makes these games hard to access and deploy regularly, especially in remote regions. Solutions can range from detailed tutorials with information on the context to multiplayer digital games with technology enabled communication channels and discussion portals. Two multiplayer digital games developed by the Centre for System Solutions - *Lords of the Valley* and *Forest@Risk* - seem to have employed such methods.

Another method for digital formats would be to incorporate Artificial Intelligence (AI) mediators, but this has not been attempted in any of the cases we studied. All 8 single player digital games for professional training - *In 90 Days*, *FloodSim*, *A Force More Powerful*, *Disaster in my Backyard*, *SerGIS: Malmö Flood Scenario*, *Supervolcano*, *VR for a New Climate* and *Disaster Relief Game* - use traditional algorithms to drive the gameplay and goals rather than the flexible moderation a human or advanced AI facilitator could provide.

Finally, the games could be designed with an open-ended narrative that would encourage players to draw their own conclusions, but then the results could deviate from pedagogical goals and also subvert the players' expectation of participatory and virtual completeness, particularly in digital games. (Van de Mosselaer and Gualeni, 2022)

4.2 Lack of Diversity and Difficulty of Adapting to Different Settings

Games are fiction and thus subject to the incompleteness problem. (Van de Mosselaer and Gualeni, 2022) To overcome this, serious games adopt great specificity in subject, context or setting to more authentically depict its issues. As researchers note, "Serious Games were initially conceived as being designed to train people for tasks in particular jobs [...] they are characterized by their specificity and applicability for particular work-related purposes." (Klopfer *et al.*, 2009)

Games such as *DisCoord: The Disaster Coordination Game*, developed for the Rwenzori Mountains in Uganda were developed for a particular socio-political and geographical context facing specific types of humanitarian issues - floods, landslides and displacement, while others that did not correlate exactly to a real-world setting were nevertheless focused around a particular problem – such as a flood prone region (*Lords of the Valley*, *Game of Floods*, *Flood Resilience Game*, *FloodSim*, *Disaster in my Backyard*, *SerGis: Malmo Flood Scenario*, etc.) or a volcanic eruption (*Supervolcano*) or an earthquake (*Aftershock: a humanitarian crisis game*, *Crossroad: Kobe*). These can be hard to adapt to different contexts without a design framework to guide the changes.

Like the 2018 report on disaster risk management games, which noted the lack of diversity in the disasters covered by those games (Solinska-Nowak *et al.*, 2018), our study also found that few games attempted to address less common natural disasters such as wildfires, temperature fluctuations or epidemics, or man-made crises such as insurgency, war, terrorism, genocide, or resource scarcity, some of the exceptions being the *Disaster Response Game* - a flexible digital platform addressing a range of disaster scenarios including, but not limited to, earthquakes, floods, pandemics, storms, and wildfires, *ISIS Crisis* on the conflict in Iraq and Syria, *The World's Future* on sustainable development, and *Ramsete I*, *II*, and *III* on inter-country cooperation, climate change adaptation and storm preparation.

As also noted by the 2018 report, most of the games failed to acknowledge issues such as gender inequality or social divisions that complicate the work of humanitarian professionals in these regions. "Surprisingly enough, little attention is given to issues such as cultural diversity, gender equality or learning from past events, which certainly could also positively affect communication and thus support disaster preparedness and/or resilience." (Solinska-Nowak *et al.*, 2018) This is especially relevant when local customs contradict the learning goals. For example, in *DisCoord: The Disaster Coordination Game*, the designers noted that when the game was tested with local policy makers, the use of contraceptives was the least proposed and voted among the methods to curb population growth, due to local religious beliefs opposing the solution. (Delima *et al.*, 2021)

Solutions to address the problem of adaptability to new contexts and diversity of viewpoints can be achieved by devising gameplay systems that work with changeable content to swap contexts, as seen in the *Disaster Response Game*. Another way is to map real-world data into the game for effective simulations, as done in the *Disaster Relief Game* to teach logistical planning.

With multiplayer games, asymmetric gameplay systems can be used to represent different interest groups and any social divisions. For example, in *Aftershock: A Humanitarian Crisis Game* the players represent the different interests of local governments, international agencies and defence professionals who need to cooperate in a crisis but may have different priorities.

4.3 Lack of Scientific Methods to Direct Their Design and Prove Their Efficacy

While a few frameworks have been proposed by different researchers to help create and analyse serious games in general, there is no industry-standard framework or testing methodology that can be universally applied for the development and analyses of serious games and none that have been proposed for serious games in the humanitarian sector in particular.

Moreover, the existing frameworks each have their own limitations that designers and researchers must be aware of. For example, the Serious Games Design Assessment (SGDA) Framework was found to be somewhat useful for a qualitative analysis but not for design (Mitgutsch and Alvarado, 2012) and the Activity Theory-based Model of Serious Games (ATMSG) was useful only to design simpler games, but could not be used for more complex simulations (Gauthier *et al.*, 2022). Problems with all existing frameworks include - the roles of all stakeholders not always being clear, no guidelines for the right balance between fun and pedagogy, and a lack of instruments to guide researchers and game designers in utilizing their evaluation results for validating and appropriately revising the design of their games.

In addition, there is a lack of follow-up studies and third-party studies to understand the long-term effect of these games. The report by the NGO Save the Children was the only detailed third party study that looked at the effectiveness of tabletop games vs digital serious games for the humanitarian sector via qualitative surveys of participants (Stevens *et al.*, 2020) whereas other studies were conducted by the designers themselves as in the case of *DisCoord: The Disaster Coordination Game* (Delima *et al.*, 2021), *Ramsete I* (Abad *et al.*, 2020), *Ramsete III* (Schueller *et al.*, 2020), *SerGIS: Malmö Flood Scenario* (Blochel *et al.*, 2013) or *Crossroad: Kobe* (Kikkawa, 2014).

A few games such as the digital single-player *Disaster Relief Game* (2018) for government personnel and non-technical professionals involved in disaster relief who need to understand the importance of logistical optimisation (De Souza *et al.*, 2018), or the multiplayer digital game *Disaster Response Game* (2020) for graduate students on co-ordination, communication, and decision making under pressure during disaster relief operations (Klein, Jackson and Mazereeuw, 2022), were proposed via research papers but have no information on their real world deployment.

None of the studies looked at long term effects of the games by reconducting the surveys months or years after the gameplay or by looking at changing performance metrics over time.

5. Conclusion

We used web search, a serious games database and references in research papers to find 89 serious games developed for the humanitarian sector. We analysed their availability, format, purpose, target audience, NGO involvement and research papers on their efficacy to discover the reasons for the paucity of games in this genre and potential for growth in the future.

From our study we noted that there is a pressing need to archive serious games made for the humanitarian sector to avoid losing the detailed research that went into their design, and to allow future developers and researchers to study them to improve their own methodologies and develop more robust design and analyses frameworks. The lack of availability and short shelf life is thus the first and foremost hurdle to the adoption and growth of educational and professional training games in the humanitarian sector. Methods to address this would be to digitize the games or game materials and instructions, create an archive to maintain the game files and ensure this archive remains publicly available.

Secondly, we need more researchers willing to study serious games developed by others in this field in order to devise design frameworks that can enable easy development and adaption of these games in different contexts. Researchers and developers designing their own games in this field should accompany their design methodology with instructions for adaption into different regional, social or cultural contexts. Scientific design frameworks will also help researchers and professionals in the humanitarian sector work closely with professional game developers to create more interesting gameplay, combining their academic insights with professional game designers' mastery over their craft.

Finally, serious games in the humanitarian field suffer from a lack of any quantitative data on their efficacy as well as qualitative surveys removed in time from the gameplay to understand their long-term effects on the audience. Third-party evaluators are needed to follow-up after the deployment of serious games for professional training in particular to gather performance metrics and conduct surveys at a later date to understand their long-term usefulness and potential.

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Appendix 1: https://docs.google.com/document/d/1WlXSnnfZFZ2tTqDy9X3lJ3YbSHpWiJxz/edit

List of 89 Serious Games for Education and Training in the Humanitarian Sector studied for our paper with abridged data

Enhancing Digital Game-Based Learning Through Reflective Game Design (RGD)

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Abstract: Reflective learning is an acknowledged and effective mode of acquiring knowledge in every domain. Ongoing studies indicate that digital games possess reflective characteristics that offer experiential learning, creating an immersive and secure environment for stealth learning. Such games empower learners to autonomously identify, explore, fail, and retry, fostering a dynamic learning process. The fundamental game elements such as user interface (UI), head-up displays (HUDs), maps, prompt messages, and social interactions inherently embody reflective attributes. This inherent reflective nature within digital games contributes to the development of critical thinking, problem-solving skills, and motivation, seamlessly aligning with the fundamental principles of reflective learning. This research investigates the incorporation of Reflective Game Design (RGD) within digital game-based learning (GBL) and assesses its impact on learning outcomes. The primary objective of the study was to comprehensively examine and quantify the educational influence of RGD in achieving learning objectives, enhancing the overall learning experience, and improving retention rates, in comparison to non-RGD game design. Therefore, two digital prototypes were developed as part of this study: one featuring explicit integration of reflective learning, referred to as RGD design, and the other without RGD design, termed non-RGD. In order to assess the learning, a study was conducted that revealed substantial positive results through a comparative analysis of two groups: the experimental group (N=69), engaging in digital game design with reflective learning, and the control group (N=69), with non-RGD design. The findings demonstrate that Reflective Game Design effectively infuses reflective learning recommendations into the game-based learning environment. The incorporation of RGD not only provides immediate feedback to students, fostering self-directed learning but also elevates the immersive nature of digital games, thereby facilitating deeper learning experiences. This study contributes to the effectiveness of the game design by offering the RGD framework and valuable insights for researchers, educators, and game designers aiming to create impactful educational games.

Keywords: Reflective Learning, Game Design, Reflective Game Design, Learning Theories.

1. Introduction

In the field of education, the utilisation of games as a tool for learning has gained significant attention. In Game-Based Learning (GBL), theories such as behaviourism, constructivism, and cognitive theory provide foundational frameworks for optimising learning experiences. Over the past decade, there has been notable advancement within the GBL field, with a growing emphasis on integrating learning theories to better understand how games can effectively engage learners. Digital games in GBL provide interactive learning with authentic practice (Kapp, 2013) and high retention rates. Games immerse players in simulated environments, offering experiences that parallel real-life situations. Through gameplay, individuals encounter diverse scenarios, allowing them to apply theoretical knowledge in practical contexts (Gee, 2004). For instance, strategy games require players to make decisions about resource allocation, diplomacy, and warfare, encouraging them to reflect on the consequences of their actions within the game world.

Reflective learning involves revisiting and reassessing past actions to engage intentionally in the learning process. John Dewey emphasised reflection as integral to the learning process, influencing the skill development (Dewey, 1933). It progresses from unconscious learning or experience to mindful awareness, empowering individuals to absorb everyday experiences and make conscious choices. Reflective learning also involves the critical examination of experiences, allowing individuals to gain insights, develop new perspectives, and enhance their problem-solving abilities (Moon, 2013). Games offer an immersive and safe medium for stealth learning, allowing players to identify, explore, fail, and retry (Kapp, 2013). Games captivate players' interest and engagement through interactive gameplay and compelling narratives, raising intrinsic motivation for learning (Ryan et al., 2006). This high level of engagement sustains individuals' involvement in reflective activities, enhancing their commitment to self-improvement and learning. Therefore, they provide a structured environment where players encounter challenges, make decisions, and face consequences, thus facilitating the reflective process. Moreover, games offer immediate feedback on players' actions, enabling iterative learning cycles. Whether through in-game mechanics or narrative consequences, feedback prompts players to reflect on their strategies, adjust their approaches, and experiment with alternative solutions (Squire, 2008). Key game elements such as feedback in user interfaces (UI), heads-up displays (HUDs), maps, prompt messages, and social

discourse are inherently reflective (Villareale et al., 2020a), making games effective tools for triggering and supporting reflective learning.

For the last few decades, reflective learning has been considered as one of the acceptable means of learning in traditional learning. However, despite its potential to enhance teaching and learning experiences, dedicated work on reflective design in GBL remains limited. Various studies have integrated reflective practices into learning environments to improve learning outcomes, yet these practices vary across domains and produce differing results. While current game design comprises all features that facilitate reflection "as a whole set" (Garris et al., 2002, Hughes et al., 2016, Yusoff et al., 2009), it misses individual reflection differences. However, getting maximum usage of the reflective nature of games with authentic learning content while maintaining the fun criteria can be challenging. Therefore, further exploration and study are required in this context (Khaled, 2018, Mekler et al., 2018). Villareale et al. (2020b) surveyed programming games to find out the reflection in GBL and encouraged researchers to extend their work to a larger sample and investigate other genres of educational games. As Khaled (2018) quoted, "Games are reflection machines. Hence, a sound design methodology and guidelines are needed to assist the game designer in aiding effective learning with reflective practices.

1.1 Reflective Game Design (RGD) Framework

Sengers et al. (2005) coined "Reflective Design" to incorporate reflective practices into technology. This concept includes broad principles that assist technology designers in reimagining metaphors to enhance skilled user engagement. Educational games hold immense potential for fostering reflective learning due to their inherent alignment with experiential learning principles. The literature identified game features promoting reflective feedback. These features, when incorporated into educational games, can encourage deeper reflection in players, leading to improved learning outcomes and even behavioural changes (Villareale et al., 2020b, Shaheen et al., 2021). Digital games, with traits like freedom (Klopfer et al., 2009) and elements of fantasy, promote stealth reflective learning, overcoming disengagement and fostering authentic practice (Malone, 1980, Kapp, 2013). A survey by Shaheen and Fotaris (2023) showed strong support (86.5%) for reflection through digital games, highlighting practical elements like Heads-Up Displays (HUDs) and social collaboration. The interview phase emphasised the consequences' role, stating that games' losses mimic real-life learning from mistakes, reinforcing reflective behaviour.

It is well-established that games offer a platform for authentic experiences, making them particularly conducive to learning. In this context, Kolb's Learning Model (Kolb, 1984), often referred to as the *experiential learning cycle*, proves to be highly relevant to the goals of GBL. This model is adapted to formulate the Reflective Game Design (RGD) framework (Shaheen et al., 2022).



Figure 1: The RGD Framework (Shaheen et al., 2022), the arrow pointing away from the reflective feedback signifies the integration of reflective learning at every stage of the framework.

Reflective Game Design (RGD) framework (Shaheen et al., 2022) as illustrated in Figure 1 is an iterative model, where each cycle enhances learning through reflective feedback. Reflective feedback, both in-action (during gameplay) and on-action (after gameplay) is an integral component within this framework, offering reflective

insights across all stages of the design process. The foundational building blocks within each stage include reflective learning principles and game-reflective features. Here's a brief explanation of each stage:

i. **Gameplay:** The first stage in the framework is to design gameplay, which can be a small game activity or a complete level. Gameplay enables learners to engage with a game using various elements such as game rules, mechanics, challenges, stories, feedback, and levels. This interaction provides authentic practice, offering concrete experiences related to the learning objectives.
ii. **Assessing Conceptualisation:** After authentic gameplay experience, the next stage is to use in-game mechanics to assess the learner's understanding. Ensuring learning and critical reflection, this stage involves incorporating ongoing reflective feedback and asking players to assess their skills during gameplay. It involves grasping complex ideas, while reflective assessment entails critically examining experiences, fostering a deeper comprehension.
iii. **Level Up:** A level-up represents the active experimentation of a learned skill in a fresh environment or situation. In game design, level design plays a pivotal role, as each level-up, coupled with the integration of previously acquired skills, enhances authentic practice and learning. Therefore, the RGD framework's third stage is to design a level-up with previous experience to engage learners in active participation.
iv. **Reflective Feedback:** In the RGD framework, reflective feedback is a central stage, which suggests providing reflective feedback after creating each digital during and post-game activity, i.e., gameplay, assessment, level and so on.

1.2 Research Question

This ongoing research seeks to engage the target audience to validate and assess the learning outcomes of reflective game design. A crucial aspect of this study involves evaluating the effectiveness of learning facilitated by RGD, Therefore, the objectives of the study are as follows:

- Conduct a comparative study to evaluate the educational impact of Reflective Game Design (RGD) in comparison to game design that does not incorporate explicit reflective practices (non-RGD).
- Measure and quantify the effectiveness of RGD in achieving learning objectives.
- Evaluate the extent to which RGD enhances the overall learning experience.
- Analyse the impact of RGD on improving retention rates among participants.

2. Methodology

2.1 Research Design

The study adopted a pre-test-post-test control-experimental group design, where participants were selected from two existing classes. The experimental group underwent a specific treatment, while the control group did not receive any intervention (Sauro and Lewis, 2016). The evaluation of interest occurred at two-time points: before the intervention (pre-test) and after the intervention (post-test).

This design comprised three key components:

- Participants were purposefully assigned to either the experimental or control group, ensuring that each participant belonged exclusively to one group and not both.
- Both groups experienced identical conditions, differing only in the presence of the intervention. The experimental group received the specified RGD digital prototype, whereas the control group received a non-RGD digital prototype.
- Measurement of outcomes for both groups simultaneously at the pre-test and post-test stages

2.2 Game Design

Based on the systematic review and initial user research (Shaheen et al., 2021, Shaheen and Fotaris, 2023), preliminary game design decisions were made. It was decided to develop a serious game aimed at enhancing self-awareness to validate learning in RGDs. To incorporate learning effectively into the game designs, Learning Objectives (LO) were formulated with the assistance of content matter experts. Low-fidelity and high-fidelity prototypes were then developed in co-design sessions with selected participants, utilising the RGD framework. The digital game titled "The Mend", a house renovation puzzle game was designed and developed. In this game, the player's self-awareness is symbolised by a house that has been damaged by uncertainties and a lack of self-

awareness. The player's objective is to solve puzzles with mindful activities to repair the house, thereby gaining insights into self-awareness throughout the gameplay.

In the game, reflective game design features (Lin et al., 1999) were utilised to promote reflection-in-action and on-action, which are briefly explained below in the context of digital games.

a. **Reflective Process Displays and Prompts:** The UI/HUD visual aids make implicit learning processes explicit, allowing learners to assess their progress and reflect on ongoing actions. For example, process displays and prompts, i.e., Figure 2 (a) illustrates the breathing exercise with visual aids, including an activity description and a timer indicating the seconds to breathe in and out.
b. **Process Models:** These are benchmarks or standard solutions that present standardised process steps, enabling learners to compare and relate to their progress. The process model example in Figure 2 (b)) depicts the diary, which displays reflections on feelings before and after the breathing exercise for comparison.



(a) Breathing exercise – Mindful Activity. (b) A diary to record self-journal.

Figure 2: Illustration of game activities

Moreover, Shaheen and Fotaris (2024), briefly explained the process with learning objectives, game design, game narrative and game mechanics with user testing. As the RGD framework process is iterative, an initial non-RGD prototype was created. Subsequent iterations integrated reflective feedback, resulting in two prototypes: one without RGD, termed non-RGD, and one with RGD.

2.3 Learning Measurement Instruments

It's widely acknowledged that using a standardised test on the intervention's subject matter is preferable to developing a study-specific test. To measure learning in the game aimed at enhancing self-awareness, this study identified several standardised tools for measuring self-awareness, including the "Construction of the Self-Awareness Outcomes Questionnaire" (Sutton, 2016), "Emotional Self-Awareness Questionnaire" (Killian, 2012), "Self-Reflection and Insight Scale" (Grant et al., 2002), and "Self-Awareness Questionnaire" (Wong and Law, 2017). However, these tools primarily measure aspects like emotional and personal awareness, which didn't fully align with the specific learning objectives outlined. Therefore, in collaboration with subject matter experts, initial questionnaires were developed and tested with a small sample. Feedback from this testing phase refined the questionnaire, resulting in a final instrument with six items to evaluate learning, administered both before and after gameplay to assess learning outcomes.

2.4 Research Intervention

2.4.1 Recruitment

The study recruited young adults aged 18-24, primarily targeting undergraduate students at the University of Brighton, social forums, and online gaming communities. Ethical approval was obtained, ensuring proper handling of human subjects. Participants with gaming experience were selected to avoid diversity, and identified through a screening question in the recruitment survey.

2.4.2 Data Collection

This research followed strict anonymisation procedures during data collection. Interviews and group sessions avoided personal or confidential inquiries. Participants were given a consent form with an information sheet to read and sign. The digital prototypes (RGD and non-RGD) were hosted on a website using the Google Firebase service for seamless distribution to the target audience. User surveys, integrated with questionnaires, were created using JISC Online Surveys to ensure a streamlined experience. A mechanism was implemented to redirect participants between the survey and the game for smooth navigation. The web URL guided users through:

- **Pre-test**: Participants completed six multiple-choice questions (MCQs) to gauge baseline knowledge.
- **Gameplay:** Participants engaged with web-based high-fidelity prototypes.
- **Post-test:** Participants completed another set of six MCQs to assess knowledge retention post-gameplay.
- Participants were categorised into the following two groups,
- **Control Group:** The pre-test survey gathered 73 responses, with 69 in the post-test. Responses lacking a corresponding post-test were excluded.
- **Experimental Group:** The pre-test survey collected 86 responses, with 76 in the post-test. Responses without a corresponding post-test were excluded.

To ensure equal sample sizes, data from the last participants in each group were excluded, resulting in a total sample size of 69 for both groups. All data was stored on the JISC database for analysis.

2.5 Data Analysis and Results

Since the participants in both the pre-test and post-test questionnaires were the same, the data falls within the area of the dependent variable. This involves before-and-after observations on the same subjects, such as students' diagnostic test results before and after a specific module or course. Since the number of samples was bigger than 20 (which is a general guideline), a standard T-paired test was decided to use. The paired t-test, alternatively recognised as the Student's t-test for paired samples, was introduced by William Sealy Gosset (Gosset, 1908). A paired t-test is used to compare two population means of two samples in which observations in one sample can be paired with observations in the other sample (Shier, 2004). The results are shown in Table 1.

- The control group received the non-RGD design, and the test comprised six content-specific questions, each scored one point, yielding a total score of six.

To calculate Student's t-test for score difference, the null hypothesis (Ho) in this case was the true mean difference is zero ($\mu_0 = 0$),

$$Ho > 0 : Improvement, Ho \leq 0 : no\ improvement$$

The paired T-Test analysis, reveals that the hypothetical mean is 0.00, while the actual mean is 0.8696, indicating a difference of 0.8696. The calculated T value is 5.53449461, which exceeds the critical value of 1.667 from the Consequently, with a T value of 5.53449461 greater than 1.667, the mean of the dataset significantly differs from the hypothesised mean, $\mu_0 = 0$, with $p < .001$. Therefore, the null hypothesis is rejected, providing evidence of learning among participants who engaged with the non-RGD digital game prototype.

As the experimental group received the RGD digital game prototype, and the test comprised six content-specific questions, each scored one point, yielding a total score of six.

Similarly, to calculate Student's t-test for paired samples, null hypothesis (Ho) in this case was the true mean difference is zero ($\mu_0 = 0$.),

$$Ho > 0 : Improvement, Ho \leq 0 : no\ improvement$$

Table 1: The paired T-test results (N=69) with alpha 0.05 and $\mu_0 = 0$.

Parameters	Control Group	Experimental Group
Mean of $\bar{d}$	0.8696	2.53623188
Standard Deviation of $\bar{d}$	1.3051	2.26598706
Variance of $\bar{d}$	1.1424	1.5021
standard error of difference $SE(\bar{d})$	0.15711737	0.27279279
T value	5.53449461	9.29728358
Critical value	1.667	1.667
Confidence interval of this difference	95%	95%

The paired T-Test analysis, reveals that the hypothetical mean is 0.00, while the actual mean is 2.53623188, indicating a difference of 2.53623188. The calculated T value is 9.29728358, which exceeds the critical value of 1.667 from the Consequently, with a T value of 9.29728358 greater than 1.667, the mean of the dataset significantly differs from the hypothesised mean, $\mu_0 = 0$, with p < .001. Therefore, the null hypothesis is rejected, providing evidence of learning among participants who engaged with the RGD digital game prototype.

2.5.1 Comparative Results

After the intervention the descriptive static analysis (refer to Table 2) shows that the pre-test mean scores for both groups were recorded as 2.83 and 2.44, indicating a relatively similar level of knowledge among students in both groups before the intervention. Subsequently, the post-test mean scores showed a slight increase, with mean scores of 3.42 and 4.98 compared to the pre-test mean scores of 2.83 and 2.44, respectively. This suggests that participants in both groups experienced some level of learning as a result of their engagement with the GBL prototypes. Remarkably, the experimental group exhibited a higher mean post-test score of 4.98 compared to the control group's mean score of 3.42. This significant difference in post-test scores indicates a substantial improvement in participants' knowledge levels resulting from their interaction with the experimental intervention of the RGD prototype.

Table 2: The average, variance, and standard deviation values of participants' scores, with a total score of 6.

	Group	Mean	Standard deviation	Variance
Pre-test	Control	2.83	1.72	2.96
	Experimental	2.44	1.52	2.33
Post-test	Control	3.42	1.42	2.01
	Experimental	4.98	1.89	1.37

The paired T-test was conducted to assess the effectiveness of learning between the RGD prototype and the non-RGD prototype. The null hypothesis (Ho) stated that "the means of the non-RGD and RGD prototypes will be equal", represented as:

$$Ho: \mu_1 = \mu_r$$

Results (Table 3) indicated that participants using the RGD prototype (N = 69, M = 2.54, SD = 2.27) reported significantly higher learning outcomes compared to participants using the non-RGD prototype (N = 69, M = 0.87, SD = 1.31), with a significant difference observed (t (69) = 5.2943, p < .01). Since the means are not equal the p-value is less than the alpha level (i.e., 0.01 < 0.05), the null hypothesis (Ho) is rejected.

Table 3: The paired T-test results comparing the learning rates of the non-RGD prototype (N=69) and the RGD prototype (N=69) with Alpha (α) 0.05.

Parameters	Values
Mean	non-RGD = 0.87; RGD = 2.54.
Standard Deviation	non-RGD = 1.31; RGD = 2.27.
Standard error of difference $SE(\bar{d})$	0.315
T value	5.2943
Degrees of Freedom (d.o.f)	136
Critical value	1.658
Confidence interval of this difference	95%

The boxplot (refer to Figure 3) visually represents the median and range of accuracy scores for each prototype group. The median accuracy score for the RGD prototype appears higher than that of the non-RGD prototype, indicating that, on average, participants in the RGD group achieved higher levels of accuracy in learning compared to those in the non-RGD group. This suggests that the RGD prototype had a greater impact on the learning rate of participants than the non-RGD prototype. This suggests that the RGD prototype was more effective in facilitating learning compared to the non-RGD prototype. The result shows that within the experimental group, participants who engaged with the RGD game displayed significantly higher scores compared to those in the control group who engaged with a non-RGD game. Consequently, it can be inferred that the implementation of RGD principles positively impacted participants' learning outcomes.

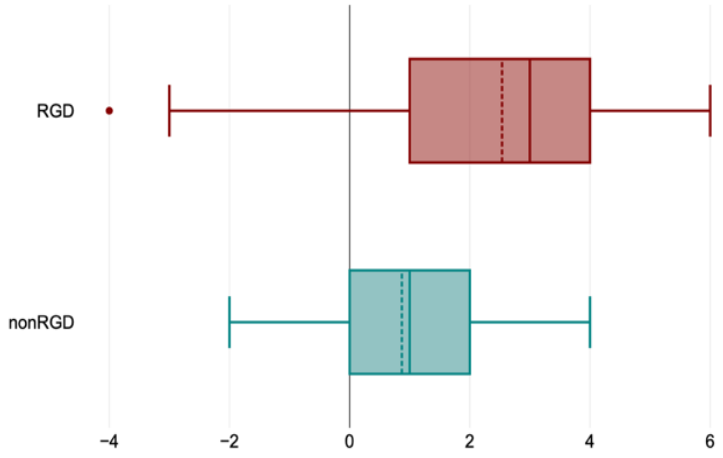


Figure 3: visual representation of comparative analysis of control group and the experimental group.

2.5.2 Qualitative Data

The qualitative data was collected from the open-ended questions in the survey questionnaire administered to the experimental group (N = 69) following their interaction with the RGD game. The data collected was analysed by categorising responses into themes or topics related to different elements of the program. Each theme corresponds to a specific aspect of the intervention, such as game activities, assessments, reflection points and game narrative. Participants Specific responses include:

Table 4: Open-ended responses (N=69).

Topics	Responses
• Game activities	• Participants appreciated various aspects of breathing exercises, such as techniques and simple activities like inhaling and exhaling. • The benefits include stress reduction, relaxation, and a calming effect on both the body and mind. • Specific responses include: • "*The breathing exercise made me feel less stressed".* • *"I like the breathing exercise; it was really joyful and a relaxing activity".* • *"Breathing exercises help me relax and reduce my stress".* • *"The breathing exercise really helped me relax".* • *"I expected hard puzzles, I would have liked them more of they were harder".*
• Diary	• The use of a diary or journal was highlighted as a preferred activity for emotional expression and self-reflection. • Participants find value in describing their emotions, indicating that the process aids in self-awareness. One response was: • *"I like journaling the most because it helps in describing my emotions"*
• Game narrative	• While some participants found joy and relaxation in the game, others expressed some improvements can be made in games to make it more engaging. Suggestions for improvement include incorporating more captivating elements, such as escaping horror rooms and introducing self-aware journeys within the game. • Specific responses include: • *"I like the game idea".* • *"The puzzle one and inhale exhale".* • *"The character because make the game looked unique, and also breathing exercise because it make me cool down and make other cool down when you are in a bad mood".* • *"OK, so firstly I liked the way the proper info of society is depicted in the initial story, but unfortunately, the game was not that much captivating".*

The analysis involves understanding participant responses in relation to specific elements of the program. It provides insights into what aspects of the intervention were well-received, areas that participants found engaging, and suggestions for improvement. The emphasis on a holistic experience, combining engaging game elements with relaxation activities like breathing exercises, is notable in the participants' feedback.

3. Discussion

The comprehensive approach to assessing the impact of learning involved the implementation of digital RGD and non-RGD prototype interventions via the website platform. This intervention was preceded by administering pre-tests and post-tests comprising six sets of questions aligned with the learning objectives. The subsequent detailed comparative statistical analysis yielded significant and insightful results, which are elaborated upon below:

Game-based learning generally demonstrates a positive effect on the rate of learning. This indicates that engaging with educational content through game mechanics enhances the learning process, making it more effective and enjoyable for participants. Game elements such as challenges, rewards, and interactivity contribute to increased engagement and knowledge retention.

Reflective game design prototypes yield higher mean scores compared to traditional game design prototypes. This suggests that incorporating reflective elements into game-based learning experiences enhances their effectiveness in facilitating learning outcomes. Reflective game design encourages players to actively reflect on their experiences within the game, leading to a deeper understanding and retention of the educational content.

Quantitative responses yielded valuable insights and suggestions for improvement that will be used in the reflective game design recommendations.

Quantitative and qualitative data revealed a positive reception of the RGD approach and offered suggestions for improvement, affirming the efficacy of the reflective design in GBL experiences. These findings serve as a foundation for further refinement and development of reflective game design, aiming to optimise their efficacy in facilitating educational objectives. Therefore, it can be seen that the integration of reflective elements significantly enhanced the learning experience and outcomes.

4. Conclusion and Future Work

In conclusion, the comprehensive study examining the impact of reflective game design on learning outcomes reveals several key insights. Initially, marginal differences were observed between the control and experimental groups in pre-test results, indicating similar knowledge levels among participants. However, post-intervention, both groups showed significant improvements in mean scores, with the experimental group outperforming the control group in the post-test. A detailed statistical analysis further confirmed the substantial difference between the two groups, providing robust evidence for the effectiveness of the RGD prototype in enhancing learning outcomes.

In the future, these findings will serve as the groundwork for establishing recommendations for Reflective Game Design, offering valuable insights for researchers, educators, and game designers striving to develop impactful educational games.

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Mr. Tumbles' *Maya* and the Multiplicity of Personas: Leveraging Illusion and Reality in Educational Game Design for SEN Language Learners

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Abstract: Educational research for Special Educational Needs (SEN) students has increasingly recognised the necessity for tailored approaches that accommodate diverse learning needs. Despite advancements, there remains a significant gap in the development of digital interventions, particularly video games, that cater to the language acquisition and communicative needs of SEN learners. This study explores how psychological paradigms from the popular children's television show 'Mr. Tumble' (made specifically for children with special educational needs) can inform the creation of language learning video games. By analysing the use of 'Makaton' a multimodal communication tool that combines signs, symbols, and speech the study highlights the potential of integrating similar techniques into game design to enhance accessibility and engagement for SEN learners. The philosophical understanding of *Maya*, which emphasises the illusory nature of multiplicity, serves as a theoretical framework to understand how a single character can embody multiple roles within a game, providing a consistent yet diverse learning experience. This approach not only aids in language comprehension but also fosters emotional and social development through relatable Non-Player Characters (NPCs) designed to interact meaningfully with learners. The study posits that incorporating these elements can create immersive, emotionally resonant educational experiences and the development of parasocial relationship between the learner and the digital intervention, that better meet the needs of SEN students, ultimately leading to more inclusive and effective language learning environments. Children simultaneously navigate multiple roles and perspectives, each reflecting a different aspect of reality in make-believe play. The critical importance of integrating this cognitive theoretical framework similar to that into the design of NPCs in educational video games is highlighted in this research. The paper argues that the paradigms of 'multiplicity of mirrors', when effectively incorporated into NPC design, can reflect different aspects of language, culture, and social interaction, offering learners a more immersive and multifaceted learning experience.

Keywords: Para-social relationship, Special Educational Needs, Inclusive Education, Non-Player Characters, Empathy Mapping, Make believe Play

1. Introduction

The Early Years Foundation Stage framework 2024 acknowledges the need for a curriculum that provides equal opportunities and inclusion, meeting the individual needs of all children especially those with special educational needs (SEN) (Sheehy & Duffy, 2009). The building blocks of literacy and communication are speaking and listening skills, and these foundational skills are crucial for the development of reading and writing as well. The teaching of quality phonics is imperative in the teaching of reading, with systematic synthetic phonics being proven to be the most effective method for teaching children with SEN to communicate. However, while the importance of such phonics programs is evident, these programs alone are not sufficient in supporting the comprehension of pupils with SEN (Solity, 2006). Whilst it is appealing to believe that of the development of the education system as a steady and inevitable progression, the thinking and beliefs of older practices do not necessarily disappear in the new era. Vestiges of older beliefs remain within later attitudes and practices (Crowe, McLeod & Ching, 2012).

Educational spaces are still primarily built on integrative mechanisms, assimilating children into existing groups and systems. However, there is a lack of development in creating new educational environments that are inclusive wherein new environments are built; that prioritises creating an environment that values and respects all individuals, regardless of their differences (Namburi & Hopkins, 2023).

This gap highlights a missed opportunity to foster an educational setting that not only accommodates diversity but actively celebrates and incorporates it into the learning experience. Access to communicative interactions is important for the educational participation and social inclusion of students with SEN. Researchers have reported low frequencies of communicative interaction between students with SEN and their teachers, potential reason being limited understanding about their needs. Students with SEN have limited engagement in classroom activities and the frequency of communicative interactions remain low because they do not have the space to acquire and practice communication skills (Evmenova & Behrmann, 2011) (Gu et al., 2023). Schools need to become an optimal place to better understand how to support students with SEN to make the education system a place where they realise their potential as communicators (Evmenova & Behrmann, 2011).

In the United Kingdom, approaches have been pre- dominantly monolingual, with a focus on the development of spoken English for communication and as a means of instruction. Monolingual "nonvisual/visual continuum" exists, with approaches strongly emphasising auditory over visual modes of English.

Extensive research has been conducted on developing video games for teaching languages and communication skills to children. However, there has been comparatively less focus on creating similar educational tools tailored specifically for children with SEN. The growing disparity in the development of proper communication skills and language use between children with special educational needs and those in mainstream schools remains largely unaddressed.

There is a critical need to develop more literacy and language learning video games with user interfaces that are accessible and friendly for students with special educational needs (SEN). One approach to achieving this could be by incorporating insights and observations from the most-watched children's television shows in the UK, Mr. Tumble. By analysing and reflecting the interaction style and use of Makaton (cued speech language, which uses a series of specially created handshapes near a speaker's lips to cue phonemes) in the popular show, developers can create game interfaces that are engaging, intuitive, and supportive of SEN learners. This approach can help ensure that educational games are inclusive and cater to the diverse needs of language learners because if an 'emotional barrier,' also known as an 'affective filter,' is present, it can prevent the acquisition of comprehensible input by limiting the amount of information received by the language acquisition game by learners with SEN (Walker, 1987).

The CBeebies ‘Mr. Tumble-Something Special’ show offers a refreshing and innovative approach to communication and language learning for children with special educational needs.

The show Mr. Tumble has demonstrated the effectiveness of enabling children with SEN to become conscious of their language use and process language at a deeper level. In the show Mr. Tumble uses Makaton, a multi-modal language program based on the principles of signing, symbols, and speech, provides additional support in this area. This approach not only makes language comprehensible but also considers the emotional needs of learners (Mistry & Barnes, 2013) (Walker, 1987).

This sets a precedent for emphasising the importance of social experiences in language learning, which can be further incorporated into the development of Non-Player Characters (NPCs) in educational video games that foster meaningful interactions and relationships.



Figure 1: Image of Mr. Tumble and the characters he portrays on his show (Sourced from Google)

2. Review of existing literature:

The social experience children with SEN have when they play language learning video games should be of primary focus. Development of Non-Player Characters (NPCs) in games can be a key factor to engage a player and bring about this experience. Over time, a pattern of interactions between a player and agents develops into a relationship, if the game and its NPCs are designed to accommodate this the NPCs with such capabilities will provide a new experience when playing games.

Developing game companions that are capable of perceiving and exhibiting emotions, complete with the ability to develop simple social relations over time is essential to learners with SEN. Developing a game companion that forge social relations and make appropriate use of social signals would increase in player experience when

playing the game with the additional influence of interactive emotion, personality and relationships to the game companion's behaviours (Chowanda et al., n.d).

A key goal in designing the language learning game companion would be to make them relatable and believable. The idea of "believability" is not directly proportional to reliable characters but development of one that provides the illusion of life, and thus permits the audience's suspension of disbelief.

The focus should not be on creating Non player characters that are realistic, but ones that do not break the illusion. In games, implementing the illusion results in an increase of player experience. Social believability in games improve the experience. Character's believability influences the players immersion and enhances the game-play experience. The aim is then to develop a user experience that has an emotional, cognitive and behavioural connection between a user and a resource. That connection can then be linked to emotion, personality and social relationship aspects. The uniqueness of a character in comparison to others in the game and their ability to exhibit emotions provides a feeling of immersion to the player. Games such as The Sims, Animal crossing, My time at Portia, House flippers have the ability to forge a relationship with the players and their NPCs as a part of their storyline. Research has been done to enhance the player experience by improving their believability. However, only limited research has been done to incorporate emotion, personality and social relationships models together. Social relationships models can be adjusted to enrich the game story as well (Calvert and Wilson, 2008).

The portrayal of characters significantly impacts the learner's engagement. The distinction between shows like Mr. Tumble, Dora the Explorer, Blue's Clues lies in the portrayal of characters. In Dora the Explorer and Blue's Clues, each character is represented by distinct individuals, contributing to a diverse character ensemble. In contrast, Mr. Tumble features a unique format where the titular character, Mr. Tumble, assumes the roles of all other characters within the show. This is highlighted by the consistent use of nose paint makeup across all his portrayals, making it evident to children that it is the same individual embodying multiple personas. This approach is also visible in show's like Sesame Street, Magic school bus and Teletubbies.

3. Mr. Tumbles' illusion of multiplicity:

The concept of an individual embodying multiple personas, as seen in shows like Mr. Tumble, mirrors the philosophical notion of *Maya* (Illusion) in *Vedanta* (concepts of the soul) metaphysics. *Maya* represents the illusion of multiplicity, where a singular reality manifests as various forms and identities. This illusion creates the perception of distinct, separate entities, despite being rooted in a single underlying reality.

Maya is the pivotal concept in Vedanta metaphysics which declares the external world and the individual self to be illusory. *Maya* is relational rather than intrinsic. This relational truth allows the finite beings to perceive and relate to the infinite. *Maya* enables a relationship between the finite and infinite, allowing the perception of this relationship. It is an illusion that manifests as a lesser degree of reality, existing only in relation to the ultimate reality. It is the semblance of reality (like the reflection of the sun in a pot of water—real yet not real) According to *Advaita Vedantas* Mirror models the main focus of multiplicity of mirrors is on the reflection of consciousness, the illusory multiplicity of individual selves. The reflection analogy addresses the interaction between consciousness and intellect (Dimock, 1991).

This is when something is cognised in itself without objectively existing, and (while existing objectively) is not cognised. The illusory nature of *Maya*, allows things to appear that do not have inherent reality.

In the same way in the episodes of Mr. Tumble perceived realities can influence interactions and relationships. This is not merely an illusion but a relational power that enables viewers to experience reality at a certain level, distinct from the ultimate truth. This relational aspect of *Maya* can be leveraged to enhance social interactions and relationships, particularly in creating believable and meaningful connections.

Maya allows for a semblance of reality that is perceivable, though not fully comprehensible. This semblance can manifest in various forms, such as compassion, love, or other emotions that bind people together. The theological understanding of *Maya*, as a power makes possible an additional aspect without corresponding reality to appear, facilitating a relationship between the finite and the infinite. This dual nature of *Maya*—being real in one sense and not real in another can be a powerful tool in social relations, as it allows individuals to connect over shared perceptions and experiences, even if they are not grounded in absolute reality (Oxford University Press, n.d.).

Mr.Tumble creates a shared sense of reality. He presents himself and the narratives he shares in such a way that it creates a common ground, even if this is not entirely based on an objective truth. This shared reality, while

not absolutely true, becomes a basis for trust and rapport, enhancing the believability of the interactional. His ability to present an appearance of reality without being fully real allows for the management of emotional connections. For example, in the relationships he shares, expressions of empathy or compassion, although they may not entirely capture the true nature of the situation, create a comforting and supportive environment. This is similar to how *Maya* functions in enabling finite beings to relate to the infinite.

His interactional patterns align with the social phenomena of role-playing and the use of social masks. He adopts certain roles or personas in different social contexts to navigate relationships effectively. These roles, while not entirely representative of an individual's true self, help in maintaining social harmony and fostering meaningful interactions. The interplay between these roles and the underlying reality mirrors the relationship between *Maya* and the ultimate truth.

He plays a crucial role in the lives of children by shaping social perceptions and interactions; enhancing the believability and quality of interactions, making his personas a potent tool in forging and maintaining social relationships.

Mr. Tumble effortlessly presents the perceived plurality of individual selves, all of which are reflections of the singular ultimate reality, underscoring the interconnectedness of individuals and the projection of a singular underlying consciousness through multiple personalities.

The social interactional patterns learnt from Mr. Tumble could be integrated into a framework for social and emotional game companions to enhance their believability and quality of interaction in language learning games specifically designed for learners with SEN.

Interactive media, where children can control or influence the actions of a character, have further proven to enhance cognitive skills like critical thinking, decision-making, and creativity. Characters in shows are designed to be engaging and approachable, speaking directly to the camera as if addressing the child personally. This direct engagement has helped children feel like they have a personal relationship with these characters. Mr. Tumble engages children by asking them questions and pausing to allow them to respond, creating an interactive experience (Calvert and Wilson, 2008). This engagement fosters a parasocial relationship where children feel as though they are friends with him. Such relationships enhance a child's understanding of their own self-regulated metacognitive educational skill (Namburi & Hopkins, 2023). When Mr. Tumble demonstrates problem-solving or language skills, children who feel connected to him are more likely to internalise these lessons and apply them in their own lives.



Figure2: A visual representation of his persons (Sourced from Google)

4. Mr. Tumble episodes

In the episodes of 'Mr. Tumble he is seen interacting with children who have disabilities and SEN and involves them in activities and themes that teach them about communication, integral life skills, and interaction. The episodes under the "Something Special" banner directly address and engages with its neurodivergent audience, making every child feel seen and valued. Across it's episodes the show covers topics themed around everyday experiences and places that children with SEN communication learners experience in real life.

1. Children visit the park, supermarket, and post office, friends' houses providing children with a virtual experience of public spaces and what one can do there.
2. Visits to the zoo, farms, lakes, playground, museum are common, where children learn about animals, nature, and historical artifacts.
3. Engaging in daily activities like going to school, cooking, playing games.

4. Being a part of events like birthdays, Christmas, festivals, explaining traditions and customs; Introducing children to global cultural activities, fostering diversity and inclusion.
5. Learning about academic concepts like numbers, animals, flora and fauna, counting, identifying colours, and recognising basic shapes. These are integrated into playful activities or explorations of different socio-cultural environments.
6. In the beginning and ending of each episode there is a strong emphasis on the development of communication skills using Makaton signs and symbols, helping children express themselves and understand others.
7. Many episodes explore daily routines like getting ready in the morning, meal times, and bedtime routines, helping children understand and adapt to daily life activities and uncertainty of events.
8. Each episode is structured to be inclusive by using visual aids, repetition of concepts during the same episode, and Makaton signing to ensure effective engagement.
9. Mr. Tumble interacts with both children and adults during each episode, modelling polite social interactions.
10. Biweekly episodes focus on engaging children in arts and crafts, encouraging creativity while developing fine motor skills.
11. All episodes include singing and dancing to repetitive songs that incorporate Makaton signs.

These episodes are specifically structured in a way that the language development is accessible to children with learning and communication difficulties and who rely on alternative communication methods.

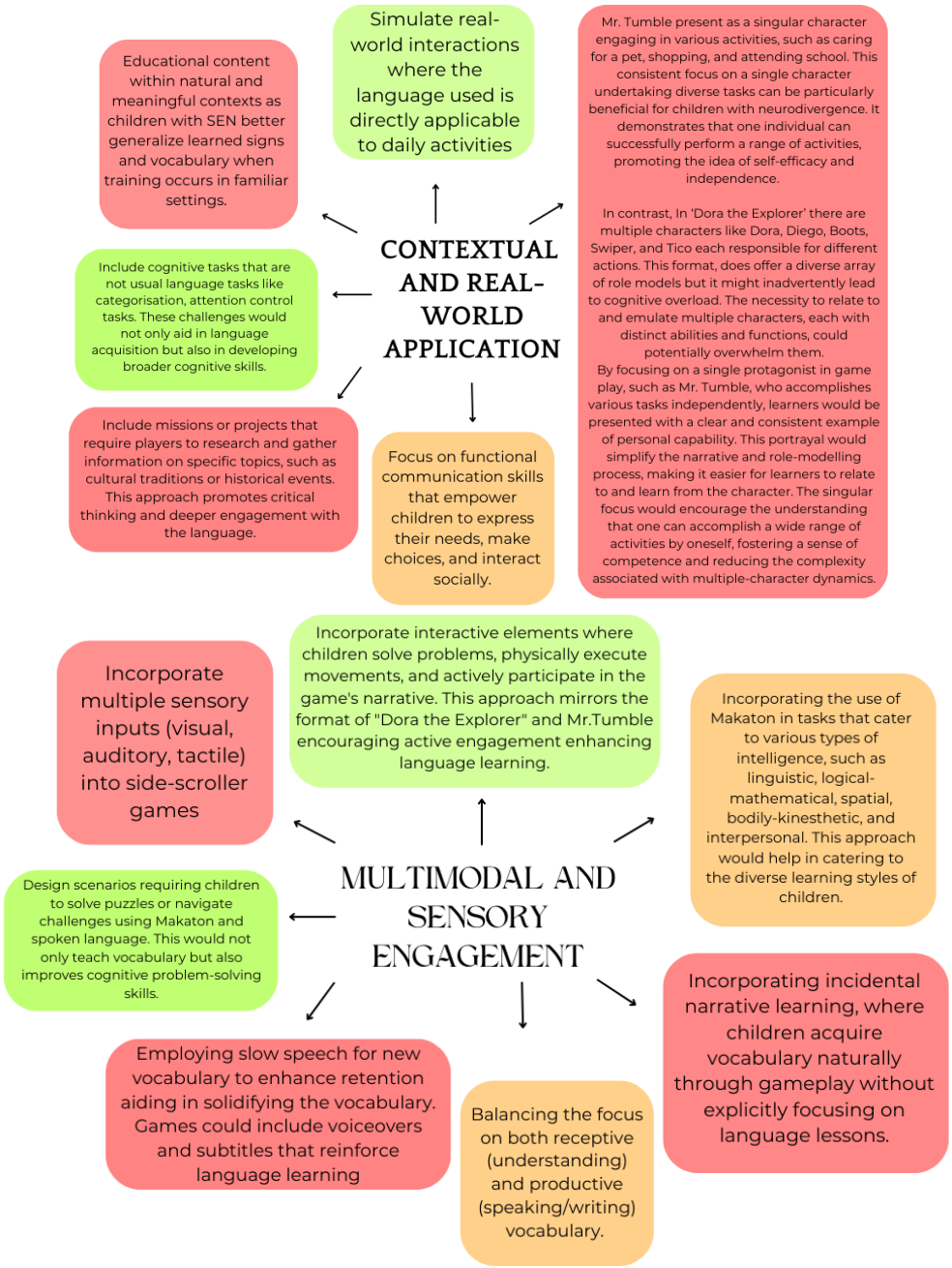


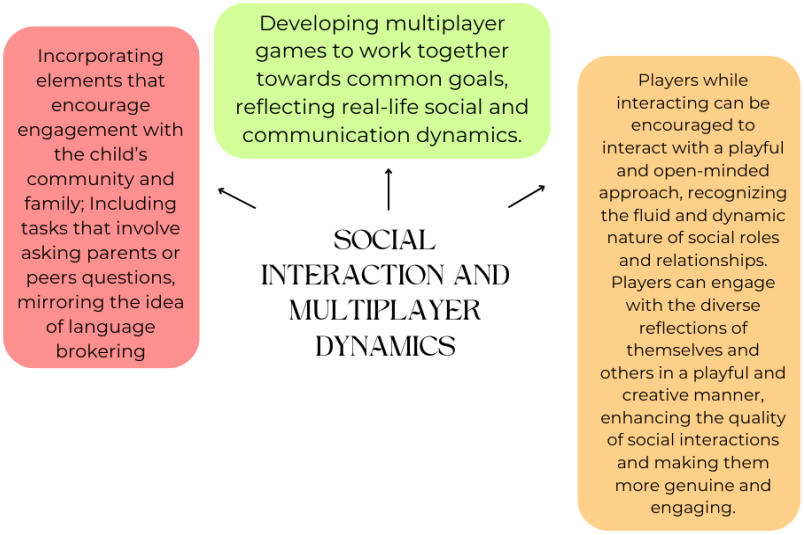
Figure 3: Across it's episodes the show covers topics themed around everyday experiences and places that children with SEN experience in real life. (Images from Google)

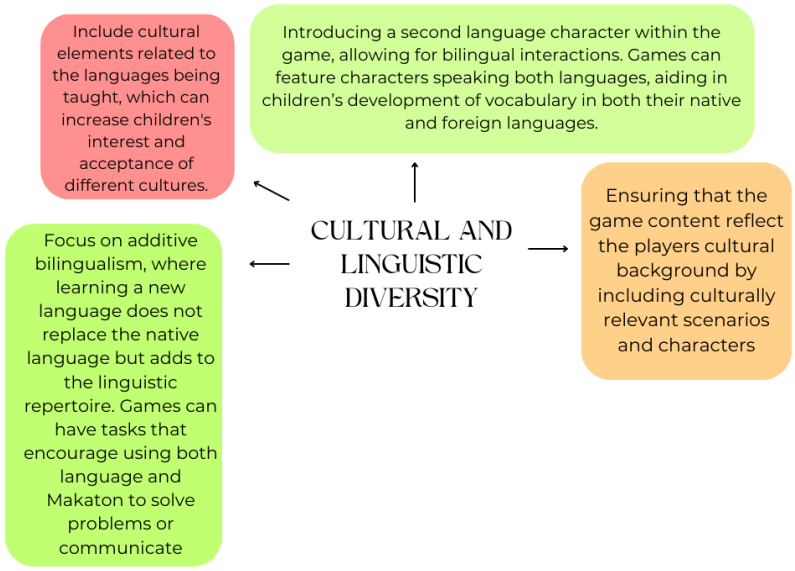
5. Developing educational games that incorporate features inspired from Mr. Tumble

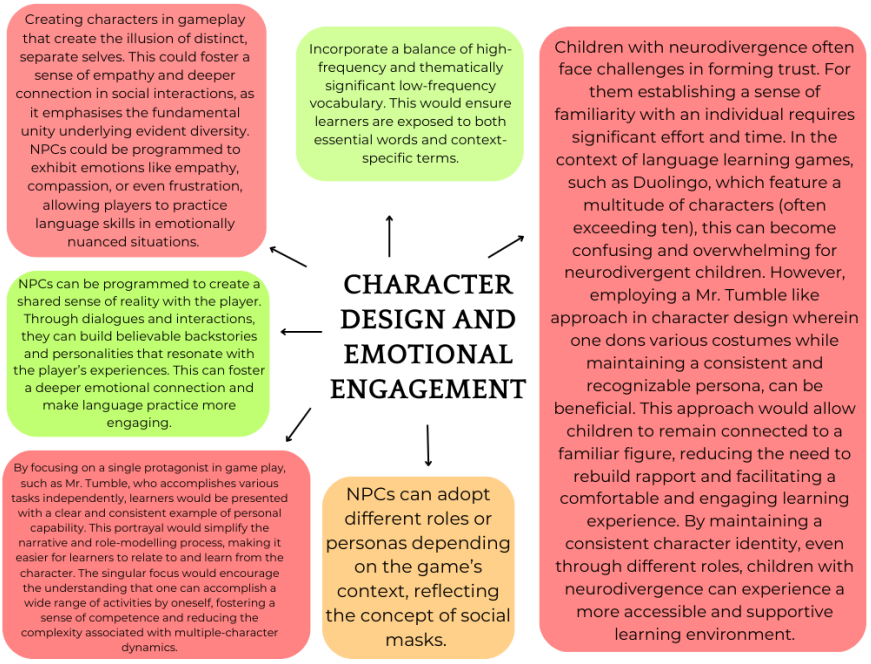
Using personas in the design process could help develop a stronger sense of empathy towards users. By engaging with detailed personas, developers could be better able to understand the needs, desires, and challenges faced by SEN users, encouraging a user centred approach. Developing personas would help shift the focus from the designer's own preferences and biases to the needs of the SEN users, fostering creativity that is more aligned with user expectations and real-world scenarios (Calvert and Wilson, 2008). Research is being conducted on the development of storylines in language learning games engaging players in dialogues and decision-making processes, similar to the interactive elements of "Dora the Explorer". What now needs to be developed in these games are NPCs that exhibit emotions like empathy, compassion, or even frustration, allowing SEN players to practice language skills in emotionally nuanced situations whilst also developing a para-social relationship with the NPC (Namburi & Hopkins, 2023).

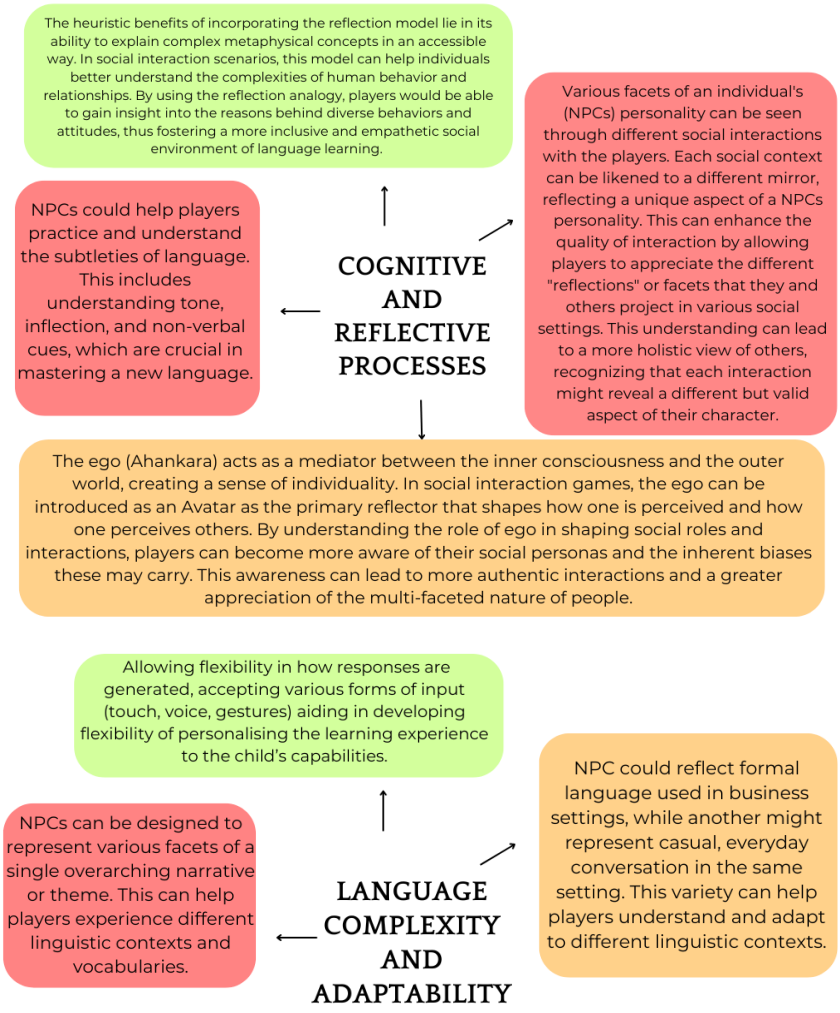
To develop communication and language learning video games that are inclusive of children with special educational needs, observations from the show Mr. Tumble can be integrated.




Developing multiplayer games to work together towards common goals, reflecting real-life social and communication dynamics.
Incorporating elements that encourage engagement with the child's community and family; Including tasks that involve asking parents or peers questions, mirroring the idea of language brokering
Players while interacting can be encouraged to interact with a playful and open-minded approach, recognizing the fluid and dynamic nature of social roles and relationships. Players can engage with the diverse reflections of themselves and others in a playful and creative manner, enhancing the quality of social interactions and making them more genuine and engaging.
SOCIAL INTERACTION AND MULTIPLAYER DYNAMICS


Include cultural elements related to the languages being taught, which can increase children's interest and acceptance of different cultures.
Introducing a second language character within the game, allowing for bilingual interactions. Games can feature characters speaking both languages, aiding in children's development of vocabulary in both their native and foreign languages.
Ensuring that the game content reflect the players cultural background by including culturally relevant scenarios and characters
Focus on additive bilingualism, where learning a new language does not replace the native language but adds to the linguistic repertoire. Games can have tasks that encourage using both language and Makaton to solve problems or communicate
CULTURAL AND LINGUISTIC DIVERSITY


Creating characters in gameplay that create the illusion of distinct, separate selves. This could foster a sense of empathy and deeper connection in social interactions, as it emphasises the fundamental unity underlying evident diversity. NPCs could be programmed to exhibit emotions like empathy, compassion, or even frustration, allowing players to practice language skills in emotionally nuanced situations.
Incorporate a balance of high-frequency and thematically significant low-frequency vocabulary. This would ensure learners are exposed to both essential words and context-specific terms.
Children with neurodivergence often face challenges in forming trust. For them establishing a sense of familiarity with an individual requires significant effort and time. In the context of language learning games, such as Duolingo, which feature a multitude of characters (often exceeding ten), this can become confusing and overwhelming for neurodivergent children. However, employing a Mr. Tumble like approach in character design wherein one dons various costumes while maintaining a consistent and recognizable persona, can be beneficial. This approach would allow children to remain connected to a familiar figure, reducing the need to rebuild rapport and facilitating a comfortable and engaging learning experience. By maintaining a consistent character identity, even through different roles, children with neurodivergence can experience a more accessible and supportive learning environment.
NPCs can be programmed to create a shared sense of reality with the player. Through dialogues and interactions, they can build believable backstories and personalities that resonate with the player's experiences. This can foster a deeper emotional connection and make language practice more engaging.
CHARACTER DESIGN AND EMOTIONAL ENGAGEMENT
By focusing on a single protagonist in game play, such as Mr. Tumble, who accomplishes various tasks independently, learners would be presented with a clear and consistent example of personal capability. This portrayal would simplify the narrative and role-modelling process, making it easier for learners to relate to and learn from the character. The singular focus would encourage the understanding that one can accomplish a wide range of activities by oneself, fostering a sense of competence and reducing the complexity associated with multiple-character dynamics.
NPCs can adopt different roles or personas depending on the game's context, reflecting the concept of social masks.



6. Limitations of Incorporating the cognitive frameworks of Mr. Tumble into NPC development:

Learners could overidealise the characters perceiving them as perfect or infallible or develop a confusion between fantasy and reality. Overreliance on the NPCs for cognitive stimulation could lead to passivity if the NPC is not interactive or educational. This could create unrealistic expectations about real-life relationships. Leading to disappointment or frustration when real people do not meet these idealised standards (Ariyurek, Surer and Betin-Can, 2023). Learners in early developmental stages could develop strong parasocial relationships that can blur the boundaries of illusion and reality, hindering their understanding of social interactions and relationships (Calvert and Wilson, 2008). The characterisation of SEN learners as a homogeneous group has been oversimplified in language learning games like Duolingo. SEN learners encompass a broad spectrum of conditions, including ASD, ADHD, dyslexia, and other cognitive or developmental challenges. Each of these conditions presents distinct cognitive, emotional, and learning profiles that require specialised and differentiated educational interventions. Incorporating the diversity within the SEN population is necessary to ensure the effectiveness of these interventions. The key challenge in implementing such differentiated NPC designs lies in gathering comprehensive cognitive data that accurately reflects the diverse needs of SEN learners. Understanding how the learners process information, engage with content, and develop social and emotional skills is critical to creating responsive NPCs that can adapt to individual user profiles.

7. Effectiveness Supported by Cognitive Frameworks Proven in Make-Believe Play

The portrayal of NPC'c significantly impacts the learner's engagement, much like how children benefit from engaging with personas and illusions of reality in make-believe play. Just as in games where relatable and believable NPCs enhance the immersive experience, children engaging in make-believe adopt different personas, which fosters their linguistic and social development. Both scenarios emphasise the importance of creating characters, whether in education or play allowing for emotional, cognitive, and behavioural connections, enriching the learners experience through the exploration of diverse language and social cues.

Cognitive processes and knowledge structures of SEN learners should be taken into consideration when developing NPCs incorporating a user-centred design. Traditional NPC persona development focus on demographic and behavioural data, but I argue that including cognitive aspects—such as how users process information and their existing knowledge can lead to effective and attuned educational tools (Lanius et al., 2020).

There is a need for creating personas that reflect the cognitive and knowledge-related characteristics of SEN learners. This involves gathering data not only on user behaviours and demographics but also on how users learn, their cognitive challenges, and the prior knowledge they bring to the learning process (Marsden et al.,2017). For each segment, personas should be created with detailed attributes reflecting their knowledge levels, cognitive characteristics, and learning behaviours. These personas could include demographic information, goals, challenges, and specific cognitive traits, such as how they process information or their preferred learning methods. The personas could be iterated and refined based on feedback and user research. This ensures that the personas accurately represent the target users' cognitive and knowledge-related characteristics and needs (Anvari et al., 2019). Developers cannot run the risk of overlooking the distinct needs of various subgroups within this population. The cognitive and learning challenges faced by individuals with dyslexia, differ significantly from those experienced by individuals on the autism spectrum, who may present with unique sensory processing and social communication difficulties. Similarly, learners with ADHD struggle with sustained attention and require tools that promote engagement and focus, whereas those with intellectual disabilities may benefit from strategies that support cognitive development at a different pace and level of complexity. Without recognizing this diversity, NPC designs would fall short of addressing the specific needs of different SEN learners, thereby limiting their educational efficacy. Developers could design multiple NPC personas, each tailored to specific cognitive profiles within the SEN population. NPCs designed for learners with autism might include features that accommodate sensory sensitivities and support social communication skills, while NPCs designed for learners with ADHD might focus on strategies to sustain engagement, promote attention regulation, and mitigate distractibility. NPCs for learners with dyslexia could incorporate tools that address phonological processing and reading fluency, while those for learners with intellectual disabilities might focus on simplifying instructions and offering scaffolded learning experiences.

The benefits of engaging with personas and illusions of reality and learning communication and language through this method is also prominently observed in children's make-believe play as well. Therefore, engagement with NPCs designed on such cognitive frameworks would inevitably lead to the practice of understanding and predicting what others might think or feel. Children would learn to take perspectives crucial for effective communication development in children, helping in children tailoring their language and behaviour to the needs and expectations of others. They would learn about how each character would speak or respond; requiring them to use language in diverse ways, experimenting with different tones, vocabularies, and speech patterns, enriching their linguistic repertoire. Symbolic thinking has been linked to language development, where words themselves are symbols for objects, actions, or ideas just like the use of Makaton. By engaging in symbolic learning learners would practice and observe the use and understanding of metaphors and analogies, inevitably enhancing their ability to use language creatively and effectively.

Exposure to and use of words that are beyond their everyday vocabulary would benefit in comprehension and phonological development. When pretending to be a doctor or superhero with a NPC, they might use specialised terms or jargon, expanding their vocabulary in contextually meaningful ways like how MR. Tumble teaches the same (Severson and Woodard, 2018).

This inherently narrative style of learning, would require children to create, follow, and sometimes change stories. This practice would develop their ability to construct coherent narratives, an essential skill in both written and spoken communication. This creation of stories, understanding the sequence of events and using appropriate grammatical structures to convey them would help SEN learners better their communication skills. Learners would be able to grasp the rules of syntax and how different sentence structures could be used to express various ideas or emotions aiding in the development of pragmatic language skills, which are critical for effective communication in real-life social situations.

Would learn to interpret and respond to social cues, such as body language, tone of voice, and facial expressions improving their ability to understand and use these cues in actual conversations, enhancing their communicative competence (Bretherton, 1989).

SEN learners would develop a level of metacognition, were children would think about how they are using language. They would consciously decide to change how a character speaks or what they say to fit a particular

scenario. This reflection would help them become more aware of the nuances of language and how it can be adjusted to suit different contexts or audiences. As children become more aware of their own language use they would develop the ability to self-correct, leading to greater language proficiency and flexibility.

SEN learners would collaborate with other NPCs, requiring them to negotiate roles, rules, and scenarios. This collaborative process would provide rich opportunities for language practice, including negotiation, persuasion, and explanation. More knowledgeable peers or adults guide NPCs, could introducing new vocabulary and complex language structures like how Mr. Tumble does in his show. This scaffolding could help children internalise new language forms in a supportive environment. The NPC's could encourage children to use language in creative ways, such as inventing new words, phrases, or even languages to fit the fantasy worlds they create. This creativity in language use would help them develop linguistic flexibility and the ability to play with language structures. As SEN children start to imagine different scenarios, they could also explore how language changes depending on the context; helping them understand the situational nature of language and preparing them to use language appropriately in a wide range of real-world situations.

These recommendations are likely to be effective because the same cognitive frameworks have proven successful in make-believe play, which has demonstrated significant benefits for language and communication development. The established efficacy of these frameworks in fostering linguistic and social skills suggests that their application to NPC design in educational tools could similarly enhance learner outcomes.

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Enhancing Algorithmic Thinking Skills through Phygital Games: The Case of Space Codyssey

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Abstract: This paper presents an educational phygital game, Space Codyssey, aiming at cultivating the algorithmic thinking skills of young children. Space Codyssey is a phygital game, and its contains programming activities for the Sequence, Repetition, and Selection Structures, as well as Code Debugging activities (Debugging). The game utilizes Augmented Reality technology to present missions via QR cards. Additionally, digital storytelling is used as a means of assistance and teaching for preschool and early primary students. In the game, reading skills are not a prerequisite, and programming is accomplished using symbolic commands through a "Visual Programming Language." The participatory design methodology that was adopted, involving 28 educators from various specialties, reflects a holistic approach to the development of educational technologies. This interdisciplinary collaboration allowed for the integration of diverse pedagogical perspectives, ensuring that the game meets the multifaceted needs of modern education. The paper highlights the educational goals and learning outcomes for the designtated age group. It presents the scenario, the subject, the elements of the game, the rules, and the game mechanics. It also describes the implementation stages and the development of the application. Finally, it presents the results from a study, which involved 28 educators and aimed to improve the game before its use in educational settings.

Keywords: educational board games, computational thinking, augmented reality, digital storytelling, primary school

1. Introduction

Understanding algorithmic structures is a fundamental skill in the digital era, of growing importance for child education beginning from the preschool age. Algorithmic structures are the basis of computational thinking and programming while fostering the development of logical thinking and problem-solving (Wing, 2006).

Integrating the algorithmic structure teaching in preschool and primary education has multiple benefits. However, teaching algorithmic structures in such early ages is a challenging task. Careful planning of instructional activities is required so that they are appropriate for children's developmental level and keep their interest high (Fessakis et al., 2013). Moreover, it is critical to both avoid overemphasis on technology and preserve a balance with other essential aspects of children's development (Bers, 2018).

Learning through play is a powerful educational approach, especially for children of this age. Board games, in particular, offer a unique framework for developing a variety of skills and reinforcing learning in a fun and engaging way (Bratitsis et al. 2023, Tsapara et al. 2023).

Research shows that board games can contribute significantly to the development of cognitive, social, and emotional skills. According to Cleto et al. (2019), the use of physical and virtual objects in hybrid games can enhance learning of key programming concepts. This is supported by Jin et al. (2018), who developed a tangible programming tool that uses augmented reality technology to boost children's computational thinking.

The need to create a board game like Space Codyssey that works in conjunction with a smart device arises from the increasing importance of computational thinking and programming skills in modern education. The game offers a unique approach to learning basic algorithmic structures by combining the advantages of traditional board games with Augmented Reality (AR) technology. This combination creates an environment that bridges the real and digital worlds, helping children to better understand abstract programming concepts. The game is presented in the next section. Then the results from an assessment study, involving 28 educators is presented before the concluding discussion.

2. Game description

Space Codyssey, with its combination of physical and digital elements, offers an inclusive approach that can cover this need engagingly and appropriately for the target age group.

2.1 Introduction

The basic goal for players is to learn basic programming and computational thinking principles through a fun and interactive game. This is achieved by "visualizing" and "clarifying" the creation of algorithms to solve problems.

2.2 Learning outcomes:

- Understanding of basic algorithmic structures
- Development of programming logic
- Improving debugging skills
- Strengthening spatial perception

2.3 Game design

The game story script is that the players are lost in the universe and are looking for a habitable planet to colonize. But to do this they have to pass through other planets and solve activities (by programming) that will give them fuel to keep going. The game includes a 30-point track up to the finish line, 28 cards measuring 7cm x 8xm, divided by color, 6 red, 6 green, 6 blue, 6 orange, and 4 black. 6 14cm x 9cm programming explanation cards and spaceship-shaped pawns (Figure 1).

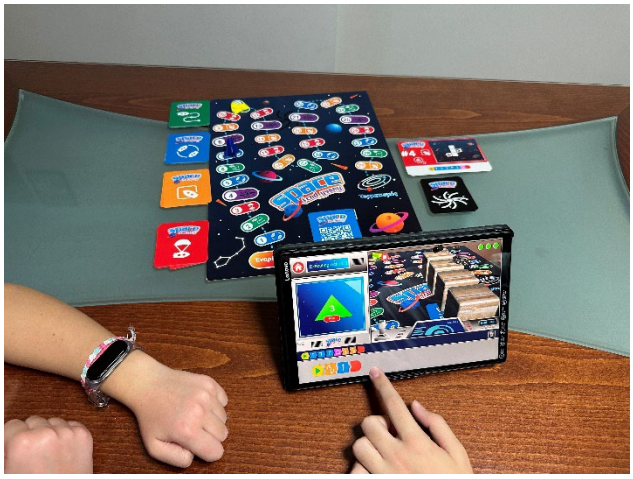


Figure 1. The board game and the corresponding mobile application

2.3.1 Game rules

The game rules are simple as it addresses the needs of children 5 years old and above. The first player who gets the highest number on the digital pyramid dice starts the game. At each position on the track, there are some actions to be carried out. The player who reaches the finish line (galaxy) first is the winner.

2.3.2 Game mechanics

The player depending on the number on the dice, moves the spaceship across the spots on the tableu. All positions are colored and thus when reaching them the player has to pick a corresponding colored card. The cards are divided into colored categories: Green cards for Sequence Structure activities; Blue cars for Repetition Structure activities and the Orange ones cards for Choice Structure activities. All the cards incorporate a QR code on one side. By scanning it displays the activity the player has to carry out in a 3D form quiz/puzzle. Correct solution of the puzzle leads the spaceship to fuel and the player can proceed during the next turn. Failing to solve the puzzle requires that the player stays on the same spot, selecting a new card in the next turn. The Red cards incorporate numbers and when scanned display a robot assistant who PROVIDES audio instructions for program debugging (cards with incorrect codes). Additionally the robot assistant helps players understand basic principles of computational thinking.

2.3.3 Technological implementation

Unity3D (Figure 2) is particularly well-suited for serious game development due to its flexibility and powerful engine, which allows for the creation of high-quality 3D environments and the integration of advanced features. In addition, the platform can create applications for PC and mobile devices with VR/AR technologies. The Vuforia SDK was selected for developing the AR material, as it is considered one of the best choices for "cross-platform" (Android, iOS) applications. For the game, cards with QR codes were designed, which when scanned by Vuforia's recognition engine, display the missions that the player must solve to get fuel and continue.

A "Visual Programming Language" was also designed. This language "runs" through the application and works cooperatively with the 3D graphics so that if the player designs the code correctly, the activity is solved fuels is received. This language relies on graphics and visual representations instead of text. Programming commands are presented as puzzle pieces with specific symbols that users can drag and place to build a program. This type

of programming is suitable for young children, as it reduces code complexity and promotes understanding of basic programming concepts.

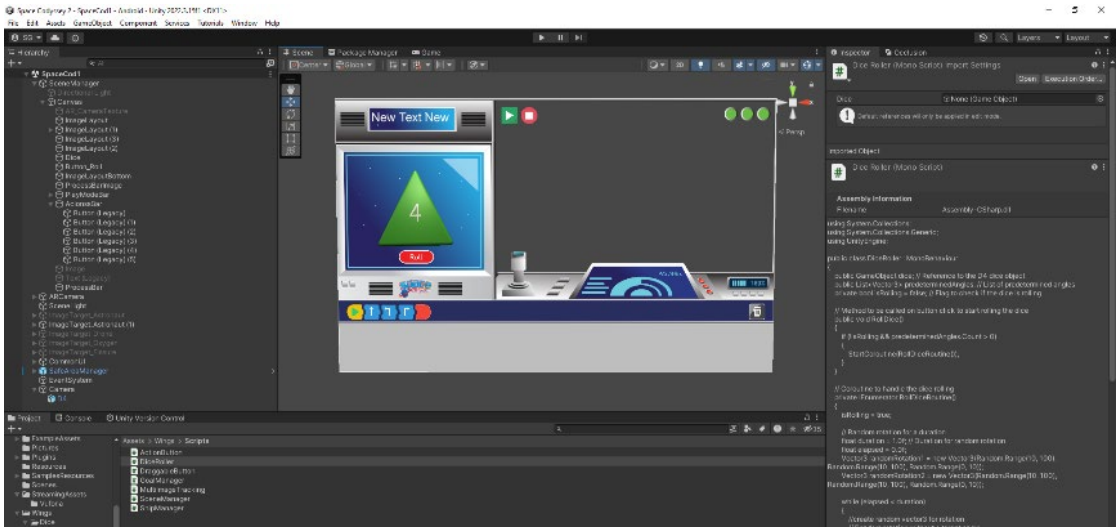


Figure 2 Developing the application on Unity3d

The design and development stages of Space Codyssey reflect an evolving process, adjusted to the needs and characteristics of preschool and primary school children. The game track was transformed from a simple flowchart to a living, space-based landscape. The graphics were enriched with bright colors and child-friendly characters, while the cards and images were designed with bright, cheerful patterns to attract young players. Each element was designed with visual clarity and ease of use in mind, allowing children to focus on the learning process. Particular attention was paid to the clear delineation of the different functional areas of the application. The pyramid dice area, the governance (camera) screen and the programming area have been designed to be clearly visible. This visual separation helps players quickly understand the function of each part of the app, thus improving the overall user and learning experience.

3. Participatory design, pilot testing, and reviews

The development of the game followed an itterative approach, with five consecutive trial versions, each of which was subject to strict evaluation and optimization based on teacher feedback.

The participating teacher sample is characterized by a high degree of interdisciplinarity, consisting of 28 primary school teachers. Their contribution to the development of the game was made through semi-structured interviews, initial concept presentations, and different versions of practical testing.

A detailed interview protocol was designed and followed that covers various aspects of the game, from its design and implementation to its educational value. The categories of questions are as follows:

- Introductory questions
- Implementation of the physical elements of the game
- Appearance and functionality of the application
- Combined QR code card function with Augmented Reality and Digital Storytelling
- Educational benefits
- Improvement proposals

This multi-dimensional approach to design ensured Space Codyssey pedagogical suitability and educational efficacy in a variety of educational settings. The synergy between different specialties contributed to the creation of a holistic educational tool that integrates best practices from different areas of education and computer science teaching.

The key findings from the teacher interviews focused on the following areas:

- Improving the direct interaction between QR code cards and the Vuforia SDK engine, as well as enhancing the visual presentation of activities.
- Adjusting the 3D graphics to make the planet's positions clearer. This involved changing from spherical to cubic representations to help students better understand the steps.

- Teachers suggested using a smaller die with numbers only up to 4. This suggestion was based on the observation that young students might struggle with larger numbers and that the limited number of spaces on the game board didn't require larger numbers. The design team adopted this change, which is expected to make the game more accessible to young players and improve game flow.
- Educators recommended refining the robot's audio instructions to make the concept of debugging easier for students to understand. This suggestion arose from observations that younger students often struggled with the abstract nature of debugging in programming.

4. Future plans

The next important step in the game development is the application. A study will be carried out on a sample of 5 to 9-year-old pupils in educational institutions in the region of Western Macedonia, Greece. The methodology entails the use of pre-experimental and post-experimental tests, specifically designed to assess the understanding of basic algorithmic structures. This approach allows the collection of quantitative data to measure the effectiveness of the software as an educational tool. The results of the study will undergo statistical analysis to identify the statistical significance of the observed learning outcomes. The findings are expected to provide empirical data on Space Codyssey effectiveness and lead to software future improvements. It is to be noted that Space Codyssey was designed for the needs of a doctoral thesis.

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Traditional Quizzing with a Twist: Involving University Students in the Development Process

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Abstract: Quizzes have been used for educational purposes for many years. Mainly it has been digital quizzes like Kahoot or ZippyGo. However, there is an ongoing debate on the security of students' data. As the university cannot be responsible for what is stored in computers outside of Norway and at the same time paying attention to the General Data Protection Regulation (GDPR). The General Data Protection Regulation (GDPR) is a critical framework for data privacy across Europe, including the UK, Norway, and the EU (ICO, 2024). The GDPR came into force in 2018, agreeing data privacy laws across all member states. It applies to any organization processing personal data of individuals in the EU, regardless of the company's location. The regulation grants rights such as data access, correction, and deletion, and imposes strict penalties for non-compliance (ICO, 2024). As part of the European Economic Area (EEA), Norway implements the GDPR similarly to EU countries. The regulation applies to Norwegian businesses processing data of EU citizens, ensuring that data privacy standards are uniform across the region (Team, 2016; ICO, 2024). Therefore, utilizing digital games have become increasingly difficult. The students, however, are missing the gaming, and the lecturers are missing the opportunity to utilize games-based learning techniques. This leads the lecturer in the research methodology course to "Go Native" and turn to the "old style" analogue quizzing. However, previous research showed that students are not only engaged in the solving of the quizzes, but also, they engage in the development of the questions and answers for the quizzing, i.e. 'co-creating'. This paper will present a pilot study of a paper-based quiz developed by university students, and their reactions from this. Through informal interviews, data was collected to establish how they felt about this "old school" quiz type of learning after having had several different digital tools for educational games. In this paper, and based on our previous research findings (from the informal interviews with the students), we will develop this further into a digital but low-tech version of a quiz game; it should be still both fun and educational.

Keywords: quiz games, games-based learning, student involvement, low tech gaming,

1. Introduction

Since Elizabeth Magie Phillips developed the game "The Landlords Game" in 1902 to 1903 to teach people about "land grabbing and its consequences" (NPR, 2015), games have been developed for learning purposes. Even before this we have reasons to believe that games have been played for educational purposes predating dice (Hellerstedt and Mozelius, 2019).

Games-Based Learning is a significant area of research because they are integrated in many educational and business fields as a pedagogical tool (Slyman, 2018, 2022). Games-Based Learning is a type of games that use technology to deliver/enhance teaching, learning & assessment (Vos, 2014; Slyman, 2018). These games have clear learning outcomes where players can experiment with real-life scenarios in a risk-free environment (Malaka, 2014). We propose that through games with its characteristics, design and mechanics (Gee, 2005) and as a motivating pedagogical tool for learning we could enhance teaching and learning of complex subjects such as research methods. Since games allow students to engage in real-life experimental experience and use decision-making skills to resolve real-world problems in a safe environment (Slyman, 2018, 2022). In today's era of evolving digital technology, games have advanced so much from dice and boardgames to fancy graphics and advanced game technology. Games such as Sid Meier's Civilization have been used to teach strategy and history (King, 2021) whilst other games, such as SimCity, are used for teaching and learning business statistics (Slyman, 2022).

In traditional classroom settings, games for learning are often either as a simulation game to simulate a situation or a real-life case (Vold et al., 2018), or as for example quiz game (Haave and Vold, 2018; Slyman et al., 2019).

Previously, Kahoot! have been used in some of the courses (Research Methods, ECTS 7,5) (Haave and Vold, 2018). The students enjoy gaming as an aspiration as it makes a welcomed change from ordinary classroom lectures. However, with the introduction of General Data Protection Regulation (GDPR) several universities had to go through programs used in education to secure that data regarding students are not exposed to illegal or inappropriate use. This led to the withdrawal of several licences, amongst them Kahoot! as this their databases

are placed outside Norwegian jurisdiction. Only organizations with databases in Norway and with the correct security level were allowed. This means that we had to use traditional low-tech quizzes where we read the questions, and the students write down the questions on a piece of paper. They then exchanged and corrected each other's answers. The questions were developed by students, but from different classes.

In the following, we will present the theoretical foundations behind games for learning purposes, our method of inquiry, initial findings and suggestions/ improvements for our future research. Moreover, we will propose ways of using previous research data, elements of digitalization and student inputs to organize a quiz that meets the requirements of the GDPR, but at the same time offer students different inputs and a motivational boost during classes.

2. Theoretical foundations

Playing is an essential part of being a human since, for example, children learn social behaviour from play (Huizinga, 1971). Indeed Eicher-Catt (2016) find that play is an essential part of "human learning and, in some of its manifestations, can be linked to the sacred dimension of human existence."

Research on learning outcomes of games has had different labels such as serious games, educational games, games for learning, and games-based learning, and has been conducted for several years (Noemí and Máximo, 2014, Vold and McCallum, 2011, Vold et al., 2018, Haave and Vold, 2018; Slyman, 2018, 2022; Slyman et al., 2019).

One of the first game pioneers to seek a definition was Clark C. Abt, as he descried serious games to be effective devices for training and teaching (Abt, 1966). Serious games can suit students of all ages as they seemed to be supporting motivation and enabled effective communication regarding concepts and factual information regarding several subjects. Also, it allowed for explorations of different types of problems in a safe environment.

Sawyer (2007) claims that serious games are simulations of what happens in the real world and thus developed for the purpose of problem solving whilst Noemi and Máximo (2014) suggest that the main purpose of serious games is "to train or educate users". Serious games may be used for marketing and/or advertising. According to Noemi and Máximo (2014) a game "is a physical or mental contest played according to specific rules, with the goal of amusing or rewarding the participant."

Another definition of a game is offered by Salen and Zimmerman (2004) "a game is system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome." For a quiz game the "conflict" is the competition, the rules are "the correct answer acquires points" and the "quantifiable outcome" is winning the quiz.

A video game is a mental challenge played on a computer, following specific rules for fun, recreation, or competition. A serious game, on the other hand, is defined as a mental challenge played on a computer with specific rules, using entertainment to achieve goals in government or corporate training, education, health, public policy, and strategic communication (Zyda, 2005). The reintroduction of fun has led to the concept of edutainment (Gee, 2005; Prensky, 2001). The common belief is that learners' interest in a subject increase through the enjoyment and rich experiences provided by the game. According to Abt (1966) it is not only the interest, but also the *motivation* increases and this may be one of the clearest advantages.

Serious games are typically designed to balance educational content with gameplay, ensuring that players can retain and apply the knowledge in real-world situations. (Video) Games are not adversaries but rather valuable tools to engage in genuine learning processes (Prensky, 2003; Gee, 2003). This points out to the difficulty of designing serious games, the intersection between being a game designer and an educator. Educational games should educate, and other games are for entertainment. However, the entertainment is an "instrumental value", although not the objective for the design (Abt, 1966).

Limitations of serious gaming may be the teachers' attitude towards gaming and the balancing of explaining rules versus letting the students just play and discover the rules (Abt, 1966). Some teachers do not trust the outcome of a game such as validity of the content.

Another limitation that arose with the introduction of the General Data Protection Regulation (GDPR) (Team, 2016) was the protection of students' data. Not being in control of the storage and usage of data that is recorded from systems databases as they are not within the boundaries of the Norwegian jurisdiction. As it is not possible to sufficiently secure this data, many universities have decided to stop utilization of such programs and applications that are working on servers and databases outside of Norway.

Also, the classrooms are not adapted to utilize games for learning purposes (Shaffer et al., 2005). The facilitation is still of ordinary classroom settings with little or no adaption to the digital advancements that have been developed over the years. Abt explained back in 1966 that " if learning is based on experience and drawing analogies to previous experiences, it seems clear why the effective teaching of social studies is most difficult when only conventional techniques are used" (Abt, 1966). The classrooms – with few exceptions – are still based on a setup used for centuries.

3. Method of Inquiry

The method of inquiry for the pilot study was informal group interviews (Dalen, 2011). This qualitative approach (Patton, 2002) allows the informants to speak freely and even discuss the quizzes amongst each other. This may provide a richer source of information as informants' experiences are elaborated and developed further. The researcher conducting the informal group interviews took notes and did a check back (Guba and Lincoln, 1989) with the students to ensure the validity and reliability of the research notes. These notes were then analysed and interpreted line-by-line, sentence-by-sentence using colour coding highlighting key themes within each section. We looked for hidden meaning & actions. Asking questions, engaging/interacting with data, such as why participants are expressing their views/experiences the way they did. We reflected on each data and examined it. At this stage, all the coded data were linked back to the literature.

4. Initial Findings and discussion

The results from the preliminary investigations show that students really enjoy the quizzing experience, as they claim that "it provides a welcoming disturbance" besides claiming to learn from it. "It put some themes in a different perspective" and "it is really motivating to view the curriculum from this angle". Supporting statements such as these support the idea of gaming supporting education, as stated by Noemi and Máximo (2014).

Our participants referred to the quizzing as being motivating which is in line with what a number of researchers have reinforced (Abt, 1966; Prensky, 2001; Gee, 2005; Vold et al., 2018; Haave and Vold, 2018; Slyman, 2018, 2022).

Our participants also recognized that their teacher is willing to alternate classroom lectures for learning purposes. This is parallel to what Abt (1966) remarked as 'possible limitations' and 'teacher reluctance', which is not an issue here. On the contrary, teachers have been more than willing to utilize novel techniques to support teaching and learning outcomes (Haave and Vold, 2018).

Shaffer et al. (2005) pointed out that classrooms are not designed to play games, however, the layout of the classrooms do not seem to interfere with playing the game. On the contrary, it is important that there is a focus on the teacher (or the one reading the questions for the quizzes) and that all students are able to see the same screen, hence ordinary classroom setups will work for quizzing.

5. Conclusion and Future Research project

The students found the quizzing both engaging and something that they can learn from even if it is a low-tech version of a game. It allows the teacher to provide a change in the ordinary teaching regime which is also welcomed by the students who find this motivating and fun. Moreover, it can be played without reorganizing an ordinary classroom setting.

For future research project, we will use a mixed methods approach (Creswell and Clark, 2007; Patton, 2002), qualitative and quantitative. Qualitative research will be conducted using semi-structured interview guidelines on a one-to-one basis and in groups. Quantitative research will be carried out using surveys (Dwyer & Slyman, 2016). The students will be invited to take part in survey. Together, these mixed data will provide us with sufficient information to use games-based learning for further development and greater support for learning outcomes.

The new project will be about re-introducing quizzes developed by previous students. The students will play these quizzes prior to the gaming (Haave and Vold, 2018). Then they will be required to develop more questions and answers from a designated part of the textbook and add a photo/picture they find suitable for the questions. Questions and answers will then be incorporated into a PowerPoint file and sheets (paper). The presentations (MS PowerPoint) will be put up on the teacher screen, and students will have to fill in the (analogue) schemes, as the quizzes are presented. After this, students will swap schemes and the teacher will go through the answers. Next, research will be conducted amongst students to get their immediate feedback. Surveys will follow and be distributed to gain further understandings of how students perceive this type of quizzing. Moreover, we will ask them to provide examples of learning as well as suggestions for further developments.

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