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Proceedings of the

23rd European Conference on e-Learning

Hosted by Universidade Portucalense, Porto, Portugal

24-25 October 2024

Professor Fernando Moriera

A conference managed by ACI, UK

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23rd European Conference on e-Learning

ECEL 2024

A Conference

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Edited by Professor Fernando Moriera

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Contents

The papers in these proceedings were presented at the conference in sessions organised by topic, but are presented here by type of paper and then alphabetically by lead author surname.

Preface **v**

Committee **vi**

Biographies **vii**

Academic Papers

Digital Tools in the Thesis Process: A Case Study from Sweden
Naghmeh Aghaee, Thashmee Karunaratne 1-8

Examining the Relationship Between Student Online Learning Readiness and Their Satisfaction on Distance Learning
Mardeya Alblooshi 9-16

The Impact of the EduIntegrity Suite on Academic Integrity: A Qualitative Study
Don Anton Balida, John Navarro, Elvie Gonzaga, Wilfermina Landicho, Ma. Flora Collado 17-25

Slow and Steady or Fast and Furious: An Analysis of Completion Duration in open.uom.lk
Tiloka de Silva, Lakmini Bandarigodage, Eshana Ranasinghe, Vishaka Nanayakkara 26-35

An Innovative Course Structure to Teach Excel to Business School Students
Delphine Billouard-Fuentes 36-42

Predictive Modeling for Enhancing MOOC Completion Rates: A Case Study
Muditha Buddhika, Buddhika Karunarathne, Vishaka Nanayakkara 43-51

Tailoring Entrepreneurial Education: Demand-Driven Insights for an Entrepreneurial Online Mentoring Program
Henry Nicolai Buxmann, Katrin Singer-Coudoux, Karim Houssni 52-59

Perspectives of Czech High School Students on Cheating in Remote Education
Miroslava Černochová, Hasan Selcuk, Tomáš Podoljak 60-68

Gamifying Sustainability: Leveraging Game-Based Learning to Champion Sustainable Development Goals (SDGs) – A Case Study
Yvonne Costin, Michael O'Brien, William Hogan 69-76

AI chatbot: I want help, not the answer!
Olav Dæhli, Bjørn Kristoffersen, Per Lauvås 77-84

Examining the Views of non-e-Tutoring Students on Potential Benefits and Drawbacks of Incorporating e-Tutoring into Their Learning Experience
Prince Enwereji, Annelien van Rooyen 85-93

Frustration Gap Bridging: A Second Look at Vocabulary Proficiency with the Yes/No Test
Thomas Goetz 94-103

Predictive Regression Modeling for Forecasting Graduation Duration in Online Offsite Degree Program
Buddhini Gunarathna, Vishaka Nanayakkara, Buddhika Karunarathna, Tharanee De Silva 104-113

Enhancing STEAM Education with AR: A Primary Education Teacher Training Study
Jan Guncaga, Lilla Korenova, Eva Severini 114-121

The Problem of AI Hallucination and How to Solve It
Antonin Jancarik, Ondřej Dušek 122-128

Flipped Classroom in the Czech Republic
Kateřina Jančaříková, Lucie Loukotová, Antonín Jančařík 129-137

Industry Mentoring Program: Empowering External Degree Students for Career Success – Case Study from University of Moratuwa, Sri Lanka
Sumudu Jayathissa, Vishaka Nanayakkara, Buddhika Karunarathna, Niranjan Gunawardena, Malik Ranasinghe, B.H Sudantha, Roshan Sawanawadu 138-146

Factors Affecting the e-Learning Implementation in UAE Public Sector Organizations
Amira Kamali 147-152

The Effect of the Byod Model in Comparison with the Traditional use of ICT in Primary Schools
Michael Kancner, Tomas Javorcik, Tatiana Havlaskova 153-160

A Probability-Based Model for Course Completion Prediction in Online Asynchronous Learning
Pavindya Methsara Kankanamge 161-169

Utilising Blended Learning for Large Classes to Deliver an Introductory Programming Course
Buddhika Karunarathne, Vishaka Nanayakkara 170-177

AI literacy in Teacher Education in the Czech Republic
Petra Kočková, Kristyna Kilianova, Marta Slepankova; Angelika Schmid; Katerina Kostolanyova 178-186

Augmented Reality for Exploring Solids: A Study on Improving Pre-Service Teachers
Lilla Korenova, Jan Guncaga, Katarina Zilkova, Martina Totkovicova 187-196

Digital Technologies in Primary Mathematics Education: Insights from Future Teachers' Portfolios
Lilla Korenova, Radek Krpec, Tomas Barot 197-208

GREENCOOL-Case Study of an International MOOC Course's Green and Communication Content Development
Edit Kovari, Brigitta Ferenczik Takacsne 209-218

Didactic Innovation in Mathematics Using Technologies
Ana Paula Lopes, Filomena Soares, Cláudia Neto, Mário Nuno Fernandes, Manuel Monteiro 219-226

From Traditional to Challenge-Based Learning: A Case Study
Birgy Lorenz, Kaido Kikkas 227-234

E-learning Supporting Infrastructure Investment in South Africa:
Perspective of a Developing Economy
Dumisani Godfrey Mabasa 235-241

Deconstructing the AI Myth: Fallacies and Harms of Algorithmification
Dagmar Monett, Bogdan Grigorescu 242-248

Flipped Classroom Trial for Python Programming with Raspberry Pi Using Moodle
Kazuhiro Muramatsu 249-256

Implementing Technology-Enhanced Support for First-Year
Students on Blackboard: Lessons Learned
Nathunathi Mvunge, Nobulali Tsipa-Booi , Bongo Mqukuse 257-263

Smartphones: A Catalyst for Tobacco Control Training in India
Eve M. Nagler, Priyanka Ghosh, Smita P. Warke, Chuck Sigmund,
Paromita Mehta, Leah C. Jones, Samhita Kalidindi, Mangesh Pednekar 264-272

WhatsApp Support for School Experience e-Portfolio Development:
A Conversational Approach
Bongo Mqukuse, Vuyisile Nkonki, Nobulali Tsipa-Booi 273-279

A Model for Collaborative Immersive Classroom Management Development
Using Multi-user Virtual Reality
Lucas Paulsen, Jacob Davidsen 280-288

Enhancing Higher Education in Portugal: Leveraging Generative Artificial
Intelligence for Learning-Teaching Process
Carla Santos Pereira, Maria João Ferreira, Sónia Rolland Sobral,
Natércia Durão, Fernando Moreira 289-298

Digital Skills' Impact on the Use of Digital Learning Tools
Sue Petratos, Reinhardt Botha, Mxolisi Mtshabe 299-306

Enhancing Reusability Practices in Massive Online Open Courses
Roberta Pireddu, Frederik Truyen 307-312

The Understanding the Effectiveness of Email Prompts to Online
Asynchronous Course Participants
Eshana Ranasinghe, Dilini Thoradeniya, Vishaka Nanayakkara,
Gaindu Saranga Jayathilaka, Malik Ranasinghe 313-319

Human-AI Collaboration: A Student-Centered Perspective of Generative
AI Use in Higher Education
Liana Razmerita 320-329

Exploring the Impact of Artificial Intelligence Generative Tools on Research
in Higher Education Institutions: A Perspective from Portugal
Sónia Rolland Sobral, Maria João Ferreira, Carla Santos Pereira,
Natércia Durão, Fernando Moreira 330-339

Phrase Frame Use in EFL Learners' Argumentative Essays:
A Corpus-Based Comparative Study
Yingming Song, Tianfeng Sun 340-347

The Digital Revolution in Education: The Role of AI
from the Perspective of Future Teachers
Otto Suchanek, Michael Kancner, Tatiana Havlaskova, Tomas Javorcik 348-356

Student Learning Performance Evaluation:
Mitigating the Challenges of Generative AI Chatbot Misuse in Student Assessments
Chun Meng Tang, Lee Yen Chaw 357-364

Online teaching and Learning post-Covid: An Analysis of LMS
Usage and Student Outcomes Following the Pandemic
Tiloka de Silva, Sanidi Uthsari, Sulanie Perera, Asanka Gunawardana 365-373

Teaching Online in a Developing Country Context
Elzette Van Niekerk, Geoff Lautenbach 374-380

ChatGPT in Higher Education: A Comprehensive Study of the Literature. Friend or Foe?
Henriette van Rensburg, Natasha Reedy 381-386

The Content and Form of School Reading as a Factor Influencing
Text Comprehension in Society 4.0
Dana Vicherková, Veronika Murinová; Martin Kolář 387-395

Video-Feedback on Assignments:A Case Study From Norway
Tone Vold, Ole Jørgen Ranglund, Monica J. Lervik 396-401

Post COVID-19 – Students' Expectations of HyFlex Learning Opportunities
Tone Vold, Ole Jørgen Ranglund, Linda Vibeke Kiønig 402-405

Generative AI in Higher Education: Educators' Perspective
s on Academic Learning and Integrity
Naghmeh Aghaee, John Vrågård, Freddie Brorsson 406-414

Towards Responsible Use: Student Perspectives on ChatGPT in Higher Education
Hong Yang 415-422

Goal-Setting, Active Practice, Self-Monitoring: a Web-Based
System to Improve Programming Proficiency
Libor Zachoval, Daire Ó Broin, Ken Power 423-431

Supporting Educators to Co-Design Interdisciplinary Projects
Integrating Educational Robotics and Arts
Eleni Zalavra, Kyparisia Papanikolaou, Maria Tzelepi,
Juan I. Asensio-Pérez, Yannis Dimitriadis, Mohamed Saban, Nafsika Pappa 432-441

Microlearning: Innovative Digital Learning for Various Educational Contexts and Groups
Magdalena Zavodna, Michaela Mrazova, Jakub Poruba, Tomas Javorcik,
Jan Guncaga, Tatiana Havlaskova, Daniel Tran, Katerina Kostolanyova 442-450

Development of Corporate University Evolution Scenarios
Maria Zinchenko, Konstantin Bagrationi, Olga Gordienko 451-457

Using Continuous Online Assessment of Learning Outcomes for Grading:
A Case Study
Marijana Zivic Djurovic, Gordan Durovic, Martina Holenko Dlab 458-466

PhD Papers

The Impact of Generative Artificial Intelligence on Education: A Comparative Study
Zohair Elmourabit, Asmaâ Retbi, Nour-Eddine El Faddouli 470-476

Cultivating Digital Skills: Assessing Trainee Digital Skills and Individual Needs
Tonderayi Moyana, Christopher Roast, Tonderai Maswera 477-486

Enhancing Geometry Learning with GeoGebra: A Study
Angelika Schmid, Lilla Korenova 487-496

Masters Papers

The Role of AI-Driven Personalized E-Learning In Enhancing Economic
Competitiveness: A Comparative Analysis of Developed And Developing Countries
Sabahat Ahmed, Muhammad Meraj 498-505

Non-Academic Paper

Empowering Student Transition and Engaging Students Using Actionbound:
A Gamified Collaborative Community Learning Platform
Xiangping Du, Govind Pothabathula, Madeline Tan 507-515

Work in Progress papers

Strengthening Teacher Agency: Supporting the Orchestration
of Ethical Dilemmas With EthicApp
Víctor Alonso-Prieto, Alejandra Martínez-Monés,
Sara Lorena Villagrá-Sobrino, María Jesús Rodríguez-Triana,
Yannis Dimitriadis, Gustavo Zurita, Claudio Álvarez 517-521

Bucco-kid®, an Innovative Tool for Learning Oral Hygiene at School
Stéphanie Jager, Maria DENAMI, Sana Athmani , Jérôme Dinet 522-526

Analysis of the Learning Achievement Gap Between Courses Adapted
to Virtual Modality and Courses for a LMS in Undergraduate Studies
Gustavo Quevedo 527-530

Tapping into Gen Z Ways to Enhance E-learning and Meaningful Connections
Natasha Elizabeth Reedy, Peter Ayriss, Max Alcock,
Henriette van Rensburg, Jo Kay, Julie Lindsay 531-534

Digital Open Library Development : A Real Path Towards Sustainable Math Education
Filomena Soares, Ana Paula Lopes, Anne Uukkivi, Carles Serrat, Vlad Bocannet 535-537

Technological Aspects of Gamification: Criteria for the Selection
of Digital Tools and Platforms
Ana Vrcelj Božić, Nataša Hoić-Božić, Kristian Stančin 538-541

About the 23rd European Conference on e-Learning, 2024

The European Conference on e-Learning (ECEL) is a prominent academic conference that serves as a platform for researchers, educators, and practitioners in the field of e-learning to share and discuss their findings and insights. With a history spanning 23 years, the conference has established itself as a vital forum for exploring advancements and innovations in e-learning.

The Proceedings of the 23rd European Conference on e-Learning, 2024 includes academic research papers, PhD research papers, Master's Research papers and work-in-progress papers, which have been presented and discussed at the ECEL 2024 conference. The proceedings are of an academic level appropriate to a 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

The primary aim of ECEL is to foster collaboration and knowledge exchange among those involved in e-learning. It seeks to advance the field by providing a space where latest research, technologies, and pedagogical strategies can be presented. The conference encourages participation from a diverse group of attendees, including academics, industry experts, and policy-makers, reflecting the multifaceted nature of e-learning.

Topics Covered

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

- **Educational Technologies**: Innovations in digital tools and platforms designed to enhance learning experiences.
- **Blended Learning:** Strategies for effective teaching and learning in online and hybrid environments.
- **Distance Education**: Best practices and challenges in implementing distance learning programs.
- **Learning Analytics**: Use of data to improve educational outcomes and personalize learning experiences.
- **Inclusive Education**: Addressing accessibility and inclusivity in e-learning environments.
- **Mobile Learning**: Exploring the impact of mobile technology on education.
- **Game-Based Learning**: Integration of games and gamification in educational contexts to encourage engagement and motivation.

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

- **Technology in Teaching and Learning**
- **Intelligent Adaptive e-Learning**

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/ecel/

ECEL Preface

These proceedings represent the work of contributors to the 23rd European Conference on e-Learning (ECEL 2024), hosted by ACI and the Universidade Portucalense, Porto, Portugal on 24-25 October 2024. The Conference Chair was Professor Fernando Moriera, and the Programme Chair was Shital Jayantilal**,** both from Universidade Portucalense.

ECEL is a well-established event on the academic research calendar and in its 23rd year the key aim remains the opportunity for participants to share ideas and meet the people who hold them. The subjects covered illustrate the wide range of topics that fall into this important and ever-growing area of research.

The opening keynote presentation was given by Professor António Teixeira from the Universidade Aberta, who spoke about *Openness, Flexibility, Adaptability and Personalisation: How AI is Impacting Digital Education* and Professor Marta Mena from The National University of Tres de Febrero-UNTREF Argentina gave a keynote discussing *When Virtualization and Hybridization Causes Challenges for Teaching at University.* The final keynote address was given by Professor Cesar Alberto Collazos from University of Cauca-Colombia on the topic of *Collaborative Games as A Mechanism Supporting Monitoring and Evaluation of Collaborative Learning Processes.*

With an initial submission of 111 abstracts, after the double blind, peer review process there are 56 Academic research papers, 3 PhD research papers, 1 Masters Research paper, 1 non-academic paper and 6 work-in-progress papers published in these Conference Proceedings. These papers represent research from Algeria, Australia, Austria, Belgium, Bhutan, Canada, China, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hong Kong, China, Hungary, Ireland, Japan, Morocco, Norway, Oman, Pakistan, Chile, Portugal, Singapore, Slovakia, South Africa, Spain, Sri Lanka, Sweden, United Arab Emirates, UK and USA.

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

Professor Fernando Moriera and Professor Shital Jayantilal
Universidade Portucalense
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Conference and Programme Chairs

Professor Fernando Moreira has been a member of the Science and Technology Department at Portucalense University since 1992, currently as a Full Professor, and a visiting professor at the University of Porto Business School. He was the head of the Science and Technology Department from May 2018 until February 2022. He is graduated in Computer Science (1992), M.Sc. in Electronic Engineering (1997) and PhD in Electronic Engineering (2003), both at the Faculty of Engineering of the University of Porto and Habilitation (2018). He teaches subjects related to undergraduate and post-graduate studies. He supervises several PhD and M.Sc. students. He is a (co-)author of more than 200 scientific publications with peer-review on national and international journals and conferences. He serves as a member of the Editorial Advisory Board for several journals and books. He organized several special issues from JCR journals. He has already regularly served as a member of Programme and Scientific committees of national and international conferences. He was the MSc in Computation coordinator during the last ten years. He holds editorial experience, and he is co-editor of several books. He is associated with NSTICC, ACM and IEEE. His principal research areas are mobile computing, ICT in Higher Education, Mobile learning, Social business and Digital transformation. He was awarded Atlas Elsevier Award in April 2019

Shital Jayantilal is the Head of the Department of Economics and Management at Portucalence University. She lectures under graduate and graduate courses in Strategy and Strategic Management. She has a PhD in Business Studies from Extermadura University (2016) and a degree in Economics from the Faculty of Economics, University of Porto (1999). She is also a practitioner and an experienced Senior consultant, with more than 15 years hands-on experience in aiding more than 50 SMEs and family firms, across diverse industries promoting their sustainability and enhancing trans-generational family business wealth. She is a member of the research unit REMIT – Research on Economics, Management and Information Technologies, Porto. Her main topics of research are Family Firms; Strategy and Game Theory, and she has published in various international journals. She has been awarded the 2021 Schulze Publication award by Entrepreneurship and Innovation Exchange and Family Business editorial teams.

Keynote Speakers

António M. Teixeira is Associate Professor of open, distance and network education at the Universidade Aberta where he has been Pro-Rector for Innovation in Distance Education and chaired the Department of Distance Education and e-Learning. He is a researcher at the Laboratory of Distance Education and e-Learning and at the Centre for Philosophy at the University of Lisbon. He has been on several boards of directors and many expert committees at national and international level. He's currently an external expert at AQU Catalunya and ACPUA quality assurance agencies and the research and innovation national agency of Uruguay (ANII) among others. António M. Teixeira has participated in many international research projects and authored a number of scientific articles and publications. His main research interest is educational innovation and learning futures; open education, particularly MOOCs; distance

learning and educational ethics. He has been part of the MOOC movement for some time co-authoring the first institutional pedagogical model dedicated to massive open education – the iMOOC. He has also co-designed the sMOOC pedagogical model.

Marta Mena is currently a Professor at the National University of Tres de Febrero-UNTREF Argentina. She is a director of the Virtual Training Program for Researchers-PROFORVIN at the National Technological University-UTN-Argentina, an Advisor at the National University of San Luis for the development of the Hybrid Classrooms Project and the Current Ambassador for Latin America at the International Council for Distance Education (ICDE) and member of the editorial board of Open magazine Praxis. Professor Mena received the Award of Excellence from the International Council for Open and Distance Education in November 2023. She has written countless articles and books about modality in Latin America.

Cesar Alberto Collazos received the Ph.D. degree in computer science in 2004. He is currently a Professor at the Systems Department, Faculty of Electronic Engineering and Telecommunications, University of Cauca-Colombia. Coordinator of IDIS Research Group and also a Coordinator of the HCI-Collab Network:Collaborative Network Supportung HCI education on Iberoamerican countries. His areas of interest focus on human–computer interaction, collaborative systems, ICT, and education. Has published a lot of papers in recognized conferences and journals.

Mini Track Chairs

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Digital Tools in the Thesis Process: A Case Study from Sweden

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Abstract: The emergence of autonomous learning has revolutionized educational systems, offering new pathways to enhance higher education. Across most Swedish universities, Bachelor's and Master's theses (final projects) represent an important part of students' academic journey. Embracing technology as a tool, rather than an end in itself, has become imperative in contemporary higher education and thesis processes. Departing from traditional instructional methods, the focus has shifted towards interactive and autonomous learning, propelled or supported by digitalization. Despite the growing emphasis on autonomous learning and the benefits of technology-enhanced learning (TEL), there are concerns about the misuse of digital tools such as Generative Artificial Intelligence (GAI) in educational contexts. The scarcity of knowledge to properly use available tools would potentially affect students' academic performance and future employment prospects, which has recently caused significant concern for educational authorities, educators, and even policymakers. This study reflects on students' perceptions of using digitalization and GAI to facilitate autonomous and interactive learning to support the thesis writing process. The focus is to understand how digital natives (predominantly Gen Z) view the integration of new digital tools in autonomous learning. A case-based approach in the form of an open survey conducted during the spring semester of 2024 gathered 52 responses from students within the informatics discipline at bachelor's and master's levels in a Swedish university. Results indicate that most students used digital tools such as GAI interactively, in the thesis process, mainly for constructive learning. They indicated that learning about digital tools as part of their formal learning leads them towards effective and more structured use of the tools for brainstorming, drawing inspiration, and developing interactive learning, which simulates real-world peer interactions or teacher-student dynamics. This instructional approach equips students with the skills to responsibly use tools as academic support rather than for any other inappropriate purposes. Effective utilization of digital tools promotes autonomous learning, leading to improved quality of bachelor's and master's theses and overall academic performance in higher education. Conversely, inadequate knowledge and improper use of these tools can negatively impact students' educational outcomes.

Keywords: Thesis, Autonomous learning, Digital tool, Generative AI, ChatGPT

1. Introduction

A thesis course is typically a core course of the final year in many undergraduate and graduate programs (Aghaee, 2015a; Hashim & Hashim, 2010). The terminology of “thesis” carries a common understanding of documents mandatory for partial fulfilment of degrees in higher education (Evans, Gruba, & Zobel, 2011; Eco, Farina, Farina & Erspamer, 2015). A thesis project integrates students’ academic knowledge with future career prospects and research (Hashim & Hashim, 2010), and hence a thesis course adds significant value to the student’s transcripts. Peer collaboration in the thesis process involves students working together to share ideas, develop the thesis work together, share resources in the same thesis group, and even in some phases, provide some constructive feedback for other groups (Aghaee & Hansson, 2013). This cooperative effort enhances understanding, critical thinking, and overall quality of the thesis (Aghaee, 2015a).

Technology-enhanced autonomous learning potentially opens new opportunities and challenges to thesis courses at universities (Rosli & Saleh, 2023, Hashim, Tlemsani & Matthews, 2022). Technology Enhanced Learning (TEL), in general, has become an essential component of modern education systems, providing students with tools that support interactive and autonomous learning environments (Al Mansoori et al., 2023; Aghaee & Keller, 2015). According to contemporary literature, engagement or disengagement in TEL significantly impacts student performance, and, therefore, highlights the need to understand digitalization and its influential factors on their learning process and performance, to better support learning outcomes (Rosli & Saleh, 2023; Bergdahl, Nouri, & Fors, 2020; Jaldemark & Lindberg, 2013).

However, the quality variation and attrition in higher education, notably among thesis students, is a major concern for most institutions (Aghaee, 2015b). The quality of a thesis varies due to various challenges in the thesis process, including lack of necessary information support, clear instructions, right type of interaction, good supervision, and digital skills (Bergdahl et al. 2020; Jusslin & Hilli, 2024; Aghaee, 2015a; Aghaee et al., 2014). Although digitalisation in education supports student learning and outcomes (Crittenden, Biel & Lovely, 2019), it is undeniable that there is a gap in understanding how students use digital tools at what scale (Jusslin & Hilli,

2024) and how educators can provide a concrete solution to support the thesis process in higher education Aghaee et al., 2014).

Previous research has indicated that students experience procedural and technical challenges in the thesis courses (Jusslin & Hilli, 2024) and suggesting that they need support in their thesis process (Aghaee, 2015b; Jusslin, & Widlund, 2024). It is a question of whether universities have recognised the need to educate students on how to use digital tools in the thesis courses, in the limited time available for thesis work. In the current landscape, digital competence enables students to utilize various digital technologies and independently adopt additional tools beyond those provided by the university (Crittenden, et al., 2019).

The prerequisite to understand how students use digital tools during the thesis process is to know which tools they use and for what purposes. It is also important to assess whether students see the university as a facilitator in developing these competencies or rely mostly on informal learning tools for educational purposes. According to some references, digitalizing the thesis process and providing structured formal learning guidelines could help address this gap (Aghaee, 2015b; Jusslin & Hilli, 2024). This study hence empirically investigates students' perceptions of digitalizing the thesis process and the tools they use. The study aims to answer the following research questions: 1) What digital tools do students use in thesis courses, and for what purposes? 2) How can educational system facilitate the use of digital tools in the thesis process?

2. Digitalisation of the Thesis Process

Metaphorically, the digitalization of the thesis process parallels playing a card game (Aghaee, 2015a), where players follow rules and learn about them, similar to learners in a thesis course receiving basic requirements, resources, and instructions (Aghaee, 2015a). Supervisors act as advisors, guiding learners like dealers in a card game, yet learners autonomously decide how to play or fulfil course requirements (Aghaee, 2015a). However, the lack of standardized information and instructions limits autonomy and equal learning opportunities (Aghaee et al., 2013). Digital tools, such as Learning Management Systems (LMS) (Al Mansoori et al., 2023), Information and Communication Technology (ICT), and social media, support educational interactions and facilitate educational interactions among learner-instructor, learner-content, and learner-learner, which are crucial for effective learning outcomes, rather than being a hinder (Aghaee, 2015a). This means, the thesis writing demands clear instructions and rules, while a high level of independent research and problem-solving skills are also required.

Based on these insights, addressing the pedagogical and administrative aspects of thesis, promoting autonomous learning and reducing dependency on individual supervision can be achieved through the use of technology (Aghaee, 2015a). It is hence important to determine how digital tools are used in learner-supervisor, learner-content, and learner-learner interactions, and how the structured use of these tools can support the thesis process while ensuring transparency. On the other hand, even if the emergence of Generative Artificial Intelligence (GenAI), particularly tools like ChatGPT, support the autonomous learning, it makes the interactions less transparent. GenAI is transforming higher education by promoting student-driven learning through guidelines, instructions, ideas, and language support (Dai, Liu & Lim, 2023). ChatGPT can enhance personalized learning, conduct autonomous assessments, offer virtual assistance, create content, and recommend resources (Nikolopoulou, 2024). However, given the potential for academic dishonesty, it is crucial to provide ethical training (Chan, 2023) to reduce the risk of GenAI misuse (Rogers, Hillberg, & Groves, 2024; Whalen & Mouza, 2023), particularly in academic writing and thesis courses.

3. Methodological Approach

The purpose of this study was to investigate digitalisation, specifically in the thesis courses from the perspective of university students and, such research demands an instrument of explorative case strategy-based survey study. Furthermore, due to that digital skills and understanding of digitalization significantly correlate with the level of students' use of digital systems, and it can vary from discipline to discipline (Hashim, et al., 2022; Bergdahl, et al., 2020), and the variation of Gen Z daily use of digitalisation in their life and education (Katz, et al., 2022), a case study was chosen for providing a deeper understanding of the unit of measurement concerning specified characteristics in a quantitative study (Roni, Merga, & Morris, 2020). The chosen case, therefore, is students within the informatics discipline at a university in Sweden, and the data was collected during the spring term of 2024. The case was conveniently chosen as the students were doing their theses during this period and were asked to fill in the survey. The population size was over 150 students in total.

Semi-structured questionnaires were used as the data collection instrument. A questionnaire was beneficial in this case since the data is required to be collected and analysed anonymously to avoid any respondents' bias about being honest. As the focus of this study is on the general perspective and experiences of students, regarding digitalisation in thesis courses a representative data sample from the chosen case was needed to be able to make the study more transferable, through the survey results (Bryman, 2006). The questions were designed to capture the frequency and types of digital tools used in the thesis courses followed by a few open-ended questions to reflect on students' experiences of using digital tools and the benefits and challenges of using such tools in the thesis process (in-line with the reflections by Jusslin & Hilli, 2024). There was a total of 52 responses, from two classes (almost 33% response rate).

The composition of the questions includes three segments about digitalisation in the thesis process, namely, 1) for gathering information and language help, 2) facilitating student-supervisor interaction to get guidelines 3) facilitating or compensating peer interaction for exchanging and developing ideas, getting feedback and develop the ideas further, and finally whether there is a clear need of formal education for the use of digitalisation in higher education, specifically for the thesis courses. The structured questions rate the frequency of use of each specific type of digital system/platform in levels of "less than once a week" to "several times a day", in 5 different scales, based on Likert scales. The students were asked to answer honestly based on their own experience of using the tools for this specific thesis course. Some open questions followed the structured ones to let the respondents present their experiences of using tools in their own words and reflect on how useful the tools were for which specific purpose. The open questions aimed to get students' reflections in their own words (Creswell, 1999). However, the finding themes and the codes based on the open questions were also used quantitatively.

The respondents belong to two groups: 17 participants from the master program, who answered almost all questions, while the second group with 35 participants from the bachelor programs, answered most of the closed-ended questions, but fewer answered open-ended questions. The responses to the open-ended questions were merged and analysed together. Both groups of students participated voluntarily and were informed that this would not in any way have any influence on their course results and grades. An informed consent was sent to the participants to get their agreement, before starting the data collection. The respondents were given the option to terminate participation at any point in the data collection process or to skip any questions if they did not wish to answer any questions. Furthermore, none of the sensitive or personal information was collected through the questionnaire.

4. Results and Analysis

According to the literature, digital systems facilitate diverse types of interaction in higher education. Nonetheless, it is imperative to equip students with the necessary information and training to comprehend and effectively utilize emerging digital tools, such as Generative AI, to enhance both their efficiency and ethical application of such tools within academic environments.

4.1 Technology for Information Seeking

The results revealed diverse ways that digitalisation can support student interaction, such as playing a role as an information resource, covering and fulfilling peer support to get inspiration and ideas, exchanging ideas and even getting language help. Figure 1 shows that students on average believe that they generally use the different types of resources in the following order:

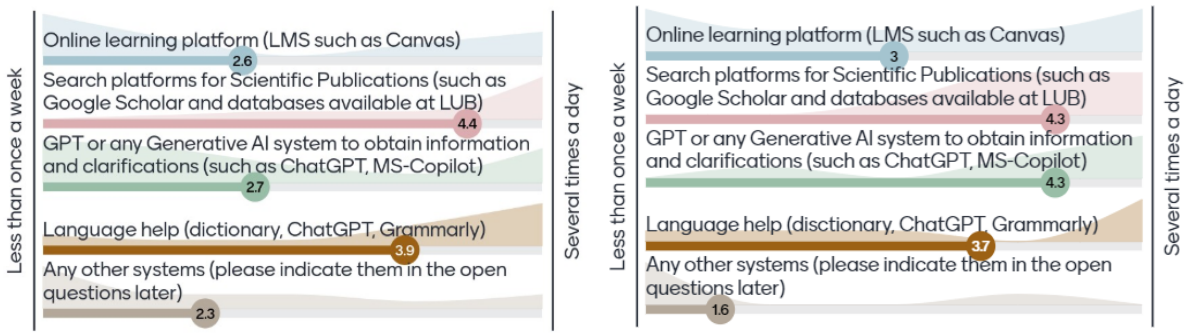

Figure 1: Digital systems to access information among bachelor's (left) and master's students (right)

As shown in Figure 1 (left), the highest average frequency of the usage of technical tools among the bachelor's students is for the "Search platforms for Scientific Publications" and Generative AI systems to obtain information and clarification, with a frequency scale of 4.3 out of 5, which means almost several times per day. The distribution of technology for search is also skewed towards the right end, which means almost everybody uses these types of tools more frequently. For the use of GenAI, a few participants do not use it frequently for obtaining information. The result also shows an average use of technology for language help with a frequency scale of 3.7 out of 5. The comparatively lower average for the use of LMS reflects the fact that the LMS may not contain the information they frequently sought. This is similar among both bachelor and master students (Figure 1- right). However, master students are not using GenAI as frequently as bachelor students for information seeking.

The students also explained how and why they have been using the chosen technology tools, for e.g., "*ChatGPT for summarising papers and assisting with paraphrasing, Grammarly for language and consensus AI for searching relevant papers*". Google Scholar was the main source of information among many students, i.e., "*Google scholar was most helpful as we found the literature and research gaps from there*"; "*Google Scholars. It is always the starting point of every research I make. I don't like to use chat GPT if not for seeking specific documents or have any general ideas about something I don't know*". These reveal their priority of subject-specific information seeking and explain the reasons for accessing LMS (Canvas) which may have the general information of the course, as the detailed responses describe, "*ChatGPT 4 was used most frequently, however, it was not used for obtaining necessary information. Canvas, Google Scholar, the most helpful in that regard. They were crucial in obtaining articles*", and "*Canvas, because it is the source of the information*".

4.2 Technology for Student-supervisor interaction

Regarding the outcome of the technology for supervisor-student interaction, Figure 2 shows the averages and distribution of the types of tools used for this purpose.

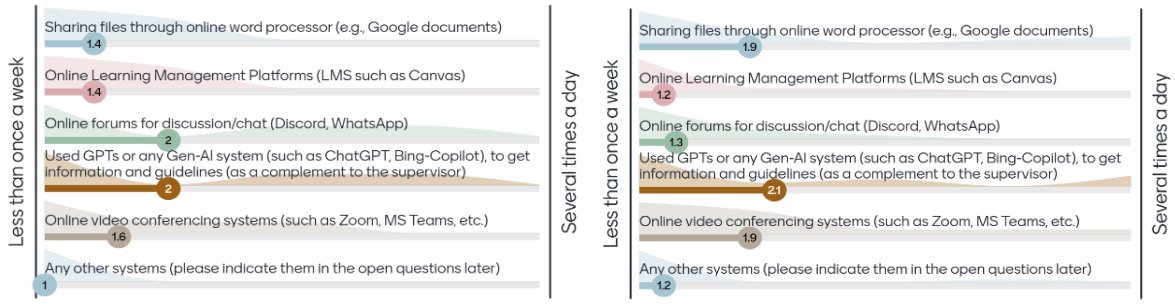

Figure 2: Digital systems to facilitate student-supervisor interaction for bachelor's (left)/master's (right) students

In general, the interaction with the supervisor is not so frequent. Irrespective of the group they communicate with supervisors through online communication tools (synchronised), and LMS-like platforms (asynchronised). Complementary guidelines are sought through advanced technology, such as GenAI as well.

4.3 Technology for Peer-to-Peer interaction

According to Aghaee & Hansson (2013), peer support and peer interaction help generate knowledge. It has great potential in the autonomous learning process, which also makes the learning more learner-centred and less dependent on their supervisors. Peer interaction through different digital systems is common in the thesis process (4 out of 5). Can GenAI serve as a peer for students to help achieving the learning outcomes? Surprisingly, the answer is yes, although not to a high degree, as shown in Figure 3. The score for using GenAI as a study buddy exceeds the average for peer communication and learning.

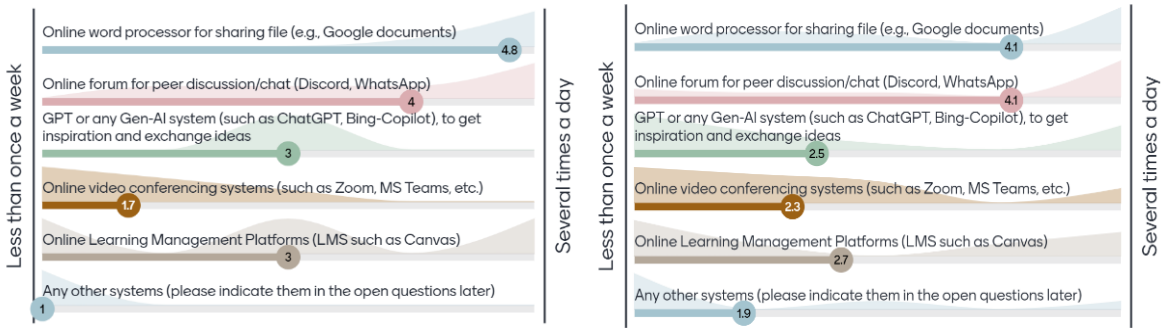

Figure 3: Digital systems to facilitate peer interaction for bachelor's (left) and master's (right) students

These findings indicate that students increasingly rely on GenAI for many aspects and interactions in their thesis work. Hence, to prevent misuse of this technology, clear instructions and guidelines are necessary, as they can enhance the communication and information-gathering skills essential for research and thesis writing. Consequently, supervisors not only retain their traditional responsibilities of supporting and guiding students through the thesis process, but also have an additional responsibility to instruct students on how to effectively use AI-based digital tools as structured learning aids, rather than as means for academic dishonesty.

4.4 Digital Tools in the Thesis Process

Apparently, students use a spectrum of tools at different stages in the thesis process. The open questions regarding the main digital systems they used mostly in their thesis work are for capturing their reasoning behind the choice of the tools. In Figure 4, word clouds, the left-hand side shows the respondents indicated their three highest prioritised and most used tools in their thesis. The word cloud on the right-hand side however shows the times they mentioned the most important tool in their thesis.

Figure 4: Word Clouds indicate the digital tools used by most students (n=52) (left) and as the most important tool for students (n=51) (right) in the thesis process

Students elaborated on the importance of digital tools at various stages, i.e., "*Technology has assisted me a lot during the writing process*"; specifically, for:

- ideation; "Generate ideas for getting the writing going. Had massive struggles with motivation and generating ideas to write about helped a bit",
- language correction: "Spelling and Grammar check - because English is my second language, writing in academically correct manners need checking",
- resource finding; "Finding and collecting materials (journal articles, statistics et c.)"
- summarizing texts; "Thinking critically, analysing big text, moving past jargon to get core ideas, summarizing, comparing textual data to spot how far my results add to the literature"
- reference styling; "It is hard to keep up with the APA guidelines as they are in constant change. But it is also hard that the university has their own guidelines that do not always align to APA"
- solving the writer's block; "Mainly writers' block. Generative AI helps but it doesn't feel good to submit AI generated text as guidelines are vague"

The final point above also shows the student's pain of not having clear guidelines for using GenAI in their thesis writing. Furthermore, students are uncertain about many other aspects regarding the digital tools they can or have to use, e.g., "*I know some students uses Overleaf for structure the thesis. I do not know if that would be*

easier, but it definitely has its benefits". For some students "*The structure of the thesis was sometime a challenge, what should be included and what needed to be included. That was solved by reading previous work published on Canvas and asking ChatGPT/Teacher*". The more advanced technology appears the more confusion and uncertainty can occur such as "*Part of the fun of writing the thesis is developing a writing style. I think students who constantly use AI tools are at risk of losing their own judgement and miss out on their learning development*".

5. Discussion and Concluding Remarks

This study addresses challenges in students' thesis works, building on earlier research (Eco, et al., 2015; Jusslin & Hilli, 2024; Aghaee, 2015a), highlighting issues like insufficient support and lack of digital skills (discussed by Bergdahl, et al., 2020; Jaldemark & Lindberg, 2013) and the variation of Gen Z daily use of digitalisation (Katz, et al., 2022). The result emphasizes providing tools for interactive and autonomous learning environments (Al Mansoori et al., 2023; Rosli & Saleh, 2023; Bergdahl et al., 2020), which is defined by Aghaee (2015a), as students gathering information independently to enhance self-directed learning, using digital systems. Digitalization improves learning outcomes, as discussed by earlier studies, also evidenced in this study by over 80% of students positively responding to technology, especially GenAI in thesis courses.

Students rely on GenAI for most of their needs in the thesis work, which is emphasizing the need for educators to provide clear guidelines to help students use these systems effectively and pedagogically, echoing the importance of guidelines (discussed in prior studies Jusslin & Hilli, 2024), rather than misusing such tools (as discussed by Rogers, Hillberg, & Groves, 2024). The results of this study show digital tools that are predominantly chosen and used by the students (shown in Figure 4) without a systematic way of embedding them into the process of thesis work (also discussed by Aghaee, 2015a; Rogers et al., 2024; Whalen & Mouza, 2023). The study's findings serve as a warning to educators to provide clear guidance on GenAI usage, as the extensive use of GenAI exceeds the traditional resources such as LMSs and even surpassing use of scientific publications and resources.

This study also indicated majority of students utilize digital tools, including GenAI for constructive learning activities such as brainstorming, developing ideas, and seeking inspiration. Students reported that these tools significantly enhance their ability to conduct independent research and manage the thesis writing process more effectively. This emphasizes the importance of formal education on digital tool usage, which equips students with the necessary skills to use these tools responsibly and productively (Jusslin & Hilli, 2024; Aghaee, 2015b). The use of technology for the benefit of interactive and autonomous learning is also highlighted in this study; providing structured support and reducing confusion about the various phases of the thesis process is appreciated (Aghaee, 2015a).

As mentioned by earlier studies, there is a lack of necessary information support, clear instructions, right type of interaction, good supervision, and digital skills (Bergdahl, et al., 2020; Jusslin & Hilli, 2024; Jaldemark & Lindberg, 2013). It is so important to provide students with tools that support interactive and autonomous learning environments (Al Mansoori et al., 2023; Aghaee & Keller, 2015; Rosli & Saleh, 2023). Hence, to equip learners with more instructions and information about the available tools and technologies in the thesis courses is a must, as they can engage more professionally and morally, which metaphorically means, playing a more professional game (as mentioned above). As also showed by the result of this study, students valued the enhanced peer interactions facilitated by digital systems, which simulate real-world collaborative dynamics and improve the overall quality of the academic work.

As mentioned above, autonomous learning is a more learner-cantered approach (Aghaee, 2015a), which provides possibilities of learning under learners' own control and preferences. The answers to the open-ended questions in the survey revealed concerns about the potential misuse of digital tools, particularly GenAI (as also studied by Rogers, et al., 2024). Some respondents admitted using such tools for academically purposes could be considered dishonest, underscoring the need for clearer guidelines and more comprehensive training on ethical tool usage (Chan, 2023). This justifies the growing need to educate students on the proper use of digital tools to ensure digitalisation enhances academic performance, students' skills, and future employability rather than hinder them.

5.1 Technologies and Tools for Thesis Writing

In the realm of thesis writing, several technologies and tools have emerged in the survey outcome. Among these, ChatGPT stands out as a versatile companion. It excels in translating articles swiftly, providing feedback on structural elements, and even rewriting sentences. However, its strength lies in its ability to generate ideas—a crucial aspect of any scholarly work (Jusslin & Hilli, 2024; Jusslin, & Widlund, 2024). When combined with Gemini,

ChatGPT becomes a dynamic duo for brainstorming and refining concepts (Whalen & Mouza, 2023). In addition, Consensus (ChatGPT 4) is shown effective for searching relevant papers, ensuring that the literature review process is comprehensive and efficient. The result helped escalate pedagogies to enhance supporting and develop the digitalisation of higher education (as discussed by Crittenden et al., 2019). To enhance the thesis writing process, the study result led to the development of the following strategies:

Refine Idea Generation: ChatGPT and Google Gemini offer valuable insights, providing more specific prompts and guidelines, which may yield better results and higher learning outcomes. By teaching students how to use the tools in the best and most effective way, we encourage them to explore various angles and contexts when seeking creative ideas, information and guidelines.

Improve summarization and language development: Investigate why Adobe's AI assistant fell short in summarizing papers. As suggested by respondents, fine-tuning ChatGPT 4.0 for summarization could bridge this gap and help students reach out for more scientific articles, find the most relevant theoretical basis and relevant studies, and develop better conceptual frameworks in their theses (as also discussed by Evans, et al., 2011). A well-crafted summary can save time and help students grasp the essence of complex research areas and develop their thesis based on cutting-edge and relevant studies. Hence a structured education about how to do the summaries and how to use digital tools to assist in summarizing and using the literature would be immensely useful (Dai, Liu & Lim, 2023; Nikolopoulou, 2024)

Collaborative Tools: Beyond individual efforts, collaborative tools like Overleaf or Google Documents foster teamwork. Students can collaboratively structure their theses, share ideas, and collectively refine their work through collaborative tools if they learn how to use them systematically. By combining human expertise with AI assistance, the educational aspects and learning outcomes elevate the quality of thesis writing and contribution to academic excellence. Peer interaction (Aghaee & Keller, 2016) is a very important part of the thesis, both with their groupmates as well as their opponent groups. Using collaborative tools to find a partner in the thesis course, decide about the topic, and continue collaborative work throughout the entire thesis work, would enhance peer interaction (Anderson, 2008). GenAI can also play the role of a peer to get inspiration and reflection from.

5.2 Concluding Remarks

The study underscores the critical role of digital tools in enhancing autonomous and constructive learning and improving the thesis process in higher education. Students' perceptions highlight the benefits of these tools in facilitating independent research and fostering interactive learning environments. However, the potential for technology misuse necessitates the implementation of educational strategies that promote responsible use. Integrating formal training on digital tools into academic curricula can ensure that students are well-equipped to use these technologies effectively and ethically, ultimately improving academic outcomes and preparing them for future professional challenges.

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Examining the Relationship Between Student Online Learning Readiness and Their Satisfaction on Distance Learning

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Abstract Assessing Student's Online Learning Readiness is among the critical factors that help higher education institutions to achieve their goals. However, majority of these studies were conducted in western countries. Thus, the current research aimed to examine the relationship between Student's Online Learning Readiness (SOLR) constructs and their satisfaction on distance learning in the higher education institutions in the United Arab Emirates (UAE) context. A quantitative research methodology was used to answer the research question. The questionnaire was distributed among 621 students. SPSS software was used to examine the preliminary data, while SmartPLS software was used for the measurement model and hypotheses. Statistical analysis indicated that there was a positive relationship between satisfaction on distance learning and the following constructs of Student Online Learning Readiness: 1) Technical competencies, 2) Communication competencies, and 3) Social competencies with instructor. While there was no relationship between satisfaction and the following constructs of Student Online Learning Readiness: 1) Social competencies with classmates, and 2) Self-directed learning. The findings extended both student e-learning readiness and satisfaction literature, and supported the applicability of western models such as the Student Online Learning Readiness model developed in the United States in higher education institutions in not often examined contexts such as the UAE. Furthermore, the achieved result extended Yu and Richardson's (2015) model by examining the impact of self-directed learning as additional construct to overcome the limitation of the used model. Concerning contextual contribution, this research is among the first studies to examine this relationship in the UAE context, which can help decision-makers to understand the significance of investment in student experience and the overall role of student's different competencies on achieving outputs such as their satisfaction with distance learning. With regards to managerial implications, this study confirms the need for implementing national level strategy to identify and enhance human capital required competencies and skills which could help students in the short and long term to achieve the required objectives.

Keywords: Student online learning, Readiness, Student satisfaction on distance learning, E-learning, Higher education institutions, The United Arab Emirates

1. Introduction

Maan and Malhotra (2024) suggested that there is a growing interest in studying student e-learning readiness. Thus, several authors (e.g. Hung, et al., 2010; Yu and Richardson, 2015; Alem et al., 2016) have developed scales for measuring student e-learning readiness.

According to Al-Juda (2017) higher education institutions should be keen to sustain a competitive advantage by delivering high-quality learning services by e-learning systems, as they consider student satisfaction on distance learning as one of the main elements in determining the quality of their programs (Topal, 2016). However, limited studies examined the relationship between student e-learning readiness and their satisfaction on distance learning (Wu, et al., 2023).

Context variations (Kuo, 2010) is among the factors that influence the relationship between student online e-learning readiness and their satisfaction on distance learning, which limits the generalizability of the existing literature and leads to a mix in results in the same studies that have been conducted in different contexts.

The United Arab Emirates (UAE) pays great attention to education since excellent education is among the four Pillars of UAE Centennial 2071 (The United Arab Emirates' Government portal, 2024). The majority of the higher education institutions in the UAE conduct face to face learning style, however after Covid 19 the UAE has introduced e-learning at all higher education institutions. Moreover, in order to increase the level of e-learning readiness the UAE has provided adequate e-learning requirements such as launching smart learning platforms, developing guidelines to manage students' behavior during e-learning and offering free home internet connection for families who lack internet (The United Arab Emirates' Government portal, 2024). In 2018 the Ministry of Education in the UAE launched its National Program for Advanced Skills**,** which targets both students and employees. The program comprises soft skills and technical skills to provide students and employees with adaptable skills appropriate among diverse professions and sectors. Communication and creativity are among the competencies that they must possess (The United Arab Emirates Government portal, 2024). Limited studies examined student e-learning readiness in one of the higher education institutes (e.g. Tubaishat and Lansari, 2011) and satisfaction towards e-learning (e.g. Malkawi, Bawaneh and Bawa'aneh, 2020) in the UAE context.

However, there is lack of studies that investigated the relationship between student e-learning readiness and their satisfaction on distance learning.

Therefore, this research aims to fill in these theoretical and conceptual gaps by investigating the following research question: What is the relationship between the following Student Online Learning Readiness (SOLR) constructs: 1) Technical competencies, 2) Social competencies with classmates, 3) Communication competencies, 4) Social competencies with instructor, 5) Self-directed learning, on their satisfaction on distance learning in the UAE higher education institutions?

The following sections outline the literature review, theoretical background and hypotheses development, methodology, results, discussion, as well as limitations and future directions.

This study would inform the practitioners and the decision makers about the significance of Student's Online Learning Readiness constructs to enhance their satisfaction on distance learning in the higher education institutions.

2. Literature Review

2.1 Student e-Learning Readiness

According to Al-Juda (2017: p. 325) e-learning is "a system which utilizes technology in the form of computers, multimedia devices, and the internet to improve the traditional classroom interactions between students and teachers". Several authors (e.g Uddin, 2013; Bledsoe, 2013) mentioned that the following term ;online, e-learning and distance learning are used interchangeably. Maan and Malhotra, (2024: p. 27) defined e-Learning readiness as "the extent to which an institution and its students are prepared to implement e-Learning".

Maan and Malhotra (2024) clarified that there is a strong emphasis with regards to higher education institutions' student e-learning readiness over time, since student possession of e-learning readiness is an indicator of e-learning success (Maan and Malhotra, 2024), and crucial for student to be engaged in such context (Alem, et al. 2016).

Thus, several authors (e.g. Hung, et al., 2010; Yu and Richardson, 2015 ; Martin, Stamper and Flowers 2020) developed instruments to predict constructs of e-learning readiness. Martin, Stamper and Flowers (2020) clarified that these instruments concentrate on eliciting student e-learning readiness competencies like self-directed learning and communication competencies. However, it was noticed that the majority of these studies were conducted in specific countries such as United States (Yu and Richardson, 2015; Martin, Stamper and Flowers 2020), China (Hung et al., 2010) and United States, Australia, Malaysia and Taiwan (Maan and Malhotra, 2024).

Küsel, Martin and Markic (2020) argued that cross-cultural differences in the culture of teaching and learning is among the factors that influence the student e-learning readiness. Consequently, it is difficult to generalize the achieved result in other different contexts. Thus, a recent study conducted by Küsel, Martin and Markic (2020) showed student e-learning readiness is different between German students and United States students. Therefore, there is a need for further studies to examine student e-learning readiness in order to generalize the findings of Tubaishat and Lansari's (2011) study which targeted students in only one university in the UAE context and to compare to what extent the existing literature in different contexts are applicable to other countries.

2.2 Student Satisfaction on Distance Learning

Satisfaction on distance learning is "student's perception related to learning experiences and perceived value of a distance course" (Kuo, 2010:p. 11).

According to Al-Juda (2017) e-learning enhances the student's degree of satisfaction, because various interactive graphics, sounds, aesthetics, texts and videos greatly attract the student. Indeed, student's satisfaction on distance learning plays a significant role in the assessment of e-courses by both institution leaders and instructors (Topal, 2016); it is both a crucial indicator to examine student's online experience (Wu et al., 2023) and also related to their academic achievement (Yavuzalp and Bahcivan, 2021). However, Kuo (2010) stated that relatively little is known about student satisfaction when participating in e-learning, including what contributes to or enhances satisfaction on distance learning.

Thus, further empirical studies are needed to examine factors related to student satisfaction on distance learning which could help to fill in this gap and both improve the student e-learning environment and achieve better outputs.

2.3 Student e-Learning Readiness and Their Satisfaction on Distance Learning

Khong (2023) elaborated that student e-learning readiness constructs facilitate their satisfaction which, in turn, influence their retention. Though Wu et al., (2023) demonstrated that there is a lack of studies that examine student e-learning readiness in addition to satisfaction on distance learning.

To fill in this gap, limited studies (e.g. Yilmaz, 2017 ;Yavuzalp and Bahcivan, 2021; Khong, 2023) have focused on examining which student e-learning readiness constructs are related to satisfaction on distance learning. That's why, as a direction for future research, Alem et al., (2016) recommended to examine the influence of student e-learning readiness instruments on both satisfaction on distance learning and performance.

Kuo (2010) stated that context is among the factors that lead to differences in results of limited studies that investigate the relationship between student e-leaning readiness constructs and satisfaction on distance learning. For instance, the results of studies that examined the relationship between self-directed learning - as an e-learning readiness construct - with student satisfaction on distance learning were positive in Turkey (Yilmaz, 2017) while they were negative in Malaysia (Khong, 2023). This leads to additional studies to understand this relationship in specific context.

With regards to student e-learning readiness in the UAE context, the findings of limited studies showed that the student is ready for this type of learning (Tubaishat and Lansari, 2011) and another few studies (e.g. Malkawi, Bawaneh and Bawa'aneh 2020) concluded that they are satisfied with e-learning. However, no prior studies have examined the relationship between student e-learning readiness and satisfaction on distance learning.

3. Theoretical Background and Hypotheses Development

3.1 The Student Online Learning Readiness (SOLR) Model

According to Martin, Stamper and Flowers (2020) student e-learning readiness reflects their possessed competencies. Yu and Richardson (2015: p. 122) defined competencies as "individual's perception of his or her ability or capability".

Yu and Richardson (2015) developed their SOLR model and instrument in the United States to be examined by the following four competencies: 1) Technical competencies, 2) Social competencies with classmates, 3) Communication competencies and 4) Social competencies with instructor. The authors clarified that these competencies are positivity related to student learning outcomes or satisfaction on distance learning.

Lin and Dai (2022) mentioned that SOLR have been conducted in different countries where e-learning is well-developed. In spite of that, limited studies (Khong, 2023) have examined the relationship between the SOLR constructs and satisfaction on distance learning.

Additionally, Yu and Richardson (2015) recommended to examine additional constructs that would influence SOLR and impact successful learning outcomes or satisfaction on distance learning. In order to fill in this gap, self-directed learning has been added as an additional construct to the current model. The justification for selecting self-directed learning is that it is considered among the main constructs that reflect student e-learning readiness (Martin, Stamper and Flowers, 2020).

3.2 Hypotheses Development

Based on the literature review, it was expected that these five student e-learning readiness constructs impact positively on satisfaction on distance learning, as follows:

First, Heo (2011: p. 61) defined technical competencies as "self-efficacy in technology". Ilgaz and Gülbahar (2015) clarified that the student should be ready and qualified to use the Internet for learning. Khong (2023) stated that possessing technical competencies make student feels more relaxed and confident to best use these competencies to access course materials which lead to high satisfaction on distance learning.

H1: Technical competencies positively affect satisfaction on distance learning.

Second, social competencies with classmates are "skills, competencies, and the feeling of control essential for managing social situations and building and maintaining relationships with classmates" (Yu and Richardson, 2015: p. 125). Jevtić, Đorić and Milošević (2019) explained that a student is more satisfied if they have a good relationship with their peers. Supporting this argument, Alqurashi (2019) demonstrated that student interaction with other learners is among the factors that represent both their satisfaction and perceived learning.

H2: Social competencies with classmates positively affect satisfaction on distance learning.

Third, communication competencies are defined as "the ability to demonstrate knowledge of the socially appropriate communicative behavior in a given situation" (Myllylä and Torp, 2010: p. 24). Martin, Stamper and Flowers (2020) mentioned that communication competencies are among the basic skills that a student should possess, particularly those who receive distance education, and they are one of the important factors for the student's e-learning readiness. Khong (2023) elaborated that if the student can efficiently communicate with others during e-learning, they could have optimistic learning practice, which leads to increased satisfaction level with learning.

H3: Communication competencies positively affect satisfaction on distance learning.

Fourth, according to Yu and Richardson (2015: p. 125) student social competencies with instructor are defined as "skills, competencies, and the feeling of control essential for managing social situations and building and maintaining relationships with the instructor". Khong (2023) mentioned that using the social competencies while interacting online with the instructor helps the student to freely discuss activities or share issues related to their e-learning progress, which supports the relationship between instructor and student and makes them more satisfied.

H4: Social competencies with instructor positively affect satisfaction on distance learning.

Finally, Knowles (1975) defined self-directed learning as "a process in which individuals take the initiative in understanding their learning needs, establishing learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes". Hung et al., (2010) argued that self-directed learning is among student's e-learning readiness constructs. Yilmaz (2017) explained that availability of student self-directed learning skills increases satisfaction and motivation.

H5: Self-directed learning positively affects satisfaction on distance learning.

4. Methodology

4.1 Data and Sample

The study employed quantitative methodology to address the research question.

Data were collected through an online questionnaire sent to the students who have experienced online learning, studying at different higher education institutions in the UAE.

The sample size was 621 students from different universities who participated voluntarily and were selected randomly. Most respondents were female (70.5 %), most of them (87 %) were of UAE Nationality. Concerning the type of university, most respondents (66.3%) were studying in Government higher education institutions.

4.2 Instrument

The questionnaire used was divided into three main sections. First, demographic information including the following three items; gender, nationality, type of university (government or private). Second, SOLR was measured by the instrument developed by Yu and Richardson (2015) used in this study, consisting of 66 items with the following four constructs: technical competencies (6 items), social competencies with classmates (5 items), communication competencies (4 items), social competencies with instructor (5 items) and self-directed learning (4 items) developed by Hung et. al, (2010). Finally, satisfaction on distance learning (5 items) developed by Kuo (2010).

A five-point Likert scale ranging from 1 = never to 5 = always was used for each item.

4.3 Data Analysis

SPSS (version 25) was used to examine the preliminary examination of data. The measurement model and hypotheses were tested using structural equation modelling (SEM) by performing partial least squares (PLS) approach. In order to conduct the analysis SmartPLS software (version 3.2.9) was used.

4.3.1 Descriptive statistics and normality

The results of mean scores for all of the items across the study indicate the mean value is above average. Moreover, the results of the skewness and kurtosis reveals that the values of observed variables in the proposed models had skewness and kurtosis within the acceptable level (+2 and -2) (George and Mallery, 2010). It should be noted that the kurtosis of only one item (SCI5) was higher than (2.052) the acceptable level. These results indicate that the data was distributed normally.

4.3.2 Evaluating the validity and reliability of measurement model

The Factor loadings were greater than 0.70 for all constructs at all points of measurement as recommended by Hair et al., (2011). The Cronbach's Alpha results are higher than 0.7 range, which exceeded the recommended levels of acceptance (Hair et al., 2011). The values of rho_A were in the range of 0.927–0.972, which is beyond the recommended value of 0.7. (Dijkstra and Henseler, 2015). All the Composite Reliability values in this study are greater than 0.7 which is considered the minimum value that supports the reliability of the measures (Bagozzi and Yi, 1988). Results showed that the convergent validity is supported since the average variance extracted (AVE) is larger than 0.50 (Hair et al., 2011)

4.3.3 Discriminant validity

According to Fornell and Larcker (1981), to establish the discriminant validity, the square root of average variance extracted (AVE) of each latent variable should be higher than the any other latent construct. The results showed that no correlations were equal to or greater than the square root of the AVE, indicating there was discriminant validity; thus, discriminants are deemed to be valid when the diagonal elements (square root AVE) are greater than the off-diagonal elements in the corresponding rows and columns.

In addition, the result showed that the HTMT ratios of correlation of each construct is below 0.9, which means the discriminant validity has been established based on (Henseler, Ringle and Sarstedt, 2015) suggestion.

4.3.4 Structural model assessment and hypotheses testing

After obtaining the sufficient quality measurement model, we proceed to assessment of the structural model. According to Hair et al., (2016), the structural model evaluation consisted of the following steps: assessment of the structural relationship in the model for multicollinearity assessment, coefficient of determination (R^2), f2 effect size and Q2 predictive relevance and estimation of path coefficients. A detailed list of the R2, f2, VIF and Q2 are presented in Table 1 outlines the results deemed sufficient in the study.

Table 1: Results of hypotheses testing

H	Direct path	Beta	T value	P Value	f2	VIF	Result
H1	Technical Competencies -> Satisfaction on distance learning	0.343	6.360	0.000	0.166	2.462	Accepted
H2	Social Competencies with classmates -> Satisfaction on distance learning	0.095	1.540	0.124	0.094	3.598	Rejected
H3	Communication Competencies -> Satisfaction on distance learning	0.149	2.075	0.038	0.020	3.829	Accepted
H4	Social Competencies with instructor -> Satisfaction on distance learning	0.323	4.681	0.000	0.094	3.867	Accepted
H5	Self-directed learning -> Satisfaction on distance learning	0.034	0.609	0.543	0.009	3.091	Rejected
	R2 (Satisfaction on distance learning) = 0.712						
	Q2 (Satisfaction on distance learning) = 0.606						

5. Results

After validating the structural model assessment, path analysis to test the study hypotheses was proceed. The consistent PLS bootstrapping resampling procedure using 5,000 subsamples and the default settings (i.e. parallel processing, no sign changes) was used to assess the path coefficients and their significance levels.

As shown in table 1, the results confirm H1 predicted a positive effect of technical competencies on satisfaction on distance learning (H1:β = 0.343, t =6.360, p< 0.000), but the positive effect of social competencies with classmates on satisfaction on distance learning (H2: β=0.095, t= 1.540, p > 0.05) is rejected. The anticipated positive relationship between communication competencies and satisfaction on distance learning (H3:β =0.149, t = 2.075, p < 0.038) is accepted. Also, the direct effect of social competencies with instructor on satisfaction on distance learning (H4: β= 0.232, t= 4.681, p > 0.00) is accepted, but the positive effect of self-directed learning on satisfaction on distance learning (H5: β= 0.034, t= 0.609, p > 0.05) is rejected.

6. Discussion

Five hypotheses were formed to address the research question and aim of the study, the results are discussed as follows:

First, technical competencies - which is among SOLR constructs - was found to be significantly related to satisfaction on distance learning. Topal (2016) argued that student technical competencies, which are related to their ability to use technology and develop activities that enhance their motivation and use it repeatedly throughout learning, has a positive relationship with satisfaction on distance learning. Consistent with prior limited studies (e.g. Kirmizi, 2015; Yavuzalp and Bahcivan, 2021; Khong, 2023) the results of this study have confirmed that possessing technical competencies is positively related to student satisfaction on distance learning. The findings provide a better understanding for focus of the UAE's National Program for Advanced Skills on student technical skills to achieve the goals such as satisfaction on distance learning. Moreover, this result is a message to decision makers in higher education institutions in all countries (e.g. the UAE) to include technology subjects as a general compulsory subject due to its positive impact in enhancing e-Learning readiness and satisfaction on distance learning, which could have also long-term impact and make student ready and satisfied to adopt remote working after graduation from the higher education institution.

Second, the result clarified that the student's social competencies while interacting with classmates did not lead to satisfaction on distance learning. Although few limited studies (e.g. Khong, 2023) showed that there was a positive relationship between the two variables, this result is aligned with those few studies (e.g. Alqurashi, 2019; Wu et al., 2023) that showed that during e-learning the relationship between learner-learner interaction and satisfaction on distance learning were not significant. Wu et al., (2023) justified this result that the e-learning classes might not be designed with sufficient learner-learner interaction activities. Thus, there is a need to redesign some group activities that enhance relationships between classmates which leads to satisfaction on distance learning. Moreover, this result calls for the need for further studies to identify the mediating variables that may affect the relationship between student social competencies with classmates and satisfaction on distance learning.

Third, the findings indicated that when the student employs communication competencies - as a construct of SOLR – this results in an increase in satisfaction on distance learning. Gunawardena and Duphorne (2001) explained that when learning approaches involved a high comfort level, the student utilizes their communication competencies while participating in discussions and dealing with others which will help in increasing the level of satisfaction in the e-learning. The findings are supported by some studies (e.g. Gunawardena and Duphorne, 2001; Yilmaz, 2017; Yavuzalp and Bahcivan, 2021; Khong, 2023). Although this is beyond the focus of the research, this result showed the effectiveness of adapting national level strategies to enhance student competencies and skills such as the National Program for Advanced Skills which has been implemented in the UAE context. As communication, for example, was among the highlighted competencies in National Program for Advanced Skills required for student and employee to positively engage with the environment, this adaptation – as per the achieved result - helps to fulfil goals such as satisfaction on distance learning.

Fourth, the result reveals that while interacting online with the instructor, student uses effectively their social competencies – as one of the SOLR constructs - to get further clarifications during learning which leads to satisfaction on distance learning. Kuo (2010) stated that interaction with instructor is among the strongest predictors of student satisfaction on distance learning. However, there was a mixed result as limited studies showed that there was no positive relationship between the variables (e.g. Wu et al., 2023). The obtained result is aligned with a few studies (Kuo, 2010; Khong, 2023) that showed a positive relationship between both variables. Since the student values their instructor, this result encourages key decision makers to involve instructors in change management initiatives to convince the student about changes and reduce resistance to change.

Finally, self-directed learning was negatively related to student satisfaction on distance learning. Kirmizi (2015) clarified that self-directed learning is among student e-learning readiness -which represents the way they could carry out their own study plan and have a high degree of expectation from learning – that is positively related to satisfaction on distance learning. However, there is inconsistency in the existing literature; the achieved result is against those few studies (e.g Kirmizi, 2015; Yilmaz, 2017) that showed that there was positive relationship between self-directed learning and student satisfaction on distance learning. The result was supported by limited studies (e.g. Yavuzalp and Bahcivan, 2021) that showed a negative relationship between student self-directed learning and satisfaction on distance learning.

7. Conclusion

This study aimed to investigate the relationship between SOLR and satisfaction on distance learning in higher education institutions in the UAE.

The results showed that there is a positive relationship between student satisfaction on distance learning and the following SOLR constructs: technical competencies, communication competencies and social competencies with instructor; while social competencies with classmates and self-directed learning were not positively related to satisfaction on distance learning.

The findings make a theoretical contribution as follows; it has extended Yu and Richardson's (2015) model by examining the impact of self-directed learning as an additional construct to the SOLR. Furthermore, the finding confirmed the applicability of the SOLR model which has been developed in United States in the UAE context. Third, this study answered the call of Alem et al., (2016) for further research to investigate the relationship between student's e-learning readiness constructs and satisfaction on distance learning, which helped to fill this gap in the literature.

Also, this study has contextual implications since no prior studies examined the relationship between SOLR and satisfaction on distance learning in the UAE higher education institutions. Thus, this study has helped in filling this gap. Moreover, this study generalized the findings of Tubaishat and Lansari's (2011) which confirmed student e-learning readiness in one of the UAE higher education institutions. Though cross-cultural differences influence student e-learning readiness (Küsel, Martin and Markic, 2020) and the variation in context (Kuo, 2010) impact the relationship between SOLR and satisfaction on distance learning, this result showed that there are other factors that would influence this relationship. For example, the launching of government policies such as National Program for Advanced Skills and increasing the level of e-learning readiness in higher education institutions by providing students with required tools as in the UAE context (The United Arab Emirates' Government portal, 2024) are other factors that should be taken into consideration in this field.

Finally, this study provided useful managerial implications by emphasizing one of the core policies of Ministry of Education to identify effectively the required skills and competencies to achieve the required outputs by adopting best practices and analyzing the market's needs to fill existing gaps in the market. Thus, creating student competencies management and development strategies could be one of the solutions.

8. Limitations and Future Directions

First, this research discussed only student readiness for e-learning, however according to Topal (2016) there are several types of e-learning readiness including the student, the teacher, and the institution readiness. Therefore, there is a need for future research to examine both teachers and educational institutions in the UAE context. Second, this study focused on student satisfaction on distance learning as an output, thus there is a need for additional studies to examine academic achievement (Yavuzalp and Bahcivan, 2021) as an output.

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The Impact of the EduIntegrity Suite on Academic Integrity: A Qualitative Study

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Abstract: The EduIntegrity Suite, a collection of tools designed to promote academic integrity, has garnered significant interest within educational institutions. This study explores the Suite's perceived effectiveness and its influence on various stakeholders through a mixed-methods approach. Semi-structured focus group interviews were conducted with students, educators, and administrators at institutions utilizing the Suite. Student discussions explored their perceptions of the Suite's impact on their learning environment and potential concerns. Educators discussed how the Suite influenced their teaching practices and addressed suspected misconduct. Administrator focus groups provided insights into the decision-making process for implementing the Suite, its effectiveness, and its broader cultural influence. An online component complemented the focus groups, involving a comprehensive review of documents and websites related to the Suite. Company websites and product information for the Suite's individual tools were examined. Academic resources discussing the Suite's functionalities and potential applications were reviewed. News articles and blog posts offering insights from educators, administrators, and students regarding their experiences were explored. The findings highlight the Suite's multifaceted functionalities, including plagiarism detection, grammar and citation checking, originality reports, and remote proctoring services. While students acknowledged the Suite's potential deterrent effect, concerns about workarounds and a shift in focus from learning to detecting cheaters were also voiced. Administrators, however, emphasized the Suite's potential as a tool for promoting a culture of academic integrity, not just detecting plagiarism. Transparency and clear communication emerged as crucial for fostering trust and student acceptance. The EduIntegrity Suite appears to offer a promising approach to academic integrity when implemented strategically and combined with effective pedagogical practices. However, the success hinges on a multi-pronged approach that addresses student concerns, utilizes the Suite's functionalities effectively, and fosters a culture of ethical learning within the institution. To achieve this, institutions can prioritize clear communication about the Suite's purpose and limitations, support and develop staff with the Suites functionality and ethical consideration. Moreover, encourage educational initiatives that promote critical thinking, responsible research practices, and proper citation skills. Collaboration between educators and administrators can leverage the Suite's capabilities to create a more supportive and ethically sound learning environment.

Keywords: EduIntegrity Suite, Academic integrity, Digital tools, Plagiarism detection, Qualitative research

1. Introduction

1.1 Background and Rationale

The digital revolution has fundamentally reshaped how students access and engage with information (Bates, 2023). While technology offers a plethora of benefits for learning, it also presents significant challenges in upholding academic integrity (Sinclair & Cullen, 2022). The rise of online learning environments has exacerbated concerns regarding plagiarism, contract cheating, and other forms of academic misconduct (Zepeda-Hernández et al., 2022). This has necessitated the development of tools and strategies to promote ethical learning practices (Aalborg & Egeltoft, 2023).

The EduIntegrity Suite, a novel term coined by the researchers in this study, represents a potential solution within this evolving landscape. It encompasses a collection of digital tools designed to address these challenges. The Suite integrates functionalities to detect plagiarism, assist with grammar and citation verification, and facilitate secure remote proctoring of online assessments. While the Suite's technical capabilities hold promise for deterring academic dishonesty and fostering a culture of academic integrity, a

comprehensive understanding of its impact on various stakeholders within educational institutions is crucial for its successful implementation.

1.2 Objectives of the Study

This qualitative, exploratory study delves into the impact of the EduIntegrity Suite on academic integrity in educational institutions. The primary objectives are:

- To assess the effectiveness of the EduIntegrity Suite in detecting and deterring plagiarism, contract cheating, and other forms of academic misconduct.
- To explore student perceptions and attitudes towards the use of the EduIntegrity Suite.
- To investigate educator and administrator perspectives on the Suite's influence on teaching practices and academic integrity.
- To critically evaluate the ethical considerations surrounding the use of the EduIntegrity Suite, such as potential privacy violations and bias in automated algorithms.
- To understand the broader impact of the EduIntegrity Suite on the academic culture within institutions.

1.3 Overview of the Research Questions

This qualitative, exploratory study investigates the impact of the EduIntegrity Suite on academic integrity in educational institutions. The research seeks to answer key questions such as how effective is the Suite in detecting and deterring plagiarism, contract cheating, and other forms of academic misconduct, how do students perceive and react to the Suite's presence in their learning environment, and how do educators and administrators adapt their teaching practices and address suspected misconduct when the Suite is in use.

2. Literature Review

2.1 Definition and Importance of Academic Integrity

Academic integrity refers to a fundamental set of ethical principles that guide honest and responsible academic work (International Center for Academic Integrity, 2019). It encompasses core values like honesty, trust, fairness, respect, responsibility, and courage (International Center for Academic Integrity, 2019). Upholding academic integrity is crucial for ensuring the quality and legitimacy of academic achievements (Sinclair & Cullen, 2016). It fosters a learning environment where students develop critical thinking, independent research skills, and a genuine understanding of the subject matter (Aalborg & Egeltoft, 2017).

2.2 Evolution of Digital Tools for Academic Integrity

The digital landscape of education has transformed how students access and process information (Bates, 2023). While technology offers numerous benefits for learning, it also presents significant challenges in upholding academic integrity (Sinclair & Cullen, 2022). Concerns regarding plagiarism, contract cheating, and other forms of academic misconduct have necessitated the development of tools and strategies to promote ethical learning practices (Aalborg & Egeltoft, 2023).

Early digital tools focused primarily on plagiarism detection. Software like Turnitin and Urkund utilize text-matching algorithms to identify potential instances of copied content (Turnitin, 2024; Urkund, 2024). However, the evolving digital landscape has witnessed the emergence of more sophisticated tools incorporating Artificial Intelligence (AI). Large language models, such as ChatGPT (OpenAI, 2023), can generate human-quality text, raising new concerns about AI-powered plagiarism and the potential for students to misuse these tools. In response, digital tools have expanded their functionalities to include:

- Grammar and Citation Checking: Tools ensure proper mechanics, formatting, and referencing styles (Aalborg & Egeltoft, 2017).
- Originality Reports: These reports go beyond simple text-matching, analyzing writing style, vocabulary use, and paraphrasing techniques to provide a more nuanced understanding of a student's work (Aalborg & Egeltoft, 2017).
- Remote Proctoring Services: These services utilize webcams, screen recording, and other technologies to deter cheating during online assessments (Aalborg & Egeltoft, 2017).
- AI-powered Writing Assistants: While some AI tools pose challenges, others can be used ethically to support student learning. These assistants can provide feedback on grammar, clarity, and sentence structure, or suggest relevant sources (e.g., Grammarly, 2024).

These advancements equip educators with resources to detect and deter academic dishonesty (Balida and Encarnacion, 2020). However, with this evolution comes the need for ongoing research to address concerns about:

- Privacy: Data collection practices and student privacy protections require careful consideration (Aalborg & Egeltoft, 2017).
- Algorithmic Bias: AI-powered tools can perpetuate biases present in their training data (Egebæk et al., 2023). Educators need to be aware of these potential biases and use the tools critically.
- Overemphasis on Punishment: A focus solely on detection can overshadow the importance of fostering a culture of academic integrity through ethical research practices and critical thinking skills (Aalborg & Egeltoft, 2017; Davies & Graff, 2013).

The EduIntegrity Suite, a collection of these tools, warrants further investigation into its impact on navigating the complexities of academic integrity in the digital age, particularly regarding the challenges and opportunities presented by AI.

2.3 Existing Research on Plagiarism Detection Tools

Plagiarism detection tools have been a mainstay in the fight for academic integrity. These tools, like Turnitin and Urkund, utilize text-matching algorithms to scan student work against vast databases of online and academic sources (Turnitin, 2024; Urkund, 2024). While effective in identifying blatant plagiarism, research highlights limitations (Vani & Gupta, 2016). Text-matching software can struggle with paraphrasing, non-electronically available sources, and translated content (Vani & Gupta, 2016). Studies report issues with false positives and negatives, highlighting the need for critical analysis alongside automated reports (Davies & Graff, 2013).

2.4 Student Attitudes toward Academic Integrity Tools

Students' perspectives on academic integrity tools are a double-edged sword. Studies by Hendricks et al. (2021) acknowledge that awareness of plagiarism detection tools can deter students from blatant copying. However, on the flip side, research by Zepeda-Hernández et al. (2022) suggests students might become more adept at outsmarting these detection methods. A crucial concern lies in a potential shift in student focus, as identified by Aalborg & Egeltoft (2023). The emphasis might move away from genuine learning and towards simply avoiding getting caught. Some students might perceive these tools as a lack of trust or a form of surveillance, according to Nguyen (2023). To bridge this gap and cultivate a positive learning environment that prioritizes academic integrity, fostering open communication about the purpose and limitations of plagiarism detection tools is crucial, as emphasized by Nguyen (2023). This transparency can help alleviate student anxieties and refocus the conversation on fostering a culture of ethical learning.

2.5 Educator Perspectives on Academic Integrity and Technology

While technology offers valuable tools for promoting academic integrity, educators hold diverse perspectives on their implementation. Some educators appreciate the efficiency and objectivity offered by plagiarism detection software (Aalborg & Egeltoft, 2017). However, concerns exist regarding over-reliance on technology and the potential for neglecting pedagogical approaches that foster critical thinking and responsible scholarship (Sinclair & Cullen, 2016). Effective use of academic integrity tools requires educators to go beyond automated reports (Nguyen, 2018). Integrating discussions about ethical research practices, source evaluation, and proper citation into the curriculum is crucial (Aalborg & Egeltoft, 2017). In this way, technology can complement a holistic approach to fostering academic integrity that emphasizes understanding and ownership of ethical learning.

2.6 Ethical Considerations in Using Digital Tools for Academic Integrity

The use of digital tools for academic integrity raises important ethical considerations. Concerns regarding student privacy and data security are paramount. Institutions need transparent policies outlining data collection and usage practices (Aalborg & Egeltoft, 2017). The potential for bias in algorithms used by plagiarism detection tools warrants attention (Perkins & Roe, 2023). Algorithmic biases based on language or cultural context could lead to unfair accusations of plagiarism. Educators need to be critically aware of these limitations and utilize such tools in conjunction with human judgment. A reliance on technology for academic integrity enforcement may foster a "catch-and-punish" mentality (Aalborg & Egeltoft, 2017). The primary focus should remain on creating a culture of academic integrity that emphasizes learning, ethical research practices, and responsible scholarship (International Center for Academic Integrity, 2019).

3. Methodology

This study employed a qualitative, exploratory research design to investigate the impact of the EduIntegrity Suite on academic integrity in educational institutions. An exploratory approach allowed for in-depth exploration of a relatively under-researched phenomenon, the EduIntegrity Suite, and its multifaceted influence on various stakeholders (Creswell & Creswell, 2018). Data was collected through two primary methods:

3.1 Focus Group Interviews

To gain a well-rounded understanding of the EduIntegrity Suite's influence, the study utilized semi-structured focus groups with various educational stakeholders (Morgan, 2019). This approach fostered rich discussions about participant experiences and viewpoints. Student groups explored their perceptions of the Suite's impact on their learning environment and potential concerns. Educators discussed how they adapted teaching practices and addressed suspected misconduct in light of the Suite. These discussions explored educator perspectives on the Suite's effectiveness in promoting academic integrity. Finally, administrator groups provided insights into the decision-making process for implementing the Suite, their experiences with its effectiveness, and its broader influence on the institution's academic culture. To further enrich the understanding of the Suite's impact, the focus groups were complemented by online research using recent (within the past five years) documents and websites found through search engines and academic databases (Creswell & Creswell, 2018). This combined approach aimed to capture a nuanced picture of the Suite's influence on academic integrity within educational institutions.

3.2 Online Research

To supplement the focus group interviews, the study also conducted a comprehensive online review of documents and websites related to the EduIntegrity Suite. This online component included examining company websites and product information for the various tools within the Suite. Academic resources and reports discussing the Suite's functionalities and potential applications were reviewed. News articles and blog posts offering insights from educators, administrators, and students regarding their experiences with the Suite were explored. This multi-pronged approach provided a broader context for understanding the Suite's impact beyond the focus group discussions. Through this online research, the study aimed to gain a comprehensive understanding of the Suite's intended purposes, technical capabilities, and any publicly available information about its implementation and impact.

3.3 Participants and Sampling

A convenience sampling strategy was used to recruit participants due to the study's initial exploratory nature (Creswell & Creswell, 2018). This involved recruiting accessible participants from a local institution with the Suite implemented. Students were found through online forums and email lists, while educators were recruited through departmental meetings or email. Administrators were identified through the directory. The online research component involved recent (within the past five years) documents and websites found through search engines and academic databases. This sampling method, while acknowledging limitations in generalizability (Creswell & Creswell, 2018), is cost-effective for initial research stages. The focus group discussions aimed for a balance between rich interaction and individual participation, with 20 students and 6 administrators ultimately participating. The study recognized the limitations of convenience sampling, particularly on generalizability of findings, and suggests exploring broader recruitment strategies in future research stages (Crisostomo et al., 2020).

3.4 Data Analysis Approach

The data collected from the online research and focus group interviews underwent thematic analysis. This qualitative approach involves identifying, analyzing, and interpreting recurring themes within the data (Braun & Clarke, 2006). Thematic analysis allows for a flexible and iterative process, enabling the researcher to explore the data inductively and identify key themes that emerge from the participants' experiences and perspectives (Braun & Clarke, 2006). For the online research, data was analyzed by systematically coding relevant excerpts from documents and websites. Codes were categorized and grouped to identify emerging themes related to the Suite's functionalities, perceived benefits and drawbacks, and its potential impact on academic integrity.

The focus group interviews were audio-recorded and transcribed verbatim. The transcripts were coded by the researcher using a thematic analysis approach. Similar to the online research data, codes were categorized and

grouped to identify recurring themes within and across the focus group discussions. This process allows for the exploration of student perceptions, educator adaptations, administrative perspectives, and the Suite's broader influence on the academic culture.

3.5 The EduIntegrity Suite: Overview and Functionality

3.5.1 Unveiling the Suite's Toolbox

The EduIntegrity Suite aimed to tackle academic integrity through a range of functionalities. At its core, plagiarism detection tools like Turnitin or Urkund utilized text-matching algorithms to scan student work against vast online and academic databases. These tools identified potential instances of copied content and provided instructors with similarity reports for further analysis. Grammar and citation checking offered another layer of support, assisting students in maintaining proper mechanics, formatting, and referencing styles within their work. Building upon plagiarism detection, originality reports provided a more in-depth analysis, potentially including details on paraphrasing, use of external sources, and areas with potential originality concerns. Remote proctoring services facilitated online assessments in a secure environment. These services may have utilized webcams, screen recording, and other technologies to deter cheating during exams and quizzes.

3.5.2 Comparing functionalities: A synergistic approach

The EduIntegrity Suite's success lies in its multifaceted approach. While plagiarism checkers identified potential issues (Nguyen, 2018; Sinclair & Cullen, 2016), human judgment remained crucial (Aalborg & Egeltoft, 2017). Grammar and citation checkers further refined analysis (Aalborg & Egeltoft, 2017), and originality reports prompted deeper exploration of concerns (Aalborg & Egeltoft, 2017). These reports, along with remote proctoring, served to deter misconduct (Aalborg & Egeltoft, 2017). However, educators stressed the importance of using these tools alongside methods that promote genuine learning, not just detection (A1, A2; Davies & Graff, 2013). Ultimately, the Suite's strength lies in its combined functionalities, creating a more comprehensive and supportive environment for academic integrity.

3.5.3 Building a wall against academic dishonesty

The EduIntegrity Suite aimed to tackle academic integrity through a multifaceted approach. By making plagiarism and contract cheating more difficult to get away with, the Suite served as a deterrent for dishonest behavior. Tools like citation checking and originality reports fostered responsible research habits by encouraging students to develop proper citation practices. The Suite also promoted transparency by allowing instructors to identify potential issues early on. This facilitated open communication with students about academic integrity expectations. The Suite supported online learning by offering remote proctoring services, which helped ensure the fairness of online assessments.

4. Findings

This section presents the findings according to the objectives as follows:

Objective 1. To assess the effectiveness of the EduIntegrity Suite in detecting and deterring plagiarism, contract cheating, and other forms of academic misconduct.

A review of existing research (Creswell & Creswell, 2018; Morgan, 2019) alongside focus group discussions provided insights into the perceived effectiveness of the EduIntegrity Suite. While students acknowledged the Suite's potential to deter plagiarism due to the increased awareness of detection tools (Nguyen, 2018; Sinclair & Cullen, 2016), concerns lingered about potential workarounds or the development of more sophisticated cheating methods. Educators, however, emphasized the importance of human judgment alongside automated reports (Aalborg & Egeltoft, 2017). Investigating flagged content, considering context, and open communication with students were identified as essential practices (Davies & Graff, 2013). Administrators further highlighted the Suite's potential to go beyond detection and promote a broader conversation about academic integrity (International Center for Academic Integrity, 2019). Initiatives such as educational workshops and clear policies were viewed as crucial for fostering a culture of responsible scholarship.

Despite the lack of direct observation on implementations, focus group discussions revealed promising applications of the EduIntegrity Suite when used strategically alongside effective teaching practices. For instance, an instructor in a distance learning program highlighted the Suite's remote proctoring service in ensuring the integrity of online exams (Aalborg & Egeltoft, 2017). The authors note that this fostered a sense

of fairness among students and allowed the instructor to prioritize assessing understanding over policing potential cheating. Another educator described utilizing originality reports as a springboard for discussions with students about proper citation and ethical research practices. This proactive approach aimed to address potential issues early on and promote responsible scholarship among students.

The study acknowledged limitations in generalizability due to the convenience sampling approach (Creswell & Creswell, 2018). The research focused on perceived effectiveness based on participant experiences. Future research could involve quantitative analysis of data on academic integrity violations before and after Suite implementation to provide a more objective assessment of its impact (Vani & Gupta, 2016). The findings suggest that the EduIntegrity Suite holds promise as a tool for promoting academic integrity. However, its effectiveness appears to be maximized when used in conjunction with clear communication, educational initiatives, and a focus on fostering a culture of ethical research and learning.

Objective 2. To explore student perceptions and attitudes towards the use of the EduIntegrity Suite.

4.1 Student Perceptions and Attitudes

Table 1: Analysis of student views on using academic integrity tools

Factor	Analysis of Student Views	Influences Acceptance/Resistance	Implications for Student Learning & Behavior
Awareness and Deterrence	Students acknowledge the presence of plagiarism detection tools and their potential deterrent effect.	Fear of getting caught Awareness of consequences	May deter intentional plagiarism, but may not address underlying causes.
Workarounds and Sophistication	Some students express concerns about finding work around or developing more sophisticated cheating methods.	Belief in the "beat the system" mentality Lack of understanding of ethical research practices	May lead to an arms race between detection and evasion, undermining the learning process.
Focus on Detection vs. Learning	Students may perceive tools as punitive measures. The focus is on detecting cheaters, not fostering learning.	Prior negative experiences with academic integrity enforcement Lack of clear communication about the Suite's purpose	May create a culture of fear and suspicion, hindering genuine learning and engagement.
Value of Ethical Research	Limited understanding of ethical research practices and proper citation can lead to unintentional plagiarism.	Lack of exposure to plagiarism education Insufficient guidance on responsible scholarship	Tools like originality reports can be springboards for discussions and learning about proper citation and ethical research.
Transparency and Communication	Students value clear communication from instructors about expectations and the purpose of academic integrity tools.	Trust in instructors Open communication channels	Transparency builds trust and fosters a learning environment where students feel comfortable asking questions and seeking clarification.

The focus group discussions revealed a fascinating tapestry of student perceptions regarding the EduIntegrity Suite. While some students acknowledged the Suite's presence with a hint of apprehension, **Student 1 (S1)**, a psychology major, admitted, "*Honestly, knowing there are plagiarism checkers out there makes me think twice before copying anything*." This sentiment echoed the potential deterrent effect the Suite might have. However, others, like **Student 2 (S2)**, a computer science student, expressed concerns, saying, "*I've heard rumors about ways to get around these tools. It feels like an ongoing battle.*" These comments highlight the potential for a "beat the system" mentality that could undermine the Suite's effectiveness. The discussions also revealed a concern that the Suite might prioritize detection over learning. **Student 3 (S3)**, an art history student, voiced this worry: "*It feels like they're just trying to catch us cheating, not actually help us learn how to do things properly.*" This perception, if unaddressed, could create a culture of fear and suspicion that hinders genuine learning.

However, the focus group also offered glimpses of hope. Several students, like **Student 4 (S4)**, a biology major, expressed a desire for more support: "*I sometimes get confused about proper citations. Maybe these tools could help explain things better, not just catch me doing something wrong.*" These comments point to the potential of the Suite as a learning tool, particularly when used in conjunction with clear communication and educational initiatives. Transparency emerged as another key theme. Many students, like **Student 5 (S5)**, an English major, emphasized the importance of clear communication: "*If professors just explained what they expect and how these tools work, it would be a lot less stressful.*" Building trust and fostering open communication channels seems crucial for student acceptance and effective utilization of the Suite.

Student reactions to the EduIntegrity Suite during the focus groups were a fascinating mix. **One student (S1)**, acknowledging the Suite's presence, admitted, "*Honestly, knowing there are plagiarism checkers out there makes me think twice before copying anything*." This sentiment echoed the potential deterrent effect the Suite might have. However, concerns also surfaced. **Another student (S2)** expressed anxieties about finding loopholes, stating, "*I've heard rumors about ways to get around these tools. It feels like an ongoing battle.*"

Objective 3.To investigate educator and administrator perspectives on the Suite's influence on teaching practices and academic integrity.

These comments highlighted the potential for a "beat the system" mentality that could undermine the Suite's effectiveness.

Administrators (A1, A2) presented a contrasting perspective, emphasizing the Suite's potential as a tool for fostering a culture of academic integrity, rather than just detecting plagiarism. **Administrator 1 (A1)** noted, "*The Suite's potential lies not just in catching plagiarism, but in fostering a culture of academic integrity*. Educational workshops and clear policies can play a crucial role in achieving this." This emphasis on a holistic approach resonated with **a student (S4)**, a biology major, who expressed a desire for more support: "*I sometimes get confused about proper citations. Maybe these tools could help explain things better, not just catch me doing something wrong.*"

Transparency emerged as another key theme. **A student (S5)**, an English major, emphasized the importance of clear communication: "*If professors just explained what they expect and how these tools work, it would be a lot less stressful.*" Building trust and fostering open communication channels seemed crucial for student acceptance and effective utilization of the Suite.

The focus groups revealed a dynamic between educators and administrators regarding the EduIntegrity Suite. Educators (S1, S3) acknowledged the Suite's potential to deter plagiarism but expressed concerns about a potential arms race with students seeking workarounds. Administrators (A1, A2) countered by emphasizing the Suite's role in promoting a broader conversation about academic integrity. They envisioned the Suite as a tool for educators (S4) to initiate discussions about proper citation and responsible scholarship (A2). The discussions highlighted the need for a multi-pronged approach. Combining the Suite's capabilities with clear communication strategies and a focus on fostering a culture of ethical learning can empower educators and administrators to create a more effective and supportive learning environment for students

Objective 4. To critically evaluate the ethical considerations surrounding the use of the EduIntegrity Suite, such as potential privacy violations and bias in automated algorithms.

The Suite's potential access to student work and data necessitates transparent data handling practices and robust security measures to protect student privacy. Algorithmic bias in plagiarism detection tools requires institutions to critically evaluate algorithms and implement human oversight alongside automated reports. Overreliance on the Suite for detecting plagiarism can overshadow the importance of fostering a learning environment that emphasizes ethical research practices. Institutions need to ensure the Suite complements, not replaces, pedagogical approaches promoting critical thinking and responsible scholarship. Constant monitoring through tools like remote proctoring could create a stressful learning environment. Institutions should prioritize trust-building measures and ensure the Suite is used judiciously.

To address these concerns, institutions need to develop clear policies outlining the Suite's purpose, data handling practices, and student rights. These policies should be readily available to students, faculty, and staff. Faculty training on the Suite's functionalities and limitations, alongside ethical considerations, is crucial. Equipping educators to use the Suite effectively alongside pedagogical best practices is essential. Fostering open communication with students about academic integrity expectations, the Suite's role, and available support systems is key to building trust and promoting ethical behavior. Institutions should prioritize

educational initiatives that promote critical thinking, responsible research practices, and proper citation skills. This holistic approach can help shift the focus from detection to fostering a culture of academic integrity.

Transparency about the Suite's capabilities and limitations is crucial. Students should understand the tools used and how they might be impacted. Automated reports generated by the Suite should always be reviewed with human judgment and contextual understanding. The Suite should be used in conjunction with educational initiatives and open communication to promote responsible scholarship and ethical research practices.

Objective 5. 1. To understand the broader impact of the EduIntegrity Suite on the academic culture within institutions.

The EduIntegrity Suite's impact extends beyond individual student behavior, influencing the broader academic culture within institutions. Focus group discussions revealed concerns from **Student 3 (S3)**, an art history student, who worried, "*It feels like they're just trying to catch us cheating, not actually help us learn how to do things properly.*" This sentiment highlights a potential pitfall: a culture focused solely on detection can create a climate of fear and suspicion.

However, the Suite also presents opportunities for fostering a more positive academic culture. **Administrator 2 (A2)** emphasized, "*The Suite, when used strategically, can be a springboard for discussions about ethical research practices and responsible scholarship*." Integrating academic integrity into the core values and practices of an institution is crucial for achieving this.

Administrator 1 (A1) noted the importance of educational initiatives, stating, "*The Suite's potential lies not just in detecting plagiarism, but in fostering a culture of academic integrity*. Educational workshops and clear policies can play a crucial role in achieving this." With students who are equipped with the knowledge and skills for responsible scholarship, alongside clear expectations and readily available support systems, institutions can create a learning environment that fosters trust and ethical behavior.

The future implications for academic culture hinge on how the Suite is implemented. If used primarily for detection, it may lead to an arms race of workarounds and a culture of fear. However, by leveraging the Suite alongside educational initiatives, clear communication, and a focus on ethical research practices, institutions can cultivate a more positive academic culture. As **Student 4 (S4)**, a biology major, expressed, "*Maybe these tools could help explain things better, not just catch me doing something wrong.*" The Suite, when used strategically, has the potential to empower students to become responsible scholars and contribute to a more ethically sound learning environment.

5. Conclusion

Students acknowledged the Suite's potential deterrent effect but expressed concerns about workarounds and a shift in focus from learning to detecting cheaters. Administrators, however, emphasized the Suite's potential as a tool for promoting a culture of academic integrity, not just detecting plagiarism. Ethical concerns regarding data privacy, algorithmic bias, and a potential overemphasis on detection were also identified.

These findings hold significant implications for practice and policy. Institutions should prioritize clear communication with students about the Suite's purpose and limitations. Faculty training on the Suite's functionalities and ethical considerations is crucial. A focus on educational initiatives that promote critical thinking, responsible research practices, and proper citation skills is essential. The Suite's effectiveness appears to be maximized when used in conjunction with these practices.

Further research is recommended to explore the Suite's long-term impact on academic integrity and student learning behavior. Quantitative analysis of data on academic integrity violations before and after Suite implementation could provide a more objective assessment of its effectiveness. Research on the Suite's influence on faculty teaching practices and the broader institutional culture of academic integrity would offer valuable insights for future policy and practice development.

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Slow and Steady or Fast and Furious: An Analysis of Completion Duration in open.uom.lk

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Abstract: The open.uom.lk platform is an open learning platform developed by the University of Moratuwa, Sri Lanka, offering free asynchronous online IT related courses. The platform was developed as an initiative to meet the growing human capital requirement of the IT industry in Sri Lanka, one of the only sectors showing strong growth even during the country's recent economic crisis. In the two years since the release of its flagship course Trainee Full-Stack Developer, there have been over 270,000 enrolled learners. The course consists of six subjects covering Python programming, web design, and a professional practice module that includes a capstone project. Despite the massive number of enrollments, as in many other MOOCs, completion rates remain low. For instance, for the two beginner courses in programming and web design, into which all participants are enrolled automatically, completion rates stand at 7-10%. Completion rates for subsequent subjects are higher given that enrollment is conditional on completing prerequisites. From a planning perspective, it is not just estimates of how many participants complete the programs but also the time they take to do so that are integral for determining the future growth of the IT industry. As such, this study aims to develop a model for course completion using survival analysis which has the advantage of being able to model censored data (e.g. when duration is unknown due to non-completion) and provide forecasts of completion rates at different points in time. The analysis uses student activity completion reports and demographic information of participants including employment and educational background. The findings suggest that the course interaction variables, particularly the speed of completing early activities, are more important for predicting course completion than the demographic variables, though education and employment status are also significantly correlated with completion. The survival model could then be used for purposes of predicting both the completion probability as well as the timeframe within which the completion may be expected.

Keywords: MOOCs, Course completion, Completion duration, Survival Analysis, Learning analytics

1. Introduction

Massive Open Online Courses (MOOCs) have become increasingly widespread since their inception in the 2010s and are now an important part of the education landscape. The disruptions caused by the Covid-19 pandemic including social distancing measures and closure of physical learning spaces provided an opportunity for MOOCs to be positioned as a viable solution for the education sector (Rulinawaty et al, 2023). Given the massive uptake and potential for outreach, there is an active debate on their role and value in higher education: while online, asynchronous learning allows a large amount of independence and flexibility for learners as well as coverage of a wide array of subjects for larger student numbers, these courses face challenges of low persistence and completion rates (Impey and Formanek, 2021).

The Centre for Open and Distance Learning (CODL) of the University of Moratuwa, Sri Lanka, launched the open.uom.lk platform for asynchronous online learning in 2021 as a response to the shortage of skilled workers in the IT industry in the country. Despite the digital technology sector showing strong economic growth even during the country's recent economic crisis, a clear gap between the market demand and supply of ICT skills has been identified (ICTA, 2019). Accordingly, the Trainee Full-Stack Developer (TFSD) course was developed in consultation with members of the IT industry to cover the knowledge and skills required by the sector (Ranasinghe et al., 2023). The course is offered completely free of charge and is open to anyone.

The TFSD course consists of 6 subjects: two courses in Python programming, three courses in web development, and the final course that covers professional practice and a capstone project. A registering student is automatically enrolled into the introductory course in Python programming and web development. Enrolment into subsequent courses is based on the completion of the prerequisites. Given that the goal of the program involves the creation of skilled workers who are employable in the IT industry, the course is rigorous. As such, (like in many other MOOCs) completion rates for the course are low. While 273,179 users have enrolled in the program as of the 21st of May 2024, only 350 of the enrolled users had completed the full course, while only 19,316 and 13,291 had completed the introductory courses for programming and web development, respectively.

With the observed high levels of enrolment and low completion rates, and the urgent requirement for skilled workers for the IT industry, it would be useful to predict not just how many students will complete but also the time horizon within which those numbers can be expected. While standard classification models do the former, they do not necessarily make use of the duration of completion and therefore cannot be used for the latter. Survival analysis provides an alternative for this type of scenario given that it makes predictions on the time to an event, rather than the event itself.

This paper aims to use survival analysis to model student completion in the open.uom.lk platform, making use of student activity reports from the Web Design for Beginners course and demographic information. The development of the model would facilitate the prediction of completions within a particular time frame, while also allowing for the identification of key factors that contribute to the timely completion of the course. The former is important from an overall sector planning perspective whereas the latter is useful for further developing the course itself.

The growing use of learning management systems (LMS) and educational technology has resulted in the creation of highly detailed educational datasets, facilitating the development of learning analytics for improving student retention and reducing student attrition (Villano et al., 2018). MOOCs provide a particularly rich environment for this type of analysis given the large user bases and digital format of the courses and the widespread problem of low completion. Previous work on predicting dropouts or completion has identified student-specific demographic and social factors as well as interaction-specific factors that can be used to predict various outcomes including course completion, probability of dropping out, prediction of scores, etc. Moreno-Marcos et al (2018) provide a system review of this literature.

As discussed in Moreno-Marcos et al. (2018), a majority of publications focused on predictive models using MOOCs make use of variables that can be constructed using the activity logs and records generated within the LMS itself. These range from simple measures such as time spent on the LMS, total clicks, and frequency of access (Ulfa and Fatawi, 2021; Damianov et al, 2009; Vengross and Bourbeau, 2006), to more sophisticated measures such as logs on video events such as playing, pausing and skipping (Brinton et al. 2016) or time spent on specific activities such as solving exercises or watching videos (Ruiperez-Valiente at al. 2018; Boyer et al. 2015). Many studies also make use of demographic characteristics obtained either from course registration forms or surveys carried out on course participants. Commonly used characteristics include age, gender and educational background, including familiarity with the course topic (e.g. Greene et al. 2015; Al-Shabandar et al. 2017; Labrador et al. 2019).

There is a large literature making use of classification models including logistic regression, support vector machines, decision trees, and random forests (among many others) for predicting completions or drop-outs in MOOCs. For instance, a study by Chaplot et al. (2015) finds that by using Sentiment Analysis and Neural Networks they could predict the students who are likely to drop out. Their method had high accuracy (88%) and low occurrences of false negatives (0.095). Machine learning can also be used to predict student attrition such as in the study by Matz et al. (2023) who used user engagement metrics and socio-demographic characteristics data for their linear and non-learning machine learning model. They found their models had a 78% average accuracy. Machine learning and deep learning techniques have been widely applied when predicting student outcomes in online courses and evident in the review by Alhothali et al. (2022).

Work on the application of survival analysis models to this problem is less extensive. However, as argued by Greene et al. (2015) survival analysis has the advantage of using information on the timing of events (in this case, completion), while also accounting for censored data (i.e. participants for whom the event is not experienced over the course of the analysis but may do so in the future) which gives rise to better estimates of the effect of covariates used to predict event probabilities. Work by Green et al. (2015), Gitinabard et al. (2018), Labrador et al. (2019), Wintermute et al. (2021) provide notable examples of survival analysis applications to the learning analytics context. Given this background, this research applies survival analysis techniques to model course completion in the open.uom.lk platform, making use of both demographic and interaction-specific characteristics. In doing so, it not only provides actionable insights to local policymakers and administrators of the open learning platform but also adds to the literature on the potential for open and distance learning of IT-related subjects in a developing country context.

2. Data

This paper makes use of activity completion reports of Web Design for Beginners, the introductory web development course in the TFSD program offered on the open.uom.lk platform. The Web Design course has a

total of 45 activities that must be completed sequentially before the overall course can be completed. The activity completion report has information about the date and the time of the completion of each activity for each user, allowing for the construction of indicators for activity and course completion at the time of report generation as well as the duration taken for completion of individual activities as well as the overall course.

The activity completion data is supplemented with demographic data from the registration survey. The available demographic information includes gender, level, field of education, and field of employment. Given that the registration survey was introduced after the Web Design course was launched the demographic data is only available for a subset of 25,625 users. Moreover, since Web Design for Beginners is one of the introductory courses in the program, all students who register for the TFSD course are automatically enrolled. Accordingly, a large number of users who appear in the activity report have not completed a single activity. Given the issue of class imbalance with non-completions greatly outnumbering completions, we restrict the analysis to those who have completed at least the first activity, resulting in a sample of 5,802 observations.

The percentage of dropouts and median duration for each activity in the course highlights several bottlenecks. For instance, the dropout rates are highest after the 1st and 2nd activities at 15% and 16%, respectively, while the next bottleneck is at activity 6 (10% dropout). We use this information to create course interaction variables to be included in the model. Specifically, we construct indicators for completion of the first five and ten activities, completion of the 2nd activity within 24 hours of the first, completion of the first five activities within three days of the first activity and the completion of the first ten activities within seven days of the first. The last three variables are constructed on the basis that behaviour of the learner in the first week of starting the course can predict student performance and course completion (Jiang et al. 2014). Finally, the response variables are an indicator for completion of the Web Design course and time taken to complete the course (right censored as many students had not completed the course at the time of report generation).

The descriptive statistics show that among those who have completed at least the first activity in the course, the completion rate is 28%, with a mean time to complete of 51 days. The median time to completion was 13 days. The fastest time to completion was 36 minutes while the longest time to complete was 681 days. Figure 1b illustrates the distribution of the completion duration for those who completed the course.

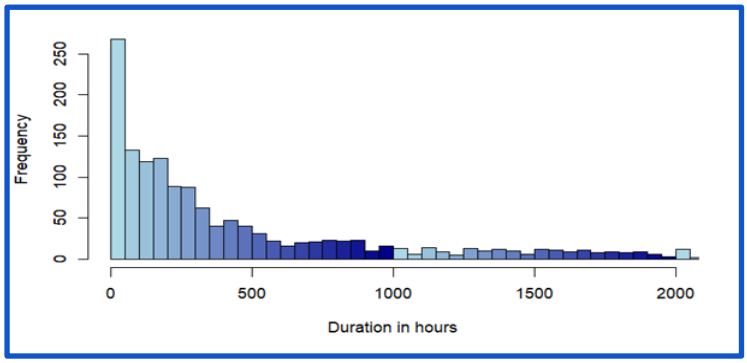

Figure 1: Histogram of time taken to complete the course (among completing students)

Table 1 provides the list of variables used and their descriptive statistics for the sample used for the analysis.

Table 1: Descriptive statistics

Variable	Mean
Completed whole course	0.283
Time taken to complete (only for those who completed) (days)	51.22
Completed 5 activities	0.608
Completed 10 activities	0.290
Completed the 2nd activity within 24 hours of 1st activity	0.673

Variable	Mean
Completed 5 activities within 3 days of 1st activity	0.399
Completed 10 activities within 1 week of 1st activity	0.290
Gender (excluded category = male)	
Female	0.374
Secondary education status (excluded category = Have not done Ordinary Level exam)	
Completed Ordinary Level exam but not passed Advanced Level exam	0.050
Completed Ordinary level exam but not sat for Advanced Level exam yet	0.146
Sat for Advanced Level exam and waiting for results	0.060
Completed Advanced Level exam	0.543
Higher education (excluded category = Have not done a degree)	
Doing a degree in the IT field	0.320
Doing a degree in a non-IT field	0.084
Completed the degree in IT field	0.033
Completed the degree in a non-IT field	0.045
Employment (excluded category = not working)	
Working in a non-IT company	0.089
Working in an IT company	0.046
Self-employed	0.055

3. Methods

This paper uses survival analysis to predict completion and time to completion of the Web Design for Beginners course. The activity logs allow for the computation of the duration taken to complete in minutes, with the origin time period (t=0) considered to be completion of the 1st activity in the course. Given that the event in this study is completion of the course, survival in this model refers to non-completion as of the date of the activity report being generated.

We start by plotting Kaplan-Meier curves for the selected categorical covariates. The Kaplan Meier curve graphically represents probability of surviving in a given length of time (Goel, et al. 2010), allowing for a visual representation of the probability of not completing the course over time. By plotting the curves for the selected covariates, we can visualize differences in survival functions between groups, if any. The p-value of the logrank test for comparing the survival curves of the groups is also reported, where rejection of the null hypothesis suggests significant differences in survival rates between groups. These results form the basis for the selection of covariates for the multivariate analysis that follows.

A Cox proportional hazards model is then fitted to the data, to estimate the level of risk associated with the failure event (in this case, completion) for the selected covariates. The model is similar to a logistic regression for course completion with the key difference that the Cox model takes into account the time unit the event occurs. Accordingly, the Cox model has the advantage of being able to predict probabilities of completion over different time horizons (van der Net et al., 2008). Three separate specifications of the Cox model are estimated: the first uses only demographic variables as covariates, the second only the course interaction variables and the third uses both sets of variables.

The concordance statistic, which is commonly used for evaluating goodness of fit for Cox models, is reported for the three models. The concordance statistic is the fraction of all possible pairs of predicted and actual values that are concordant (i.e. have the same ordering) (Therneau and Watson, 2017) - a higher concordance statistic refers to higher level of agreement between and actual values.

4. Results

Figure 2 plots the Kaplan-Meier curve for the Web Design course completion. Note that survival here refers to not completing the course. As the Graph shows, the probability of not completing the course at time zero is 1, with the probability of non-completion declining thereafter. For instance, the probability of taking more than 50 days to complete the course is approximately 0.75. However, the curve plateaus out - the probability of taking more than 300 days to complete the course remains above 0.6. The curve is steepest in the first 20-30 days, indicating that most completions occur around this duration. These features are consistent with the low completion rates that are observed in the data and the relatively shorter completion times for those who complete the course.

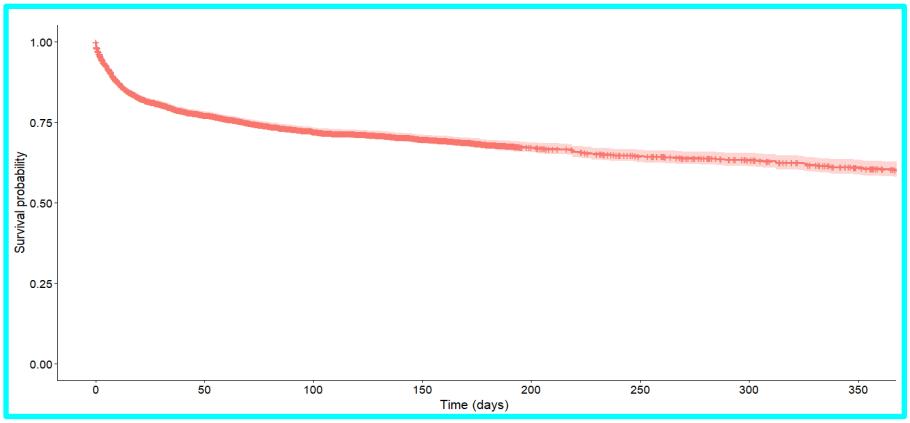

Figure 2: Kaplan-Meier plot for the probability of completing the course

Figure 3 plots the Kaplan-Meier curves for some of the covariates considered in the analysis, both demographic and interaction specific variables. The p-values of the logrank tests comparing survival rates between groups is less than 5% for all covariates considered and smaller than 0.0001 for all covariates other than gender, suggesting that there are significant differences between the survival rates of these groups. For instance, the survival rate for males has a steeper fall than that of females, suggesting that male students are more likely to complete the course. Similarly, students following a degree in an IT-related field are more likely to complete the course than those who are not, students who are not working are more likely to complete than those working in a non-IT company and so on. It should be noted that differences between groups are strongest when considering the variables related to course interactions. For example, the probability that a student who has completed the first ten activities within one week will take more than 20 days to complete the course is less than 0.5, whereas the same probability for a student who did not complete the same activities within a week is close to 0.9. These graphs motivate the use of the selected covariates in the Cox models that follow.

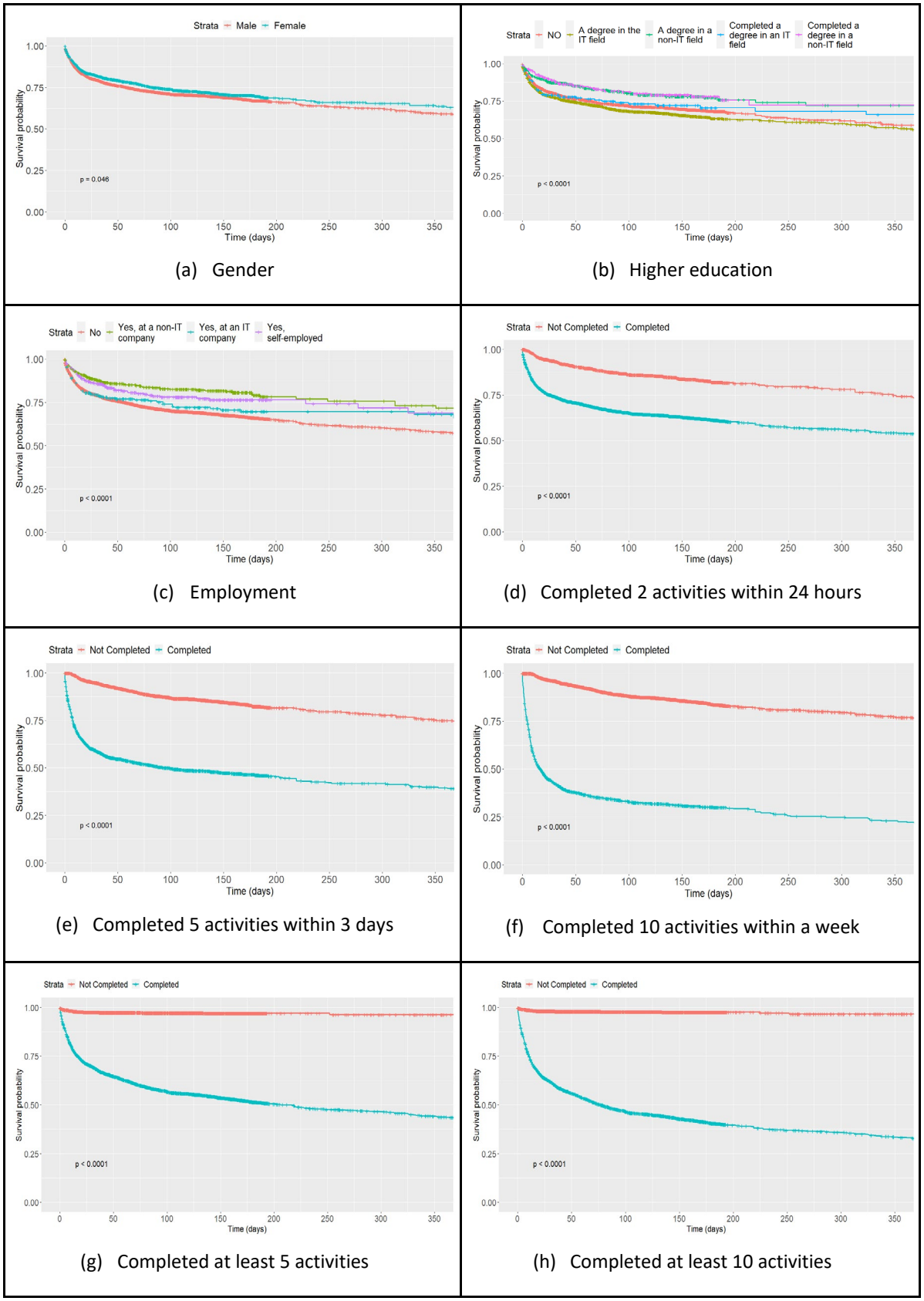

Figure 3: Kaplan-Meier plot for covariates

The output of the Cox regressions for three sets of covariates (only demographic, only course interactions, and both demographic and course interactions) are presented in Table 2.

Table 2: Estimates of the Cox proportional hazard models for course completion

Explanatory variables	**(1)**	**(2)**	**(3)**
Female	-0.123 *		0.010
	[0.032]		[0.865]
Secondary education (reference: have not done the O/L exam)			
Completed OLs not passed ALS	-0.265		-0.345*
	[0.056]		[0.014]
Completed OLs not done ALs	-0.203*		-0.397***
	[0.036]		[0.000]
Sat for ALs	-0.292*		-0.335*
	[0.029]		[0.013]
Completed ALs	-0.281**		-0.567***
	[0.003]		[0.000]
Employment status (reference: not working)			
Non-IT company	-0.390***		-0.234*
	[0.00]		[0.048]
An IT company	-0.054		0.106
	[0.676]		[0.406]
Self-employed	-0.378**		-0.386**
	[0.006]		[0.006]
Higher education (reference: have not done/not doing a degree)			
Doing a degree in the IT field	0.305***		0.108
	[0.000]		[0.127]
Doing a degree in a non-IT field	-0.250*		-0.058
	[0.043]		[0.640]
Completed degree in IT field	0.167		0.323*
	[0.300]		[0.044]
Course interactions			
Completed degree in a non-IT field	-0.162		-0.211
	[0.387]		[0.264]
Completed up to 5 activities		-1.897**	-1.884**
		[0.001]	[0.002]
Completed up to 10 activities		4.370 ***	4.359***
		[0.000]	[0.000]
Completed first and second activities within 24 hours		-0.156	-0.151
		[0.055]	[0.061]
Completed first five activities within 3 days		0.170*	0.195*
		[0.041]	[0.02]
Completed first ten activities within 1 week		1.156 ***	1.171***
		[0.000]	[0.000]
Model concordance	*0.5689*	*0.8429*	*0.8209*

Note: The table reports the coefficients and associated p-values (in brackets) from the estimated Cox models. Significance levels: * 0.05 ** 0.01 *** 0.001

The table reports the estimated coefficients and p-values from the three regressions. Focusing on the model with only demographic covariates (Column 1) first, gender, secondary education status, employment status and higher education status all have significant effects on the probability of completing the course. Negative coefficients show negative associations so female students are less likely to complete than male students; students who have completed the Advanced Level or Ordinary Level examination are less likely to complete than students who have not yet completed the Ordinary Level examination; students who are not working are more likely to complete than those who are; and students pursuing a degree in an IT field are more likely to complete than students who are not pursuing any degree whereas student pursuing degrees in non-IT fields are less likely to do so. The exponentiated coefficients in the Cox model can be interpreted as the marginal effects on the hazard rate. So, for instance, a male student has an expected probability of completing the course that is 1.13 times more than for a female student. Similarly, a student who is not working is 1.48 times more likely to complete the course than a student who is working in a non-IT company.

Column 2 presents the results with only course interaction variables, all of which are statistically significant aside from the completion of the second activity within 24 hours of the first. As expected, having completed 10 activities means that a student is much more likely to complete the whole course - specifically, they are 79 times more likely to do so than a student who has not. The speed of completing the activities also mattered. Completing the first ten activities within a week meant that a student was 3 times more likely to complete than a student who did not. However, students who work through the course fast, completing at least five activities in three days and ten in a week, are more likely to finish the course. Somewhat surprisingly, the effect of completing just five activities at the time of the activity report being generated was significantly negatively associated with overall course completion. The final column combines both sets of covariates together but most of the variables, aside from gender, retain their statistical significance and estimated sign though there are changes in the estimated magnitudes.

The last row in Table 2 presents the concordance statistics for the three models providing us with the means of making comparisons of the goodness-of-fit of the three models. The statistics show that it is the course interaction variables that have the largest impact on improving the goodness of fit, driving the concordance statistic up from 0.57 to 0.84. Including both demographic and course interaction variables has only a marginal improvement, going up to 0.86.

5. Discussion and Conclusion

This paper uses data from a MOOC on the open.uom.lk platform to study course completion and the time taken to do so using survival analysis methods, which has the advantage over standard classification models of using information on the timing of course completion and accounting for censored data to provide better estimates of the effect of covariates on the probability of course completion. Specifically, using the activity logs and registration survey for the introductory web design course in the Trainee Full Stack Developer program, we exploit both details of course interactions as well as demographic characteristics to predict the probability of completing the course within a given time frame. The results highlight student characteristics that are significantly associated with course completion while also enabling a comparison of the explanatory power of demographic vs course interaction variables.

The results suggest that the course interaction variables are more important for predicting course completion than the demographic variables. Specifically, students who have completed more than 10 activities and completed the first five or ten activities in a relatively short period of time are more likely to complete the course sooner. Interestingly, completion of only five activities is strongly negatively associated with completion overall suggesting that there may be a bottleneck in the course between the 5th and 10th activities. Further analysis making use of additional details of activity completion could be carried out to ascertain this.

These findings are consistent with the literature. Work by Brooks et al. (2015) find course interactions are more predictive of course completion than demographic characteristics in MOOCs, though demographic factors have been used to predict outcomes in traditional higher education systems. There is also evidence that students who maintain momentum during an online course are more likely to complete the course (Jiang et al. 2014; Bitkimirov and Klassen, 2008; Baugher, Varanelli and Weisbord, 2003). This implies that those at risk of dropping out could be flagged within the system and perhaps targeted with different types of interventions. However, the interventions must be carefully thought out - work by Borrella et al. (2021) suggests that while ad-hoc email reminders are not effective, interventions that make course content more approachable have a positive impact on course completion.

Among the demographic characteristics, gender is only marginally significant but educational background and employment status are significantly associated with completion. For example, students with a degree in IT are more likely to complete than students who are not following any degree. This is intuitive - these students are already motivated and have the foundation to learn the technical skills required for web development more quickly. On the other hand, students who are not employed are quicker to finish the course than those who are, particularly more so than those working outside the IT domain or are self-employed. This could be due to fewer time commitments on the part of those who are not employed. Perhaps surprisingly, students who are yet to do the Ordinary Level examination are more likely to finish the course than those with higher levels of secondary education. A potential explanation is that this group has a greater interest in the subject matter, where among the higher levels of education, there is a wider range of interest and experience in IT. The demographic characteristics identified as being associated with course completion suggest that the course is already positioned as one that is useful to those seeking to build their skills for entering into the IT industry.

The analysis presented here is subject to limitations. For instance, the class imbalance between completing and non-completing students is only partially addressed by selecting students who have completed at least the first activity. Using additional techniques to address the imbalance could improve the model further. The analysis is also constrained in terms of the available background characteristics of the participants, including their programming skills, though this may be partially captured by the variables indicating IT as the domain of higher education and employment. The analysis uses only a limited number of course interaction variables. Given the finding of their importance in predicting course completion, further work to identify bottlenecks in the course and behavioural patterns linked to faster completion of this course as well as the overall TFSD program should be carried out.

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An Innovative Course Structure to Teach Excel to Business School Students

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Abstract: Mastering Microsoft Excel is an essential skill for any business school student, whether during their studies, their internships, or their future jobs. This competency is difficult to teach as many students think they master the software when they only use a tiny part of it. In this paper, we will describe an innovative course we've created to train a large group of students in our business school. This course combines e-learning paths, online synchronous sessions, and an adapted support. Having taught this course for several years, we will first describe the first sessions of the course. After these sessions, we observed that as some students are aware of the necessity to develop their skills, some others are not involved at all in the process. Following these sessions, we introduced some evolutions we will present. These evolutions improved the course. We will describe these evolutions and present the results on students' training. Finally, we will present the future developments we plan to implement for next year.

Keywords: Hybrid, Innovative course, Excel teaching

1. Introduction

Microsoft Excel is a tool used widely in companies. Whether in scientific disciplines or in management, this software is a standard in most professional activities. With this tool, the user can organize data, make calculations, have a graphic representation of data, and have some statistical analysis. In the management field, Excel is widely used in accounting, finance, operations management, logistic or marketing for example. Whatever path a student chooses, this skill will be a strong asset for their future (Bell, 2000).

Paradoxically, most students are not formally "trained to use or design spreadsheets" (Madahar, 2011). A survey was made by this author, showing that 77% of Tuck Business School Alumni consider they have a large experience in Excel but they lack expertise. This might lead to critical errors in the decision-making process (Frownfelter-Lohrke, 2017).

In this article, we will describe a course we developed for master's students in a business school. The particularity of this course is the large cohort of students concerned. In a first part, we will describe the course as it was first developed. We will analyse the results and feedback of this first year. We will then explain how the course evolved in the following years. We will then focus on the tutoring proposed to students during the course. And in a last part, we will explain the improvements we plan to implement.

2. Design of the First Version of the Course

Our business school proposes several programs: a global BBA, a master's degree, several master's in science, MBA programs and a PhD program. In this article, we will focus on an Excel course created specifically for the master's degree program. An Excel course existed in the curriculum a few years ago. It was abandoned regarding the lack of involvement of students. But progressively, a demand of new students to have a course on this topic emerged. The particularity of this program is the large cohort of students in first year: about 1200 students. These students come from diverse backgrounds: almost half of them followed a typically french curriculum called "Classe Préparatoire" (Draelants & Darchy-Koechlin, 2011). This curriculum is an intensive two-year program that prepares students for competitive entrance exams for admission to prestigious higher education institutions in the engineering field or in business schools. The other students have studied two years in classical higher education institutions. This diversity of profiles makes it impossible to know their levels in digital tools.

The objective of the course is to give all students the skills to use Microsoft Excel in a professional manner.

For the first year, in 2021-2022, only students from "Classe Préparatoire" were following the course. 597 students were registered, and they were divided into 16 groups. We studied the literature to determine which solution will be the best for this course format. Weller (2004) identifies five models to cope with large cohort courses:

- Low support model, in which there is low or no contact with the teacher. This is mainly used with web-based training materials, in the Information Technology trainings.

- Hierarchical support model, consisting of specific teaching materials supported by part-time tutors.
- Expert plus part-time support, which is similar to large lecture hall approach. The teaching is handled by the expert and the support is provided by part-time tutors online.
- Automatic creation of personalized courses, using learning-objects automatically combined to meet the needs of each learner.
- Peer-supported community model, which relies on dialogue and support between learners.

As this classification shows, support is the main challenge for large cohort courses. Blended courses combine several of the models described by Weller. It allows to maintain support and retention in large cohorts (Nagel, 2010).

The course we describe in this article was combining, in its first version, an e-learning track and online synchronous teaching sessions. This structure was completed by the support of a teaching assistant. As stated by Nagel (2010), several studies show the importance of employing a teaching assistant to guarantee the success of large cohort classes.

The e-learning track is provided by an editor who proposes e-training programs and certifications. The Excel e-learning program is composed of three different levels. The first one is about the basics of Microsoft Excel: create a table, make simple calculations, display data, and manage worksheets. The second level refers to more complex tables, graphs, data lists and pivot tables. And the third level deepen the content by focusing on advanced functions and security. This e-learning solution was chosen for its interactive functionality. It's combining pedagogical videos with practice in a virtual environment. The feedback to students is immediate and they have the possibility to repeat the exercises as many times as needed. The e-learning solution by itself can be considered as a low support model pedagogy. But we decided to add online synchronous sessions with Professors to add some specific exercises and create dialogues with students.

We developed four sessions of three hours with specific contents to deepen the training but also to focus on management topics:

- Session 1: Introduction to Microsoft Excel, basic calculations, table formatting, data importation, data types and exportations.
- Session 2: Graphs, data visualizations and descriptive statistics.
- Session 3: Financial functions and conditions.
- Session 4: Database, sorting, filtering, solver and scenario manager.

Four Professors were involved in the teaching of these sessions, each professor teaching to four groups of students. The evaluation of the course was composed of: results to the e-learning tracks (30% of the grade), four intermediary quizzes (30% of the grade) and a final quiz (40% of the grade). A bonus point was also added to very involved students.

The following figure describes the course structure:

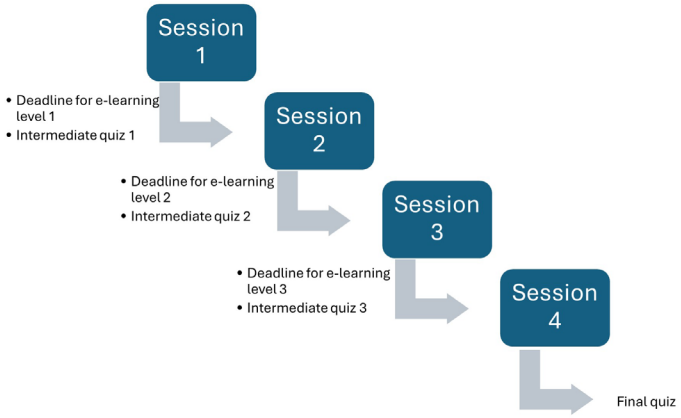

Figure 1: Initial course structure

On the 597 students registered to the course, 536 students validated the course and 57 of them had to pass a catch-up exam. 12 students didn't participate to the catch-up exam and 5 failed to pass it. You can look at the average grades for all the evaluations in the following table (grades are upon 100):

Evaluation	
E-learning Level 1	90,22
E-learning Level 2	77,80
E-learning Level 3	72,17
Intermediary Quiz 1	62,24
Intermediary Quiz 2	58,71
Intermediary Quiz 3	59,21
Final Quiz	68,79
Final Grade	69,55
Catch-up exam	49,17

Figure 2: Grades in 2021-2022

The results are very good for level 1 and decrease in level 2 and 3 of the e-learning tracks. The increasing difficulty of the levels is clearly visible in these grades. These results show that the e-learning is effective to teach students how to use Microsoft Excel. It allows "self-pace learning and remote access to large number of students" (Mio et al, 2019).

In our course, e-learning practices can be repeated as many times as needed. By practicing enough, all students should be able to have high grades in this part of the course. This is quite different for quizzes, for which students can answer just once for each question. And for this part, it appears that grades are ranging from 58 to 68 out of 100 points. These being averages, we can see that quite a lot of students had difficulties answering the questions of the quizzes.

The synchronous sessions were taught online using Zoom software. Before covid, online courses were quite rare in France (Billouard-Fuentes, 2020). Since then, it has become more frequent, but it remains challenging to create interactions and students' involvements during these courses. The four professors who taught these sessions were unanimous: few students were involved, and the most participative ones were the best ones. This lack of investment relies on the topic of the course itself. Most students know how to create tables in Microsoft Excel, this leads them to believe that they master the software. But they might create tables containing errors (Frownfelter-Lohrke, 2017). There is a huge gap between the perception students have of their knowledge in Excel and the perception faculty have (Ramachandran Rackliffe & Ragland, 2016).

This first version of the course was quite successful but was a bit deceiving for the professors involved.

3. Course Expansion and Adaptation

For the first year, the course was taught only to students coming from "Classe préparatoire". The second year, the program decided to display the course to all first-year students. The number of students was then 1.120, making necessary an evolution of the course.

The four professors involved the first year all agreed that the synchronous sessions were not very useful. The students who needed them were not involved and the students involved already had a good mastery of Microsoft Excel. The synchronous sessions facilitated interaction, but they did not create an affective learning climate, as only good students were feeling well enough to participate. As stated by Boelens et al. (2017), this climate is one of the key challenges in an online environment.

For the second year, we decided to focus the course on the e-learning tracks and to reinforce the tutoring. The grade was then composed of two parts: the e-learning tracks and a final quiz. Both were counting for 50% of the final grade. The average final grade was 86,67 upon 100, when it was 69,55 the precedent year. This might suggest that it was easier for students to validate with this new format. But if we look at the grades in detail, the explanation is quite different.

Evaluation	2021-2022	2022-2023
E-learning Level 1	90.22	98.05
E-learning Level 2	77.80	95.24
E-learning Level 3	72.17	93.84
Final Quiz	68.79	77.67
Final Grade	69.55	86.67

Figure 3: Comparison of the grades between year 2021/2022 and year 2022/2023

As you can see in this table, the average grades in the e-learning tracks have increased significantly for all levels. The most impressive is the level 3 for which the average grades were 72,17 in 2021/2022 and rise to 93,84 in 2022/2023. As we said before, students can retake the e-learning exercises as many times as needed to validate them. By increasing the weight of the e-learning tracks in the final grade, students were more involved than the precedent year. This can be seen also in the results of the final quiz, for which the average grade increased from 68,79 to 77,67 upon 100 points.

This new format appeared to be quite efficient as students were more involved in the e-learning tracks. But the pedagogical team identified a new behavior in students: some students decided to stop working in the e-learning when they considered that the validation of the course would be guaranteed even if they have a bad grade at the final quiz. Thus, 3 students validated only the first level of the e-learning and 21 students validated the two first levels and didn't work on the third one! Two of these students didn't pass the final quiz. But for the others, they got very good results with an average of 77,67 to the final quiz. Those students decided to focus on the grade, but they miss all the content of the level 3 of the e-learning. This is a shame, especially because these students have a good level in Excel and could have improved further.

After this second year, the pedagogical team was satisfied of the results, especially with the increase in the size of the cohort. But it was a little disappointing to see that some students had not taken full advantage of this opportunity to improve their skills.

That's the reason why, for the third edition of the course, they decided to change the rules. The content of the course and the evaluation scheme remained the same, but they added a new constraint. To be authorized to access the final quiz, students must have obtained at least 75% to all the three levels of the e-learning tracks. This instruction was given at the beginning of the course and repeated several times during the course.

For this third year, 1.176 student followed the course. 37 didn't validate it. Amongst those students, 29 of them were not authorized to pass the final quiz. You will find the comparison of the grades for the three first cohorts of this course:

Evaluation	2021-2022	2022-2023	2023-2024
E-learning Level 1	90.22	98.05	98.53
E-learning Level 2	77.80	95.24	96.74
E-learning Level 3	72.17	93.84	96.01
Final Quiz	68.79	77.67	69.62
Final Grade	69.55	86.67	83.34

Figure 4: Comparison of the grades for the three cohorts

As you can see in this table, the results are quite similar for the e-learning tracks between year 2022/2023 and 2023/2024. This new format is functioning well and the new restriction for passing the final quiz was effective. The decrease of the average grade for the final quiz can be explained by the fact that some students were not allowed to take the quiz and had a grade of 0.

This analysis is confirmed by the standard deviation of these grades. The following table shows the standard deviation for the three cohorts:

Standard deviation	2021-2022	2022-2023	2023-2024
E-learning Level 1	24.99	11.27	8.21
E-learning Level 2	32.43	13.94	10.42
E-learning Level 3	38.28	19.72	12.16
Final Quiz	16.95	15.94	17.65
Final Grade	16.96	11.98	12.02

Figure 5: Standard deviation for the three cohorts

As this table shows, the standard deviation for the e-learning levels is decreasing year after year. This reflects the fact that grades close to 0 and under 75 upon 100 gradually disappear. The new version of the course allows a greater involvement of students and above all reduces the number of students not getting involved at all. This can be visualized in histograms. We present here only the third level of the e-learning track, but the same conclusion can be seen for the other levels.

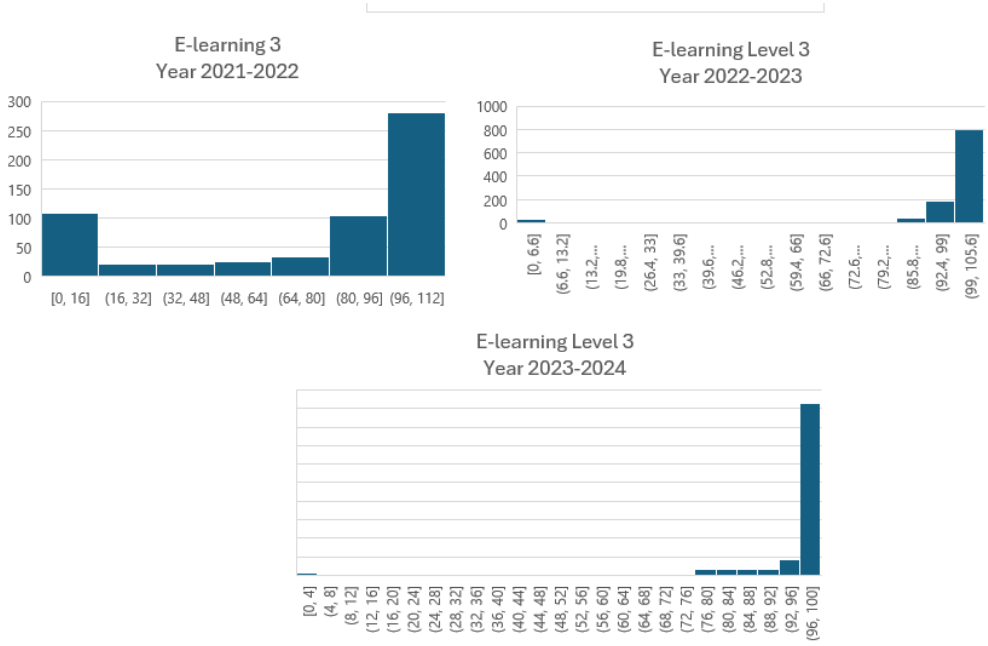

Figure 6: Histograms for e-learning level 3

4. Students' Tutoring

In this part, we will focus on the current version of the course. The course is mainly composed of an e-learning content. But students need to be supported to succeed.

Since the second session, the course is managed by one professor, and one tutor. At the beginning of the course, an introducing video is recorded by those two people to explain the rules, the e-learning's tracks, and the evaluations. This video is displayed on the LMS of the school and should be watched by every student. In this video, the professor also explained how students should behave if they have questions. With a large cohort like this one, many students ask the same questions or have the same issues. The team decided to use the forum tool of the LMS to centralize the questions and answers. The procedure to follow for students is: first, to look at the forum to check if the question was already answered. If not, the student was supposed to write to the tutor, who was responsible for answering the question and adding it in the forum. This worked for most of the students. But the professor and the tutor still received many emails. Some of them were related to the content of the e-learning course, but quite a lot of them were related to technical issues. It was surprising to see that many students don't have a good knowledge of the functioning of their own computer. Another surprising element was the fact that students were writing either to the tutor, to the professor or to both. It was clearly indicated that they were supposed to contact the tutor first. Tutoring is a crucial pilar to guarantee the success of an online course (Noam, 1995). But in the French context, it appears that students are not familiar with this new role. Tutoring (or mentoring) is a very good solution to create and maintain interactions during online courses (Glazier, 2021). As professors have many responsibilities and courses, tutors have more time to create interactions during e-learning paths. In our Excel course, we also decided to have some office hours for students. Two sessions of office hours were proposed each week during the course: one face-to-face, and one by videoconferencing. It appeared that this option was not widely used by students although it would have made it possible to create interactions and an affective climate. But some students might be afraid to contact tutors (Klimova & Poulova, 2011).

Several options can be used to communicate with large cohorts of students. In our course, we decided to use forums, but other solutions as blogs can also be used (Farmer and al, 2008). Forums were used successfully in other contexts (Power, 2014). But in our case, most questions were too specific to feed the forum. Some students have technical issues, and it needed several emails or a discussion with the tutor to solve the issue. Students frequently wrote emails during the weekends. They were benefiting from being at their parents' home, with a good internet connection, to work on the e-learning tracks. The tutor and the professor were not always available to answer questions during weekends. This was not good for students' motivation.

5. Future Evolutions

During the three first sessions, we collected many questions and solved several technical issues. Relying on this knowledge, we decided to develop a new tool for the next session: a chatbot.

A chatbot is "a conversational agent that interacts with users using natural language" (Abu Shawar & Atwell, 2015). Chatbots are becoming more and more common in higher education, either for teaching purposes or for service purposes. In both cases, they improve efficiency and timeliness in answering students' questions (Abbas et al, 2022). In the Excel course, we decided to create a chatbot to answer generic questions, and to give students the opportunity to send an email if the chatbot is not able to answer them correctly. Atmosukarto et al (2021) developed a chatbot for a chemistry course. In their study, they collected quantitative feedback on a Beta Testing version of the chatbot. Most feedback were positive, as the chatbot was clearly answering questions, was easily accessible and some of them also indicated that they were less shy to ask questions to a chatbot than to a human tutor. The authors identified some limitations: sometimes the answers are not clear enough for students, some content is missing and sometimes the chatbot was unable to understand the question of the student. These limitations are very important for us as we will try to avoid them when creating the chatbot for our course.

We will use the chatbot component of Powerapps to create the chatbot. Powerapps is a low-code platform proposed by Microsoft. This tool is available in our school and the chatbot can be implemented in Teams to give an easy access to students. We plan to implement it for the next session in September 2024.

6. Conclusion

Teaching to large cohorts of students is challenging. In this article, we describe a course created to teach Microsoft Excel to master's degree students. Starting with a cohort of almost 600 students, the pedagogical team is now managing cohorts of almost 1.200 students. For the first session, the team used a blended approach combining e-learning tracks and online synchronous sessions. At the end of this session, it appeared that the synchronous sessions were not useful as only the best students were participating.

For the two next sessions, we focused the course on the e-learning tracks and students were more involved in it. The succession rates rise but the communication with students was not optimal as they sent email either to the professor or the tutor.

For next session, we decided to develop a chatbot to answer more effectively to students' questions. This should improve the responsiveness and efficiency of answers.

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Predictive Modeling for Enhancing MOOC Completion Rates: A Case Study

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Abstract: In the realm of online asynchronous learning platforms, accurately tracking student performance to predict course completion times poses a significant challenge. Completion rates for MOOCs are typically low, with a bias towards participants with higher education levels. Understanding factors such as student motivation, engagement, participation, and learning pathway design is crucial for improving student outcomes in online courses. This research developed a predictive framework utilizing advanced deep learning techniques to accurately forecast course completion times for participants enrolled in an introductory programming course ("Python for Beginners" course on the Open Learning Platform of University of Moratuwa Sri Lanka). By accurately tracking student performance and leveraging a diverse dataset encompassing demographic and educational variables, the research seeks to identify factors influencing course completion and predict individual student outcomes. By utilising deep learning techniques, the prediction performance of the model will be improved, ultimately contributing to a more precise forecast of course completion times for participants. Evaluation of the model resulted in low Mean Absolute Error (MAE) of 0.0080 and low Mean Squared Error (MSE) of 0.0033 which promises the effectiveness of the developed method in accurately predicting course completion times for students. The findings of this study may help increase the successful completion rate of such courses which are delivered in the online asynchronous mode. The study employed advanced deep learning models optimized through Bayesian methods, highlighting the potential of these techniques to enhance MOOC completion rates by offering precise forecasts and actionable insights into student engagement. The comprehensive analysis revealed that variables such as 'Current_Lesson', 'Session Time Category', and 'District_Score' significantly influence completion times. The robust methodological framework, including feature engineering, model training, and hyperparameter optimization, sets a precedent for future research in the field. This research contributes to educational data mining and predictive analytics, offering a scalable approach to improving completion rates and educational outcomes across various online learning platforms. Future research should explore incorporating real-time data and longitudinal studies to enhance model accuracy and generalizability. Additionally, addressing potential biases in the dataset, such as demographic, prior knowledge, and resource access disparities, is essential to ensure the fair and equitable application of the model across diverse student populations. Expanding the research to include a wider range of courses and institutions will further validate the model's robustness and applicability in different educational contexts.

Keywords: Online asynchronous learning, Predictive models, Course completion time, MOOC analytics, Deep learning in education, Educational data mining

1. Introduction

Massive Open Online Courses (MOOCs) have revolutionized education by providing accessible learning opportunities to a global audience. However, one of the most significant challenges these platforms face is the low completion rate, which undermines their potential impact. Understanding and predicting student performance, particularly course completion times, is essential for developing strategies to enhance student engagement and success (Jordan, 2014; Hew & Cheung, 2014).

Predicting course completion times in MOOCs is crucial due to historically low completion rates among students with diverse educational backgrounds (Jordan, 2014; Hew & Cheung, 2014). Accurate predictions can enhance course design and delivery, benefiting both students and educational institutions by providing targeted interventions to improve learning outcomes. Previous studies have highlighted various factors influencing student performance in MOOCs. Research by Jordan (2014) and Hew & Cheung (2014) emphasizes the diversity in educational backgrounds as a critical factor affecting completion rates. Additionally, Kizilcec, Piech, and Schneider (2013) and Lee, Choi, and Kim (2013) have explored the impact of student motivation, engagement levels, and participation rates on learning outcomes.

While these studies provide valuable insights, there remains a need for predictive models that can accurately forecast course completion times and identify key influencing factors. This study aims to address the research question: Can a predictive model accurately forecast the time required for students to complete an introductory programming course, 'Python for Beginners,' at the University of Moratuwa in Sri Lanka?

The primary objective of this research is to develop a robust predictive model utilizing a comprehensive dataset that includes demographic and educational factors. By employing advanced deep learning techniques and Bayesian optimization, the study seeks to achieve high accuracy in predictions.

This research highlights the critical role of predictive modeling in education, particularly for MOOCs. By leveraging advanced deep learning techniques, the study provides actionable insights that can enhance student success and retention in online learning environments. The comprehensive analysis, which includes feature engineering, model training, and hyperparameter optimization, sets a precedent for future research in the field. This research contributes to educational data mining and predictive analytics, offering a scalable approach to improving completion rates and educational outcomes across various online learning platforms.

2. Methodology

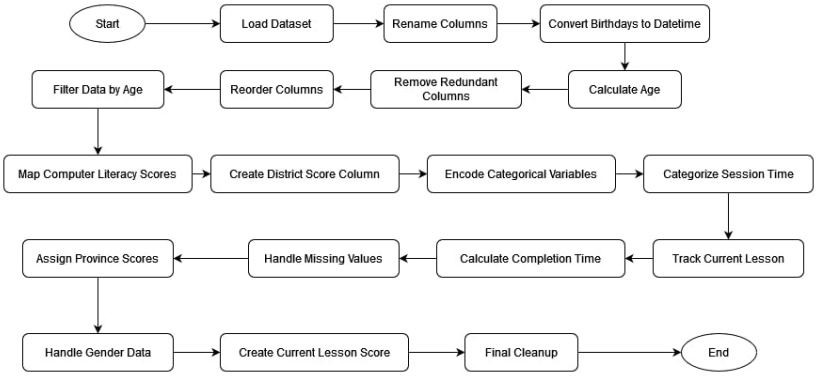

Figure 1: Data Preprocessing Steps

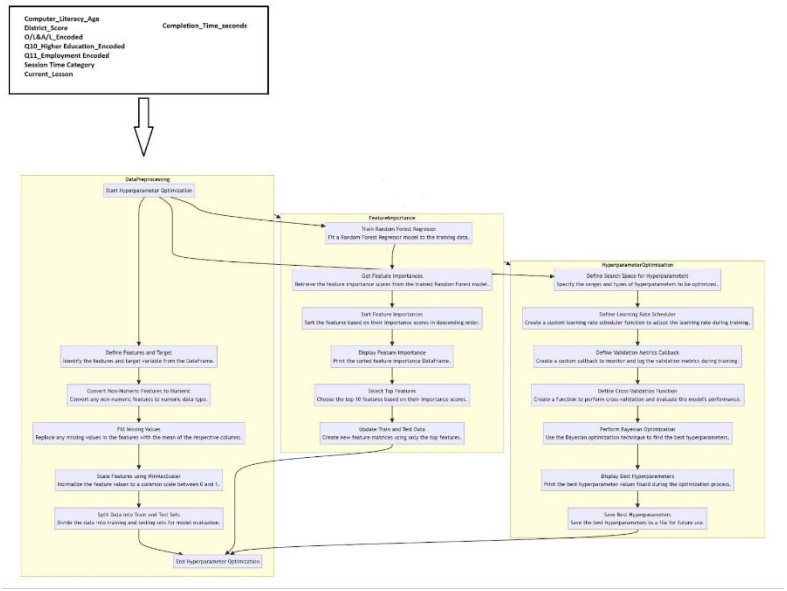

Figure 2: Model Architecture

The architecture for predicting MOOC completion times begins with data preprocessing, where key features such as 'Computer_Literacy_Age', 'District_Score', 'O/L&A/L_Encoded', 'Q10_Higher Education_Encoded', 'Q11_Employment Encoded', 'Session Time Category', and 'Current_Lesson' are identified, conversion of non-numeric data, filling missing values, normalization, and data splitting. A Random Forest Regressor determines feature importance, selecting the most significant features. Hyperparameter optimization is performed using Bayesian methods, incorporating custom learning rate schedulers and validation metrics. The best hyperparameters are saved for future use. This approach ensures high predictive accuracy and provides insights into factors influencing course completion times.

2.1 Participants

The dataset comprised 16,215 records sourced from a CSV file provided by the course Learning Management System (LMS). It included personal and educational information such as age, gender, district, and various columns representing exercises and assignments.

2.2 Data Preprocessing

2.2.1 Loading the dataset

The dataset was loaded from a CSV file and included columns such as Response, Submitted on, Institution, Department, ID, Full name, Username, Q05_Birthday, Q06_Gender, Q07_District of Permanent Residence, and various exercise and assignment columns.

2.2.2 Feature engineering

In this study, several steps were undertaken to preprocess and engineer features from the dataset.Firstly, the 'Q05_Birthday' column was renamed to 'BirthDay' for clarity and consistency. The 'BirthDay' column was then converted to a datetime format using the pd.to_datetime() function to ensure uniformity in date representation. Invalid dates were filtered out during this conversion to maintain data integrity. The age of each student was subsequently calculated by subtracting the birth date from the current date using pandas datetime functionality, resulting in a new column 'Age'. Age is a crucial demographic factor that can influence learning outcomes and engagement.

After extracting the age information, the 'Q05_Birthday' column was removed to streamline the dataset. The columns were reordered to enhance readability and facilitate easier interpretation of critical data points. Removing redundant columns helps in reducing the complexity of the dataset and improves processing efficiency.

To focus on the primary audience of the course, data filtering was applied to include students aged between 10 to 60 years. Outliers in the 'Age' column were identified using z-scores and were either removed or replaced with the median age to maintain data integrity and reliability. This age filtering ensures the dataset remains relevant to the target population while handling outliers effectively.

Computer literacy scores were mapped to predefined age groups using data from the "Computer Literacy Statistics 2022 from Department of Census and Statistics in Sri Lanka" report. These scores were normalized using Min-Max scaling to ensure consistency across age groups. Computer literacy is a significant factor affecting course engagement and completion in an online learning environment. Additionally, a "District_Score" column was introduced by associating each district with its corresponding province and literacy scores from the same report. Understanding regional disparities in computer literacy helps in analyzing the influence of socio-economic factors on course completion.

Categorical columns such as 'O/L&A/L', 'Higher Education', and 'Employment' were label encoded using scikit-learn's LabelEncoder to convert them into a numerical format essential for model training. Converting categorical data into numerical format is critical as deep learning algorithms require numerical input.

A new column, "Session Time Category", was created to categorize assignment submission times into Morning (6 AM - 12 PM), Afternoon (12 PM - 6 PM), or Evening (6 PM - 12 AM). The time of day can influence student performance and engagement, making it an important variable for analysis. Another column, "Current_Lesson", was introduced to track the specific question each student was currently working on by analyzing the completion status of exercises. Tracking current progress helps in understanding the engagement level and identifying potential drop-off points.

Finally, a "Completion_Time_seconds" column was added to calculate the total course completion time by analyzing timestamps of question submissions using pandas timedelta functionality. Completion time is the primary target variable for the predictive model, making its accurate calculation crucial.

2.3 Model Training and Hyperparameter Optimization

2.3.1 Feature and target definition

The features used in the model included 'Computer_Literacy_Age', 'District_Score', 'O/L&A/L_Encoded', 'Q10 Higher Education_Encoded', 'Q11 Employment Encoded', 'Session Time Category', and 'Current_Lesson'. The target variable was 'Completion_Time_seconds', which represents the total time taken to complete the course.

2.3.2 Data preprocessing for deep learning

Converted non-numeric features to numeric using label encoding and one-hot encoding as necessary. Imputed missing values using median or domain-specific methods to ensure the dataset was complete and ready for model training. Split dataset into training (80%) and test (20%) sets using train_test_split from scikit-learn to ensure that the model was evaluated on unseen data, providing a reliable measure of its performance. Performed feature scaling using MinMaxScaler to normalize features and target values, preventing features with larger scales from dominating the model training process.

2.3.3 Model selection and training

Chosen for its robustness, ability to handle non-linear relationships, and feature importance evaluation, a Random Forest Regressor was trained on the training set with hyperparameters fine-tuned using cross-validation. The rationale for using Random Forest is its effectiveness in handling high-dimensional data and capturing complex interactions between features. For hyperparameter optimization, Bayesian optimization was employed using the bayes_opt library, defining the search space, implementing a learning rate scheduler, and creating custom callbacks for logging validation metrics during training. Bayesian optimization is more efficient than grid search or random search as it requires fewer evaluations to find optimal hyperparameters (Snoek et al., 2012). Neural Network Training involved defining a neural network model using TensorFlow, incorporating dense blocks with residual connections to enhance information flow and gradient propagation. Cross-validation was carried out to evaluate model generalizability, and Bayesian optimization was used to fine-tune hyperparameters, iteratively exploring configurations to identify the optimal set for maximum performance. The best model and hyperparameters were saved for future deployment. Neural networks, particularly with advanced architectures like dense blocks and residual connections, are powerful in capturing non-linear patterns and improving prediction accuracy (He et al., 2016).

3. Results

3.1 Before the Analysis

The dataset was collected from an online learning platform over six months, including student demographics, course interactions, and completion status. Initially, 16,215 participants enrolled in the course, but 618 participants dropped out and were excluded from the final analysis. Key steps in data cleaning included parsing dates to calculate age, and removing outliers (ages below 10 or above 60). Feature engineering involved creating new features like 'Session Start Category' to capture temporal aspects of student activities.

3.2 These Steps Ensured Data Consistency and Relevance for the Subsequent Analysis

A Random Forest Regressor was initially trained to determine feature importance. The selected features included 'Computer_Literacy_Age', 'District_Score', 'O/L&A/L_Encoded', 'Q10_Higher Education_Encoded', 'Q11_Employment Encoded', 'Session Time Category', and 'Current_Lesson'. Bayesian Optimization was employed to optimize the deep learning model's hyperparameters, such as learning rate, dropout rate, and the number of hidden units. This process aimed to minimize the Mean Absolute Error (MAE) using cross-validation. The model's performance was evaluated using MAE and MSE metrics over ten epochs of training and validation.

3.3 Results

Model Performance: The deep learning model achieved a Mean Absolute Error (MAE) of approximately 0.0087 on the validation set. The Mean Squared Error (MSE) was observed to be around 0.0035, indicating the model's accuracy in predicting course completion times. Validation metrics were monitored using custom callbacks during the training process, providing insights into the model's performance at each epoch. The final MAE and MSE scores on the test data were 0.0080 and 0.0034, respectively. The model's performance was verified for overfitting: Training MAE 0.0080, Training MSE 0.0033, Test MAE 0.0080, and Test MSE 0.0034.

Table 1: Model Performance for Training and Testing Data

Training MAE	0.0080
Training MSE	0.0033
Test MAE	0.0080
Test MSE	0.0034

We noticed that there are close values between training and test metrics.

Feature Importance: The Random Forest Regressor identified 'Current_Lesson', 'Session Time Category', and 'District_Score' as the most important features for predicting course completion time. Heatmap and the feature importance graph for this is included below.

Feature Correlation Heatmap: Displays correlations between features. Notable correlations: 'Q10_Higher Education_Encoded' and 'O/L&A/L_Encoded' (0.41), 'Q11_Employment Encoded' and 'Computer_Literacy_Age' (-0.37). Most features show low correlation with 'Completion_Time_seconds'.

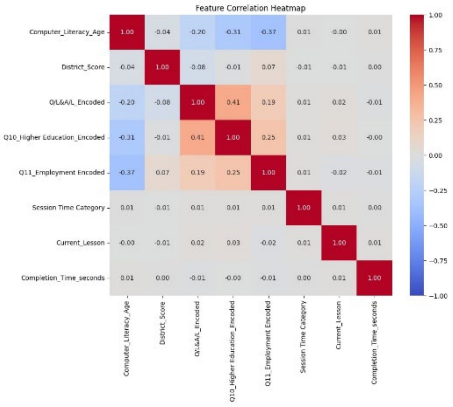

Figure 3: Feature Correlation Heatmap

While the deep learning model developed in this study demonstrates high predictive accuracy, improving its interpretability is crucial for making it more transparent and actionable for educators and course designers. I applied SHAP (Shapley Additive Explanations) values to analyze and rank the importance of various features, which significantly influence completion time predictions. The feature importance bar chart (Figure 1) illustrates the contribution of each feature to the model's output, providing clear insights into how these factors impact predictions. This visual representation enables educators to identify key areas for intervention, fostering trust and enabling data-driven decisions to improve student engagement and success.

Feature Importance Bar Chart: Highlights key features in predicting course completion times. Most important features: 'District_Score', 'Current_Lesson', and 'Session Time Category'. 'Q10_Higher Education_Encoded' is the least important but still contributes.

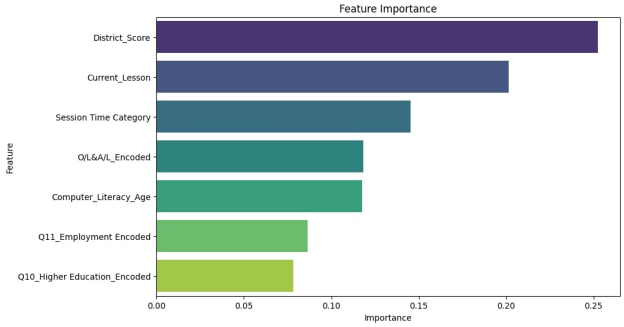

Figure 4: Feature Importance Bar Chart

Visualization involved various plots that visualized the distribution of completion times and dropout rates across different questions. A line plot highlighted key points where student engagement dropped.

Distribution of Age: This histogram shows the age distribution of participants in the "Python for Beginners" course. Most participants are between 15 and 25 years old, with a peak around 20 years. The frequency drops significantly for ages above 30.

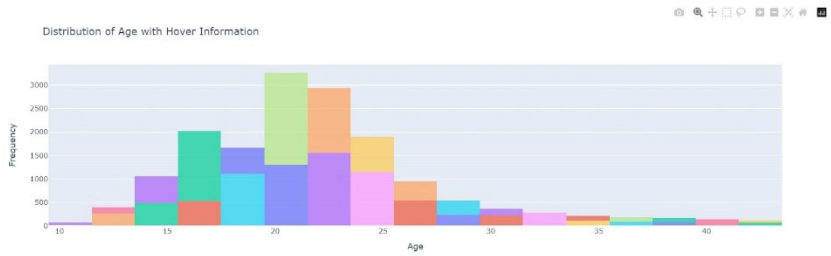

Figure 5: Distribution of Age

Distribution of Current Questions: This bar chart depicts the distribution of questions participants are currently on. The majority are at the beginning of the course, with a sharp decline in participation as the course progresses.

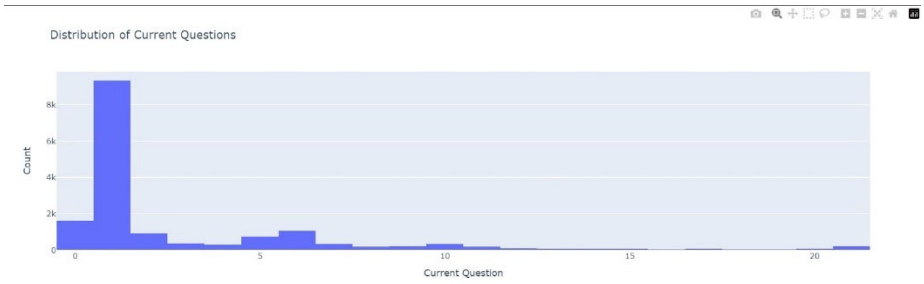

Figure 6: Distribution of Current Questions

Dropout Rate Compared to Previous Question: The line graph illustrates the dropout rate at each question compared to the previous one. Notable spikes in dropout rates occur at questions 3 and 7, indicating points where participants tend to disengage from the course.

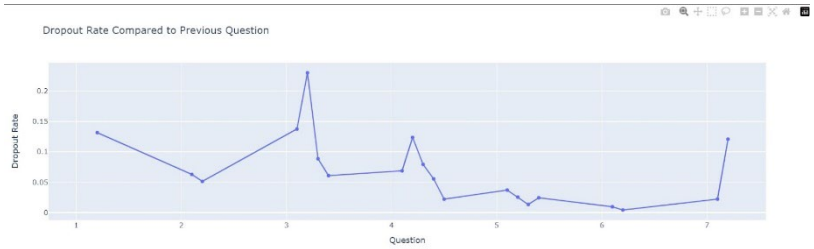

Figure 7: Dropout Rate Compared to Previous Question

Distribution of Question Scores: This histogram shows the distribution of scores for current lesson questions. Most scores cluster around 0.1, indicating that many participants score similarly on these questions, with fewer participants achieving higher or lower scores.

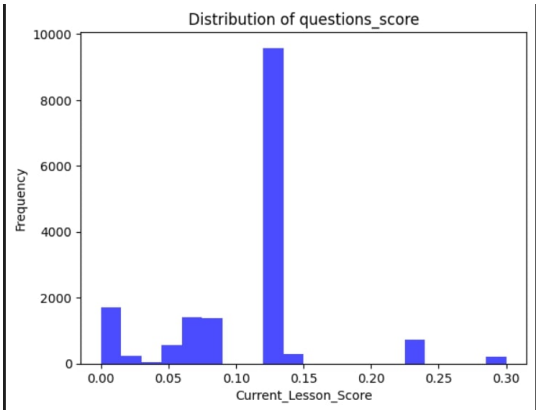

Figure 8: Distribution of Question Scores

Distribution of Completion Time (seconds): This histogram shows the distribution of completion times in seconds for the course. Most participants complete the course in a relatively short time, with a few outliers taking significantly longer.

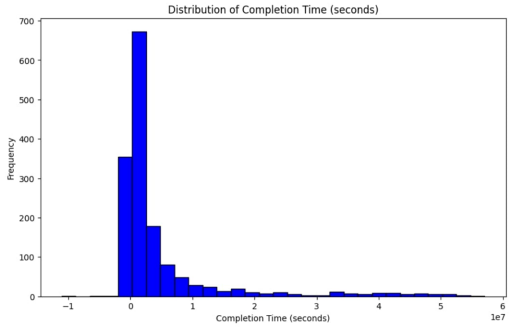

Figure 9: Distribution of Completion Time (seconds)

Distribution of Completion Time (seconds) - Values > 0: This histogram, focusing on completion times greater than zero, reveals a similar trend where the majority of participants complete the course quickly, with a long tail of participants taking longer.

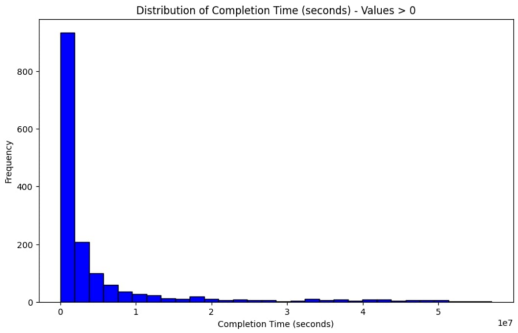

Figure 10: Distribution of Completion Time (seconds) - Values > 0

Best Hyperparameters: The optimization process identified the following best hyperparameters for the deep learning model:

Table 2: Best Hyperparameters for the Predictive Model

Learning rate	0.005708735304309941
Dropout rate	0.30833370401032956
Hidden units 1	126
Hidden units 2	118
Hidden units 3	112
Hidden units 4	99
Optimizer	rmsprop

By leveraging advanced deep learning techniques and robust feature selection, the model provides valuable insights into factors influencing student performance in MOOCs.

4. Discussion

4.1 Summary

The primary goal of this study was to develop a predictive framework to forecast the time it takes for students to complete the "Python for Beginners" course at the University of Moratuwa in Sri Lanka. By employing advanced deep learning techniques, particularly a Random Forest Regressor for feature selection and a deep learning model optimized through Bayesian methods, the study achieved high predictive accuracy. The model's performance, indicated by low Mean Absolute Error (MAE) and Mean Squared Error (MSE) values, underscores its potential in predicting course completion times. These results have significant implications for the design and

delivery of Massive Open Online Courses (MOOCs), offering insights into enhancing the learning experience and outcomes for students in online educational settings.

4.2 Interpretation

The analysis identified several critical factors impacting course completion times. The most influential features were 'Current_Lesson', 'Session Time Category', and 'District_Score'. These findings underscore the importance of student engagement and educational background in shaping course outcomes. For instance, students actively engaged in their current lessons and those who participate in specific session time categories tend to complete courses faster. The influence of 'District_Score' suggests that socio-economic background plays a crucial role in educational success, aligning with established literature by Kizilcec, Piech, & Schneider (2013).

The optimized deep learning model, which included hyperparameters such as a learning rate of 0.001 and a dropout rate of 0.3, demonstrated robust performance. The practical applications of these findings are substantial. Educational institutions can leverage such predictive models to identify at-risk students early and implement targeted interventions. By understanding the key factors influencing student performance, educators can tailor course structures and support systems to enhance completion rates. This approach aligns with the broader goal of improving the quality and accessibility of online education, particularly in asynchronous learning environments.

4.3 Integration

The findings of this study contribute to the existing body of knowledge in predictive analytics within educational settings. Previous research has highlighted the role of engagement, motivation, and socio-economic factors in student performance (Jordan, 2014; Hew & Cheung, 2014; Kizilcec, Piech, & Schneider, 2013). This study extends these insights by providing a robust predictive model that accurately forecasts course completion times. It integrates well with the existing literature, offering a practical application of deep learning techniques to address real-world challenges in MOOCs.

4.4 Implications

The implications of this research are extensive and transformative for educational practices. Predictive models enable educational institutions to proactively address student engagement and retention issues by designing effective, personalized interventions, thus improving course completion rates. For instance, early identification of at-risk students allows for timely support and resources, enhancing their chances of success. This research aligns with the strategic objectives of online learning institutions to provide high-quality educational experiences to a diverse student population. Moreover, the study's methodology and findings can be adapted to various courses and educational contexts, offering a robust framework for broader applications in predictive analytics. Educators and platform developers can use these insights to refine course content, optimize student support systems, and foster more engaging learning environments.

4.5 Limitations

Despite the positive outcomes, this study encountered several challenges and limitations. The variability in student engagement and performance data introduced noise, potentially affecting model accuracy. Future research should explore advanced data normalization and feature engineering methods to mitigate these effects.

Additionally, the reliance on historical data may not fully capture the intricate nuances of student behavior and engagement, potentially overlooking dynamic changes, contextual influences, and the evolving nature of student interactions. Real-time data and longitudinal studies could provide a more nuanced understanding of student engagement and enhance the model's predictive accuracy.

Moreover, the dataset may contain biases related to demographics, prior knowledge, or resource access, which could affect the model's performance and fairness. Addressing these biases through careful data collection and analysis is crucial to ensure the model's equitable application.

The study's collection and analysis of student data raise ethical concerns about privacy and consent. Future research should prioritize obtaining informed consent from participants and ensuring the responsible and ethical use of educational data.

Lastly, this research focused on a Python for beginners course at the University of Moratuwa. To improve generalizability, future research should consider adapting this model to various student demographics and

different courses at multiple institutions. Including a wider range of courses and institutions in the analysis would enhance the model's applicability and robustness.

5. Conclusion and Future Directions

5.1 Conclusion

This study has demonstrated the potential of using deep learning and predictive modeling to forecast course completion times in MOOCs. The findings offer valuable insights for shaping the structure and delivery of online courses, leading to improved student participation and achievement. By integrating predictive analytics into educational strategies, there is a promising outlook for the advancement of online learning, paving the way for more personalized and efficient educational opportunities.

5.2 Future Directions

Future research should aim to broaden the dataset to include a wider range of courses and institutions, enhancing the model's generalizability. Integrating additional factors such as student motivation, learning styles, and external influences like internet access and socio-economic status could further improve the model's predictive accuracy. Incorporating real-time analytics and adaptive learning technologies can provide personalized learning experiences, leading to better student outcomes. Beyond predicting course completion, predictive modeling can forecast dropout rates, identify effective learning pathways, and customize content delivery to enrich learning experiences. Continuous refinement of these models and incorporation of new data will enable educational institutions to better meet their students' needs and achieve higher educational success.

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Tailoring Entrepreneurial Education: Demand-Driven Insights for an Entrepreneurial Online Mentoring Program

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Abstract: The 2023 European Innovation Scoreboard reveals that there is an innovation asymmetry between different European Union (EU) regions, which is leading to an innovation gap. In particular, southern and eastern EU countries showcase a lower level of innovation compared to their northern and western counterparts. To tackle this issue, the ENTRPRENEDU project, funded by the European Union, endeavors to bridge the innovation and educational divide across EU regions through a scalable "Venture Building Program". At its core lies the precisely crafted ENTREPRENEDU mentoring program, which aims to nurture 12, through hackathons selected, teams from the emerging to moderate-innovation countries Italy, Greece, and Bulgaria. This paper presents the methodological framework, execution, and results of the demand analysis underpinning the development of the ENTRPRENEDU online mentoring program. Employing a qualitative research design for the demand analysis, semi-structured interviews were conducted to delve into the nuanced needs and experiences of the participating teams. These hour-long sessions followed a pre-defined guideline and aimed to determine the specific entrepreneurial needs of the participating teams. For the analysis of interview data, a thematic approach was utilized revealing clusters of predominant demands among the teams, serving as the cornerstone for deriving six overarching mentoring modules. These modules were tailored to address the identified demands and laid the foundation for the program's curriculum development. Each mentoring module was crafted to align with the specific learning objectives of the teams, ensuring targeted guidance tailored to their unique journey. This paper highlights the symbiotic relationship between the identified demands of the teams and the structured mentoring curriculum, underscoring its significance in providing tailored support conducive to their success. The findings not only contribute to the academic discourse on mentoring program development but also hold practical implications for policymakers, educators, and entrepreneurs striving to foster innovation and entrepreneurship in their respective contexts.

Keywords: Innovation, Entrepreneurship, Mentoring, Curriculum, Demand analysis

1. Introduction

The European Union (2023) notes, in the European Innovation Scoreboard (EIS), that despite significant progress, there is still a critical need to close the innovation gap between European countries and regions. Specifically, southern and eastern European countries show lower levels of innovation activity compared to their western and northern counterparts. Closing the innovation gap requires urgent development of educational programs and support mechanisms to nurture young talent and drive teams' growth. However, challenges like knowledge gaps, limited human resources, financial constraints, and effective use of information technologies continue to pose obstacles in the low innovation regions in the European Union (European Union, 2023). The ENTREPRENEDU project aims to address these challenges through the creation of a versatile, scalable educational model empowering young European entrepreneurs in navigating financial and market challenges. The project aims to equip individuals with the resources and knowledge for market success by aligning their needs with potential investors, offering technology transfer, networking, mentoring, and funding opportunities. The overarching goal of ENTREPRENEDU is to establish a "Venture Building Program" that fosters knowledge sharing, capacity building, and strengthens European entrepreneurial ecosystems while reducing the innovation and educational gap in the EU. The project consists of a consortium of eight European partners which are namely: Fondazione E. Amaldi (FEA), Fraunhofer IPK, the European Business Angel Network (EBAN), Corallia, Cleantech Bulgaria (CTBG), F6S Network Limited, Luiss university and the university of Thessaly.

In the initial phase, the project focused on identifying the needs of educational and business ecosystems that can benefit from ENTREPRENEDU's services. In the second phase, these needs were transformed into concrete challenges that are of high importance for the EU. These challenges form the basis for ENTREPRENEDU's three hackathons, where individuals aged 18 to 40 and teams participated, generating business ideas addressing one of the challenges which are namely: The deep tech industry and sustainability. During the third phase, a focus lied on providing support to 12 teams chosen from the ENTREPRENEDU hackathons. These took place in the moderate innovation countries Italy, Greece and in the emerging innovation country Bulgaria. At each hackathon the four most promising teams have been selected and take part in the ENTREPRENEDU online mentoring program. The four selected teams at each hackathon formed a cohort leading to the assembly of three cohorts

in total. Over a duration of six months, these teams received up to 60 hours of online mentoring, totalling 720 hours, through a combination of video sessions and coaching workshops from six of the consortium members. The first hackathon took place in Rimini, Italy from the 15th to 17th of June. The participating teams pitched their solution addressing the previously established main challenges in the European Union. The names of the four winning teams of the first Hackathon are As You Like, Backwards, BOBIS and Shades of Blue. The ENTREPRENEDU online mentoring program is structured to the needs of the winning teams. Thus, a demand analysis was conducted with the four winners of the first hackathon in Rimini, Italy.

2. The Importance of Entrepreneurial Mentoring

Entrepreneurial mentoring plays a pivotal role in the growth and success of new ventures, particularly in environments where innovation is emerging or moderate. The literature on mentoring highlights its importance in skill development, network expansion, and overcoming challenges specific to entrepreneurs. Kubberød et al. (2018) underscore that effective mentoring fosters the development of essential entrepreneurial skills, expands professional networks, and stimulates innovation and growth. Moreover, mentoring can reduce the sense of isolation that many entrepreneurs experience by offering a supportive network to navigate entrepreneurial challenges (Jabeen et al., 2017).

2.1 The Role of Demand Analysis in Shaping Mentoring Programs

A demand analysis serves as a critical tool in customizing mentoring programs to meet the specific needs of entrepreneurs. This process involves identifying the particular types of support that entrepreneurs seek and the resources necessary to fulfil these requirements effectively. Research by St-Jean and Mathieu (2015) emphasizes that a demand-driven approach ensures that mentoring is relevant and impactful, particularly when addressing the diverse needs of entrepreneurial populations. For instance, Baluku et al. (2020) highlight how tailored mentoring programs, designed based on demand analysis, can address the unique challenges faced by different segments, such as women, minorities, and entrepreneurs in various sectors.

Despite the extensive recognition of demand analysis in shaping entrepreneurial mentoring, there is a gap in applying these insights to regions with varying levels of innovation, such as those within the European Union. The majority of existing studies focus on general entrepreneurial contexts without considering the regional disparities in innovation capacities. This paper addresses this gap by conducting a demand analysis for entrepreneurs from emerging and moderate-innovation regions within the EU, thereby contributing to a more nuanced understanding of how mentoring can be customized to different regional contexts.

2.2 Mentoring in the Context of Regional Innovation Disparities

Studies such as Autio et al. (2014) have shown that regional innovation ecosystems play a crucial role in determining the success of entrepreneurial ventures. However, there is limited research on how online mentoring programs can be tailored to support entrepreneurs in medium and less innovative regions. This study builds on the work of Isenberg and Daniel (2010) which discusses the concept of entrepreneurial ecosystems, by focusing on how demand-driven mentoring can address the specific challenges faced by entrepreneurs in regions with lower innovation activity.

Moreover, the literature suggests that mentoring effectiveness is maximized when programs are adapted to individual circumstances and contexts (Mouammer and Bazan, 2021). In regions with emerging or moderate innovation levels, entrepreneurs often face distinct challenges such as limited access to resources, inadequate support structures, and a lack of entrepreneurial culture. By understanding these regional disparities, this study aims to design an online mentoring program that is not only context-specific but also scalable and adaptable to other regions facing similar challenges.

2.3 Factors for Entrepreneurial Success

This paper draws on theoretical contributions to explore how tailored mentoring can facilitate the spread of innovative practices in medium and less innovative EU regions. Kiss et al. (2012) found that entrepreneurs in emerging markets who set clear, strategic business objectives are better able to align their limited resources and capabilities with market opportunities, leading to improved business performance. Further, Lingelbach et al. (2005) demonstrated that entrepreneurs in less innovative regions who effectively leverage informal networks and community resources are more successful in securing resources and support necessary to grow their businesses. Moreover, Miller and Wedell-Wedellsborg (2013) found that entrepreneurs who systematically evaluate and refine their products or services based on market feedback are more likely to achieve product-market fit, leading to higher chances of success in resource-constrained environments. Additionally, London and

Hart (2004) found that entrepreneurs who focus on inclusive business models that target underserved segments, such as low-income target groups, can achieve significant social and financial returns. Furthermore, Khanna and Palepu (2010) argue that entrepreneurs who can identify and exploit institutional challenges by creating innovative solutions, such alternative distribution networks, can turn these challenges into opportunities. In their study George et al. (2012) demonstrated that entrepreneurs who successfully integrate local trends and global innovations into their business strategies are better positioned to compete and thrive in emerging markets. Further, Brixiová et al. (2015) found that entrepreneurs who possess practical know-how and adopt a proactive attitude are more likely to identify opportunities and innovate, even in challenging environments. Lastly, Naudé (2013) emphasized that entrepreneurship training programs in emerging regions are more effective when they focus on practical, context-specific learning objectives that directly address the challenges entrepreneurs face in their local environments.

2.4 Global Perspectives and Emerging Trends in Entrepreneurial Mentoring

While the focus of this study is on the European Union, it is essential to consider global trends in entrepreneurial mentoring. Studies from regions such as North America and Asia have shown the increasing importance of digital tools in mentoring, particularly in the context of online and remote mentoring programs (Li et al., 2018). The integration of digital platforms can enhance the scalability of mentoring programs, making them more accessible to entrepreneurs in remote or less developed regions.

Additionally, the impact of the COVID-19 pandemic on entrepreneurship has accelerated the adoption of digital mentoring tools (Ratten, 2021). This shift highlights the need for mentoring programs that are adaptable to online environments, which is particularly relevant for the ENTRPRENEDU project's focus on online mentoring. Moreover, the growing emphasis on sustainability and social entrepreneurship, as discussed for instance by Kickul et al. (2018) or Elkington (2018) suggests that mentoring programs should incorporate these themes to remain relevant to current and future entrepreneurial challenges.

Despite the advancements in the field, there remains a significant gap in research that specifically addresses the customization of online mentoring programs for EU regions with low and medium levels of innovation. This paper contributes to filling this gap by providing a detailed analysis of the specific demands of entrepreneurs in southern and eastern EU countries and offering a mentoring framework tailored to these needs.

3. Methodology

This section explains the structure and purpose of the applied demand analysis. The demand analysis ensures that the mentoring program is tailored to meet the specific needs of the participants, maximizing its impact and relevance especially for young entrepreneurs from low to medium innovation countries. It also helps to set realistic goals and allocate resources efficiently, enhancing motivation and success. The analysis was conducted using the methodological approach of semi-structured interviews, a qualitative process that captures the experiences, perceptions and insights of participants to create a demand-oriented mentoring program. The data collection took place on 30th June 2023. The process comprised online interviews with representatives from each of the four teams that were selected at the hackathon in Rimini, Italy to enter the ENTREPRENDU online mentoring program. These four teams constitute the first cohort of the programme namely As You Like, Backwards, BOBIS and Shades of Blue. Each interview session lasted for one hour, aiming to capture an in-depth understanding of the participants' experiences and needs. To ensure consistency in data collection and interpretation, two researchers and one research assistant from Fraunhofer IPK conducted and protocolled the interviews. Two developers of As You Like, the two founders of Backwards, the two founders of BOBIS and the three founds of Shades of Blue took part in their respective interviews. Prior to the data collection, an interview guideline was prepared to establish a clear direction and framework for the interview. The guideline was structured around eight key dimensions which were derived from the discussed literature and is depicted in Figure 1. The figure further highlights the subsequent design and implementation of the mentoring program.

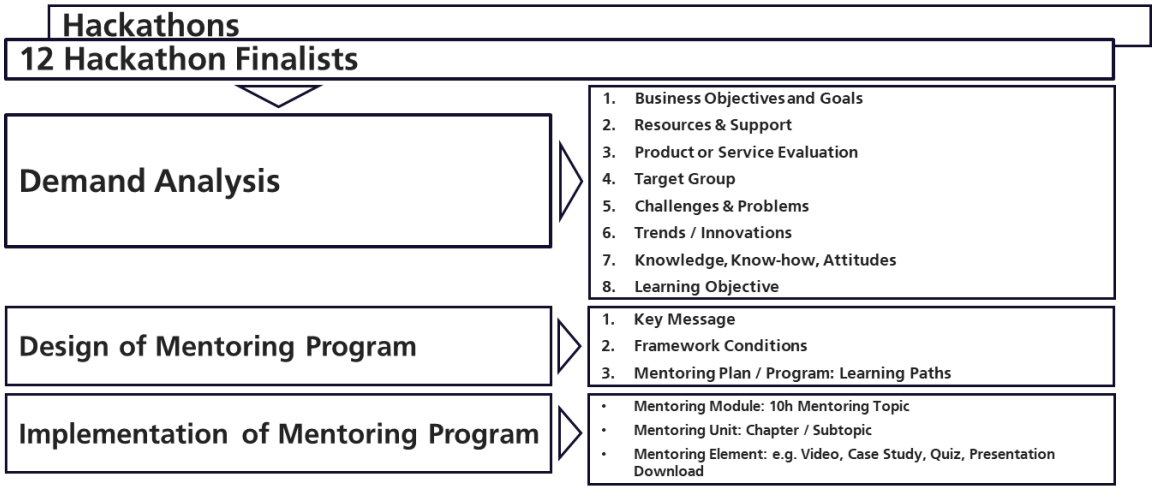

Figure 1: Demand Analysis Structure

All interviews were conducted with respect to ethical considerations, including voluntary participation, confidentiality, and privacy of the participants. Following the data collection, the subsequent stage involved an in-depth analysis of the responses obtained from each of the four participating teams. This was done through a thematic analysis, which was executed in several stages (Braun and Clarke, 2006). Based on the protocols an 'open coding' process was carried out. This is the first step in qualitative data analysis and involves identifying and defining themes that emerged from the interviews. In this process, the protocols were analysed and segments of the text that encapsulated key thoughts or concepts were labelled. After coding the protocols, the codes were examined for patterns sorted into broader categories. This stage is often referred to as 'axial coding' and it involves the clustering of related codes to identify the main themes. These themes were then compared across all teams to identify shared or unique demands. To ensure this process was rigorous and transparent, each theme was revisited in the context of the questions in the interview guide and the specific challenges and learning objectives expressed by the teams. This method was employed as it provides a flexible and useful research tool for identifying, analysing, and interpreting patterns of meaning ('themes') within qualitative data. The themes derived from this analysis process were matched with the skill set if the consortium partners engaged in the mentoring. Themes that matched with the partners skill set served as a basis for the derivation of the mentoring topics, thereby ensuring that the curriculum is tailored to meet the specific needs and learning objectives of the teams. Each mentoring topic was used to create a separate mentoring module. In this manner, the mentoring modules and the subsequent curriculum were directly linked to the identified needs of the teams, providing them with targeted guidance that would be most beneficial to their business journey.

4. Results of the Demand Analysis

The following section provides detailed insights into the results of the demand analysis as well as the derived mentoring modules. In order to ensure the confidentiality of the results of the demand analysis, the names of the teams are anonymized in the following.

4.1 Demand and Learning Objective of Each Team

The demand analysis and subsequent interviews with the four teams that were selected during the hackathon in Rimini, Italy revealed a variety of challenges and demand specific to each team, shaped by their unique business contexts and long-term goals. After an introduction of the team, their challenges and demands are presented as follows.

4.1.1 Team A

Team A is developing a multisided catering service app to offer customizable, healthy meals while addressing food waste, aiming for launch in 2024 with profitability by 2025. Despite strong technical resources and market awareness, they face challenges in strategic planning, market research, legal concerns, and engaging their target segments, indicating a need for comprehensive guidance.

4.1.2 Team B

Team B, formed at a Rimini hackathon, aims to reduce waste from food delivery packaging through reusable containers, targeting environmentally conscious young Italians. Despite strong IT and marketing skills, they lack business planning and development expertise, highlighting a need for training in goal setting, competitive analysis, and market research.

4.1.3 Team C

Team C has developed an online platform connecting local stores with customers, promoting local purchasing and reducing last-mile logistics, but lacks clear business objectives, indicating a need for strategic planning. Despite having a diverse skill set and some digital marketing abilities, they face challenges in communication, investor pitching, HR management, and market competition, suggesting a need for targeted training in these areas.

4.1.4 Team D

Team D, established in 2023, aims to create a standardized certification system for sustainable water management but lacks clear business objectives and a marketing strategy, indicating a need for strategic planning and customer engagement training. Their challenges include implementing their idea, securing pilot companies to test their product, and addressing gaps in environmental and engineering expertise. Which suggests a need for guidance in market research, business modelling, and technical knowledge acquisition.

4.2 Common Themes and Derivation of the Mentoring Topics

The in-depth interviews and subsequent demand analysis with the four teams identified several common themes and demands. Table 1 illustrates the identified themes and their respective and clustered codes.

Table 2: Results of the thematic demand analysis

Theme	**Code**
Demand for a Business Model Development	Business and legal knowledge gap
	Business model setup
	Business development gap
	Need for strategic guidance
	Incomplete business model
	Business operations ideas
Demand for Crafting a Unique and Competitive Value Proposition	Value proposition validation
	Strategic knowledge gap
	Communication challenges
	Clarifying value and mission
Demand for Technical Feasibility and Product Development Skills	Need for technical expertise
Theme	Code
Demand for Technical Feasibility and Product Development Skills	Blockchain exploration
	Materials and production knowledge gap
	Competitor product analysis
	Implementation and validation strategies
	Need for technical support
	Environmental and scientific expertise gap
Demand for Crafting a Successful Investment Pitch and Understanding Funding Needs	Networking for fundraising
	Learning funding options
	Funding calculations

Theme	Code
	Investor pitching skills
Demand for Comprehensive Business Planning	Strategic roadmap development
	Business management gap
	Learning business challenges
	Business management expertise
Demand for Access to Finance and Understanding Funding Mechanisms	Investor engagement
	Investor communication skills
	Mentorship and advice
	Business model validation
	Exploring funding options

From the analysis six primary demands emerged, and where consequently matched with the expertise of the consortium mentoring partners leading to the six mentoring modules of the program. In the following the themes and content of the mentoring modules are discussed.

4.2.1 Demand for a Business Model Development

A prominent challenge across all interviews was the *business and legal knowledge gap* and the *incomplete business model* identified by each team. The interviews revealed that the teams faced substantial challenges in creating an implementable business model. The *business development gap* further highlighted the teams' need for strategic guidance in setting up and refining their business models. Additionally, the *business model setup* and *business operations ideas* codes emphasized the necessity for practical and operational advice, underscoring the demand for a comprehensive understanding of the business model development process. One participant noted: *"We need guidance from mentors for practical and operational advice so that we can gain confidence in the global start-up world, including how to create a business canvas, plan, price, and conduct market research".*

This common demand among the teams aligned well with Fraunhofer IPK's experience in and subsequent mentoring module "Business Model Development" that provided the teams with a structured approach to developing a robust business model.

4.2.2 Demand for crafting a unique and competitive value proposition

The demand for crafting a unique and competitive value proposition was strongly linked to the *value proposition validation* and *strategic knowledge gap* codes identified during the interviews. Teams reported difficulties in identifying and effectively communicating their company's value and mission to their target audience. These, challenges underline the importance of mentoring in helping the teams to identify and communicate their unique value points to create a competitive edge. One participant stated: *"The main problem right now is communication—specifically, targeted communication to attract customers and effective marketing. We need to better explain our company's value and mission and clearly convey our value proposition to the target audience."* Given these shared demands, Luiss universities understanding of "Value Propositions" development provided invaluable assistance. Their mentoring module "Crafting a Unique and Competitive Value Proposition" involved guidance on identifying unique value points, aligning these points with the needs and wants of their target market, and effectively communicating this value to attract and retain customers.

4.2.3 Demand for technical feasibility and product development skills

The interviews revealed a strong demand for technical feasibility and product development skills, as reflected in the *need for technical expertise* and *implementation and validation strategies* codes. Teams emphasized the necessity of transforming their innovative ideas into market-ready solutions, with *competitor product analysis* playing a critical role in understanding the competitive landscape. Additionally, the *need for technical support* and *environmental and scientific expertise gap* underscored the importance of mentorship in guiding teams through the complex process of product development and validation. One participant noted: *"A critical aspect is finding the easiest and most efficient way to implement our idea, which means securing pilot companies willing to test and validate our concept. Validation is a significant hurdle at this stage because it directly impacts our ability to refine our product, develop a complete business model, and ultimately attract investors."* Given these articulated demands, FEA's background in the field of technology feasibility was instrumental in providing the

teams with practical guidance. The consequently developed mentoring module "Your Idea Pitch: from Tech Feasibility to Product Development" involved the introduction of tools to validate technical concepts, guidelines to structure the development processes, and methods to validate the product in their target market.

4.2.4 Demand for crafting a successful investment pitch

The demand for crafting a successful investment pitch and understanding funding needs was primarily driven by the *investor pitching skills* and *learning funding options* codes. Teams expressed a clear need for guidance in developing compelling investment pitches that could attract potential investors. The *funding calculations* code further illustrated the challenge of accurately quantifying funding needs, while the *networking for fundraising* code highlighted the importance of establishing connections with investors. Together, these codes underscore the necessity of mentorship in preparing the teams to secure the funding required for their business growth. EBAN's understanding of a "Pitching and Assessing Funding Needs" was extremely relevant for the teams. In their mentoring module "Investment Pitch and Quantifying Your Funding Needs" they assisted the teams in developing compelling investment pitches, understanding their funding needs accurately, and learning how to approach potential investors effectively.

4.2.5 Demand for comprehensive business planning

Furthermore, comprehensive business planning emerged as a common demand across the teams, closely tied to the *strategic roadmap development* and *business management gap* codes. Teams identified the need for structured guidance in defining their business objectives and planning their operations effectively. The *learning business challenges* and *business management expertise* codes reflected the importance of understanding the complexities of managing a business and overcoming potential obstacles. Corallia's expertise in and subsequent mentoring module "Entrepreneurial Business Planning" was relevant in this matter as the mentoring conducted by Corallia involved helping the teams to define their business objectives, plan their operations, create financial forecasts, and devise marketing strategies in the frame of a comprehensive business plan.

4.2.6 Demand for access to finance and understanding funding mechanisms

The demand for access to finance and understanding funding mechanisms was strongly associated with the *investor engagement and exploring funding options* codes. Teams highlighted the importance of networking with potential investors and identifying the most suitable funding options for their business ideas. The *investor communication skills* code further emphasized the need for effective communication strategies when engaging with investors. These codes collectively underscore the critical role of securing the necessary financing and effectively managing financial strategies. One participant stated: *"We want to improve our networking skills to generate better ideas and secure funding. Additionally, we're focused on setting up a solid business model and financial plans, learning new growth techniques, and understanding how to find the best funding options for our teams."* This common concern directly correlated with Cleantech Bulgaria's expertise in and subsequent mentoring module "Access to finance and related funding". This mentorship involved guidance on identifying suitable funding options, navigating the legalities of securing financing, and effectively managing the funds they acquire. Furthermore, it included introducing the teams to various financing mechanisms available for teams in different stages and sectors.

5. Discussion and Conclusion

The ENTREPRENEDU online mentoring program, is structured around the six themes that were identified in the demand analysis. Therefore, it is able to address the specific demands of individual entrepreneurs. Further, the programs modular structure allows for customization based on the specific needs of different cohorts, ensuring relevance and efficacy across various contexts. This flexibility is crucial for the programs scalability and extending it to other regions beyond Italy, Greece, and Bulgaria, thereby contributing to a more balanced innovation landscape across the EU. The broader implications of this paper highlight the importance of context-specific mentoring in bridging innovation gaps and enhancing the innovation capacity of emerging entrepreneurs. Hereby, this paper followed the approach suggested by Isenberg and Daniel (2010) and Mohiuddin et al. (2023) and focused on the individual context of the participants through the execution of a demand analysis. The therefore conducted demand analysis and its results support the view of Baluku et al. (2020) and played a crucial role in understanding the specific needs and challenges faced by entrepreneurs in various contexts. This analysis allowed for the design and development of a tailored online mentoring program that directly addresses the unique demands of each cohort. It revealed key areas where entrepreneurs require the most support. These key areas are business model development, value proposition crafting, technical feasibility, pitching, business

planning and funding acquisition and corelate with the prevalent issues in moderate and emerging innovation regions (European Union, 2023). Hence this paper, highlights the necessity for comprehensive and tailored mentoring programs in these regions and enriches the discussion on the customization of online mentoring programs and the demand of entrepreneurs from EU regions with low and medium levels of innovation.

For policymakers, educators, and entrepreneurs, the findings underscore the importance of targeted support and the need for continuous adaptation to local contexts. By fostering a supportive environment that addresses specific regional demands, stakeholders can significantly enhance innovation capacity and contribute to sustainable economic growth. Future research should focus on longitudinal studies to assess the long-term impact of such online mentoring programs on entrepreneurial success and regional innovation. Additionally, exploring the integration of emerging technologies and innovative practices in mentoring process could further enhance the effectiveness of these programs. By continuing to refine and adapt mentoring approaches, we can better support the next generation of entrepreneurs and bridge the innovation gap across the European Union.

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Perspectives of Czech High School Students on Cheating in Remote Education

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Abstract: This study explores the perspectives of Czech high school students on using digital technologies for cheating during remote education, a phenomenon encouraged by the abrupt transition to online learning due to the COVID-19 pandemic. Through a mixed-methods research design, this study collected data via an online questionnaire with 24 questions completed by 316 students from secondary schools and conducted individual interviews with seven teachers. In their study, the authors focus on three questions: How much do high school students know which digital technology they can use for cheating in remote online education? What are their experiences with cheating in remote online education? What are the preventive solutions recommended by students and teachers to eliminate online cheating? The research findings indicate that students perceive online cheating as justifiable, primarily due to their disengagement with the course material and lack of interest in learning under the pandemic's extraordinary circumstances. Students frequently used technical means for cheating, with mobile phones and screen-sharing during online tests being the most popular methods. Additionally, the use of internet resources to find answers was the most commonly reported form of online cheating. To address this issue, students outlined various anti-cheating strategies, categorised into three perspectives: pessimistic, practical, and critical-realistic. The pessimistic perspective indicates scepticism about the feasibility of effectively combating cheating, whereas the practical perspective offers tangible, immediate solutions. The critical-realistic view provides a thoughtful and pragmatic approach to the problem, suggesting a balance between understanding the complexities of cheating and implementing realistic measures. The study highlights educators' critical role and emphasises the importance of aligning assessment methods with students' learning needs and expectations to reduce cheating tendencies naturally. The rise of AI technologies has introduced new dimensions to the problem of online cheating, as AI tools can facilitate academic dishonesty. However, AI can help detect and prevent cheating. The authors suggest using formative assessments and creating an engaging, supportive online learning environment to deter dishonesty and promote academic integrity.

Keywords: Online cheating, Remote online education, High School, COVID-19 Pandemic, Plagiarism, Anti-cheating strategy

1. Introduction

According to the report of the Czech Government (2021), all secondary schools in the Czech Republic operated due to the pandemic for a total of 155 days in the remote online education regime in two periods: in spring (March-June 2020) and autumn-winter-spring (mid-October 2020 to mid-May 2021) using Zoom (4 % schools), Google Meet (40 %), MS Teams (53 %) or other platforms (e.g., Skype, Jitsi Meet, Adobe Connect). According to a survey of the Czech School Inspectorate (ČŠI, 2020), among 1,767 students, 48 % of them characterised their online education as self-study from textbooks, slightly more students (55 %) as online broadcasts of teachers, 58 % of students stated that online education consisted of working on assigned tasks themselves, and 63 % students as watching videos recommended by the teacher. In another survey, school principals estimated that there were 250,000 students who were not involved in remote online education in the spring semester of 2020. In the 2020/2021 school year, there were approximately 50,000 such students (3.5%) (ČŠI, 2021, p.15).

Students cheating in school education is closely related to evaluating students' activities and their learning outcomes. “Providing feedback and evaluating achieved results proved to be crucial during remote education.” (ČŠI, 2021, p.50). Implementing the traditional forms of verification of results into remote online education was the main reason why most Czech teachers were not successful. Therefore, they followed the methodological recommendations of the Ministry of Education, Youth and Sports (MoEYS). “Problems with assessment have led teachers to talk about gradual changes in their approach to assessment, but unfortunately only 7% of them report more fundamental changes in their approach to student assessment.

Most often it is a milder classification (in secondary schools the classification is exceptionally stricter), but also continuous verbal assessment is significantly more often used” (ČŠI, 2021, p.50). Engaging students to study was often challenging. The dominant organisational form of work was frontal instruction. In rare cases,

students cooperated, with group work averaging 6% and pair work only 4% (ČŠI, 2021, p.46). Video conferencing tools allowed some class grouping.

Despite improvements in remote teaching between spring 2020 and autumn 2021, the quality did not match face-to-face teaching, according to both students and parents. Students' motivation to learn deteriorated, teaching was less engaging, and students enjoyed online learning less. Additionally, parents noted that teaching improved more in schools where it was already prominent in the spring of 2020 (ČŠI, 2021, p.54).

During remote online education in high schools, teachers used various approaches to assessing students' learning outcomes, including continuous classification (94-97%), selected student portfolios (including digital) documenting the results of student learning outcomes (12-16%), or more detailed verbal information about mastered skills (12-31%) (ČŠI, 2021, p.50).

While this research was conducted in 2021, which might suggest a temporal gap between the study and its publication, it provides valuable longitudinal insights. These insights highlight persistent issues in online education that remain relevant today, offering a reflective look at the evolving educational landscape and the ongoing challenges faced by students and educators. This study mainly aimed to investigate the Czech high school students' approaches to online cheating during remote online education. More specifically, the study attempted to examine students' reasons, used technologies, modes, and frequencies of cheating in remote online education including recommendations offered by students and teachers on preventing online cheating.

2. Literature Review

Digital technology is becoming a valuable and powerful tool for learning and school cheating. According to Arnold (2016), "cheating opportunities in online test environments raise the issue of fairness. In a competitive study environment, students will have low toleration for cheating by fellow students" (p.99). School cheating supports the current school setting, which focuses on student performance, competitiveness, and gaining good grades. Online platforms offer numerous opportunities for dishonesty, where students use forbidden means or have others take tests for them (Arnold, 2016). Some young people, accustomed to the digital world and Copy + Paste, often have different views on what constitutes digital cheating. "19% of high school students do not consider copying from the Internet to be cheating" (Vrbová, as cited in Ambrožová, 2020, p.95).

Cheating is a widespread phenomenon. Not every student cheats. "14% of high school students think they do not cheat when they copy or consult with classmates, 14% of them think they do not cheat when they copy homework, 12% of them do not think they are cheating if they have sight of questions for a written exam before they are due to take it, and 11% of them do not consider that they are cheating when using crib-sheets (or secreted notes)" (Vrbová, as cited Ambrožová, 2020, p.95). Lovett (as cited Ambrožová, 2020) considers "students who are more focused on gaining good grades than understanding educational content, and students who feel dissatisfied at school, are the two groups of students who cheat most often" (p.94). Galloway (2012) concludes that one of the three main reasons for cheating is the consequences of cheating are not set to discourage students from further attempts to cheat, i.e., "the temptation to cheat has grown - there is little accountability, consequences are few, and settings lack systems to deter people from cheating" (p.382).

Recent studies have also addressed the impact of remote education on cheating behaviours. Cramarenco et al. (2023) conducted a systematic review on student perceptions of online education and digital technologies during the COVID-19 pandemic. The study highlighted that while online education offered flexibility and self-directed learning opportunities, it also presented significant challenges, including increased opportunities for cheating due to the lack of direct supervision and the ease of accessing unauthorised resources online (Cramarenco et al., 2023). Similarly, Bond (2020) synthesized research on K-12 teaching and learning during the pandemic, emphasising that the rapid shift to remote education often lacked the necessary infrastructure and pedagogical adjustments, leading to increased instances of academic dishonesty. The study recommended better teacher training and the integration of technologies to mitigate cheating in online environments (Bond, 2020). Additionally, DiPietro et al. (2020) examined the varied experiences of students and teachers during remote learning across different grade levels, finding that high school students were particularly prone to cheating due to the increased pressure to perform well and the relative ease of bypassing online supervision tools. The research suggested implementing more robust assessment methods and fostering a culture of academic integrity to address these challenges (Di Pietro et al., 2020).

Noorbehbahani et al. (2022) identified four main themes for students' reasons for cheating in online exams: (1) teacher-related, (2) institutional, (3) internal, and (4) environmental. Teacher-related reasons include unfair

favouritism, low interest in students' learning, poor pedagogical styles, course difficulty, lack of support, reluctance to punish cheaters, and poorly designed exams. Institutional reasons involve lenient cheating policies, ease of cheating, impulsiveness, less respect for online teachers, and poor quality of online learning equipment. Internal reasons include students' academic performance, low intrinsic interest in the course, and personal traits like laziness, lack of confidence, and moral attitudes towards cheating. Environmental reasons include peers' behaviour, parents' attitudes, personal issues, and societal factors such as poor economic conditions and societal attitudes towards cheating.

Research among Czech high school students (n=1542; aged 15-23; 58.0% female) showed that "high school students download work on the internet, which they later publish as their work" (Ambrožová, 2020, p.167). This research confirmed that "cheating affects more male students than female students" (Ambrožová, 2020, p.168), aligning with other international case studies. Ambrožová (2020) also found connections between school cheating and a student's grades in Czech and mathematics. With worsening grades, the incidence of digital cheating increased. "Research also revealed a high degree of correlation between school cheating and the tendency to become addicted to the internet" (Ambrožová, 2020, p.170). Inspired by Johnstone (1996), Ambrožová (2020) presents a typology of students based on their preferred learning strategies to determine how different types of students exploit the Internet. Detailists and perfectionists showed a low tendency to exploit the Internet, unlike data collectors and innovators.

According to Michal Černý, a member of the Association of Principals of Czech basic schools, "it does not have to be just a mobile phone that students cheat or disturb. For example, they use wireless headphones, which girls can easily hide under their hair, while someone tells them, which the teacher does not notice at all. Another illegal test helper is a smartwatch, which can now receive and send messages" (Rizikyová, 2021).

In conclusion, the shift to remote education during COVID-19 has increased high school students' cheating due to less supervision, more pressure, and digital tools. Addressing this requires better teacher training, robust assessments, and fostering academic integrity.

The following two research questions were formulated to conduct the current study.

RQ1: How much do high school students know which digital technology (HW, SW) they can use for cheating in remote online education?

RQ2: What are their experiences with cheating in remote online education?

RQ3: What are the preventive solutions recommended by students and teachers on how to eliminate online cheating?

3. The Study

3.1 Research Design

A mixed methods research approach was used to collect and analyse the data to understand better Czech high school students' approaches to cheating in remote online education during the COVID-19 pandemic (Creswell, 2014). The researchers employed the explanatory sequential design (Creswell, 2014) in which qualitative and quantitative data were collected sequentially in two phases. First, high school students' views (N=316) and experiences with cheating during remote online education amid the Covid-19 pandemic was assessed by a survey. Then interviews were conducted with their teachers (N=7) concerning the same topic under scrutiny.

3.2 Participants and the Settings

The study was conducted at nine high schools in the Czech Republic. Data were collected from 316 high school students through an online questionnaire and from seven teachers through individual interviews. Among the students, 56.0% were boys, 38.9% were girls, and 5.1% did not state their gender. The respondents, aged 15 to 19, were distributed as follows: 29.1% in Year 1, 31.3% in Year 2, 33.2% in Year 3, and 6.3% in Year 4. Most students (34.2%) were from secondary vocational schools with the 'maturita' exam, followed by 23.1% from secondary industrial schools, 19.3% from grammar schools, 13.0% from secondary pedagogical schools, and 8.5% from business academies. The most popular online subjects were foreign language (25.3%), Informatics and IT (24.4%), and Czech language (13.0%).

To provide demographic information about the seven teachers (1 female, 6 males) with teaching experience from 2 to 21 years (12.5 years average) aged from 23 to 41 years. The research involved mainly high schools, where alumni or part-time student teachers of MA study programs in IT of the Faculty of Education at Charles

University work. Those seven teachers showed willingness to get their students to participate in the survey of this study.

3.3 Data Collection Tools

In this study, an online questionnaire and a series of individual interviews were utilised for data collection tools. Data from students were collected from 9.6.2021 to 30.6.2021 when secondary schools in the Czech Republic returned to face-to-face education, and remote education was over. Interviews with teachers were organised online in ZOOM from 9.6. to 29.6.2021.

The online questionnaire consists of 24 questions dedicated to students (14 closed-ended questions, 9 semi-closed questions, and 1 open-ended question). The questions of the questionnaire were designed by one of the authors**.** The questionnaire questions were carefully designed to elicit specific information related to the research objectives, such as students' knowledge of digital tools for cheating and their justifications for such behaviours. This mixed-methods approach ensures a comprehensive understanding of the issues addressed in the study.

All students who participated in the study were informed about the survey's aim by their teachers before the actual distribution of the questionnaire link. The students were assured it was a completely anonymous questionnaire and were informed about the time required to answer the questions (e.g., not more than 15 minutes to complete the questionnaire). The data collection was conducted anonymously and without specific information about pupils, teachers, and schools. One online individual interview was conducted with all seven teachers, involving 10 questions.

3.4 Data Analysis Procedure

The online questionnaire was made available via a link that directed students to it. The data were analysed using descriptive statistics. Respondents' demographic information is presented using frequencies and percentages. Online individual interviews with the teachers were analysed through inductive content analysis: (1) All seven interviews were transcribed. (2) The transcript of each interview was read multiple times and coded. (3) Coded interviews were compared and contrasted, and themes were identified.

4. Findings

4.1 Students' Reasons of Cheating During Remote Online Education

The main reasons for online cheating during remote education were reported as unwillingness to learn (55.1%), especially if the subject is not interesting/useful (56.6%), inability to understand the curriculum presented in remote education (48.8%), and convenience of online cheating (48.1%) see Fig. 1.

Teachers' accounts from the online interview indicated that students cheating during remote education involve students' pursuit of better grades and teachers' lack of monitoring to detect online cheating.

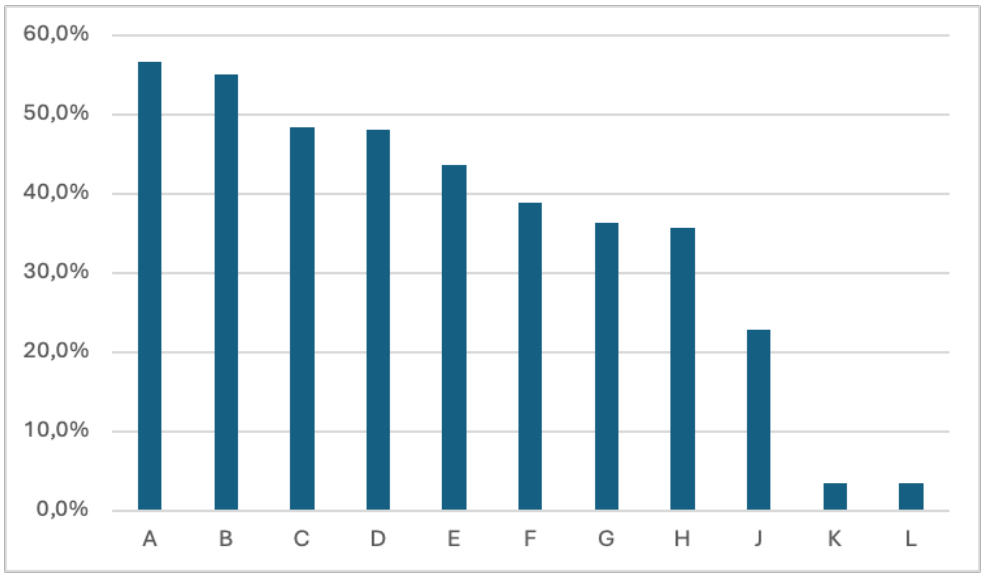

Figure 1: Reasons why high school students cheated in remote online education (N=316) (Podoljak, 2021)

(A- The subject is uninteresting/ useless, B- I didn't want to learn, C- I do not understand the curriculum, because it is online teaching that does not provide me with a sufficient explanation of the curriculum, D- In the case of online education, cheating is easier, E- The subject is very difficult, F- The subject teacher has unreasonably high demands, G- I don't spoil my transcript of records with a bad grade, H- I didn't have time to learn, J- To make my parents happy with a good grade, K- Others, L- I do not cheat)

Most respondents (66.5%) believe that online cheating is excusable during remote education caused by the COVID-19 pandemic since it brought many barriers and limitations for learning. Respondents (79.1%) found that cheating in remote online education is significantly easier than in face-to-face education. As reported by the respondents, their teachers are less likely to detect cheating, and respondents have various ways to cheat. Among the school subjects, maths (39.2%), Czech language (21.2%) and Informatics and IT (10.1%) are found by the students as the most preferred subjects in which they frequently cheated during remote online education.

4.2 Technical Means and Methods of Online Cheating During Remote Education

Regarding technical means, 50.0% of students used additional digital equipment (e.g., mobile phones, tablets, etc.) during online tests, 38.3% of students shared their screen with another person. On the other hand, 25.3% used in online tests software applications (e.g., Wolfram Alpha) - see Table 1.

Table 1: Technology used for online cheating by the high school students (N=316) (Podoljak, 2021)

Used technology	Respondents
Using other equipment (tablet, mobile phone, etc.) during testing	50.0%
Sharing a screen with another person	38.3%
Using a program to help with calculations (e.g., Wolfram Alpha)	25.3%
Using smart calculator	22.8%
Accessing to the source code of the response test page	12.0%
Using a wireless handset for hints	11.1%
Sending an intentionally corrupted file	9.5%
Using a virtual machine to bypass an application that monitors what is happening on your computer	3.5%
Modifying or pasting your own (e.g., Java script) code into a web application with a test	2.8%
Projecting information into smart glasses	0.6%

During online tests in remote education, respondents reported using various cheating techniques at least once: using Internet resources (96.5%), having open notes/textbooks (83.9%), another person/people advising using special software or hardware devices (67.1%), and another person/people in the room advising (49.7%). Students also engaged in plagiarism: 64.2% copied part or all work from the Internet, and 60.8% from their schoolmates. Only 21.2% of respondents actively participated in online lessons. These examples align with teachers' views on student cheating during online education. However, they rarely identified any students cheating.

4.3 Frequency of Online Cheating During Remote Education Across Curriculum

The most frequently self-reported online cheating was using Internet resources (46.8%), which followed using open notes or textbooks in front of the students (26.6%). Surprisingly, students' obtaining help or advice from another person using special software or hardware was 28.2% (see Fig. 2).

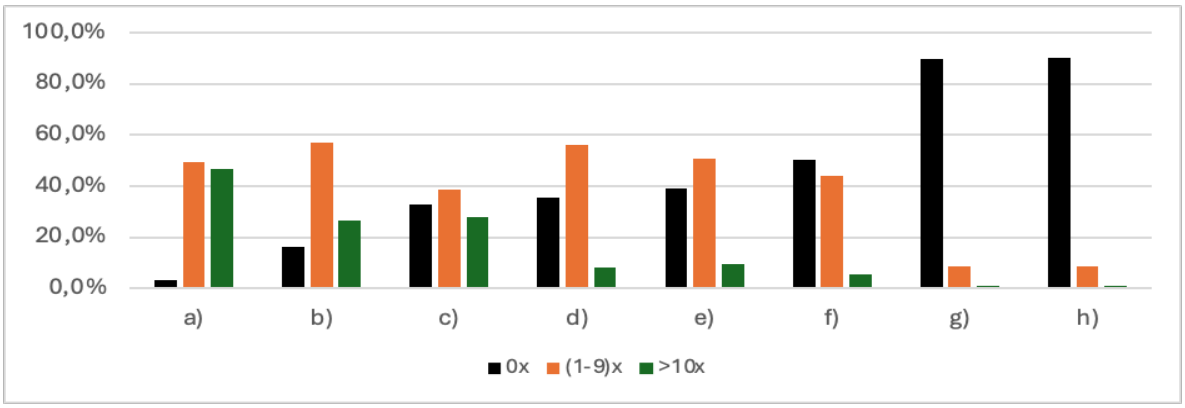

Figure 2: How often high school students used various activities during cheating during online remote education (N=316) (Podoljak, 2021)

(a) I used resources on the internet. b) I had open notes / textbooks in front of me. c) I had another person get advice using a special SW/ HW. d) I copied part/all of the work from the internet. e) I copied part/all of the work from a classmate. f) I got advice from another person in the room. g) I let another person represent me during the test who in fact did my test. h) My parents worked for me.)

4.4 Types of assessment That Lead Students to Cheat

During the remote online education, the teachers reported online tests and individual/ group work activities (both verbal and written form) as the most used types of assessment. Additionally, teachers provided feedback to their students. Usually, there were more individual / group works activities for which students were evaluated. Furthermore, emphasis was often placed on individual verbal assessment of students and one-to-one supervision with their teachers.

The most frequently used assessment types that led students to cheat during remote online education were tests, oral cheating methods, and plagiarism applied in essays and other digital documents.

Based on the self-reports, students in remote online education always cheat when taking tests and occasionally writing essays. Oral cheating methods were applied rarely or never (see Fig. 3).

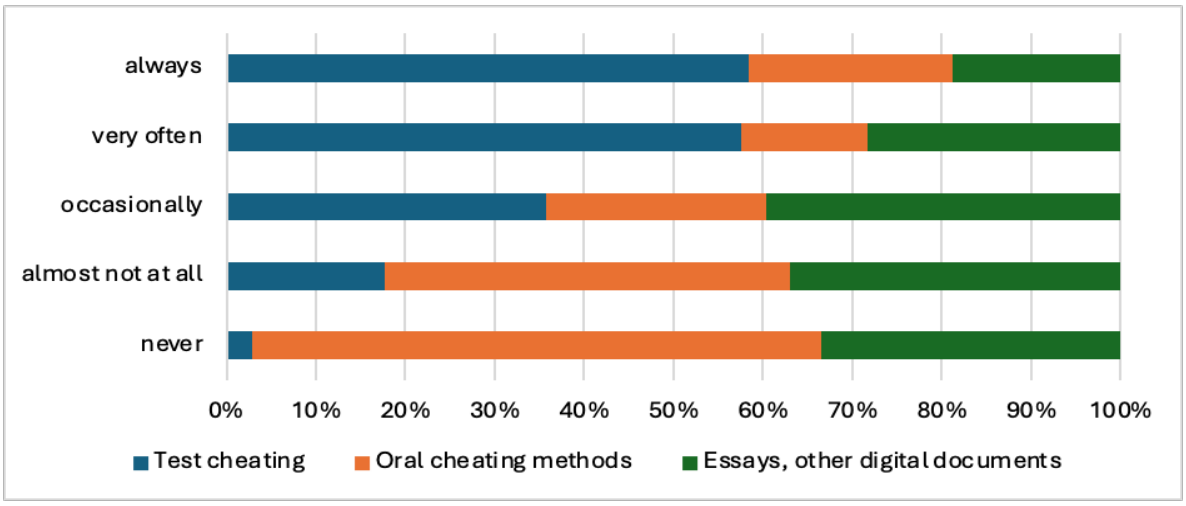

Figure 3: How often high school students cheated during remote online education (N=316) (Podoljak, 2021)

4.5 Solutions Recommended by Students and Teachers for Preventing Online Cheating

Solutions to preventing online cheating were gathered from both students and teachers. First, students' solutions were pooled under three main groups of recommendations, which were (1) *pessimistic* towards preventive solutions of online cheating based on the conviction that "people will always cheat", (2) *practical* based on the technological requirement that all students should use their camera throughout the online exams, and (3) *critical and realistic* towards elimination of cheating in school education based on criticism of

the Czech educational system (including teaching methods and forms and ways how students are assessed in the Czech high schools).

Although teachers realised that students will always try to cheat, they were not pessimistic in the interviews, but suggested a number of practical solutions. For example, to use a hidden unique identifier for each student in the assignment and then checking if each student submitted their file and did not just submit someone else's copied work.

5. Discussion

In response to the first research question, 'how much do high students know which digital technology (HW, SW) they can use for cheating in remote education?', it was found that most high school students are aware of the possibilities of cheating during remote online education. They admit they usually cheated because teachers rarely detected it, and students were rarely punished. This conclusion corresponds with Vrbová regarding "students also cheat due to low penalties for detected fraud" (cited in Ambrožová, 2020, p.94). Some students are familiar with complex cheating techniques that require expertise, such as code modifications in Internet applications, virtual computers to deceive security programs, and image sharing. They needed only basic Internet and smart device skills to cheat.

In response to the second research question, ‘what are students’ experiences with cheating in remote online education?’, it was revealed that almost all students have some experience with the misuse of digital technologies in online learning. Practically every student cheated at least once, and more than half cheated frequently (e.g., 57.3% of students copy from the Internet or their notes), with 18.7% admitting to cheating on tests constantly. 60.8% of students have copied part or all their work from a classmate at least once. Rarely did teachers notice students cheating. Students are aware that it is difficult for a sufficiently digitally literate teacher to detect and prove online cheating. Teachers admit that during remote online education during a pandemic, the number of cheats probably increased, but they had little opportunity to detect it. According to Bilena & Matros (2021), “like doping, cheating cannot be eliminated. There always was, is, and will be cheating in face-to-face and online examinations. However, we can (try to) keep it at an expected equilibrium level” (p.207).

In response to the third research question, ‘what the preventive solutions are recommended by students and teachers on how to eliminate online cheating?’, it was found that all students’ and teachers’ recommendations (see 4.5) reflect their understanding of online cheating and their experiences during the pandemic period. Often, the concept of cheating has subjective interpretations, leading to personal solutions. There was no comment from students on whether the school management or teachers issued any measures to prevent cheating during the remote education period (e.g., list of prohibited items, aids used during online exams). Galloway (2012) found similar conclusions: “students described schools as lacking clarity or consequences regarding cheating and expressed feeling forced to cheat in a school culture that promotes getting ahead over learning” (p.378). Online cheating relates to ethical and moral principles. Therefore, it is crucial to clarify this concept for all societal actors: students, teachers, parents, institutions, and policymakers. Bilena and Matros (2021) also point out the need for rules in online examinations at educational institutions as “universities should implement a uniform online exam policy where a camera captures each student’s computer screen and room is a requirement. A camera will also help to check a student’s ID and eliminate the possibility of another person taking the test” (p.207).

While this study primarily focused on digital technologies for cheating, students also use traditional methods, such as texting answers during online exams. This adaptability highlights their resourcefulness in dishonest practices. Furthermore, the "copy and paste" method remains prevalent, as supported by other research, emphasising the ease of plagiarising content from the internet. This study adds to the existing literature by examining these behaviours in Czech high schools, thus contributing to a broader understanding of academic dishonesty in digital learning environments.

In addition to confirming existing findings, our study offers unique insights into Czech high schools' specific context. These include a detailed analysis of student attitudes towards cheating and the particular methods they employ, providing a deeper understanding of the cultural and educational environment influencing these behaviours. The rise of Artificial Intelligence (AI) technologies has introduced new dimensions to online cheating, as AI tools can facilitate academic dishonesty. AI-driven platforms that assist with problem-solving can be misused by students. This study underscores the need for educators to address these impacts on student behaviour. Noorbehbahani et al. (2022) note that cheating in online exams is influenced by advanced

technological tools. Bond (2021) emphasises that the rapid shift to remote education lacked the necessary infrastructure, leading to increased academic dishonesty. Bond suggests that better teacher training and technologies are essential. Cramarenco et al. (2023) found that high school students are prone to cheating due to performance pressure and ease of bypassing supervision tools. While AI and digital technologies pose risks for academic integrity, they also offer potential solutions. Implementing robust assessment methods, fostering a culture of academic integrity, and leveraging AI to detect dishonest behaviours can help. The prominence of AI in online cheating has grown post-COVID-19, which accelerated the adoption of digital technologies in education. Cotton et al. (2024) discuss how AI tools like ChatGPT can be both a challenge and an asset in maintaining academic integrity.

6. Conclusion

Teachers commonly encounter the phenomenon of student cheating at school regardless of the COVID-19 pandemic. The reasons why students cheat remain generally the same: to achieve good grades, a fear of bad grades, a lack of motivation to learn, or laziness. For Czech students, it has probably never been so easy in the past to "copy and paste" materials for school exercises from the internet, or to get advice on exams or work with classmates to develop a test as it was during online education. Teachers increasingly rely on students' trust and belief that they will not cheat. This imaginary gap is widened not only by the number of new opportunities to cheat, but also by the aforementioned difference in computer literacy, specifically in using programs and various forms of online teaching and testing to reduce a student's chances of cheating.

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Gamifying Sustainability: Leveraging Game-Based Learning to Champion Sustainable Development Goals (SDGs): A Case Study

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Abstract: This paper examines how sustainability education can be effectively integrated into game-based learning (GBL) to enhance environmental consciousness. As global ecological challenges intensify, instilling sustainable practices in future generations becomes crucial. GBL offers an engaging platform to embed sustainability concepts through immersive and interactive virtual environments. The study explores the theoretical underpinnings of sustainability education and GBL, highlighting their synergy in raising awareness and fostering sustainable behaviours. By reviewing existing literature, it evaluates the impact of incorporating sustainability principles into GBL platforms. The discussion includes the integration of the UN's Sustainable Development Goals (SDGs), real-world scenarios, simulations, and collaborative elements to deepen players' understanding and stimulate critical thinking about complex sustainability issues. The paper also examines the role of feedback mechanisms, assessment tools, and adaptive learning approaches in maintaining engagement and knowledge retention. It concludes by advocating for the inclusion of sustainability in GBL as a means to develop environmentally conscious citizens. Leveraging the immersive nature of games, educators can cultivate a generation equipped to understand and address sustainability challenges, contributing to innovative educational approaches for promoting sustainable practices.

Keywords: e-Learning, Simulation, Higher education, Sustainability, Game-based learning, Interactive learning, Educational gamification, Sustainable development goals

1. Introduction

The United Nations' 2030 Agenda delineates a series of global challenges that integrate not only economic objectives but also social and environmental perspectives. This comprehensive agenda is anchored in 17 Sustainable Development Goals, which outline the necessary actions for the forthcoming years to be undertaken by public administrations, private enterprises, nonprofit organisations, universities, and the general populace (https://sdgs.un.org/goals). The 17 goals, encompassing 169 specific targets, strive to ensure a sustainable, peaceful, equitable, and prosperous existence for all inhabitants of the planet, both presently and in the future (see Fig. 1).

Figure 1: UN Sustainability Goals (SDGs)

These goals set environmental boundaries and integrate poverty eradication initiatives with economic development strategies, concurrently addressing social requirements and climate change. The SDGs cover a

spectrum of interconnected themes that pose significant challenges to society, including health, education, climate action, peace, and strong institutions.

Universities and higher education, as pivotal agents in the transformation towards sustainability, must commit to fostering sustainable values among students. Education should promote equity and respect, helping students to understand situations, perspectives, and needs of people from different parts of the world as well as future generations. Teaching sustainable development aims to engage students with ethical dilemmas, prompting them to determine the standards and codes society should adopt to achieve economic well-being while preserving the natural environment (Prado et al 2020). Consequently, students will need to evaluate and develop an ethical framework for sustainability, guiding their decisions on resource use to address economic, social, and environmental challenges both in the classroom and in real life (Prado et al 2020).

With this in mind, this paper investigates students' perceptions and understanding of sustainability through the lens of the Sustainable Development Goals (SDGs) and their ability to devise sustainability strategies for business development. The study aims to assess how well students grasp sustainability concepts and apply them in creating effective business strategies that contribute to environmental and social well-being. Through the examination of student reflections, the research provides insights into students' perceptions and understanding, highlighting areas for improvement in sustainability education.

2. Sustainability Education

The urgency of sustainability education stems from the growing environmental crises, including climate change, biodiversity loss, and resource depletion. These issues pose significant threats to the health and well-being of current and future generations (Evans, 2019; Marouli 2021). By incorporating sustainability into education, particularly higher education, students can develop a deep understanding of these challenges and the interconnections between ecological, social, and economic systems before they enter the workplace (Marouli 2021).

Sustainability education encourages critical thinking and problem-solving skills (Alam 2022). It allows students to analyse complex issues, consider diverse perspectives, and devise innovative solutions. This approach not only enhances cognitive skills but also fosters a sense of agency and empowerment, motivating individuals to take meaningful actions toward sustainable living (Kopina 2020). Moreover, sustainability education promotes ethical and responsible behaviour. It instils values such as respect for nature, social justice, and intergenerational equity. By understanding the ethical dimensions of sustainability, students are more likely to engage in behaviours that contribute to the well-being of both people and the planet. Furthermore, sustainability education is integral to achieving global sustainability goals. The United Nations' Sustainable Development Goals (SDGs) emphasise the role of education in achieving a sustainable future. Goal 4.7 specifically highlights the need for education systems to ensure all learners acquire the knowledge and skills needed to promote sustainable development. This global commitment underscores the importance of embedding sustainability into educational curricula at all levels.

Despite its importance, the integration of sustainability education faces several significant challenges (Evans 2019). One of the primary obstacles is the rigidity of existing curricula. Traditional higher education programmes are often structured around established modules with their respective learning outcomes, leaving little room for interdisciplinary topics like sustainability. Incorporating sustainability requires a paradigm shift that challenges the conventional compartmentalisation of knowledge. Educators play a critical role in delivering sustainability education, yet many lack the necessary training and resources. Effective sustainability education requires educators to possess a deep understanding of environmental issues and pedagogical strategies that foster critical thinking and active learning (Taimur & Sattar 2020; Howell 2021). However, many educators feel unprepared to teach these topics, as sustainability education is often not a part of instructor training programs. Professional development opportunities in this area are limited, further hindering the effective integration of sustainability into classrooms.

Systemic inertia within educational institutions also poses a challenge. Colleges and universities are often resistant to change, adhering to traditional practices and curricula. Implementing sustainability education requires institutional commitment, which can be difficult to achieve without strong leadership and a clear vision. Resistance may also stem from a lack of awareness or understanding of the importance of sustainability among administrators and policymakers. Additionally, there is a challenge in balancing sustainability education with other educational priorities. Institutions are under pressure to meet academic standards, prepare students for standardised tests, and fulfil other curriculum requirements. Integrating sustainability can be perceived as an

additional burden rather than an integral part of the educational mission. This perception can lead to resistance from educators and administrators who are already stretched thin. Another challenge is the diversity of educational contexts. Sustainability issues and priorities can vary significantly between regions and communities. A one-size-fits-all approach to sustainability education may not be effective. Educational programmes need to be context-specific, addressing local environmental challenges and cultural contexts (Evans 2019). This requires flexibility and adaptability in curriculum design and implementation, which can be difficult to achieve within standardised education systems.

Addressing these challenges requires a multifaceted approach with institutional commitment being key to driving change. Colleges and universities should develop sustainability policies and action plans that prioritise sustainability education (Taimur & Sattar 2020). Leadership from administrators and policymakers is necessary to create a culture of sustainability within educational institutions. This can be supported by building partnerships with environmental organisations, businesses, and communities to enhance the relevance and impact of sustainability education. To balance sustainability education with other priorities, it is important to demonstrate its relevance to core academic goals (Evans 2019). Research shows that sustainability education can enhance critical thinking, problem-solving, and engagement, which are valuable skills for academic success. Integrating sustainability into existing subjects can also provide a more holistic and engaging learning experience.

3. Game-Based Learning and Sustainability

Game-based learning (GBL) is an educational approach that integrates game elements and principles to engage learners and enhance their comprehension of complex concepts (Tetyana 2021; Zhan et al 2022). One of the primary advantages of gamification in higher education is its ability to boost student motivation and engagement (Kula 2021; Syafii 2021; O'Brien & Costin 2022; O'Brien & Costin 2023; Khaldi et al 2023). In game-based learning, knowledge or concepts are integrated into games from which learners naturally acquire relevant concepts or knowledge (Plass et al. 2015; Adipat 2021). A similar concept, *serious games*, refers to games designed for more than entertainment; they are intended to help learners develop new skills and knowledge. Such games touch on serious issues in education, medicine, military affairs, and corporate training.

At its essence, game-based learning harnesses the intrinsic motivations and engagement mechanisms inherent in games to facilitate educational outcomes (Yu et al 2020; Agustina & Jolanons 2024). Games often include challenges, rewards, feedback, and narratives that captivate players and encourage them to persevere despite difficulties. Embedding educational content within these game structures transforms the learning process into an interactive and immersive experience (Yu et al. 2020; O'Brien & Costin 2023). The key elements that make games effective learning tools include their ability to provide immediate feedback, foster a safe environment for experimentation, and encourage active participation. GBL has demonstrated efficacy in achieving a range of desirable learning outcomes, from cognitive skills such as problem-solving and critical thinking to social skills like collaboration and communication (Dichev & Dicheva 2017; Pratama & Setyaningrum 2018; Kailani et al. 2019). By engaging students in active learning, games can enhance retention and understanding of complex subjects. The inherent engagement and motivation provided by games capture students' interest, increasing their time on task and persistence, both critical for deep learning (Pratama & Setyaningrum 2018). The fun and competitive elements of games transform mundane learning activities into exciting challenges, fostering a more profound commitment to learning.

Games often focus on problem-solving and quests requiring strategic thinking and creativity, helping students develop problem-solving skills by experimenting with solutions in a low-stakes environment (O'Brien & Costin 2023; Dichev & Dicheva 2017; Kailani et al. 2019). Immediate feedback in games allows learners to understand and adjust their actions in real-time, mastering new skills through trial and error. Multiplayer games and collaborative tasks foster teamwork and communication, as students negotiate, share resources, and work together towards common goals, cultivating valuable skills for both classroom and real-life scenarios (Kailani et al. 2019). Games illustrate the consequences of unsustainable behaviours, aiding students in internalising the importance of sustainability and responsible decision-making. Addressing sustainability challenges requires collective action, and game-based learning (GBL) promotes collaboration through team-based objectives, fostering shared responsibility and collective problem-solving (Adipat et al. 2021). Games also enhance communication and negotiation skills, build trust, and strengthen social bonds among players, encouraging effective collaboration in various contexts.

While GBL offers significant promise, its implementation faces some challenges. Educators must select or design games that align with learning objectives, ensuring gameplay enhances educational content. Logistical and

technical obstacles, such as limited device access and the need for instructor training, must be addressed. Games should be inclusive and accessible, accommodating diverse learning styles, abilities, and cultural backgrounds. Studies show that GBL can enhance public knowledge on social issues, change attitudes toward sustainable development, increase motivation, and facilitate learning (Bilancini et al. 2021; Plass et al. 2015). It equips learners with complex, cross-disciplinary knowledge necessary for sustainable development (Jouan et al. 2020). Despite its advantages, GBL in sustainable development education often focuses mainly on the environment or a single goal, limiting a comprehensive understanding of all aspects of sustainable development (Hallinger et al. 2020).

Game-based learning (GBL) is a potent tool for achieving positive educational outcomes, such as increased engagement, enhanced problem-solving abilities, and the cultivation of collaborative attitudes (Dichev & Dicheva 2017; O'Brien & Costin 2022; O'Brien & Costin 2023). In the realm of sustainability education, GBL presents unique opportunities to simulate real-world scenarios, examine the impacts of unsustainable behaviours, and encourage behavioural change. By promoting a profound understanding of environmental issues and the significance of collective action, GBL can provide learners with the knowledge and skills necessary to contribute to a sustainable future (Douglas & Brauer 2021).

4. Research Approach

Business simulation games are representations of real business situations in a virtual environment/world. Business simulation games enhance learning experiences (Matute & Melero 2016) by providing a context in which students *learn by doing* (Caulfield et al. 2012), providing them with the opportunity to apply theory to practice. The simulation game used for this study is 'SimVenture Evolution', which requires logical reasoning to unravel many complex scenarios, while at the same time enabling students to monitor their progress through appraisals, as well as saving and loading various simulated situations. The game facilitates the development of analytical thinking skills by making demands on students in a captivating and real-world manner. Instructors facilitate rather than teach to foster an inquisitive, creative and analytical mind-set, building students' self-confidence, and promoting teamwork. The game allows users to establish and run a virtual company, testing their knowledge of the various functions of running a business (see Fig. 2).

Figure 2: SimVenture Evolution Interface

Students' decisions are central to the gameplay. The realistic simulation and detailed on-screen information provide a valuable learning resource. In SimVenture Evolution, students take on the role of entrepreneurs assembling, selling and marketing bicycles, beginning from a pre-set point where the business has already been operational for several months. Students individually - and in teams - are tasked with generating profit whilst

also operating in a sustainable business manner. The game focuses on key areas such as Sales and Marketing, Research & Development, Operations, Finance, and Organisation. Teams must identify individual strengths and weaknesses to allocate roles effectively. By the game's conclusion, students are expected to demonstrate their ability to apply analytical decision-making techniques in an integrated manner within a complex simulated sustainable business environment.

The following two sections describe the background context of the study, along with how the data were both collected and analysed.

4.1 Context of the Study

The Business Simulation module is a capstone module designed for postgraduate students completing a taught MSc degree in Business Analytics. For the most part, these students come from non-business backgrounds. The module is designed to reflect the reality of all issues linked to entrepreneurial start-up and business growth, emphasising the development of critical thinking, decision-making and problem-solving skills. Students engage in critical thinking and problem-solving as they navigate challenges within the game, integrating concepts from various perspectives—financial and non-financial. Having gained theoretical knowledge on sustainability and the SDGs, students were then invited to play to game where they had to apply their theoretical knowledge to practice, through the completion of various tasks, utilising various sustainability variables to make key decisions. At the game's outset, students had to set policies on how they will operate sustainably, both in environmental and ethical terms, reflecting the SDGs. The game demands students to pay attention to specific areas of sustainability including variables related to environment, ethics, premises, suppliers and product design whilst also drawing students' attention to the cost and customer impact of improving sustainability, highlighting the realities of "real world" business decisions. The information provided by the game helps students to analyse the outcomes of their decisions and identify potential challenges they may encounter based on their decisions within the game. Furthermore, the game presents performance data at the end of each quarter, allowing students to make more informed sustainability decisions based on emergent trends (www.simventure.com).

4.2 Data Collection and Analysis

A qualitative research method was adopted for this study in the form of student reflective journals gathered and analysed at three intervals in order to gain a deeper understanding of their perceptions, understanding and ability to devise sustainability strategies before, during, and after playing the game. Firstly, students were asked to reflect on the theoretical SDG content initially delivered, to set out their understanding of the SDGs and devise a strategy to implement in the game to achieve individual SDGs. Secondly, students documented strategies they were implementing throughout the game to achieve their goals. Lastly, students were asked to reflect on how the game helped them to achieve their goals. This holistic approach allowed the researchers to delve into student narratives to uncover underlying perceptions and understanding of the SDGs and their achievement through sustainable business practices, generating new insights into how gamification can aid in addressing and developing sustainable business practices. Having collected the reflections, thematic analysis was conducted to investigate the emergent dominant and recurring themes.

5. Research Findings

5.1 Pre-Game: Understanding the SDG's and Student Strategy for Sustainability

Having studied the SDG's from a theoretical perspective, and pledging their commitment to achieving same, students devised a strategy for achieving each goal prior to starting the game. This step was included to ascertain students' level of awareness and understanding of the goals, and to investigate what (theoretical) strategies they planned to implement,.

Students displayed meaningful understanding of **SDG 8: Decent Work and Economic Growth**, highlighting dominant themes of "*Fair wages*"; "*Good working conditions*"; "*Health and safety regulations*"; "*Staff Training & Development*"; and "*Work/Life Balance*". Further demonstrating their understanding, student teams presented various planned strategies to achieve this goal, with the majority focusing on *"employees"* as reflected in the following; "*being an equal opportunities employer*"; "*Developing equitable policy and procedures for employees*"; and "*providing employee safety training and risk assessments*".

Regarding **SDG 9: Industry, Innovation and Infrastructure**, the majority of the teams displayed a less meaningful understanding of same, appearing unsure of what strategies to propose in order to achieve this particular goal. For the most part, student teams proposed generic strategies, placing emphasis on *"innovation*" and "*research and development*" and "*sustainable practices*"; however a lack of definitive strategies was apparent. For the

teams that did demonstrate more insightful understanding of this SDG, the strategies proposed centred on investing in "*new sustainable products"*; "*placing emphasis on resource utilisation*" and "*utilising energy-efficient machinery*", showing confidence in achieving this SDG.

Students demonstrated a comprehensive understanding of **SDG 12: Responsible Consumption and Production**, and results were noticeably clear strategies of how they wanted to achieve this within the game, via the implementation of "*product life extension*" through product longevity, durability, and refurbishment. Waste reduction was also a recurring theme for this SDG, however overall students grappled with devising a strategy for its achievement, instead presenting it as a goal.

Echoing students' understanding and perception of SDG 12, students also showed meaningful understanding of **SDG 13: Climate Action**, highlighting various ways in which they wanted to achieve this goal e.g., "*carbon offset*"; "*renewable energy*", "*sustainable materials*".

Interestingly, some teams proposed mission statements and/or generic objectives rather than specific strategies in pursuit of the SDG's, reflected through the following: *"We are committed to implementing environmentally friendly processes, promoting responsible resource management, and fostering a culture of sustainability within our organisation";* "*Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all*"; and *"Our team aims to create social value by providing sustainable employment opportunities, promoting diversity and inclusion, and investing in employee development, highlighting a lack of awareness of the difference between goals and the strategies required to achieve them".*

5.2 In-Game Sustainability Strategies

Having gained an insight into students understanding of sustainability, and their devised strategies, the findings now turn to investigating students' *in-game* strategic activities in pursuit of individual SDGs. Sustainability strategies for employees, resource usage, emissions and pollution, product lifecycle, supply chain and transportation were emergent dominant themes frequently integrated and interrelated in strategy implementation.

Student teams placed significant importance on "employees" aligning with SDG 8, focusing on pay/compensation, training and development for staff and overall creating an equal, diverse and inclusive workforce. This was reflected in the strategies they set, depicted through the following comments: "*we paid more than the average salary and paid them double the salary for overtime hours*"; "*we made a conscious effort to avoid excessive overtime and only utilised it when absolutely necessary, ensuring that our employees' well-being and job satisfaction were prioritised"; "We also put a lot of effort into encouraging professional growth and offering training opportunities to improve the abilities and skills of our personnel*" and "*In order to achieve these numbers we introduced policies for equal opportunities for all, paid overtime, good working facilities with sufficient space and technology and a focus on training and development".* Resource usage was focal point throughout the game for students in achieving SDG 12 and 13. Evidence of the strategies adopted included: "*we switched to more sustainable supplier of raw materials and bought in bulk to reduce shipping emissions"; "To minimise our influence on the environment, we concentrated on creating eco-friendly products, obtaining raw materials from reliable suppliers, and streamlining our production procedures"; "preserved resources by using space and machinery more efficiently and effectively to ensure waste output is kept at a minimum....also built high quality, durable products that last".*

Interlinked and related to resource usage and SDG12, students also placed emphasis on SG13 with regard to climate action, with strategies echoing those of SDG 12, evidenced in the following examples: e.g. *"we took an excellent approach to managing our energy use, waste, and carbon footprint in an effort to take measurable action towards reducing our impact on climate change"; "we remained faithful to the principles of climate action by incorporating the Lean process to reduce waste into our operations";* and *"we prioritised reducing our greenhouse gas emissions by implementing energy-efficient practices, investing in renewable energy sources, and minimising our carbon footprint*". In addition,, product lifecycle also featured as a presiding issue for students in addressing sustainability , concentrating their activities on extending product lifecycle by making higher quality and more durable products e.g. "W*e believe that we remained faithful to the principles of 'responsible production and consumption' by incorporating the DMAIC methodology of Lean Six Sigma into our operations. With our company's growth and the introduction of new products, we placed significant emphasis on ensuring that each subsequent bicycle release was more sustainable than its predecessor in terms of lifespan";* "*Durability of our products was also of our prime importance as we deployed extensive quality control to ensure*

there are less returns"; and "*We had meticulous quality control in order to reduce returns and reduce carbon footprint".*

In terms of supply chain and transportation, reflections highlighted a high level of awareness of the costs and impact of logistics on sustainability, and student teams made concentrated efforts to tackle this in terms of their business operations. Initiatives included using "*local business for sustainable raw materials*"; "*ensuring high checks to reduce returns to reduce carbon footprint*" and "*not overproducing so as not to place pressure on the supply chain*". Additionally, the findings highlighted students' awareness and understanding of how sustainability and sustainability practices impact and influence numerous and various internal and external stakeholders of the business, highlighting engagement with "*suppliers*", "*customers*", "*employees*", and "*local community groups*", clearly demonstrating their level of understanding of the cumulative effect of developing sustainable business practices.

5.3 Post Game Reflections

Having completed the game, students were asked to reflect on if, and how, the game assisted them in applying theoretical knowledge of sustainability and the SDGs initially presented to them. All teams were positive of how the game developed their level of knowledge on sustainability and the SDGs but of more significance, students highlighted how the game helped them to understand the difference between a sustainability goal and the achievement of such, through strategy development, evidenced by their commentary: "*the game expanded my strategic thinking abilities about goals and objectives .....now recognise the importance of aligning strategic goals with objectives across different functional areas to ensure a coordinated and coherent approach to achieve the sustainability goals. Before simulation, I understood the importance of sustainability, but the experience reinforced how crucial strategy is for sustainability"; "I gained valuable insights into the impact of sustainable business practices for customers, suppliers and my business through the performance metrics. This data-driven approach allowed me to identify sustainable opportunities and optimise production levels".* Echoing this, another team highlighted that "*the simulation game has broadened my perspective on sustainability and equipped me with practical insights that extend beyond theoretical knowledge. It has strengthened my decision-making skills, strategic acumen, and ability to navigate sustainable challenges in a dynamic business environment. The experience has been transformative, preparing me to approach real-world business scenarios with a more informed and adaptive and sustainable mindset".*

6. Discussion and Conclusions

Reflecting on *pre-game* student reflections of their understanding of the Sustainable Development Goals (SDGs), and their ability to devise a sustainability strategy, it was observed that overall, students demonstrated a clear understanding of the SDGs. However, these reflections also highlighted concerns about students' ability to formulate effective sustainability strategies. While students were confident in setting broad sustainability goals, they showed less confidence in devising specific, actionable strategies to achieve these goals.

This initial gap in strategic planning appeared to be addressed through in-game experiences. As the game progressed, students not only proposed strategies with greater confidence but also implemented them more effectively. The game environment provided students with a practical platform to test their strategies and observe the impacts of their decisions. This experiential learning process helped shift students from an idealistic perspective of sustainable business practices to a more nuanced understanding that considers the effects on various business aspects, including customers, employees, and performance metrics.

Game-Based Learning (GBL) proved to be a powerful educational tool for teaching sustainability and the SDGs. It enhanced student learning experiences by leveraging game dynamics such as active learning, competitive play, and diverse performance metrics. Through GBL, students were able to take ownership of their learning journey, actively engaging with and applying their knowledge of sustainability in practical, meaningful ways. From a pedagogical perspective, GBL transformed the delivery of sustainability education into a dynamic, simulated real-world learning environment. This approach facilitated deeper understanding and skill development, as students moved beyond theoretical knowledge to practical application. They were able to see firsthand how their decisions influenced business outcomes, thereby gaining valuable insights into the complexities of sustainable business practices.

This research represents the preliminary findings of a more extensive quantitative study that will further investigate how the sustainability strategies devised by students impact the performance metrics of businesses. The initial findings suggest that GBL can effectively bridge the gap between theoretical understanding and practical application, making it a promising approach for sustainability education.

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AI Chatbot: I Want Help, not the Answer!

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Abstract: : In recent years, the integration of artificial intelligence (AI) into educational settings has become a topic of great interest. As technology continues to evolve, educators and students are exploring how AI can enhance learning experiences. University of South-Eastern Norway (USN) and Kristiania University College (HK) are developing a web-based educational tool, DbPersist, where IT students can practice tasks within the database subject and receive automated feedback. The latest version now also offers students suggestions on how to utilize AI for learning while they are solving various database related tasks. In this study, we explore the students' experiences with getting automatically generated "prompts" for further use in their preferred AI tool, whenever they request assistance. Do they see the value in gaining experience in using prompts designed for learning? Do they believe it might help them using AI for learning purposes in other courses in their study? To answer these questions, we conducted surveys and interviews. Participants included bachelor students across various disciplines and multiple campuses at USN. The participants were all enrolled in database courses with learning goals involving the database query language SQL and ER modelling (drawing Entity-Relationship Diagrams). Early findings suggest that students appreciate the assistance provided by DbPersist's AI prompts. They value the emphasis on AI-assisted learning and find the prompts useful for getting assistance in solving difficult tasks as opposed to getting complete answers. They also see the value in gaining experience in using AI chatbots using prompts designed for learning and understanding. As AI continues to shape education, tools like DbPersist offer exciting possibilities. DbPersist exemplifies how AI may be used to empower students, emphasizing learning and understanding alongside correctness.

Keywords: Artificial intelligence, Prompt engineering, Formative feedback, Active learning, Educational tool

1. Introduction

Using chatbots for educational purposes has been a research topic for several years. In a systematic literature review from 2021, Okonkwo and Ade-Ibijola describe how chatbot technology may be used for educational purpose (Okonkwo & Ade-Ibijola, 2021). Some of the primary benefits of using chatbot applications in education were having quick access and immediate assistance. A year later, ChatGPT was launched in November 2022. In the short time that has passed since ChatGPT was launched, AI chatbots have received a lot of attention in higher education and the research on how chatbots may be used for educational purposes continue (Patel et al., 2023). With the introduction of ChatGPT, some describe the dangers of cheating and misinformation (Rudolph et al. 2023). Gradually, new opportunities for learning begin to be discovered, including increased motivation (Yilmaz, 2023), individually adapted feedback, and more active learning (Rasul et al., 2023). In this paper, we look at how AI chatbots can enhance the effect of a learning tool for use by students in an introductory database course.

Learning technology and AI have a long history (Watters, 2023), and intelligent tutoring systems (ITS) have been developed for various subjects, including for learning database design and SQL (Mitrovic & Holland, 2020). Despite rapid technological development, basic educational challenges are far from being solved. It is not given that increasingly advanced learning technology will contribute to better learning for a heterogeneous student population (Watters, 2023). Although advanced ITSs have been developed and shown to have positive effects on learning in controlled experiments, these tools have not gained the widespread use one would imagine. In part, this probably has to do with the fact that it is expensive to build up the knowledge base (domain knowledge) that such systems require, but also that teachers find it demanding to fit ITS into practical teaching against fixed learning goals (Utterberg Modén et al., 2021).

Today's chatbots, such as ChatGPT, are based on artificial intelligence, machine learning and large language models. They are designed to communicate with the user in natural language. They are also quite capable at generating program code (interpreted in the broadest sense) from instructions in natural language, including for the query language SQL (Chang & Fosler-Lussier, 2023; Dong et al., 2023). Although you can communicate with the chatbot in natural language, heuristics and practical techniques have been developed for how to ask effective questions to the chatbot, e.g. prompt engineering. Chatbots are also programmable, in part you can further train it on your own data with "fine-tuning" techniques (Dong et al., 2023), and you can make the

chatbot communicate with other systems, by making lookups in external data sets using "retrieval-augmented generation" (Guo et al., 2023), e.g. to access up-to-date information on current topics.

Chatbots built on artificial intelligence and large language models open several new opportunities in learning technology, i.e. they may enrich the feedback capabilities of learning tools. In this paper, we investigate how students experience using a learning tool where they may receive prompts generated for AI chatbot use. The prompts are generated for the purpose of learning, and not for receiving a solution. Do students see the value in gaining experience in using prompts designed for learning? Do they believe it might help them using AI for learning purposes in other courses in their study?

1.1 DbPersist

DbPersist is a web-based educational tool developed for an introductory course in databases at university level. The tool is intended to give students the opportunity for volume training on exercises in areas such as ER (Entity Relationship) data modelling and SQL. It is multilingual, currently with support for English and Norwegian. Students from two universities located at several campuses have actively participated in the development of DbPersist.

DbPersist now contains around 50 exercises in data modelling. For each task, a scenario text and a proposed solution model have been created. The proposed solution is a detailed logical ER data model, which defines entities, attributes with data types, identifying and non-identifying relationships, primary and foreign keys. During exercise solving, the student has access to the names of entities and attributes used in the proposed solution and can build up a visual ER model by dragging and dropping these names into a drawing window.

For a selection of the modelling tasks, there are corresponding exercises in SQL, typically 10–20 exercises with proposed solutions for each database. The tool thus facilitates case-based working, where students can follow a case from an informal description via a data model to SQL queries for the resulting database. The SQL exercises test different problem types and techniques, but initially only SELECT queries are supported. Example data have been inserted into each database, so that it is possible to run SQL queries in the browser.

DbPersist is intended to support active and individually adapted learning through a combination of formative feedback and gamification. During exercise solving, the student can request feedback at any time, and then receive automatically generated formative feedback and hints based on a comparison of the student's answer and the proposed solution. The tool also has simple game mechanisms, such as students collecting points by solving exercises, there are leaderboards for overall performance and for each exercise, and you can obtain avatars based on effort and skills.

DbPersist is also an educational research project. The authors all teach an introductory database course. We use and experiment with DbPersist in our own teaching and collect the students' experiences, which are then used to improve the tool (Dæhli et al, 2018, 2020, 2021). The way the tool is developed is a "research lab", where we have interviewed student developers about their experiences (Lauvås & Dæhli, 2022).

The tool has recently been augmented with the option of utilizing ChatGPT, or a similar chatbot, to achieve a richer form of feedback in natural language (Steiss et. al., 2024). When the student solves an ER exercise or an SQL exercise, he/she can click an "Ask AI" button to request a custom prompt to be printed by DbPersist, adapted to the specific situation. This prompt will, among other things, contain a description of the task, the sample database and the student's proposed answer. The student can copy this prompt to the clipboard at the touch of a button, and can paste it into their chosen chatbot, and optionally edit the prompt or follow up with further dialogue with the chatbot. The AI integration is therefore transparent to the students, in a way that allows them to read and modify the prompts that are generated. In doing so, the student becomes an active participant, deciding which exercises to solve and when to request feedback.

2. Method

Students from two different study programs at different campuses at USN were invited to participate in a survey. Both groups took an introductory database course, which included training in data modelling and SQL. It was respectively 70 and 77 registered students in the two groups.

2.1 Designing the Prompt

We needed the learning tool DbPersist to generate a prompt that students could copy and paste into an AI chatbot, and the response from the chatbot should hopefully work as good feedback to the students. There exists extensive research into the effects of formative feedback, and several sound principles have been

developed on what constitutes effective feedback. Formative feedback should be supportive, timely, and specific (Shute, 2008). Also, research-based principles and heuristics for what are effective ways to design prompts for AI chatbots, are about to be discovered. A prompt should be concise and clear, include context and examples (Dong et al., 2023).

From within DbPersist, we have access to information that can be used to generate such a prompt during problem solving such as the assignment text, the student's answer, and the proposed solution. Table 1 shows prompt templates used for data modelling and SQL exercises.

We explain to the chatbot that it will play the role of a teacher and should give motivating feedback (without giving away the answer), and that it will receive both the exercise text and the student's answer. It is given a list of criteria that it should use to assess the student's answers. For SQL exercises, it also gets a compact description of the database. Data models and databases are described in JSON (JavaScript Object Notation) format, which is a textual format useful for describing structured data in a compact manner. The data model includes names of tables and columns, data types, primary and foreign keys, as well as relationships with cardinalities.

We have chosen *not* to include the solution in the prompts, since the prompts will be visible to the students. If we instead had chosen to build a solution where DbPersist passed the generated prompt automatically to the AI chatbot (without showing the prompt to the student), it would probably be better to include the solution.

Table 1: Prompt templates for data modelling exercises (left) and SQL exercises (right).

You are a helpful university teacher who gives an IT course in databases and gives formative feedback to the students. I am a student, and I will enter an assignment text and the data model I have created as an answer to the assignment. Give me motivating and constructive feedback. The feedback should not give away the correct answer, but still be concrete. Limit the response to 700 characters. Structure the feedback as follows: Are there any errors with the names of the tables? Are there errors with the names of columns, or in which table they are located? Are there errors with primary keys and/or foreign keys? Are there any errors with relationships? Are there other errors in my data model? You can skip points that are not relevant. The assignment text in HTML format: <<TEXT>> The data model in JSON format: <<JSON>>	You are a helpful university teacher who gives an IT course in databases and gives formative feedback to the students when they solve tasks in the query language SQL. I am a student, and I will enter an assignment text, the data model for the assignment in JSON format, and the SQL query I have created as an answer to the assignment. Give me a motivating and constructive feedback. The feedback should not give away the correct answer, but still be concrete. Limit the response to 700 characters. Structure the feedback as follows: Am I using correct tables in the FROM clause and are they linked correctly? Have I made a mistake in the WHERE condition? Am I showing the correct columns in the SELECT clause? Am I using GROUP BY and any aggregate functions correctly? Am I using ORDER BY correctly? Are there any other errors in my query? You can skip points that are not relevant. The assignment text: <<TEXT>> The data model in JSON format: <<JSON>> The SQL query: <<SQL query>>

2.2 Lab Exercise

Lab exercises were carried out at two campuses in the last part of the semester. The teacher first demonstrated how to use DbPersist and the chatbot “Sikt AI”, which is a “safe” wrapper around ChatGPT 4 provided for free to students at Norwegian universities. The teacher also demonstrated how to use the “Ask AI” button. The students were then assigned to solve one exercise in data modelling, and three SQL exercises. They were told to use the “Ask AI” button in addition to other help integrated in the tool. We recommended Sikt AI, but they were free to alternatively use their favourite AI chatbot.

2.3 Survey

The survey was carried out directly after the students had tried out DbPersist with AI. The first part of the survey included general questions regarding the students' use of AI in the database subject, and their thoughts on AI in their future professional life (described in chapter 3.1). These questions in the first part were influenced by the Norwegian annual student survey (Studiebarometeret, 2023, pp. 47-52) in which questions regarding student use of AI was included for the first time in 2023. The second part dealt with AI in DbPersist (described in chapter 3.2). The survey contained both multiple choice questions and free text questions. 26

and 31 students, respectively, responded to the survey. In total, this gives 57 answers, which corresponds to a response rate of 39 % of registered students at the two study programmes.

2.4 Interview

After the survey had been completed, we recruited 6 of the students (3 from each campus) for a group interview to go a little more in depth. The interview was conducted on Zoom, without recording. One of the authors conducted the interview, the other two took notes. The transcribed result was anonymous. The group interview used the results from the survey as a starting point. The students were presented some of the most important findings from the survey and were asked to comment/elaborate on the answers. They were also encouraged to follow up each other's answers.

3. Results

3.1 Students use of AI in General

Question: *To what extent do you use artificial intelligence (AI) when learning about databases?* 9% of the respondents do not use AI at all, 16% use AI rarely, 47% use AI occasionally, while 28% use AI often. So, among our respondents 24% do not, or only rarely use AI for learning in their database course. The clear majority (76%) uses AI sometimes or often for learning in their database course.

Question: *What do you use AI for when learning about databases?* Several answers to this question were possible. The result is illustrated in Figure 1. 76% of the respondents use AI to explain concepts and terminology, and 63% use AI to generate code. Close to half the respondents use AI to check their own text (quality assurance) and as a discussion partner.

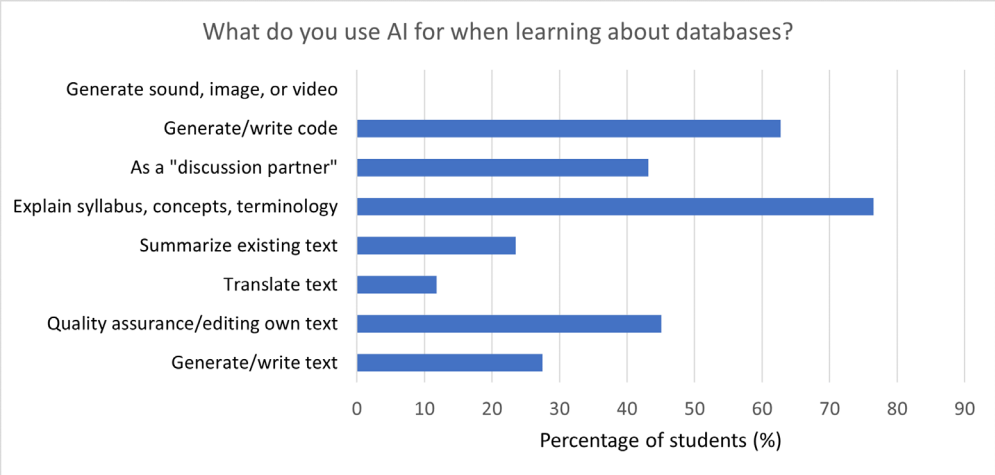

Figure 1: Use of AI when learning about databases

To this question, respondents could also enter free text if none of the given options fit. Some students mentioned the possibility of using AI to find or fix errors in their own code, and to generate test data. Generating test data were also mentioned by one of the students in the group interview: “The way I've used it is for big annoying tasks like filling databases. It has been fantastic, that you don't have to insert one and every value, so you can instead just ask: Insert 100 values, and it's done in 20 seconds.”

Question: *To what extent do you think AI will affect your everyday work in your future working career?* Figure 2 shows that the vast majory (93%) of the students in our survey believe that AI will affect their working career to some or to a large degree. 70% of the students believe AI will affect their working career to a large degree.

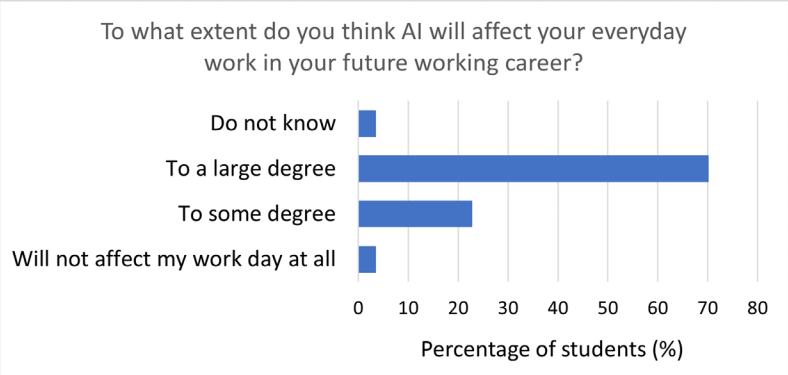

Figure 2: How students think AI will affect their future working career

Question: *To what extent do you think the use of AI should be included in the teaching of the database subject?* As most of the students believe that AI will affect their working career, it is no surprise that the students also believe AI should be included in the teaching of a database course. The majority (91%) believes that AI should be included in the teaching to some degree (52.6%) or to a large degree (38.6%). See Figure 3. However, we also notice that a minority thinks including AI is not required.

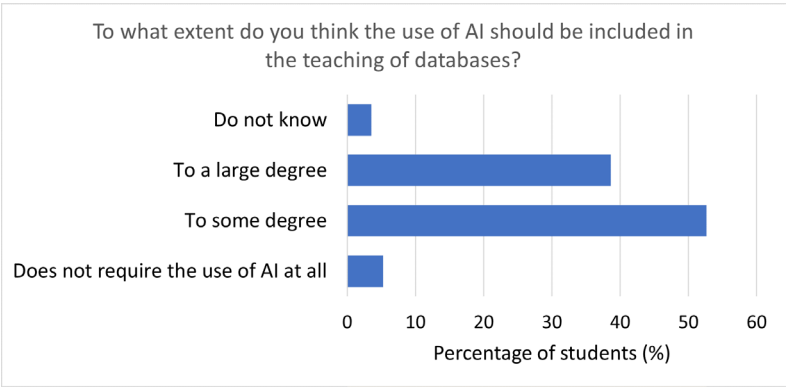

Figure 3: Including AI when teaching a database course

When following up with an open-ended question regarding *how* AI may be included in the course, we received multiple suggestions. Multiple respondents expressed a desire to learn how AI can provide aid without immediately revealing the answers. They were interested in learning how to ask effective questions to AI, and how to use AI to receive tips and guidance, rather than just conclusions. Some referred to this as using AI in "a healthy way" – for learning, as opposed to the unhealthy way for simply receiving a solution. They want to learn how to ask an AI in a way that pushes you in the right direction and encourage you to understand the substance. Some referred to this as using AI sort of like a teaching assistant.

Some respondents suggested that there should be instruction on how to use AI qualitatively to explain concepts. Some already use AI to identify where they are wrong, and most importantly, *why* they are wrong.

The inclusion of complex tasks that are difficult to understand was also suggested, with AI being used to explain these tasks. Respondents believed that AI could be used to explain things in different ways and wanted to see examples of question types that may be useful to achieve that. They also wanted to learn methods to check whether their work is correct and possibly receive feedback on incorrect SQL queries and database models.

3.2 Enriching a Learning Tool (DbPersist) with AI Prompting Capabilities

The second part of the survey consisted of a mix of open-ended questions and statements to evaluate on a Likert scale.

Question: *You have now tested "Ask AI" when working on a modelling task. How did you experience it?* Many respondents found the AI to be very helpful and effective in their learning process. They appreciated the AI's ability to guide them through tasks, provide feedback, and help them understand their mistakes. But multiple respondents found the recommended AI chatbot (Sikt AI) to be slow and imprecise at times.

Many respondents found the AI to be a useful learning tool. They liked that the AI could give them tips about things they may not fully see in the assignments, and that it could help them understand something they were missing. They liked that they could get tips and feedback without falling into the "give me the conclusion" trap.

Respondents liked that they could copy everything straight into the AI, without having to describe the task themselves. They found it great to have a pre-written text that they could copy and paste into the AI. Overall, the respondents found the AI to be a valuable tool in their learning process, despite some issues with speed and precision. They appreciated the AI's ability to provide feedback and guidance and found it to be a useful learning tool.

Question: *You have also tested "Ask AI" when working with SQL. How did you experience it?* The respondents were overall positive to their experience using "Ask AI" when solving SQL exercises. They appreciated the AI's ability to provide tips, feedback, and explanations, which helped them understand their tasks better. Some respondents felt that the AI enriched their learning experience, especially for those who were not very proficient in SQL. But to understand the response from AI, you had to be at a certain level to be able to use the response. They found the AI to be a good sparring partner that could review their work without giving specific answers, which they found beneficial for learning.

A few respondents found the AI to be a bit confusing and unclear at times. As one student put it in the interview: "It works, but you must be specific […]. It is not 100%, like asking a teacher, so to speak, who understands the context, you must be very specific." They felt that the AI occasionally oversimplified the task solution by telling them specifically what to use, instead of pointing out what was wrong and letting them figure it out themselves.

As with the former question in the survey, some respondents mentioned that the AI solution (Sikt AI) was a bit slow to work with. But overall, the respondents found the AI to be a valuable tool in working with SQL, despite some areas for improvement. They appreciated the AI's ability to provide feedback and guidance and found it to be a useful learning tool.

We further asked the students to evaluate the four statements (S1–S4) below, and answer on a scale from strongly disagree to completely agree, with the possibility of not knowing.

- S1: AI-generated answers gave me good help and direction during problem solving.
- S2: I learn more when I get hints and directions than when I get the solution.
- S3: I think it is unnecessarily cumbersome to have to copy questions and paste them into an AI chat.
- S4: This use of AI in a learning tool would be useful for learning also in other subjects in my education.

The results are shown in Figure 4.

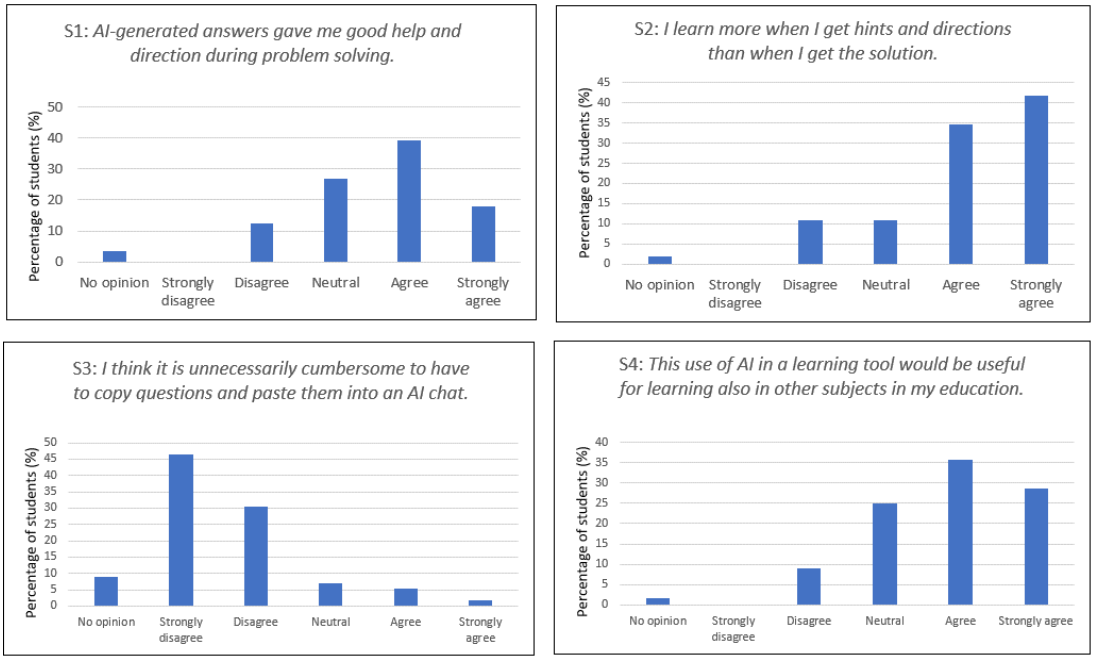

Figure 4: Answers to four statements (S1, S2, S3 and S4) regarding the "Ask AI" button in DbPersist

S1: As figure 4 shows, although not everyone agreed, there was an overall satisfaction in how the AI-generated help assisted them in their problem solving. 58% of the students answered agree or strongly agree.

S2: An even larger majority agreed to the statement that they learn more from getting hints than a solution. 76% of the students either agreed or strongly agreed.

S3: Most respondents did not find it cumbersome at all to copy and paste the AI prompt. 76% disagree or strongly disagree with this statement. On the contrary, one of the students in the group interview argued that the extra "step" was useful to be made aware of the use of AI.

S4: We see from figure 4 that the students experience using AI through the learning tool could be beneficial for other subjects as well. 64% of the students answered agree or strongly agree to this question.

Question: *After asking an AI tool for help with the recommended prompt, did you follow up with further dialogue with the AI tool?* 60% of the students occasionally followed up with further dialogue, 16% always followed up, and 16% never followed up. During the interview, students stated that an AI chatbot could be considered a conversational partner who was always available and to whom they did not have to be afraid to ask "stupid" or repetitive questions. The reason why they often did not feel the need to follow up the dialogue, was that the first response from the AI was often "spot on".

4. Discussion and Conclusion

AI chatbots are often discussed with concern in education, because of their ability to come up with solutions to exercises were students previously had to find solutions by themselves. This requires a shift towards developing the ability to ask the right questions, rather than just finding correct answers. Useful prompting requires a certain understanding of the material. Practicing preparing good and relevant prompts is therefore believed to contribute to learning and understanding.

The students obviously see the potential of AI in education, and the need for knowledge about AI in their studies and later in their professional life. They want to learn more about AI in general and how to use AI as a tool in the database course. The students are aware that you don't learn much from a tool that only output answers and see the value of getting hints that point you in the right direction, but at the same time they admit that it is tempting to use AI generated answers uncritically.

When solving exercises in DbPersist, students found it very useful to be able to generate AI prompts customized to their proposed solution. They did also like that prompts were designed to provide hints to move forward, instead of giving direct answers. Then, they could easily follow up with additional customized prompts. Working in this way, they felt they were also improving their own AI prompting skills, considered as valuable for use also in other courses. It was expected that students would find it a bit cumbersome to have prompts generated, which they then had to paste into a chatbot, but they did not. On the contrary, they see the value of having access to the prompt.

The students appreciated the chatbot's role as a "conversation partner" to whom they could freely ask questions without feeling stupid, and who did not get tired of repeated follow-up questions. There is a lower threshold for asking (many) "stupid" questions to a chatbot, compared to a teacher or tutor. At the same time, they expressed concern that AI could be used as a replacement for traditional teaching. Being able to get help from a teacher who knows the subject and the context, was seen as valuable from a student's standpoint. They considered it as important to balance the use of AI with traditional learning methods.

As for future work, we plan to further investigate how the students use AI prompts in DbPersist over time. The learning tool will still play an important part for students in multiple database courses in the coming semesters. We also want to explore new ways of tuning the prompt suggestions for AI chatbots to further improve the feedback. Over time, we hope to help students become more experienced in using AI for learning and also more self-powered learners.

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Examining the Views of non-e-Tutoring Students on Potential Benefits and Drawbacks of Incorporating e-Tutoring into Their Learning Experience

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Abstract: In recent years, technology integration in education has transformed the learning environment in online institutions. One technological advancement that has gained popularity is e-tutoring which offers personalised academic support to students through online platforms. While e-tutoring has become well-known and has been adopted to promote collaborative learning, there are still students who do not use these services for various reasons. This study explored the perspectives of students who do not utilize e-tutoring services in online education settings, shedding light on their perceptions. A quantitative research approach with a descriptive design was adopted to gather and analyse data on the perspectives of non-e-tutoring students. Online questionnaires were employed as the primary data collection method, allowing for the efficient collection of data from many respondents. The collected data was analysed using the Statistical Package for the Social Sciences (SPSS). Ethical concepts such as informed consent, anonymity of responses and protection of respondents against harm were maintained. Findings indicate that non-e-tutoring students perceive a sense of control over their own pace of learning, suggesting a preference for self-directed learning and the ability to tailor their educational experience to their individual needs and learning styles. They also perceive a lack of clarity in the roles of e-tutors, leading to uncertainty about their responsibilities. In terms of communication, students feel overwhelmed by the volume of announcements and find repetitive information frustrating. Additionally, some students face challenges with their internet connection and associated cost, which can hinder their participation in online activities. Notably, a desire for peer interactions, teamwork, and a sense of belonging in a community highlights the importance of social aspects in online learning. This study recommends that students seek alternate support systems by reaching out to academics and facilitators for guidance and clarification. Developing self-directed learning skills is essential, empowering students to take charge of their own learning through setting objectives, creating own study plans, and utilising resources. For higher education institutions (HEIs), it was recommended that they should ensure that a variety of support services are available to cater to the needs of all students, including non-e-tutoring students.

Keywords: Online-tutor, Student support, Online education, Distance education, Technology, Self-directed learning

1. Introduction

The integration of technology in education has transformed how people learn, interact and transfer knowledge, particularly in online learning environments globally. This shift has facilitated more flexible learning settings, enhanced access to educational resources and fostered global collaboration among students and educators. E-tutoring is one such technological advancement that has become well-known (Liu & Li, 2020), which offers students personalised academic support through online platforms (Maré & Mutezo, 2021). Due to the geographical dispersion of students, availability and other personal constraints, online or e-tutoring has been adopted to promote collaborative learning (Regmi & Jones, 2020). While e-tutoring has grown in popularity among some student demographics, there are still some students who do not use these services for their academic needs (Kibuku, Ochieng & Wausi, 2020). To fully understand attitudes toward e-tutoring and its possible advantages and disadvantages in the context of online education, it is essential to understand the viewpoints of these non-e-tutoring students as they may have a variety of excuses for not doing so. Some students may choose more independent learning strategies, while others may encounter difficulties due to a lack of access to technology or ignorance of the options for online tutoring. Exploring their perceptions can shed light on their understanding of e-tutoring and reveal potential gaps in the current e-tutoring implementation strategies in the Department of Financial Accounting at the University of South Africa.

This study explores how non-e-tutoring students perceive the possible advantages and drawbacks associated with incorporating e-tutoring into their learning experience. Furthermore, this research seeks to identify the perceived benefits and limitations of e-tutoring from the viewpoint of non-e-tutoring students. Understanding the potential advantages of e-tutoring, such as personalised guidance, individualised support, and flexibility in learning, can provide insights into how these benefits can be effectively communicated to non-e-tutoring students, potentially encouraging their adoption of e-tutoring services. Concurrently, investigating the alleged shortcomings or suspicions can help guide the creation of solutions that will increase students' acceptance and contentment with e-tutoring services. The results of this study will enhance comprehension of the distinct

viewpoints of non-e-tutoring students and add to the body of knowledge on e-tutoring in online education. Various studies at the University of South Africa have focused on improving e-tutoring (Enwereji & Van Rooyen, 2023; Maré & Mutezo, 2021), but none has investigated the perceptions of students who opt out of making use of e-tutoring services. The findings of this study will guide educational institutions, policymakers, and online learning institutions in developing policies that will increase the adoption of e-tutoring services and, as a result, raise the standard and efficacy of online learning for all students.

2. Literature Review

The literature review of this study explored the benefits of e-tutoring as well as drawbacks and concerns of e-tutoring usage.

2.1 Benefits of e-Tutoring

The ability of e-tutoring to deliver specialised education and support to accommodate student needs is one of its main advantages. In this regard, Lalitha and Sreeja (2021) confirm that e-tutoring platforms provide individualised learning experiences by changing instructional strategies, content, and pacing following students' particular needs. Makwara (2019) attests that this tailored approach encourages a better comprehension of concepts and improves student engagement, motivation, and self-efficacy. To make sure that the learning experiences of students are in line with their academic goals, students receive tailored guidance through e-tutoring. Bustos-Contell et al. (2021) affirm that e-tutoring offers unparalleled convenience and flexibility, making it a desirable choice for students with hectic schedules or those who need extra help outside of regular class hours. Flexible scheduling, according to Maré and Mutezo (2021), benefits students by enabling them to seek assistance whenever it is most convenient, and because of this adaptability, students can receive high-quality tutoring wherever they are in the world (Youde, 2020). This flexibility removes the restrictions of physical closeness and Eze et al. (2020) sustain that students can schedule sessions around their current commitments, allowing them to balance their academic goals with other obligations.

2.2 Drawbacks and Concerns of e-Tutoring Usage

While there are many advantages to e-tutoring, it is important to recognise and address any potential downsides and issues brought up by students who do not use it. According to Sihlangu and Kheswa (2023), non-e-tutoring students frequently express anxiety about the perceived absence of in-person engagement with e-tutors. Some students prefer the immediate responsiveness and personal connection that traditional in-person tutoring offers (Liu & Li, 2020). In the same direction, Rakoma (2018) argues that the absence of direct communication and physical presence in e-tutoring may be perceived as a disadvantage since students may lose out on the non-verbal cues and individualised attention that come with face-to-face encounters. In line with these opinions, Tartavulea et al. (2020) point out that a further issue is the effectiveness and calibre of online coaching in comparison to more conventional approaches. Some students question the ability of e-tutors to deliver the same level of expertise and instructional effectiveness as in-person tutors (Johns & Mills, 2021). Students who do not use e-tutoring services may have concerns about the perceived trustworthiness and qualifications of e-tutors as well as their capability to give thorough and accurate explanations (Okoro, Takawira, & Baur, 2021).

Kibuku et al. (2020) further assert that obstacles faced by non-e-tutoring students considering using e-tutoring include technical hurdles and problems with platform usability. Concerns may arise regarding their technological proficiency and the potential barriers they may face in navigating the online tutoring environment (Canals & Al-Rawashdeh, 2019). The entire experience and effective engagement with e-tutoring services might be hampered by problems including internet access, software compatibility, and device reliability (Rakoma, 2018). Non-e-tutoring students may express concerns about the potential dependency on technology and its impact on self-directed learning. Digital platforms and online resources are mainly utilised in e-tutoring, which could result in an overreliance on technology for academic assistance (Gomez et al., 2020). Some students may be concerned that e-tutoring may affect their independence in problem-solving, critical thinking, and self-directed learning, all of which are important abilities for their academic and professional development (Dwivedi, 2022). Even though e-tutoring has many advantages, it is important to address any concerns or negative perceptions that non-e-tutoring students may experience. Recognising and addressing these issues will improve the programme's ability to offer practical solutions to improve learning experiences.

2.2.1 Factors influencing non-e-tutoring students' perspectives

The conception of additional support needed by non-e-tutoring students may be influenced by prior academic success and self-perceptions of academic aptitude. Academically successful students may be less likely to seek

help and may believe that e-tutoring is superfluous (Parker, 2018). On the other hand, Mapolisa (2022) affirms that students who believe they are having difficulty or need more support are more likely to be receptive to the notion of integrating e-tutoring into their educational process. The attitudes of non-e-tutoring students on e-tutoring are significantly influenced by their socioeconomic background and access to technology. According to Cullinan et al. (2021), students from lower socioeconomic backgrounds often encounter difficulties getting access to the necessary technological resources, such as dependable internet connections or enabling devices. Limited access to technology can make it difficult for these students to interact with e-tutoring platforms successfully, which might affect how they perceive its advantages and viability (Raviolo et al., 2021). The digital divide, which is characterised by differences in access to and technological competence, also affects the readiness and willingness of non-e-tutoring students to participate in e-tutoring (Sauti, 2021). The adoption of e-tutoring as a learning tool may cause hesitation or anxiety in students who have not had much exposure to technology or who lack digital literacy abilities (Tran et al., 2023). The digital divide further exacerbates existing inequalities in educational opportunities, as students without adequate access or skills may feel excluded or disadvantaged.

The views of non-e-tutoring students regarding e-tutoring are also influenced by cultural variables and personal learning preferences. According to Yang and Yang (2022), cultural norms and attitudes toward traditional face-to-face instruction can affect students' openness to technology-mediated approaches like e-tutoring. While some students could appreciate the social dynamics and interpersonal connection of in-person training, others might be more receptive to using technology-mediated learning strategies (Oliveira et al., 2021). Many elements influence how non-e-tutoring students see the inclusion of e-tutoring in their educational process. Their attitudes and readiness to engage with e-tutoring are influenced by a variety of factors, including prior academic success, self-perception of academic talents, socioeconomic background, access to technology, the digital divide, cultural considerations, and personal learning preferences. Understanding these factors can inform the development of effective strategies and interventions to address barriers, promote inclusivity, and maximize the potential benefits of e-tutoring for all students.

3. Research Methods

The study adopted a quantitative research approach and a descriptive design to gather and analyse data. This design was chosen to obtain a comprehensive understanding of the non-e-tutoring students' perspectives using online questionnaires. Online questionnaires were utilised as the primary method of data collection. Online questionnaires are a convenient and efficient means of gathering data from large groups of participants (Bell, Bryman & Harley, 2022; Coppock & McClellan, 2019). The questionnaires were distributed electronically to 3575 e-tutoring and non-e-tutoring students in the target population. Question 9 of the questionnaire asked if the student makes use of e-tutors. If the student declined, the questionnaire linked directly to the last question, which they had to answer. In this case, 1412 students indicated that they do not make use of e-tutors, and these provided valid responses used in this study. The collected data was analysed using the Statistical Package for the Social Sciences (SPSS). The data obtained from the online questionnaires were entered into SPSS, and appropriate statistical tests such as factor analysis were conducted to examine the relationships and patterns within the data. Validity and reliability of data were maintained through pilot testing and formulating the questionnaires based on the focus of the study and administering it to the students. Ethical considerations were considered throughout the research process. Informed consent, protection of participants, confidentiality and anonymity were maintained by assigning unique identifiers to each questionnaire and storing the data securely. The study adhered to ethical guidelines and regulations to ensure the protection and well-being of the participants.

4. Presentation of the Study Findings

The section gives an overview of the information gathered about students who do not make use e-tutor services. To investigate the underlying aspects or dimensions of the variables connected to the performance of students and study habits, a factor analysis was carried out. This statistical method aids in locating any unobserved influences that might affect the results. The key characteristics of the data set were summarised and described using descriptive statistics. Measures like the mean, median, and mode as well as measures of variability like the standard deviation are all included in these statistics. Descriptive statistics provide a succinct overview of the data, assisting in the comprehension of major trends and variations among the variables under investigation. Communalities in the context of factor analysis describe the percentage of variance in each variable that can be accounted for by the factors found. A better correlation between the causes and the observed variability in the variables is suggested by higher communalities. This analysis helps evaluate the goodness of fit of the identified

factors. Total Variance Explained concludes by presenting the total variance explained by the identified factors. This refers to the proportion of the overall variance in the data set that is accounted for by these factors. A higher total variance explained indicates a greater extent to which the identified factors capture the variability in the variables being studied. Due to the limit of this paper, only the rotated component matrix was presented in Table 1.

Table 1: Rotated Component Matrixa

	Component					
	1	2	3	4	5	6
Q46_OwnPace	.706					
Q47_StayMotivated	.756					
Q48_AbleToStudies	.761					
Q49_AbletoOrganise	.771					
Q50_StudyonMyOwn	.703					
Q51_ContactOtherStud						.846
Q52_PartofGroup						.845
Q55_NotAddressNeeds			.859			
Q56_NotAppealing			.851			
Q57_RoleNotClear			.746			
Q60_GetTraining		.831				
Q61_TrainingOnlineComm		.895				
Q62_TechTraining		.884				
Q63_ManyAnnounce				.730		
Q64_DuplicateAnnounce				.731		
Q65_Redundant				.771		
Q67_BadConnenction					.884	
Q68_InternetCost					.902	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation.						
a. Rotation converged in 5 iterations.						

The idea of rotation is to reduce the number of factors on which the variables under investigation have high loadings. The Rotated Component Matrix shows the factor loadings for each variable and the factor where each variable is loaded most strongly on. Based on these factor loadings, students' perceptions subsets loaded strongly on Component 1, and this is the "self-management" factor group. The "training" factor is strongly loaded in Component 2, while the "non-appealing" subset is strongly loaded in Component 3. Component 4 is mainly comprised of a "repeating-related" subset. Components 5 and 6 are loaded with "internet-related" and "study support" factors, respectively. These factors are discussed subsequently.

5. Discussion of the Findings

The findings show the degree of agreement or correlation with many aspects of the academic experience of students who do not use e-tutors in their studies. The students' perception of having control over their own pace of learning (Q46_OwnPace), which is one important aspect highlighted by these results, suggests that these students generally feel empowered to set their learning speed and have the flexibility to adapt their study strategy accordingly. This data suggests that this subset of students may prefer self-directed learning. According

to Trang (2021), students prefer to tailor their educational experience to their individual needs and learning styles and this approach allows them to delve deeper into topics of interest. The study confirms that the students are motivated (Q47_StayMotivated), which shows that they exhibit a high degree of motivation in their studies while not using e-tutors. Their success in school is probably greatly influenced by their innate desire and perseverance. Additionally, according to the variables Q48_AbleToStudies and Q49_AbletoOrganise, students who do not employ e-tutors often believe that they are capable of effectively participating in their studies and effectively organizing their academic work. This suggests that they have the knowledge and confidence needed to manage their academic career on their own. According to Bujang et al. (2020), students who learn at their own pace have the chance to comprehend the material more thoroughly. This was confirmed by Slavova and Mu (2018) who confirmed that this strategy enables students to reflect on their learning, pursue their curiosities, and take charge of their education. Students can devote more time to mastering difficult topics while working quickly through content that comes more naturally to them by choosing their speed. This tailored strategy encourages self-motivation and a sense of accountability, which will ultimately result in enhanced performance (Akuratiya & Meddage, 2020). According to the variable Q50_StudyonMyOwn, these students are at ease and confident when studying on their own without the help of e-tutors. They probably show more self-reliance and self-control in managing their learning process without substantially depending on external direction or assistance.

Concerning the findings in the second component, variable Q60_GetTraining depicts that e-tutors ought to get training themselves. This shows that the students value having e-tutors who are well-versed in the knowledge and abilities required to properly support their study. They anticipate that e-tutors will be informed about their specialities, current on technological advancements, and skilled in effective teaching techniques. It suggests that these students prefer online tutors who are continually learning to improve their knowledge. This conforms with the findings of De Metz and Bezuidenhout (2018) who opine that e-tutors require constant training to perform exceedingly. The students anticipated in variable Q61_TrainingOnlineComm that e-tutors should be trained in online communication dynamics. This indicates that these students appreciate the benefits of e-tutors being vast in using online communication tools to interact with students, offer advice, and promote a feeling of community. It shows how much these students respect online instructors who can foster a positive, and engaging learning environment. The finding in variable Q62_TechTraining, further portrays students' inclination for e-tutors to obtain technology-related training. This indicates that these students understand the importance of e-tutors' proficiency with a range of technology tools and platforms. They anticipate that e-tutors should be able to help them navigate the use of technology for their studies, including conducting online research, getting access to digital materials, and using educational software. In the same view, Sedio (2021) upholds that e-tutors should be able to navigate the digital learning environment to enhance the academic performance of the learners.

The variable Q55_NotAddressNeeds in component 3 indicates that non-e-tutoring students believe that e-tutors do not sufficiently address their academic needs. This shows a disconnect between the assistance offered by online tutors and the needs or difficulties these students are facing. It suggests that these students look to their online tutors to address their specific learning needs, deliver individualized instruction, and provide support catered to their needs. In variable Q56_NotAppealing, findings depict that non-e-tutoring students do not find e-tutors to be interesting or engaging, and this shows that these students might believe that e-tutors are lacking in some traits or characteristics that would enable them to be valuable and interesting mentors. It might have to do with the educational approach, interpersonal skills, or rapport-building abilities of e-tutors with students. Their perception of e-tutors as unappealing underscores how crucial it is for e-tutors to be able to connect with students, foster a stimulating learning environment, and arouse interest in the subject. These findings are consistence with that of Sedio (2022) who sustains that e-tutors should be knowledgeable to assist students to achieve their academic goals. In variable Q57_RoleNotClear, the non-e-tutoring students confirm that the function of e-tutors is not clear or well-defined. This shows that the precise duties and expectations connected with the function of e-tutors may be unclear or confusing to these students. It might be connected to a lack of clarity in e-tutors' communication or direction, which creates a sense of uncertainty about their roles and how they might attend to students' academic issues. This concern was addressed by Ramorola (2018) who made recommendations to higher education institutions (HEIs) about the definition of e-tutor positions. The study stressed how crucial it is to specify exactly what an e-tutor's obligations and expectations are in online learning environments. The fact that the non-e-tutoring students perceive a position as being unclear shows how crucial it is to define and communicate the tasks and responsibilities of e-tutors in plain terms so that students are aware of how they might profit from their assistance.

The students indicate that they feel overburdened by the volume of announcements they receive, according to the finding in variable Q63_ManyAnnounce in the fourth component. This could indicate that there is an excessive amount of communication coming from several sources, which would result in information overload. The student's capacity to focus on pertinent and vital information may be hampered by their inability to prioritize and keep track of the notifications they receive. This emphasizes how crucial it is to streamline communication channels and make sure announcements are brief, pertinent, and made in a manageable volume to prevent overwhelming students. According to Patteti (2021), one of the institutional online services that can lead to information overload is online tutoring. The study shows that although online tutoring is a great way for students to get help and direction, there are occasions when students might become overwhelmed by the wealth of tools and information offered by these online learning settings. Students may find it difficult to sort through the massive amount of information and prioritize their learning given the growing accessibility of educational resources, discussion forums, and multimedia content. Findings in variable Q64_DuplicateAnnounce specify that these students hear announcements that contain redundant material. The recurrence of announcements across many platforms or channels may be the cause of this duplication, as well as the delivery of similar messages by multiple sources. Students may find redundant announcements annoying since it wastes their time and causes confusion. To avoid redundancy and guarantee that crucial information is disseminated properly, institutions should work to coordinate their communication efforts. According to the variable Q65_Redundant, these students believe that the information presented in announcements is redundant. Redundancy is the repetition of information or the addition of extraneous elements that don't contribute to knowledge or offer value. Repetitive announcements may be viewed as a waste of time and may cause people to tune out crucial messages. Institutions should concentrate on providing brief and focused information, avoiding repetition, and making sure that each announcement has fresh and pertinent information. According to Patteti (2021), one of the institutional online services that can lead to information overload is online tutoring. The study shows that although online tutoring is a great way for students to get help and direction, there are occasions when students might become overwhelmed by the wealth of tools and information offered by these online learning settings.

Findings on the fifth component's Q67_BadConnection confirm that students appear to be experiencing problems with their internet connection. Their capacity to participate in online activities, gain access to learning materials, and effectively communicate may be seriously hampered. A poor internet connection might make it challenging to take part in online discussions or collaborative tasks and can frustrate users. To ensure that students have access to a stable internet connection for their academic purposes, educational institutions can address this matter by constructing dependable internet infrastructure or looking into alternate alternatives. The students' worries regarding the price of internet connection are highlighted in Q68_InternetCost. For students, particularly those from financially disadvantaged homes, high internet prices might be a hurdle. Students may be unable to participate completely in online learning activities and make the most of the available resources and possibilities if they have limited access to inexpensive internet connections. To guarantee that all students have equitable access to resources, institutions should think about helping or researching solutions for affordable internet connection. In a similar vein, Doukakis, Michalopoulou, and Chira (2020) emphasize how crucial it is to guarantee that students participating in online learning have access to dependable Internet connectivity and address the issue of internet cost. The report underlines that for all students to fully engage in online learning activities and access educational resources, they must all have fair access to the internet.

In the sixth component, Q51_ContactOtherStud, findings indicate students' willingness to interact with their peers. Online learning environments may occasionally lack the social interactions and interpersonal relationships that make up the traditional classroom setting. Students appreciate the chance to interact with their peers, share ideas, work on projects together, and develop a feeling of community. According to Martin and Bolliger (2018), institutions should support platforms or initiatives that promote interactions between students, establishing a positive and cooperative learning environment. The last question, Q52_PartofGroup, reveals that students want to be a part of a team or group. Collaborative learning opportunities can improve comprehension, drive, and problem-solving abilities. The advantages of group work and collective learning may be lost on students who do not employ e-tutors. To promote teamwork and collaboration, educational institutions should give students the chance to take part in group activities, projects, or conversations, whether in person or online. The study of Chatterjee and Correia (2020) emphasise the need to support collaborative learning in an online environment. The researchers emphasize the crucial role that collaborative learning plays in encouraging students' active involvement, critical thinking, and knowledge creation. However, transitioning to online learning can present challenges in fostering effective collaboration due to the lack of face-to-face interaction and physical presence.

6. Conclusions

The purpose of the study was to investigate the viewpoints and experiences of non-e-tutoring students in their learning process. A comprehensive grasp of their experiences has been gathered by critically examining how they responded to various aspects of academic success and the use of e-tutors. From the prescripts of the study, it could be inferred that students who do not use online tutors have excellent academic self-control. They demonstrate faith in their capacity to focus, maintain motivation, and efficiently plan their studies. This study shows that this set of students has acquired the abilities and self-discipline needed to succeed in their academic endeavours on their own. It emphasises the significance of encouraging self-regulation in students since it empowers them to take charge of their learning and success. The findings suggest that training including technical skills and online communication is deemed paramount for the e-tutors to succeed. Additionally, communication and technological challenges were seen as major barriers for e-tutors to assist students in an endeavour to succeed in their academic endeavours. More so, the academic experience of non-e-tutoring students was hampered by a poor internet connection and the expense of internet costs. Regardless of whether a student uses an e-tutor or not, these findings highlight the need for institutions to resolve technology limitations and guarantee fair access to resources for all students. The study provides valuable insights for educational institutions to develop strategies and interventions that enhance the academic well-being and success of all students, irrespective of their engagement with e-tutors. By addressing the identified gaps and challenges, institutions can create a more inclusive and supportive learning environment for all students.

7. Recommendations

The study recommends that students who do not use online tutors seek alternative support systems by consulting other academic advisors for guidance. Developing self-directed learning is crucial, which involves setting clear objectives, creating study plans, and utilising resources like textbooks and online materials. Forming peer support networks, participating in study groups, and using a variety of online resources can also enhance their learning. Maintaining open communication with their lecturers for additional help and attending academic workshops and seminars are advised to improve learning strategies. Regularly reflecting on and adjusting learning tactics based on effectiveness is essential for continuous improvement.

For HEIs, the recommendations focus on providing diverse support services, such as study skills classes, tutoring facilities, and academic counselling to cater to all students, including those who do not use e-tutors. HEIs should foster close interactions between lecturers and students, encourage peer mentoring programmes, and prioritise the development of academic skills through workshops and seminars. Ensuring easy access to comprehensive online resources and fostering a supportive learning environment through peer networks and wellness programmes is crucial. Regularly evaluating and adjusting support techniques based on feedback and data analysis will help address the needs of students and enhance their academic experience.

Finally, e-tutors should ensure these learners who do not make use of these services should receive comprehensive academic assistance. Tutors can provide tailored guidance by encouraging students to seek help during office hours or through scheduled appointments, fostering a more personalised learning experience. They should actively promote self-directed learning by helping students set clear academic goals, create structured study plans, and utilise diverse resources, including textbooks and online materials. Facilitating the formation of peer support networks and study groups can also play a crucial role in enhancing student engagement and understanding. Tutors should remain approachable and maintain open lines of communication, ensuring students feel comfortable seeking additional help as needed. Tutors can significantly enhance the learning experience for students who opt not to use e-tutoring services by fostering a supportive and proactive approach.

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Frustration Gap Bridging: A Second Look at Vocabulary Proficiency with the Yes/No Test

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Abstract: This research advances the scrutiny of the Yes/No test's (Meara: 1990) efficacy in evaluating vocabulary proficiency among language learners of high, middle, and low proficiency levels, focusing on its capability to mitigate the frustration commonly encountered by this demographic. As highlighted in the recent investigation (Goetz, 2023), the Yes/No test prompted respondents to signify their word familiarity through binary choices. Yes, they know a word, and No, they don't. Involving a paltry 56 English language learners of lower proficiency to determine if the test's impact on enhancing vocabulary skills had merit, it was found that contrary to the anticipated outcomes, the test did not yield significant advancements in students' performance on subsequent unit tests compared to their counterparts who were not subjected to the Yes/No test. This absence of tangible benefits, combined with the test's failure to deliver a contextualized and nuanced comprehension of vocabulary, raises questions regarding its efficacy as a pedagogical tool for vocabulary enhancement. Nevertheless, the results did not dismiss the Yes/No test's potential utility. For this study, a second look will address two critical shortcomings: the limited sample size and the absence of a diverse range of proficiency levels among participants. This inquiry reevaluates the Yes/No test's capacity to effectively navigate the intricacies of language acquisition, proposing a more in-depth investigation into whether this binary and straightforward approach could indeed be beneficial or whether it underscores the imperative for a more holistic and contextually aware method in language instruction by expanding the sample size and including more proficiency levels. Questions remain regarding the efficacy of the Yes/No test. Is it optimally utilized as a straightforward, standalone tool, or should it be considered within the broader spectrum of comprehensive, context-sensitive learning strategies? This inquiry invites a nuanced evaluation of the test's role in language acquisition. It challenges researchers and practitioners to contemplate whether its simplicity is a virtue in isolation or if its true value emerges when integrated with a holistic approach to learning.

Keywords: Vocabulary, EFL acquisition, Moodle, Student dissatisfaction, Yes/No test

1. Introduction

The Yes/No test, devised by Paul Meara, assesses the grammaticality of a sentence or phrase by requiring a straightforward yes or no response. This test is frequently employed in linguistics to verify whether a sentence is grammatically correct or well-formed. To administer the Yes/No test, a lemma, sentence, or phrase is presented to participants, who must respond with either yes or no. A "yes" response indicates that the item is grammatically correct, while a "no" suggests that it is not. It is useful for in identifying grammatical patterns and structures. It is commonly utilized in developing and evaluating natural language processing systems. It can also assess vocabulary (Meara and Jones, 1990).

The Yes/No test consists of showing learners a series of words and asking them to confirm if they understand them. This test is quick to administer and simple to use, making it a favored method for evaluating vocabulary knowledge.

The Yes/No test can be tailored for different proficiency levels, from beginners to advanced students, assessing general or specialized vocabulary. It helps educators identify areas needing additional instruction.

This straightforward test asks learners to indicate if they know the meaning of words from a given list. This research modified the Yes/No test to suit varying proficiency levels and evaluate vocabulary.

2. Literature Review

The decision to adopt and apply the Yes/No test for this research was influenced by observations from teachers who noted during class that second-year students lacked the lexical knowledge needed to comprehend the written and spoken texts in their textbooks. In a study aimed to illuminate whether the medium of instruction—Arabic or French—used in Moroccan schools affects English vocabulary acquisition among students, a study tested 325 Moroccan Master's students in English using Meara's Yes/No test. The findings revealed an average vocabulary size of 2,293 words among these students. Further analysis showed that students taught in French had a higher vocabulary count (2,417 words) compared to those educated in Arabic (2,058 words) (Agrram, 2020), suggesting that the language of instruction might play a significant role in vocabulary development (Agrram 2020: 203).

The focus for the present study is based upon observations from (T. H. Goetz, 2023) that there may be some variation based on the instructional language, but inconclusive. Questions included curriculum design and who should be teaching, namely, should the teacher be a Japanese national? It is the current policy at a small private liberal arts university in Northern Japan to teach as much as possible in English but to do so within reason.

The Cross Departmental Program for English (CEP), which caters to around 500 first and second-year non-English majors—nearly 40% of the annual student body—holds classes twice a week. Typically, these include one 90-minute session led by a Japanese national and another by a native English-speaking teacher (T. Goetz, 2023). However, with fewer Japanese individuals choosing to teach English, maintaining this structure has sometimes been difficult. This has raised significant concerns and uncertainties about the impact of not having a Japanese national involved in teaching non-English majors. However, due to the decreasing number of Japanese individuals opting to teach English, this arrangement has occasionally proven challenging to maintain. There are notable concerns and uncertainties regarding the absence of a Japanese national within the instruction for non-English majors.[1]

In response to these concerns, it is important to consider the role and relevance of English in a traditionally isolationist Japan. While English is acknowledged as necessary for practical reasons, there is apprehension among some nationalists about over-engaging with foreign cultures, which they believe could undermine Japanese traditions (Aspinall, 2018): 79). This viewpoint has occasionally hindered the advancement of foreign language education, which is crucial in an increasingly interconnected world. Consequently, there is a growing need for more qualified Japanese English teachers, who often seek better opportunities abroad. To fill this gap, qualified non-Japanese instructors are employed, leading to scenarios where the student's first language is considered foreign by their teachers. Given Agrram's suggestion that the Yes/No test could help reduce teacher dominance in the classroom, this approach was considered and perhaps even inspired adapting the test locally, offering a chance for innovative educational practices.

In their 1984 publication, O'Neill & Perez draw attention to Fred Genesee's Classroom Based Assessment (CBA) methodology, as detailed in Genesee's 1999 work (Genesee, 1999). They describe CBA as an innovative approach for assessing the impact of instructional methods on student learning in immersion programs. By collecting data on language usage during teaching and interactive activities, CBA enables educators to adapt their teaching strategies to better meet students' learning needs (O'Neill and Perez, 1994): 6). This methodology represents a departure from traditional teacher-centered assessment methods, shifting towards a more student-focused model. O'Neill & Perez aimed to create a custom, process-oriented, student-centered, and ungraded learning environment that was well-organized and transparent, with clear objectives. They also addressed the local challenges and pressures by reducing teacher and learner frustration and introducing a tailored textbook series for second-year students. Additionally, EFL learners who are non-English majors may or may not be motivated to acquire vocabulary or the target language; instead, they are more focused on getting credit for their effort. To this end, learners must move along a gradient or continuum from passive to active learners (Ali, 2019: 211). Passive vocabulary helps the learners to comprehend written and spoken input, while active vocabulary helps them to express their thoughts and ideas in written or verbal form. Most often, due to their use of determination strategies only, learners cannot consolidate sufficient words.

3. Research Question

The central research question is: To what extent do Yes/No test activities improve learner performance on corresponding unit tests? By focusing on vocabulary competence, essential for comprehending audio texts and other materials, this investigation aims to assess how these tests can boost vocabulary proficiency, aid learners' comprehension of textual materials, and enhance their overall communication skills within the new textbook framework.

4. Materials

In 2022, the Cross Departmental English Program (CEP) adopted a new textbook series. The series adopted was the Q-Series, Listening and Speaking from Oxford University Press, book levels 1 (Scanlon, 2019), 2 (Brooks, 2019), and 3 (Craven and Donnelly Sherman, 2019). All levels were utilized. This series builds on learners' previous knowledge of English to develop more complex listening and speaking skills. The Q-Series Listening and

[1] This situation may create an unfavorable perception for students who might not feel comfortable asking questions to a teacher who doesn't share their first language. Conversely, students might also feel uneasy realizing that someone who may not have the same proficiency in Japanese as they do holds signature authority over their grades.

Speaking books use a variety of teaching strategies and techniques to help learners improve their English language proficiency.

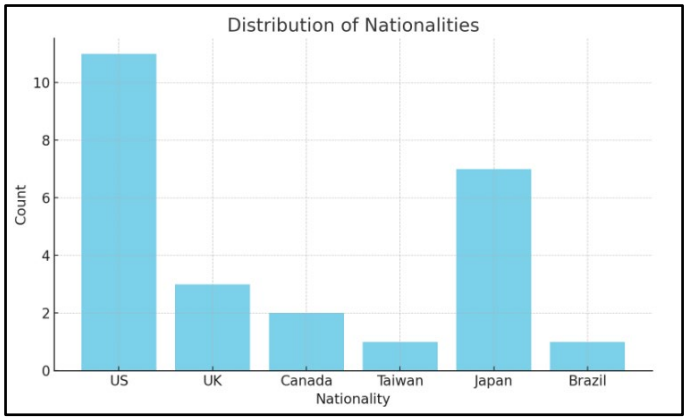
5. Method

5.1 Challenges Encountered

The students in this program are non-English majors fulfilling their foreign language requirements for graduation. Each class comprises 30 CEFR A1 to B1 second-year students.

The teaching team includes skilled individuals with master's degrees, mainly in education. This diverse group, comprising both men and women, brings a wealth of experience to the program, with many serving as adjunct faculty. The full-time tenured faculty members offer a wide range of specializations, including literature, liberal arts history, English education, and EFL training, significantly enriching the educational experience.

Table 1: Distribution of Nationalities on Duty for Instruction for CEP English Classes



In light of the frustration problem, it was decided to apply the Yes/No test to assess vocabulary familiarity with salient materials. Moodle was used as the preferred platform.

5.2 Roadmap for the Development of New Materials

The audio text, sourced from the Oxford Learning Management System (LMS), was downloaded and processed to generate word lists based on their frequency. This process involved extracting the words from the audio content and analyzing their occurrence patterns. By examining the frequency of each word, a comprehensive list was compiled, highlighting the most commonly used words in the audio material.

Lextutor, a web-based language learning tool, provides various resources and functionalities to aid vocabulary acquisition and language proficiency development. It offers a range of tools and activities designed to assist learners in improving their lexical skills and understanding of language patterns (Cobb, 2015). The primary feature of this is its Vocabulary Profiler, which helps learners identify which words and phrases to focus on based on their proficiency level, according to Brown's lists. Organizing words into levels is necessary because not all students will "pick up" necessary vocabulary through exposure alone (Lessard-Clouston, 2012). Research and practice show that explicit vocabulary teaching is often needed. A deliberate, principled approach requires structuring learning environments for such acquisition to occur with respect to the interests, needs, and goals of the students. (Lessard-Clouston, 2012: 288).

ChatGPT, developed by OpenAI and based on the GPT-3.5 architecture ("ChatGPT," 2022), efficiently generated definitions in simple English. By loading word lists from Lextutor, categorized by frequency, into ChatGPT with specific prompts, it produced definitions at the CEFR level A1/A2.[2] For example:

- tall (adjective): having a height above the average or typical
- attract (verb): to draw interest or attention toward oneself
- photo (noun): a picture taken by a camera

[2]The prompt used was: *Dear ChatGPT, please list the parts of speech in parentheses next to the words, followed by a colon and then supply a definition of the word in CEFR level A1/A2 English.*

For translations from English to Japanese on a word level, DeepL, an advanced online translation service developed in Germany, was used. DeepL generates accurate and natural-sounding translations ("DeepL Translate," 2023).

English language words used in Japanese appear in the Katakana script. This script primarily represents foreign words, borrowed words, onomatopoeic expressions, and scientific or technical terms. Words translated directly into Katakana were removed from the item bank because they had already entered the Japanese lexicon. For example, Katakana is commonly used in various contexts, including transcribing foreign words (Drakos, 2001). When Japanese speakers encounter words from other languages, they are often written in Katakana. For example, "□ □ □ □ " (*kōhī*) represents the word 'coffee' in Japanese. Loanwords and borrowed terms: Katakana is used for words borrowed from other languages that have become integrated into the Japanese vocabulary. For instance, "□ □ □ " (*terebi*) means 'television' (Daulton, 2008): 22).

All words were formatted in GIFT with appropriate categories for all twelve courses. GIFT is a plain text file format for creating quizzes and tests in learning management systems (LMS) and e-learning platforms ("GIFT format - MoodleDocs," 2022).

5.3 The Quiz

First, students saw a description on the Moodle page informing them of the tasks' purpose. For the 2,000-word level Yes/No test, students could see this description in their L1:

> *These words are included in the listening materials for this unit. Knowing these words will help you learn English in a more meaningful way. The 2,000-word Level of the New Comprehensive Service English Vocabulary List comprises 2,000 high-frequency words commonly used in English. The 2,000-word level includes everything from hello, thank you, and goodbye to more complex words such as consensus, controversial, and prevalent.*

A similar description appeared for the 3,000-word level Yes/No test.

The quiz settings afforded immediate feedback on demand while in progress, which was essential. When students click "I know this word," they receive positive reinforcement with the display of "Yes!"

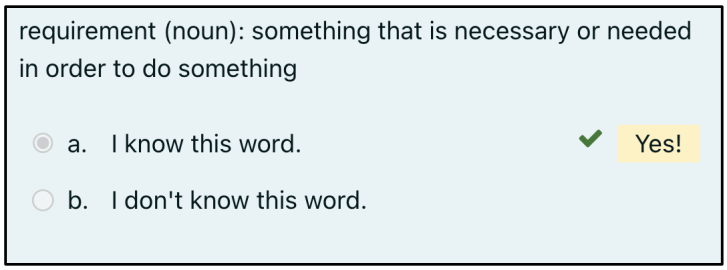


Figure 1: Feedback for a Positive Response

If students do not know the word, they are prompted with a Japanese translation and its part of speech.

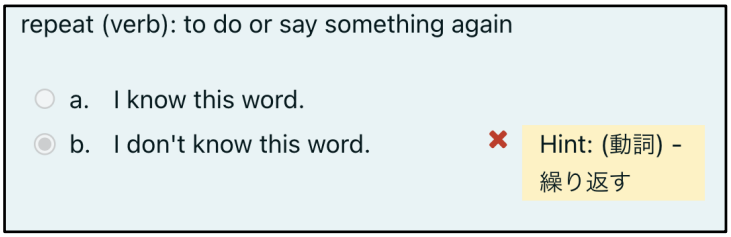


Figure 2: Feedback for a Negative Response

There are four levels of feedback. The 100% level of performance rewards excellence. Receiving a grade of 100% does not show their intrinsic performance, but rather it shows their estimation. The issue here at this top level is moral integrity. If students are honest, they receive feedback reflecting their true performance. Conversely, if

they are merely attempting to impress or deceive, they might temporarily deceive others or themselves, but ultimately, they won't have the knowledge.

Table 2: Four Levels of Feedback

Level	Feedback in Learners' L1	Feedback English Translation
100%	□ ! □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ !	You know all these words! You are ready!
90%	□ □	If you make it to this level, you are good to go. There may still be words you don't know, but be sure to look them up.
80%	□ □	You may get frustrated at this level because there are words you don't understand.
70%	□ □	You are not quite at this level yet, but if you work harder, you will surely improve!

The grade boundary of 80% emphasizes that at this level, unfamiliar words are expected to emerge, leading to moments of frustration. Despite this, persevering and maintaining a positive attitude are encouraged. For those who received a grade of 70%, it is recognized that there is still a considerable distance to go, but with continued effort and determination, significant improvement is certainly attainable. By working diligently, progress can be made. This study aims to offer supplementary support, bridge gaps in knowledge, and ultimately minimize learner frustration.

6. The Study

6.1 Subjects

All registered students in the second year were eligible. Teachers who assigned these quizzes and used the subsequent unit tests were participants. Students were sorted on a placement test into high, middle, and low-performing groups. All data were gathered on the university's Moodle site.

6.2 Data Analysis

An Analysis of Variance, ANOVA, was utilized to detect differences between class and textbook levels with respect to those who did or did not do the Yes/No quizzes according to performance on unit tests in the aggregate for variations among and between textbook groups within a population exceeding 500. This one used the full year's data with the ANOVA.[3]

6.3 Findings

Initially, Goetz 2023 found a non-significant small positive relationship between the Unit Test and Yes/No test variables, with a correlation coefficient of 0.2499 ($r(54)$, $p = .063$). The results revealed a slight positive correlation between unit test scores and Yes/No test responses, with a correlation coefficient of 0.2499 indicating a weak positive link. However, this was not statistically significant and could be attributed to chance. In a One-way ANOVA test, the differences in group means likely reflect actual differences between the groups rather than just random variation within each group. The test uses the F statistic, the variance ratio between the groups, to the variance within the groups. Interestingly, a smaller F statistic suggests that the group means are more likely to be similar and slightly different from other statistical tests.

But this is only one side of what is needed. The differences among differing groups can be found in the Tukey Kramer Test. This method, often simply referred to as Tukey's test or Tukey's Honest Significant Difference (HSD) test, is a statistical tool used to compare the means of different groups after an ANOVA (Analysis of Variance)

[3]All calculations were done online with Statskingdom.com ("Statistics Kingdom," 2017).

test. This post-hoc analysis helps identify which pairs of groups differ significantly in their means after it has been established that there is a significant variation among the groups tested by ANOVA.

6.3.1 High-Level students

Students utilizing Book 3 demonstrate a higher proficiency level, as indicated by their performance on a placement test. Within this cohort, one often finds students who excel in assessments but may exhibit limitations in their productive skills. In a One-Way ANOVA test, using an F-distribution with degrees of freedom (2, 202) and a right-tailed test, the null hypothesis that all group means are equal has been rejected. This is indicated by the p-value of 0.033589, suggesting a low probability (approximately 3.36%) of committing a Type I error("Statistics Kingdom," 2017).

Table 3: One-way ANOVA for High-Level Students

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	18.1834	9.0917	3.4512	0.03359
Error (within groups)	202	532.1398	2.6344		
Total	204	550.3232	2.6977		

As for where in particular the difference lies, further analysis using Tukey's Honestly Significant Difference (Tukey HSD) or Tukey Kramer tests revealed significant differences specifically between the means of the groups labeled High Performers who did all of the Yes/No tests and Middle Performers who did at least one but not all of the Yes/No tests.

Table 4: Tukey HSD / Tukey Kramer for High-Level Students

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
High-Mid	1.0177	0.2763	3.6829	0.09498	1.9404	0.9227	0.02664
High-Low	0.3336	0.1753	1.9026	-0.2519	0.9191	0.5855	0.3718
Mid-Low	0.6841	0.2625	2.6056	-0.1926	1.5607	0.8766	0.1585

This detailed analysis helps understand the extent and specifics of the differences among the groups studied. Notably, those who did not touch the Yes/No tests did have the lowest mean scores, but such scores were not significantly different from those of the Middle Performers. An explanation is that their base language proficiency level is such that non-participation is not a harmful option ("Statistics Kingdom, 2017).

6.3.2 Middle-Level students

Students who use Book 2 are middle-level EFL learners. These students have a decent grasp of basic English grammar and vocabulary but may struggle with more complex language structures and nuances. They can generally understand and participate in simple conversations on familiar topics but may face challenges with fluency, pronunciation, and expressing more abstract ideas. In this example, a One-Way ANOVA test was conducted with degrees of freedom (2, 140), using an F distribution. Several key results informed us about the differences among group averages. The null hypothesis, which posits that all groups have equal means, was rejected because the p-value was significantly less than the typical alpha level of 0.05 (specifically, p = 0.000002886). This very small p-value indicates a high statistical significance, suggesting a minimal likelihood of observing such extreme results due to random chance ("Statistics Kingdom," 2017).

Table 5: One-way ANOVA for Middle-Level Students

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	45.3042	22.6521	13.9917	0.000002886
Error (within groups)	140	226.6552	1.619		
Total	142	271.9594	1.9152		

The test statistic itself was F = 13.9917, which far exceeds the critical value of F at the 95% confidence level (3.0608), further supporting the rejection of the null hypothesis.

As for where the difference lies in particular, further analysis using the Tukey HSD (Honestly Significant Difference) or Tukey Kramer test, which is used for pairwise comparison of group means, identified that the means of the following pairs of groups are significantly different: High Performers and Middle Performers and High Performers and Low Performers ("Statistics Kingdom," 2017).

Table 6: Tukey HSD / Tukey Kramer for Middle-Level Students

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
High-Mid	1.0878	0.2178	4.9937	0.358	1.8175	0.7297	0.001616
High-Low	1.6225	0.2173	7.4666	0.8945	2.3505	0.728	0.00000144
Mid-Low	0.5347	0.165	3.2416	-0.0179	1.0874	0.5526	0.06019

This ensemble of results concludes that not only are there significant differences among some of the groups tested, but these differences are substantial in statistical significance and effect size. Namely, one is better off fully participating in the Yes/No tests, as those participants outscore their peers who either did not follow through or avoided them. Thus, the analysis strongly supports the hypothesis that there is a benefit for those who fully do the Yes/No tests ("Statistics Kingdom," 2017).

6.3.3 Book 1: Students

Students using Book 1 typically exhibit a lower proficiency level, reflected in their performance on the previous year's placement test. There are often "false beginners" within this group, yet some display productive skills without shyness. The analysis provided is based on a One-Way ANOVA test used to determine if there are statistically significant differences between the averages of the three groups. The degrees of freedom for the groups and the error were 2 and 419, respectively.

Table 7: One-way ANOVA for Low-Level Students

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	2	26.4507	13.2254	5.1509	0.006166
Error (within groups)	419	1075.8082	2.5676		
Total	421	1102.259	2.6182		

The F-statistic calculated from the test was 5.1509, with a p-value of 0.006166. This low p-value strongly suggests significant differences between some of the group averages (“Statistics Kingdom,” 2017).

Table 8: Tukey HSD / Tukey Kramer for Low-Level Students

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
High-Mid	0.406	0.1418	2.8638	-0.06557	0.8776	0.4716	0.1075
High-Low	0.5527	0.1272	4.3469	0.1298	0.9757	0.423	0.006361
Mid-Low	0.1467	0.1501	0.9772	-0.3527	0.6461	0.4994	0.7689

Further analyses included the Tukey HSD/Kramer tests, which identified significant differences between the means of the High and Low Performers groups. Levene's test for equality of variances indicated that variances were unequal among the groups. In other words, there was a clear benefit for those who did all of the Yes/No tests as opposed to those who did just one or ignored them altogether (“Statistics Kingdom,” 2017).

7. Discussion

In Goetz 2023, a weak correlation showed that implementing the Yes/No test in its current format at the unit level did little to enable learners to identify essential lexical items for comprehension proactively. The present study shows that those taking the Yes/No tests in full can be separated from those who do not. The criticism is that those students who click “Yes” to every item may be doing so to impress themselves, their peers, or their teacher may learn that such behavior has no benefit and stop doing it. This is evidenced by the significant findings that those who made use of the Yes/No tests attained higher scores on respective unit tests at all levels.

8. Recommendations

8.1 False Alarm Words

Introducing False Alarm Words (FAWs) into the Yes/No Vocabulary Test would enrich the assessment's evaluative depth. In this context, an FAW would require a definition, as learners would expect. Rather than defining an FAW, state to the learners that they have identified one correctly. For that to happen, learners must click “I don’t know this work” to receive a point. To be useful, FAWs must challenge participants to carefully consider their responses and avoid hasty judgments, promoting more significant attention to the tested words. This can enhance their overall engagement and attentiveness during the assessment. Additionally, they simulate real-world scenarios where individuals encounter unfamiliar words and must make informed judgments about them. With respect to the Yes/No test in its original and intended format, the final score is not just a reflection of passive knowledge but a score that shows how confident the learners are about their ability to use the words they claim to know, as evidenced by the False Alarm Hit Rate (Meara, 1990: 5). For a learner to receive a score of 100%, not only must all actual words be recognized, but the FAWs must be as well. Further research is needed to show that these recommendations can yield more reliable results.

8.2 Bridge Yes/No and Unit Tests

Unit tests should include vocabulary items that match those covered in the Yes/No tests. This strategic alignment ensures consistency and coherence across the assessments, allowing learners to reinforce and deepen their understanding of the vocabulary in the Yes/No format. Incorporating these lexical items strengthens learners' capacity to draw connections between different assessment formats, enhancing their vocabulary knowledge and proficiency. Furthermore, aligning the vocabulary in Yes/No tests with unit tests and adopting larger sample sizes could significantly enhance the instructional method's overall effectiveness. Such adjustments are poised to facilitate better vocabulary acquisition and comprehension among learners.

9. Conclusion

This study sought to foster a positive and conducive learning experience by reducing learner frustration. Frustration can arise when learners encounter unaddressed challenges or feel unsupported in their learning process. By providing additional support and resources, the aim is to empower learners and instill a sense of confidence and motivation. This can lead to improved learning outcomes on unit tests and a more rewarding educational experience.

When examining the impact of vocabulary proficiency on learners' overall performance with a new textbook series, one must consider the relationship between vocabulary competence and language learning. This highlights the importance of possessing an extensive lexicon, especially concerning the audio texts at the unit level. By adapting the Yes/No test for use at the unit level, learners will encounter crucial lexical items necessary for comprehension. They can then focus on self-studying the items they have personally identified and enhancing their understanding. During the previous year, it was observed that learners faced frustration due to inadequate vocabulary preparation. Issues such as enhancing vocabulary proficiency, enabling learners to comprehend text material, and students performing better with new textbooks showed that these could be answered from the ANOVA data collected. In other words, insufficient vocabulary knowledge hampers learners' progress and leads to frustration and demotivation. By integrating vocabulary-building activities into existing curricula and adapting pre-assessment measures, in this case, the Yes/No test, results showed that learners benefit.

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Predictive Regression Modeling for Forecasting Graduation Duration in Online Offsite Degree Program

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Abstract: The demand for Information Technology (IT) professionals continues to rise across various sectors, where they play vital roles. However, the supply of IT graduates often fails to meet industry needs and this is a huge problem for the Sri Lankan IT Industry (National IT-BPM Workforce Survey – 2019). In this context, this study presents a predictive regression modelling approach to predict graduation duration in the Bachelor of Information Technology (BIT) degree program at the University of Moratuwa, Sri Lanka. It integrates demographic data—student district, birth year, AL results, OL maths grade, gender, employability status, occupation, and AL stream—along with academic performance indicators like diploma completions and higher diploma completions. After evaluating the suggested features, the key findings indicate the significance of certain features, notably the number of semesters taken to complete the diploma, higher diploma, and the degree. Additionally, demographic factors such as district, birth year, AL results, OL maths grade, gender, and employability status were found to be important. The regression analysis was carried out using the Orange data mining tool (Orange Data Mining). Various algorithms, including random forest, neural network, linear regression, and k-nearest neighbours (kNN), were used to develop predictive models. By adjusting parameters such as metrics, weights, number of neighbours, number of iterations, and training dataset size, the models were optimised to better fit the dataset. Training and testing the models revealed consistent error metrics, including MSE, RMSE, MAE, and R^2, validating the accuracy of predictions. By considering the least and reasonable error in each model, the most suitable model to fit the given dataset was selected. The prediction model accurately forecasted graduation duration for subsequent academic batches, demonstrating its effectiveness in predicting student progress in the program. This research contributes to understanding the factors influencing graduation duration in a distance learning context and provides insights for educational institutions to optimise program planning and student support initiatives. Additionally, it is a good indicator to the companies to gain a better understanding of the availability of future workforce.

Keywords: Predictive analysis, Regression model, Graduation duration, Future workforce, IT industry

1. Introduction

The Bachelor of Information Technology (BIT) degree program is offered by the Center for Open and Distance Learning (CODL) at the University of Moratuwa. The BIT is a three-year degree program introduced primarily for students who have passed GCE Advanced Level (AL) examination in Sri Lanka. This is conducted in the open and distance learning mode. Students use Moodle (Moodle.org) as a learning management system, in a way that students can log in and access uploaded lecture materials. Lecture recordings, lecture notes, and both formative and summative assignments are provided for the students. Formative assignments do not count towards the final grade but are intended to enhance students' understanding. Summative assignments contribute to the final grade. At the end of each semester, students must achieve an average of over 40 from the summative assignments to be eligible to sit for the final examination. The final grade is calculated based on the total of the summative assignments and the final examination.

The programme consists of two semesters per year, resulting in a total of six semesters for the entire program. The programme has two intakes per year for the degree program. The batches are named as follows:

Table 1: The Naming of Student Batches

The batch name	Started Year
18S1	23/04/2018 (in Early 2018)
18S2	22/10/2018 (in mid-2018)
19S1	27/05/2019 (in mid-2019)
19S2	30/12/2019 (in end-2019)

A new curriculum was introduced in 2018, featuring 11 compulsory modules for each of the first two years and 15 modules for the third year. The third year comprises four compulsory and 11 elective modules. If students successfully complete all the modules in the 1st year with an average GPA of over 2.0, they qualify for the Diploma Certificate in IT by the end of the first year. The effective date of the diploma is determined after the completion of the last exam in the 1st year. Similarly, if students complete all modules in both the 1st and 2nd years with an average GPA of over 2.0, they are eligible for the Higher Diploma certificate in IT upon completion of the 2nd year. The effective date of the Higher Diploma is decided based on the completion date of the last exam in the 1st and 2nd years. Furthermore, to obtain the Bachelor of Information Technology degree, students are required to complete all the compulsory modules and, six electives in the third year attaining a semester grade point average (SGPA) above 2.0.

Additionally, students have a total of six years, equivalent to 12 semesters, from the date of registration to complete the program and an additional three years are provided for program completion. Failure to meet this extended deadline may result in an inability to graduate. Based on this, the final academic semester for the 18S1 batch to complete the degree is 23S2. Only students from the 18s1 to 19s1 batches who faced the new curriculum, had the opportunity to graduate by January 2023 as they had completed 6 semesters.

On the other hand, the Information Technology field is rapidly evolving, with sectors like healthcare (Evolving technology in health sector), academia (Technology in Academia: Trends Shaping the Future of Higher Education), and others increasingly dependent on information technology solutions. Transitions from manual to automated systems happen rapidly and so the demand for IT professionals grows. Many people with an IT background are involved in organisations and institutes as Data Analysts, Business Administrators, System Analysts, Data Entry Operators, and so on. Our main goal in the BIT degree program at the University of Moratuwa is to produce IT graduates for the industry. However, the supply of IT graduates remains insufficient to meet industry demands. According to the 2019 survey of National IT BPM workforce (National IT-BPM Workforce Survey - 2019) conducted by the Information and Communication Technology Agency of Sri Lanka, there is a gap of nearly around 12,000 between demand and supply in Sri Lanka. Predicting the number of IT graduates is crucial for staff planning, work planning. This research aims to develop a predictive regression model to forecast the number of semesters students will take to complete their degree, thereby predicting the number of future graduates who will complete the degree program. The belief is that this method can be used for other degree programs as well to predict the number of semesters students will take to complete their degree and forecast the future workforce.

Various studies have predicted graduation rates, student behaviors, and dropout rates at universities. Goenner et al. conducted a predictive analysis (Predicting graduation rates at Doctoral Universities) to understand the factors affecting graduation rates at 258 doctoral universities. They considered factors such as student demographics (age, state, scores) and institutional characteristics (percentage of PhD holders, educational expenditures, student-faculty ratio). In their study they suggest to enhance graduation rates by improving the identified important factors. According to Lidya et al. (Predicting student graduation - 2024), predictive models benefit both students and institutions by facilitating better decision-making. Students can make informed choices about their career paths, while institutions can identify students at risk of not graduating and take proactive measures to improve institutional performance.

The research aims to predict graduation duration using various models and identify the most effective model for prediction.

2. Objectives

The primary objective of this research paper is to predict the number of semesters needed for students to complete the Bachelor of Information Technology (BIT) degree program, drawing data from cohorts enrolled in the 18S1, 18S2, and 19S1 batches. Utilising regression analysis, the study will employ various models to assess their efficacy and select the most suitable model for the dataset. Subsequently, the chosen model will be used to forecast the completion time for future BIT students. Furthermore, leveraging this forecast, the research aims to estimate the number of graduates from the BIT program to facilitate strategic planning and ensure alignment with industry needs. Through these objectives, the study seeks to provide valuable insights into academic progression and workforce preparedness in the field of information technology.

3. Methodology

3.1 Tools

Orange Data Mining software (Orange Data Mining) is utilised in this project to enhance and support the objectives. Orange is a free and open-source software that features a user-friendly workspace for drag-and-drop functionality, allowing users to modify parameters easily. The software offers various tools, including file import, save, view data table, and Python script tools. It also comes with pre-built machine learning models, simplifying the process for users allowing them to adjust the parameters according to the specific dataset. This enables users to train the dataset with various models to enhance efficiency and select the most appropriate one. Additionally, the software enables forecasting of important features based on the designed diagram.

3.2 Feature Selection

The target here is the number of semesters taken by a student to complete the degree. For that, selecting appropriate features for a model is crucial, as the weighting of these features significantly influences the model's construction. Initially, a set of features for our dataset is identified to facilitate model fitting. The primary focus was on students' performance indicators, including the effective dates of diploma and higher diploma attainment. Using these effective dates, the number of semesters taken to reach each educational milestone was calculated from the registration date. Additionally, demographic data such as district of residence, birth year, Advanced Level (AL) examination results, AL stream, z-score, Ordinary Level (OL) mathematics grade, gender, and employability status were taken into account. Prior to incorporating these features into the model, a preliminary test is conducted to evaluate their impact using the Orange software and generated diagrams to examine the variation of the target variable in relation to these features.

		#	Univar. reg.	RReliefF
1	C District	23	NA	0.693
2	C OL Maths	4	NA	0.486
3	N Z Score		NA	0.385
4	N S		NA	0.351
5	C Gender	2	NA	0.351
6	N H.D		NA	0.298
7	N Diploma achieved semester		NA	0.293
8	N C		NA	0.276
9	C Employed	2	NA	0.177
10	N B		NA	0.154
11	N A		NA	0.060
12	N Birth Year		NA	0.046

Gender
Categorical with 2 values: 'FeMale', 'Male'

Figure 1: The impact on the dataset occurs due to the selected features

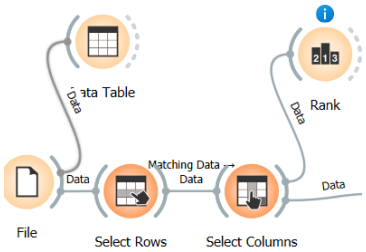

Figure 2: Feature selection

The RReliefF algorithm is utilised as the feature selection algorithm using the Orange data mining tool. The RReliefF algorithm considers both redundancy and relevance, producing a score based on these factors. In the dataset, every feature is attributed a score, and the Rank tool discerns the most pertinent features for the dataset based on this score, analysing the interaction between each feature and the target variable. This approach is efficient for feature selection in a given dataset. Figure 1 illustrates that the District of Residence emerged as the most influential feature in our dataset, exhibiting a high RReliefF score. This result may be attributed to the higher concentration of students from the Colombo District, where the Moratuwa University offers the BIT external degree. The accessibility of Moratuwa University to students residing in the Colombo

District, coupled with the reputation of the BIT external degree program, likely contributes to this observed impact.

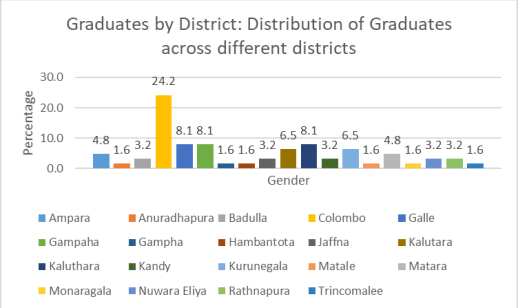

Figure 3: Graduates by District: Distribution of Graduates across different districts

Figure 3 illustrates that the highest proportion of graduates, 24.2%, are from the Colombo district. The second-highest percentage is from the districts of Galle, Gampaha, and Kalutara, at 8.1%, indicating a significant disparity. This suggests that the district of residence directly influences the final number of graduates.

Figure 1 shows that the Ordinary Level (OL) Mathematics grade and gender also significantly influenced the model. A majority of students who received an 'A' grade in OL Mathematics successfully completed the degree, with the majority being male.

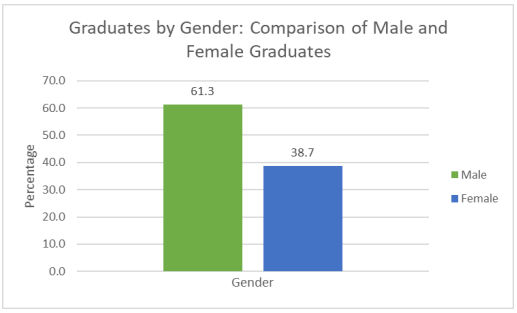

Figure 4: Graduates by Gender: Comparison of Male and Female Graduates

In Figure 4, the majority of graduates are male, comprising 61.3% of the total. Females account for 38.7% of the graduates in the BIT degree program. There was no initial differentiation based on gender at the time of registration; however, this disparity is observed in the final graduation rates.

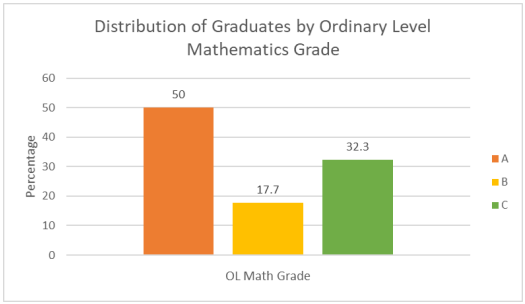

Figure 5: Distribution of Graduates by Ordinary Level Mathematics Grade

The grade in Ordinary Level (OL) Mathematics is considered a measure of students' mathematical aptitude at the time of registration for the BIT degree program. As a primary prerequisite, students are required to achieve a grade above C in their OL mathematics exam to qualify for enrollment in the BIT degree program. Figure 5 illustrates that 50% of the graduates attained an A grade in mathematics. Those who received a B grade accounted for 17.7% of the total graduates, while 32.3% had obtained a C grade and successfully completed the BIT degree program.

The z-score serves as a metric to assess intelligence among students who pursued the Sri Lankan Advanced Level (AL) curriculum across different streams in Sri Lanka. The Rank tool indicate the significance of the z-score as a feature, assigning it a RReliefF score of 0.385 and identifying it as the third most important feature.

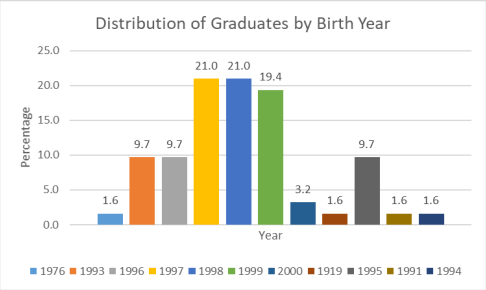

Figure 6: Distribution of Graduates by Birth Year

Figure 6 presents a simple analysis indicating that the highest number of students who graduated from the BIT degree program between 2018 and 2023 were born in 1997 and 1998, each accounting for 21%. The second-highest count is from students born in 1999.

Additionally, the effective dates of diploma and higher diploma attainment were considered, recognizing their significance as milestones toward the final degree. The number of semesters taken to complete the diploma, higher diploma, and degree was determined based on the effective dates.

Utilising the Rank tool in the Orange software and considering the significance, the features selected for the model include the number of semesters to achieve the effective date of the diploma and higher diploma, student district, birth year, z-score, OL maths grade, gender, and employability status.

The data type of our target is numeric, with values such as 7, 8, 9, and so on. Until the 19S1 semester, the number of semesters students have taken to complete the degree is documented. So that can be utilised to align with other features for constructing a predictive model. An additional feature in our dataset is the graduate status, which has binary values of 0 or 1. A status of 1 indicates that the student has completed the degree, while a status of 0 indicates he or she has not. This feature is introduced into our model to determine whether the student is a graduate or not. By analysing these selected features along with the target variable, the aim is to forecast the number of semesters new students will require to complete the degree.

3.3 File Importing and Preprocessing

For data importation, the Orange data mining tool is utilised, by dragging the file onto the workspace and selecting the necessary file. The data types could be modified through a drop-down menu, facilitating adjustments to metadata, numerical, or categorical data as needed. The File import tool allows the selection of features and the omission of unnecessary features as required. Since only the pertinent features were attached to the training dataset, there was no need to exclude any features. Once all the selected features were double-checked for their data type, role, and values, the next step was undertaken.

For the second step, only the students who have completed the degree from the dataset wanted to be selected. The 'Select Rows' tool facilitates to choose relevant records, offering built-in conditions such as 'is equal to', 'is greater than', 'is between', and so on. Using the 'Select Rows' tool, the condition 'graduate status is equal to 1' was applied to filter only the students who have completed their degree from the initial dataset. Then only the graduated students are selected to proceed to the next level.

If the target was not selected during the initial import of the file, the 'Select Columns' tool can be employed to choose the target, features, and metadata. The semester of achieving the diploma, semester of achieving the higher diploma, gender, OL maths grade, z-score, birth year, district, and employability status are identified as important features for the dataset to develop a more fitting model. The students' index number and name are also included in the dataset as metadata and will not be considered as features during the model training. The target in this context is the semester in which the degree was achieved, and it is correlated with these features to construct a more accurate model. The 'graduate status' is disregarded here since only the students who have completed their degree are selected at this stage.

When the data is selected for the model, the involvement of data sampling is considered. As the data sampling type, the tool provides access to various types such as fixed proportion of data, fixed sample size, Cross validation, Bootstrap. For our data set the fixed proportion of data is considered with 75% of the population. Since the fixed proportion of data is considered even how much the data set is, the model takes a fixed proportion of data for the inclusion in the sample. Also replicable deterministic sampling and stratified sample is available. Since a criterion is not conclusive, the stratified sample is not used for the dataset. But for the data

set the replicable sampling is selected. In every iteration a similar result should be the outcome. From this the validity and consistency of our findings can be ensured.

In 2018, students submitted their details including birthdate, Advanced Level (AL) results, Z score, etc., by completing a form and submitting it to the Centre for Open and Distance Learning. However, when students provide this information by hand, strict adherence to required fields can only be ensured if the receptionist checks them. Additionally, there may be misarrangements and displacements in some fields when information is handwritten, raising questions about accuracy. The data is not validated before being handed over to the department. After several years, the papers are then started to be inputted into the databases. Consequently, missing values emerge in such cases. It is preferable to complete the dataset before commencing modelling, as this resolves incompleteness. This necessitates performing check-ups and processes to handle missing values, incorrect values, and misarrangements. One approach involves removing rows containing missing values, while another involves replacing missing data with random values. Alternatively, missing values can be substituted with either the average or most frequent values. In our dataset, the third option, a straightforward approach wherein missing values are replaced with either the dataset's average or the most frequent values, has been chosen. Imputing missing values can mitigate biases in certain features stemming from incompleteness.

Normalisation also plays an important part in data preparation. In our dataset, according to Sri Lanka's curriculum, the Advanced Level qualification is evaluated by considering the Z-score. The AL Z-score is determined by dividing the difference between the actual mark and its mean by the standard deviation. (AL Z score calculation). In this dataset, the Z-score values range from 0.000 to 2.7564. Additionally, if the birthday is considered, it consists of an integer with 4 digits. Combining these two features onto a single pane poses a challenge. To align the numerical features within the same scale and reduce the distribution across the Cartesian plane, normalisation is utilised. In this case, Z-score standardisation is employed, with a mean (μ) of 0 and a variance (σ^2) of 1, known as standard normalisation. The following equation is used to calculate the normalised values:

$$Z = \frac{X - \mu}{\sigma}$$

Here, X represents the individual value of the specific feature.

μ denotes the mean or average value, calculated by dividing the sum of the individual values by the total number of values.

$$\mu = \frac{\sum_{i=1}^{n} X_i}{n}$$

σ^2 represents the variance, calculated using the following formula:

$$\sigma^2 = \frac{\sum_{i=1}^{n} (X_i - \mu)^2}{n}$$

Here, X_i represents the individual value of the specific feature, μ is the mean, and n is the total number of values. Given that the tool offers built-in functions for calculating standard deviation, there is no need for manual computation of each equation at this stage.

Index No.	Name	Gender	OL Maths	Z Score	Birth Year	District	Employed	Diploma achieved semester	H.D. achieved semester	Degree achieved semester
E1841008	Amarasena GCS	Male	A	0.0602	1995	Hambanthota	Not Employed	2	4	7
E1841016	Ariyarathne MUP	Male	A	0.2915	1997	Kalutara	Not Employed	2	4	8
E1841045	Fernando WMTD	FeMale	A	0.2354	1997	Kalutara	Not Employed	2	4	7
E1841048	Galabada GKDDC	FeMale	A	0.0087	1999	Colombo	Not Employed	2	4	7
E1841049	Gangadeera MBTD	Male	B		1995	Galle	Not Employed	5	8	8
E1841057	Herath HMTD	FeMale	C	0.2233	1991	Kandy	Employed	2	6	8
E1841058	Inshaf IM	Male	C	0.1045	1998	Ampara	Not Employed	2	4	7
E1841061	Jayathissa KYGVP	Male	C	0.0240	1993	Nuwaraeliya	Employed	2	4	7
E1841068	Kalhara HHN	Male	A	0.0409	1997	Matara	Not Employed	5	6	8
E1841071	Karunadhara PALS	Male	C	0.0000	1999	Gampaha	Not Employed	3	4	7
E1841083	Madhusanka KWD	Male	C	0.5491	1995	Monaragala	Not Employed	4	4	7
E1841084	Madushika AK	FeMale	B	0.6179	1995	Ratnapura	Not Employed	2	5	6
E1841086	Mendis DLK	FeMale	B	0.9739	1993	Galle	Employed	2	4	7
E1841089	Mohamed Ilham S	Male	C	0.3155	1998	Nuwaraeliya	Not Employed	5	7	9
E1841093	Naveedth Ahamed AB	Male	C	0.5618	1998	Ampara	Not Employed	2	6	8
E1841105	Piratheeba G	FeMale	C	0.0179	1996	Jaffna	Not Employed	2	4	9
E1841107	Pradeetha YCM	Male	B	0.3725	1997	Kalutara	Not Employed	2	5	6

Figure 7: Before Normalisation

Index No.	Name	Gender	OL Maths	Z Score	Birth Year	District	Employed	Diploma achieved semester	H.D. achieved semester	Degree achieved semester
E1841008	Amarasena GCS	Male	A	-0.7100	-0.3916	Hambanthota	Not Employed	-0.4856	-0.5174	7
E1841016	Ariyarathne MUP	Male	A	-0.2586	0.1469	Kalutara	Not Employed	-0.4856	-0.5174	8
E1841048	Galabada GKDDC	FeMale	A	-0.8106	0.6854	Colombo	Not Employed	-0.4856	-0.5174	7
E1841049	Gangadeera MBTD	Male	B	0.0000	-0.3916	Galle	Not Employed	2.8880	3.2766	8
E1841057	Herath HMTD	FeMale	C	-0.3917	-1.4687	Kandy	Employed	-0.4856	1.3796	8
E1841058	Inshaf IM	Male	C	-0.6236	0.4161	Ampara	Not Employed	-0.4856	-0.5174	7
E1841068	Kalhara HHN	Male	A	-0.7477	0.1469	Matara	Not Employed	2.8880	1.3796	8
E1841071	Karunadhara PALS	Male	C	-0.8275	0.6854	Gampaha	Not Employed	0.6389	-0.5174	7
E1841084	Madushika AK	FeMale	B	0.3784	-0.3916	Ratnapura	Not Employed	-0.4856	0.4311	6
E1841086	Mendis DLK	FeMale	B	1.0733	-0.9302	Galle	Employed	-0.4856	-0.5174	7
E1841089	Mohamed Ilham S	Male	C	-0.2118	0.4161	Nuwaraeliya	Not Employed	2.8880	2.3281	9
E1841105	Piratheeba G	FeMale	C	-0.7926	-0.1224	Jaffna	Not Employed	-0.4856	-0.5174	9
E1841107	Pradeetha YCM	Male	B	-0.1005	0.1469	Kalutara	Not Employed	-0.4856	0.4311	6

Figure 8: After Normalisation

Figure 7 displays the data prior to normalisation, while Figure 8 illustrates the data post-normalization. If metadata such as index number and name is considered, features like Z-score, birth year, achieved diploma semester, and achieved higher diploma semester are shown as normalised. This ensures that all variables are aligned to the same scale, ranging from 0 to 1.

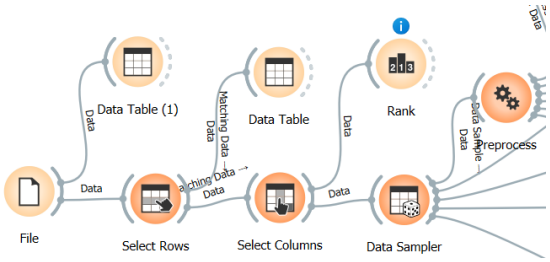

Figure 9: Data selection & Data preprocessing

Figure 9 depicts the diagram used for preprocessing the data prior to modelling.

3.4 Modelling

The subsequent step involved constructing the machine learning model, which was accomplished utilising the Orange tool. Within the tool, various built-in algorithms were available. The selection of the most appropriate model for our dataset was pivotal. Given the objective of predicting numerical values, the focus was on constructing a regression analysis model. The available built-in models, including Random Forest, Neural Network, and Linear Regression, were evaluated. The objective was to fine-tune their parameters and develop a model that most accurately defines the dataset.

3.4.1 Neural network

In a neural network, as the number of layers increases, the model's accuracy typically improves, which mitigates underfitting. However, if the number of layers exceeds the necessary amount, the model may attempt to capture all characteristics unnecessarily, leading to lower accuracy and overfitting. Therefore, it is crucial to select an appropriate number of layers that best fit the dataset. In this study, a neural network algorithm with 100 hidden layers is utilised to construct the model.

The Rectified Linear Unit (ReLU) is employed as the activation function for the dataset, defined mathematically as follows:

ReLU (x) = max(0,x)

This implies that if the input value is positive, the ReLU function outputs that value, and if the input value is not positive, it results in zero. The advantage of the ReLU function is that it does not encounter the vanishing gradient problem experienced by activation functions such as tanh and sigmoid when the gradient becomes too small.

A solver is employed as the optimization algorithm to adjust parameters such as weights and biases during the training of the dataset. This optimization function is utilised to minimise the disparity between the actual value and the predicted value. Adaptive Moment Estimation, known as Adam, is utilised as the optimization technique in this study. While balancing adaptive learning rates for every parameter, the algorithm calculates the gradient and squared gradient while considering the historical behaviour of the gradient.

The number of iterations is set to 200 so that the model undergoes forward and backward passes 200 times. Additionally, replicable training is employed, ensuring that these parameters are reproducible.

3.4.2 Linear regression

In our study, the "fit intercept" option is enabled, allowing both the intercept and gradient to be estimated by the linear regression model.

Regularisation which involves adding a penalty to the loss function to prevent overfitting is also an option here. This penalty encourages the model to be simpler, thus avoiding unnecessary complexity. However, in our case, regularisation is not employed because the features in our domain are deemed perfectly relevant. Furthermore, to effectively demonstrate the relationship between students' demographic data and their academic parameters, a simple model is preferred.

3.4.3 Random forest algorithm

In the Random Forest algorithm, the number of trees is specified as 10. Consequently, the model comprises 10 decision trees, each trained independently on the training dataset. The parameter "min_samples_split" is set to 5 in this context. "Min_samples_split" denotes the minimum number of samples required to split a node during the construction of a decision tree. As a result, if the number of samples in a node is equal to or less than 5, the decision tree will refrain from further partitioning the node.

3.5 Test and Score

Efficiency testing of various models was conducted by directly connecting the test tool to our model. Evaluation metrics including Mean Squared Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Coefficient of Determination (R2) were utilised. The training set size was configured to 75%, and the model was assessed on the test dataset.

Model	MSE	RMSE	MAE	R2
Random Forest	0.129	0.360	0.290	0.837
Neural Network	0.380	0.617	0.453	0.520
Linear Regression	0.271	0.521	0.398	0.658

Figure 10: Test scores by model

Approximately the same errors appeared after manually calculating the Mean Squared Error (MSE) for these models, confirming the values obtained from the Orange data mining tool.

Table 2: Errors manually calculated by model

	Random Forest	Neural Network	Linear Regression
$\sum Error^2$	7.1994	17.8790	12.7417
n	47	47	47
MSE	0.1531	0.3804	0.2711

All of these models aim to predict the number of semesters required for students to complete the degree program. Among them, the Random Forest algorithm was identified as the optimal model, with 10 decision trees and a min_samples_split of 5.

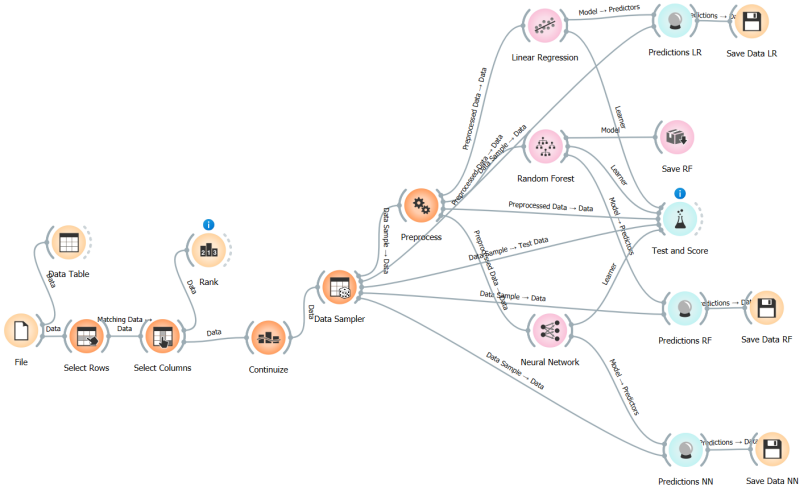

Figure 11: The diagram designed for the model building and testing

Figure 11 depicts the diagram used to design the entire modelling process.

4. Prediction

As previously mentioned, the training dataset consisted of students who graduated from the 18S1, 18S2, and 19S1 batches. Additionally, two more batches, 19S2 and 20S1, who had completed up to the higher diploma level, were included for predictions. Consequently, predictions were made regarding the number of semesters they would take to complete the degree. In August 2024, another convocation ceremony was held, resulting in the graduation of additional students from the 19S2 batch.

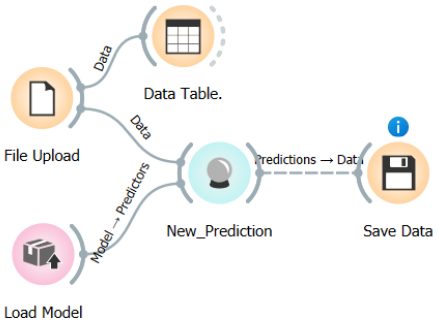

Figure 12: Diagram for prediction purpose

Figure 12 depicts the diagram utilised for prediction purposes. The process involves uploading the new dataset from the file option, followed by loading the model that best represents our dataset from the load model option. Subsequently, prediction is conducted, and the resulting output is saved in Excel file format using the save data option.

After predicting the completion duration for the 19S2 batch, a comparison was made between the predicted values and the actual values. The Mean Squared Error (MSE) was calculated as follows:

$$MSE = \frac{\sum Error^2}{n}$$

MSE = 4.15/11

MSE = 0.37

5. Conclusion

In this research, demographic features such as District, Birth Year, Gender, OL Maths, Z Score, Employability, and academic performance factors including Diploma completed semester, Higher Diploma completed semester were selected. The Random Forest Algorithm was employed for modelling, utilising 10 trees and a minimum sample split of 5. Initially, a fixed proportion sampling technique was applied, encompassing 75% of the population for sample selection. The model was trained using this data and subsequently tested on test data samples from the first three batches introduced after 2018: 18S1, 18S2, and 19S1.

The Random Forest model's performance was assessed through manual calculation of Mean Squared Error (MSE), yielding a value of 0.153, which closely approximated the tool-generated MSE of 0.129. Upon model training, it was saved as a pkls file for later use. In the prediction phase, the model was loaded to forecast the number of semesters required for students to complete their degree. Subsequently, this information was utilised to determine the overall duration for degree completion.

The model's predictive capabilities were further evaluated using data from the 19S2 batch, where predictions were made for students, some of whom subsequently graduated after convocation. By comparing the actual and predicted number of semesters taken to complete the degree, a new MSE value of 0.37 was obtained, indicating a somewhat higher level of error. It was suggested that with a sufficiently large dataset, this error could be mitigated.

The significance of this model lies in its ability to forecast the duration required for degree completion, thereby enabling estimation of the future workforce entering the industry at specific times. Additionally, by considering the backward process, it facilitates determination of the number of students needed to initiate degree programs to meet desired workforce levels. Furthermore, it allows for consideration of graduate benefits and infrastructural requirements. The versatility of this model extends to its potential application across other degree programs, provided relevant datasets are available for submission.

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Enhancing STEAM Education with AR: A Primary Education Teacher Training Study

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Abstract: This research delves into the influence of Augmented Reality (AR) on Science, Technology, Engineering, Arts, and Mathematics (STEAM) education within the domain of primary school teacher training at the university level. The core aim is to augment digital literacy within the primary education framework through inquiry-based teaching methods. This investigation was organized among students enrolled in the Faculty of Education, Comenius University in Bratislava. The empirical research is devoted to the contribution of AR technologies to the enhancement of STEAM education and its implications for future primary education teachers. Utilizing a qualitative research methodology, the study facilitated small-group project work among students, complemented by focus groups and interviews to garner comprehensive insights into their experiences and perceptions. The findings of this study illuminate the significant role of AR applications for enriching STEAM education, manifesting in motivation of future teachers and the advancement of specific STEAM competencies. The results indicate the advantage of the integration of AR technologies in educational settings as a tool for supporting digital, technical, and artistic skills among students. The research results are possible to use in the innovation of teacher training primary education study program. An interdisciplinary approach towards STEAM education can help future teachers to navigate and to understand a technologically driven world effectively. Furthermore, the study offers actionable recommendations for practicing primary school educators on the implementation of AR-based pedagogical strategies to enrich the learning experience. By doing so, it aims to bridge the gap between traditional educational methodologies and the demands of contemporary digital literacy, ultimately fostering a more engaging and effective learning environment for future generations. The research results will be implemented into the STEAM oriented subjects into the primary school teacher training at the university level and in the lifelong learning of the in-service primary school teachers from educational practise.

Keywords: Augmented reality in education, AR ruler application, Primary education, STEAM education, Teacher training

1. Introduction

The main aim of this study was to investigate the link between STEAM education using augmented reality and the development of digital, technological, and mathematical competencies. The research was conducted as action research with students of the Faculty of Education who are future primary school teachers. Participants were enrolled in mathematics, geometry, and technology-focused courses that covered certain components of STEAM education. Another research aim was to strengthen students' digital competences within the innovated primary school curriculum, which expect the usage of ICT tools in STEAM education and development of digital competences of primary education pupils.

During the courses, students were introduced to the use of augmented reality applications in pre-primary and primary education, including popular applications such as Quiver and Animals D4. Based on this knowledge, students were tasked with designing and implementing a project for pupils aged 6 to 11 years old. The project focused on STEAM learning outside of the classroom, mainly through field activities in the school or in the students' local area.

In terms of mathematics, the project emphasized concepts such as geometry, estimating distances, lengths and possibly areas, along with other related mathematical principles. Students were instructed to record their estimates of building dimensions and then use augmented reality applications to obtain measurements that they could compare to actual values. In addition, they were encouraged to investigate various mathematical aspects of the buildings or objects under investigation, such as symmetry and geometric shapes.

Art education also played a key role in the project. Students were expected to engage in discussions and guesses concerning the artistic qualities and architectural styles of the buildings or monuments they encountered. These estimates were then to be compared with information available on the internet, allowing students to gain a deeper understanding of the artistic aspects associated with the buildings in question.

In the project, students used mathematical competences such as calculating the content, volume and reduction of solids. The students calculate surfaces and volumes of different kinds of buildings. They also used technical parameters to correctly represent models of buildings, thus linking mathematics and technology knowledge. The students also developed technical competences by constructing mentioned models.

The integration of technology was achieved through searching for interesting facts about the buildings or objects, including details about the building materials used and significant historical events related to the buildings. In addition, the project considered the possibility of incorporating virtual tours of selected buildings, further enhancing the technological component of the project.

Geometry and measurement are pivotal in the mathematics curriculum of primary schools, fostering students' mathematical reasoning, spatial intuition, and real-world imagination. Estimation, deeply intertwined with number sense and measurement, is of paramount importance as a mathematical skill (Lucas & Son, 2013).

Performance standards for mathematics education emphasize the development of students' ability to estimate the lengths of line segments, shorter lengths in centimetres (or millimetres), and longer lengths in meters. Thus, mastering estimation becomes crucial in an educational context, serving as an indispensable skill for daily life and decision-making. Siegler and Booth (2004) underscore the importance of estimation in practical scenarios, such as predicting travel time, gauging object weight, and measuring distances, highlighting the necessity for reasonably accurate estimation skills.

Visualizing plane and spatial geometric figures during primary-level mathematical lessons can bolster students' measurement sense, closely tied to estimation abilities. Using concrete materials in the classroom has proven to enhance understanding of mathematical concepts related to geometric figures (Gilliland, 2002). Modern technological tools, like augmented reality applications, enrich visualization, further elevating the learning experience.

Merging contemporary technology with innovative teaching methods can effectively nurture geometric literacy, including the skill of length estimation. In our research, we adopted the project method tailored for prospective primary teachers.

Project-based learning (PBL) is a student-centric teaching approach emphasizing inquiry, collaboration, and real-world application. It engages students in addressing authentic problems or questions, fostering deeper comprehension and skill enhancement (Buck Institute for Education, 2018). Nevertheless, PBL's potential in enriching learning and equipping students for contemporary challenges renders it an invaluable educational approach. The concept of STEAM (Science, Technology, Engineering, Art, Mathematics) education is based on constructivist pedagogical principles and emphasizes teamwork, collaboration, and discovery; therefore, it shares many commonalities with PBL (compare with Wahdaniyah et al., 2023).

In our approach, we integrated a project-based method with STEAM content for training future educators, incorporating augmented reality applications to amplify measurement tasks. Adhering to STEAM principles, our action research aimed to deepen students' geometric understanding and refine their estimation skills. By leveraging augmented reality, we sought to create an immersive learning environment, arming future educators with tools to enhance geometric literacy in their students.

2. Literature review and Theoretical Background

2.1 STEAM Education for the Pre-Service Teachers

The STEAM concept, which stands for Science, Technology, Engineering, Arts, and Mathematics, is integrated into various learning areas of the Curriculum for primary education.

Innovations in science and engineering are expected to be the primary economic drivers and job creators. As technology replaces certain jobs, understanding math becomes essential for science, which subsequently drives technology. Engineers are crucial for production, and design ensures products are both functional and aesthetically pleasing. As a result, an increasing number of jobs will require STEAM knowledge. Integrating STEAM subjects can enhance learning quality, foster creativity, and motivate work. However, 21st-century educators must consistently update their skills to effectively teach emerging technologies. While their responsibilities may increase, the quality of teaching remains dependent on their commitment to content. Education should be adaptable, laying a foundation for rapid advancements and self-adaptation to technological shifts. Researchers indicates a need for more professional development for teachers in modern STEAM technology integration. (Gajić & Cekić-Jovanović, 2022).

In primary education, STEAM incorporates tasks and environments that merge knowledge from various fields, such as art, architecture, culture, and history, into mathematics instruction. This approach aims to enhance reasoning and problem-solving abilities among students, using their mathematical knowledge at their level. Students can observe buildings of different architectural styles, helping them identify connections between various disciplines of study, including mathematics, culture, and history. Through tasks, procedures, and educational activities, students can integrate primary mathematical knowledge with architectural elements found in their surroundings or places they visit. During walks or excursions with their teacher, students can gather data related to specific buildings representing different architectural styles. By designing STEAM activities that connect culture, history, and architecture to mathematical learning, the objective is to foster modelling skills, imagination, and problem-solving abilities while developing students' specific mathematical expertise, such as measuring and estimating lengths (as seen in El Bedewy et al., 2021).

The ArchiSTEAM approach in architecture education extends beyond the traditional teaching of STEAM disciplines. It incorporates collaborative learning methods that seamlessly blend these subjects. This approach aims to bolster students' 21st-century skills, fostering creativity, innovation, and improved learning outcomes. The STEAM methodology promotes a harmonious integration of disciplines and provides a teaching framework that empowers instructors from diverse fields to cultivate a progressive learning environment.

Integrating STEAM education with augmented reality (AR) applications offers an innovative approach to educating the alpha generation's pupils. Born after 2010, these pupils have grown up with technology as an intrinsic part of their lives. By merging STEAM principles with AR, we tap into their natural affinity with technology to create engaging and immersive learning experiences. This approach recognizes the alpha generation's inherent fluency with technology, enabling us to harness its potential to enhance their educational journey and cultivate their curiosity, creativity, and critical thinking skills.

Teachers in STEAM fields often face challenges such as costly or inadequate labs, equipment malfunctions, and difficulties replicating experiments (Godoy, 2021). AR provides solutions by being cost-effective, bridging the physical and virtual worlds, and enhancing students' comprehension (Restivo et al., 2014; Hsu et al., 2017). Ajit et al. (2021) reviewed literature on AR in STEAM and found it enhances conceptual understanding, learning outcomes, teamwork, and student engagement. A significant advantage of AR is its potential to increase students' interest and motivation in STEAM. As educators seek innovative engagement methods, research suggests AR tools can address motivation concerns (Mystakidis et al., 2022; Schmidthaler et al., 2023).

2.2 Estimation and Measurement

Estimation and measurement of length are specific spatial skills. According to Wai et al. (2009) and Sorby et al. (2022), there's strong correlational evidence linking spatial skills to success in STEAM education across different educational levels. Other studies have found connections between spatial skills and creativity, technical innovation (see Kell, 2013), and success in computer programming (compare with Jones, Burnett, 2008).

Spatial ability plays a significant role in mathematics and STEAM subjects. Gunderson et al. (2012) suggest that spatial skills play a crucial role in developing numerical reasoning, aiding primary level pupils in creating a spatially meaningful numerical representation. This includes the linear number line and number operations. Young et al. (2018) explain that spatial and mathematical skills are closely connected to development in STEAM subjects in the educational process. They are enhanced by concrete 3-D manipulative activities, making the estimation and measurement of space figures and objects beneficial for this development.

Mathematical concepts like symmetries, algorithms, patterns, and shapes can be observed in various architectural constructions globally (compare with Ajmera, 2020 and Wilson, 2021). According to Thui and Thi (2022), typologies and their relationship to geometries are considered significant features in architecture. For example, the use of the golden ratio or geometric shape patterns is prevalent in architecture, cultural heritage, and human history. This suggests that many iconic structures, such as the Eiffel Tower in France or the Taj Mahal in India, are built based on mathematical and STEAM contents and skills (see Dana-Picard et al., 2021).

Tom Caudell, while working at Boeing in 1990, coined the term "Augmented Reality" (AR) to describe the integration of virtual images into the real world, augmenting reality with virtual elements. This integration is facilitated through Information and Communication Technologies (ICT) using mobile devices equipped with cameras, such as computers, tablets, or smartphones with iOS or Android operating systems, which provide access to AR content. AR development also promotes higher learning autonomy, the use of mobile-learning support systems, and encourages exploration of ICT among students, fostering collaboration, innovation, and

creativity. AR applications enable the integration and interaction between the real and virtual worlds, offering great versatility and creativity in their applications (Coimbra et al., 2015).

The primary objective of an AR system is to enhance users' perception and interaction with the real world by supplementing it with 3D virtual objects that appear to coexist in the same space. While recent studies have expanded the definition of AR beyond this scope, in line with the original survey, we identify three key properties that AR systems share: blending of real and virtual elements in a real environment, real-time interactive features, and registration in 3D (Azuma et al., 2001).

3. Augmented Reality Applications in Mathematics Education

According to Arusoaie et al. (2010), augmented reality (AR) is a variation of Virtual Reality. While Virtual Reality creates a synthetic environment such that the user cannot see the real world around him, AR allows the user to see the real world, but with virtual objects superimposed onto the real-world surroundings. Therefore, AR supplements reality; it doesn't completely replace it. AR can be thought of as the "middle ground" between Virtual Reality and the real world.

In recent times, augmented reality (AR) applications with built-in measurement tools have gained significant popularity. These tools enable users to measure various quantities, including length, area, volume, and angles. They have proven useful not only in everyday tasks but also in the fields of mathematics and physics education. While developers acknowledge that the measurement accuracy is not perfect at present, they are actively working to improve it.

Berger-Halad and Ferko offer an in-depth systematic overview of Virtual, Augmented, and Mixed Reality concepts, along with their evolution and potential in education (Berger-Haladová & Ferko, 2019). Bohdal (2019) and Bohdal (2020) delve into the intricate details and progression of Virtual and Augmented Reality devices.

4. Survey and Context of this Study

In the subsequent section of this paper, we will describe the research conducted with future primary education teachers at the Faculty of Education of Comenius University in Bratislava. In Slovak conditions, primary education teacher training is a master's program, which follows the bachelor's study of the pre-primary education teacher training program. The research activities carried out with these students focus on outdoor STEAM activities appropriate for the primary level.

The study was carried out during the 2022/2023 academic year, involving both full-time and part-time students from the Faculty of Education at Comenius University in Bratislava. The participants for the research were made up of 81 students who are preparing to become primary education teachers. These students came from four different courses devoted to mathematics and technical education. The students self-organized into 37 smaller working groups for the purpose of the research.

4.1 Research Design and Methodology

It was realized an action research project involving future primary school teachers at the Faculty of Education. This study explored how augmented reality in STEAM education affects digital, technological, and mathematical skills of mentioned students. These students participated in math, geometry, and technology courses related to STEAM. The goal was to enhance their digital competencies for primary education, aligning with the school curriculum.

In these courses, students learned to use AR apps like Quiver and Animals D4 for young pupils. They designed a STEAM-based project for 6 to 11-year-olds, focusing on outdoor learning in areas like math, art, and technology. The project involved planning activities for measuring and comparing building sizes and incorporating math principles like geometry and estimation using AR tools. Art was integrated through analysing the artistic and architectural aspects of buildings, comparing these with online information. Technologically, students explored buildings' histories and materials. The project linked mathematical and technological skills by having students calculate and model building dimensions. This research aimed to understand how AR in outdoor STEAM projects develops literacy and competencies in primary education, focusing on its impact on pre-service teachers' perspectives and motivations.

We formulated the following research questions:

- How does the integration of augmented reality applications in STEAM education motivate future educators to foster pupils' individual literacies in primary education?

- What are the perspectives of prospective primary school teachers regarding the potential benefits of using augmented reality applications in STEAM education?

To address these questions, we employed focus groups as a research tool to gather insights and preferences related to our research objectives. We chose qualitative research as our approach because we sought opinions and attitudes that cannot be quantified or easily summarized in numerical data. Qualitative research was most suitable as it allows for a deeper exploration of individual and group perspectives on the subject matter.

The main advantage of qualitative research lies in its ability to facilitate open discussions within a small group, where every participant can express their opinions without getting overshadowed by others (Kostrub, 2022).

Qualitative research is based on collecting comprehensive data without predetermined hypotheses or the need to confirm or refute existing theories. Its purpose is to gather as much information and data as possible to gain a nuanced understanding of the research problem. Through the process of data collection, patterns and themes emerge, leading to tentative conclusions. If sufficient additional data is available, new theories can be developed. Qualitative research involves investigating actions and issues within their natural environment to gain a comprehensive picture of these phenomena based on the data and the specific relationships between the researcher and the research participants (Severini & Kostrub, 2018).

We conducted data collection and evaluation according to the well-known principles of qualitative research. Data collection was conducted through the collection of educational student portfolios.

The research subjects consisted of students from the Faculty of Education at Comenius University, who are prospective primary school teachers for pupils aged 6 to 11 years. The selection of participants was done through purposive sampling. The research was conducted during the summer semester of the academic year 2022/2023. In guided focus groups, students presented their own project proposals and discussed their implementation using various media such as text, images, and videos, focusing on different thematic areas of education.

In our qualitative research, we analysed the students' projects, employed the observation method to assess their project presentations, and qualitatively evaluated the data from the semi-structured interview. Its predetermined thematic framework was devoted to development of digital skills of pupils in proposed activities by students – future primary education teachers. The interview included the following prompts:

- How would your proposed activities foster primary education pupils' digital skills?
- How would your proposed activities support pupils' estimation skills?
- How would your proposed activities expand pupils' technical knowledge, such as understanding building materials and construction methods?

These prompts reflect above mentioned research questions because proposed activities of students-future teachers develop digital literacy and literacies connected with the STEAM oriented teaching in primary level.

4.2 Results and Discussion

The following activity describe the selected realized project of working group, in which there were primary education teacher training students:

Activity Project using AR (excerpt). Source: author's own elaboration.

STEAM area: Mathematics, technology, art, architecture, engineering.

Target group of pupils in the school: 6-11 years.

Activity Objective: Exploring the chapel in the Slovakian village Pusté Úľany.

Didactic resources and aids: AR Ruler app, geometric shapes worksheet, crayons, markers, didactic building blocks.

Time and space of activity: 20 minutes in the classroom, 40 minutes outdoors, 45 minutes in the classroom.

Methodical procedure in teaching:

Pre-active phase: This phase is in the classroom and pupils will try to sketch the building from the front and the side (see Figure 1).

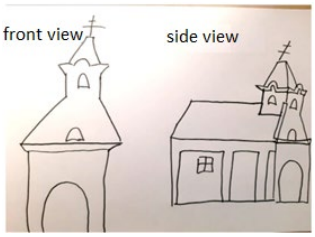

Figure 1: Sketch the chapel by pupils

During the initial stage, the teacher accompanies the pupils in the classroom where they engage in a discussion about a local chapel. Subsequently, the pupils, divided into groups, proceed to draw the chapel from different angles, including the front and the side.

Interactive phase: This phase is realized outdoor. Based on the suggestions provided by pupils for solving a learning problem and their subsequent practical implementation on an individual basis, the aim is to achieve the predefined goal. Pupils estimate the dimensions of the settlement and record them in a prepared table. Subsequently, they utilize the AR Ruler app for measurement purposes and document the measured values in the table (Figure 2).

Figure 2: Measurement of chapel dimensions by application

Moving on to the second part of the activity, the pupils go on a walk to the chapel, during which they have conversations with both their teacher and their peers. They explore various questions related to the chapel's geometry, such as identifying geometric shapes present on the building and determining if there are any symmetrical shapes. Additionally, the pupils estimate the dimensions of the chapel and employ an augmented reality (AR) app to measure them accurately.

Post-active phase: This phase is realized in the classroom. Pupils work and discuss in groups in the classroom. They drew a map and on it the path from the school to the chapel (see Figure 3).

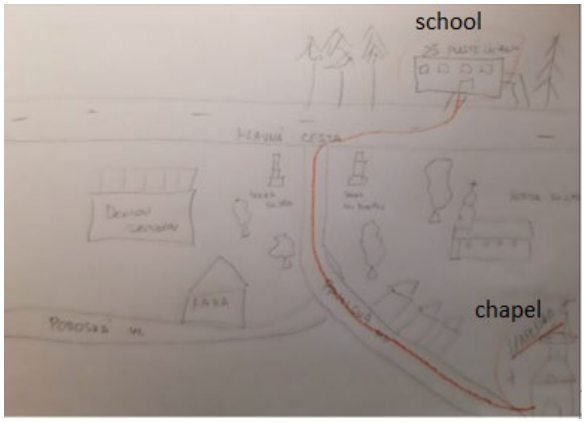

Figure 3: Map made by pupils

In the third part, the pupils return to the classroom. The activity focuses on their orientation in plane and space. They are tasked with drawing a map depicting the route from the school to the chapel. Additionally, using a square grid, they create a floor plan of the chapel. Lastly, they search for geometric shapes that can be found within the structure of the building.

During the semi-structured interviews conducted, we sought teacher training students' opinions on the STEAM outdoor method utilizing augmented reality. The responses we received confirmed a high level of motivation among the students towards this approach. Employing a qualitative methodology, we evaluated the data collected, which consisted of 52 groups of student responses addressing our interview questions. Here are the key findings:

Support for primary education pupils' digital skills: According to most of the aspiring teachers, the use of augmented reality apps can indeed enhance the digital skills of pupils aged 6 to 11. While pupils already have familiarity with various apps on their smartphones, mostly games, some respondents emphasized the importance of learning to use augmented reality apps for measurement, as it would be beneficial for their future.

Support for pupils' estimation skills: Opinions among teacher training students varied in this aspect. While some believed that the activity would greatly aid in developing pupils' ability to estimate the dimensions of buildings, the majority remained neutral, indicating uncertainty about its significant impact on fostering this geometric competence.

Enhancement of pupils' technical knowledge: Regarding the understanding of building materials and construction methods, the majority of teacher training students remained silent or neutral, indicating limited perceived benefits in this particular area for primary school pupils.

5. Conclusions and Implications of the Study

The results of the semi-structured interviews revealed that the STEAM outdoor method using augmented reality shows promise for primary school education. Future teachers expressed positive attitudes towards this approach, emphasizing its motivational and competency-building aspects within the STEAM framework. The results are limited to the sample of teacher training students, who participate in the educational project. The findings can understand in the local condition of the Faculty of Education of the Comenius University in Bratislava. It is the result of the fact, that educational experiment was lead in the qualitative direction. Key findings include:

Support for digital skills: Students believed that augmented reality apps can enhance pupils' digital skills beyond gaming, emphasizing their importance for future applications.

Support for estimation skills: Student opinions varied regarding the impact on developing estimation skills, with some confident in its effectiveness and others uncertain.

Enhancement of technical knowledge: Students were neutral or had no specific views on the method's benefits for improving children's understanding of building materials and construction methods.

This year, the Slovak Ministry of Education is launching a curriculum reform emphasizing pupils' independent thought, action, and decision-making. In line with this reform, our faculty is undertaking a project to innovate the pedagogical approaches for primary education students. The findings from our research, as detailed in this article, could contribute to achieving the objectives of this reform and enhance student experiences with fresh STEAM-related activities.

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The Problem of AI Hallucination and How to Solve It

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Abstract: AI in education is a topic that has been researched for the last 70 years. However, the last two years have seen very significant changes. These changes relate to the introduction of OpenAI's ChatGPT chatbot in November 2022. The GPT (Generative Pre-trained Transformer) language model has dramatically influenced how the public approaches artificial intelligence. For many, generative language models have become synonymous with AI and have come uncritically viewed as a universal source of answers to most questions. However, it soon became apparent that even generative language models had their limits. Among the main problems that emerged was hallucination (providing answers containing false or misleading information), which is expected in all language models. The main problem of hallucination is that this information is difficult to distinguish from other information, and AI language models are very persuasive in presenting it. The risks of this phenomenon are much more substantial when using language modules to support learning, where the learner cannot distinguish correct information from incorrect information. The proposed paper focuses on the area of AI hallucination in mathematics education. It will first show how AI chatbots hallucinate in mathematics and then present one possible solution to counter this hallucination. The presented solution was created for the AI chatbot Edu-AI and designed to tutor students in mathematics. Usually, the problem is approached so that the system verifies the correctness of the output offered by the chatbot. Within the Edu-AI, checking responses is not implemented, but checking inputs is. If an input containing a factual query is recorded, it is redirected, and the answer is traced to authorised knowledge sources and study materials. If a relevant answer cannot be traced in these sources, a redirect to a natural person who will address the question is offered. In addition to describing the technical solution, the article includes concrete examples of how the system works. This solution has been developed for the educational domain but applies to all domains where users must be provided with relevant information.

Keywords: Chatbots, AI, Mathematics education, Hallucination

1. Introduction

Artificial intelligence and the possibilities of its use in teaching have been the subject of didactic research for decades (Chen et al., 2020; Zhai et al., 2021). Zawacki-Richter has explored the possibilities of studies focusing on the use of AI in higher education and lists four areas of research focus in 2019 (Zawacki-Richter et al., 2019):

- Profiling and prediction
- Assessment and evaluation
- Intelligent tutoring systems
- Adaptive systems and personalisation

The situation was similar in mathematics teaching (Hwang & Tu, 2021). The focus of research has been on how AI can impact and enhance the performance of mathematics students in their teaching and learning process, with most research focusing on the effectiveness of AI use (Mohamed et al., 2022).

The professional and lay public's view of the possibilities of using AI in education was significantly changed by the publication of ChatGPT 3.0 in the fall of 2022. AI-driven large language models (LLMs) such as OpenAI's ChatGPT have become almost synonymous with AI. The new features offered by LLMs have taken the forefront of educational research (Zawacki-Richter et al., 2024; Crompton et al., 2024). Like all new technologies, LLMs bring benefits AND risks (Groza and Marginean, 2023). One of these risks is AI hallucination, i.e. providing incorrect or misleading results that AI models generate. Particularly around using LLMs to communicate directly with learners about educational content, AI hallucination can be a significant problem because LLMs provide incorrect answers with high fidelity, and learners may be unable to distinguish them from correct answers.

This paper presents one way to solve, or at least reduce, the AI hallucination problem. The solution was developed and used within the Edu-AI.eu project to create a chatbot for tutoring students in mathematics and the Czech language.

2. Chatbot Edu-AI

Chatbot Edu-AI is an application created to tutor primary and secondary school students. The application involves students interacting with an AI chatbot, which presents them with pre-prepared mathematical problems. It is important to note that the AI's role is not to generate or prepare mathematical content but rather

to facilitate communication with the student beyond the assigned tasks (Jančařík et al., 2023). The application currently covers all the topics that appear in the entrance exams to secondary schools in the Czech Republic. The application presents students with tasks based on their choice and previous answers (see Jančařík et al., 2022). A sample of such a task is shown in Figure 1.

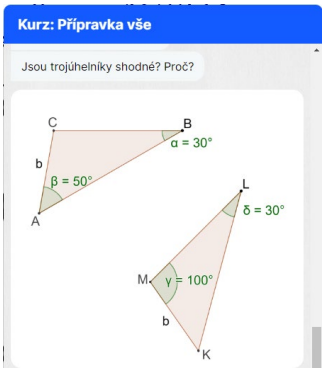


Figure 1: Sample problem: Are the triangles congruent? Why?

Since this is a chat application, there may be a situation where a student does not know what it means that the triangles are congruent and asks this question in the chat. In this case, the app's creators wanted to make sure that the answer the student receives is correct. Therefore, the learner does not receive a direct answer but is offered a link to open a menu of learning materials that address the topic (see Figure 2).

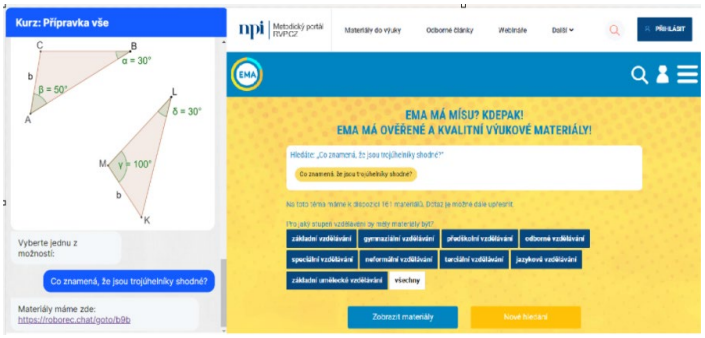


Figure 2: Answer to the question: What does it mean that the triangles are congruent?

In this case, 161 teaching materials were found, so the student must specify which materials he/she is interested in; for example, he/she can choose teaching videos for primary school. All the resources referenced by the application in the case of a factual query have been peer-reviewed and can be considered validated.

3. AI Hallucination in Mathematics

This procedure is chosen because LLMs can sometimes hallucinate and provide misleading answers. This problem occurs in various areas but is often very pronounced in mathematics (Poola, 2023). We will demonstrate the problem with the previous example. We get the correct answer if we ask the same question to the ChatGPT application (see Figure 3).

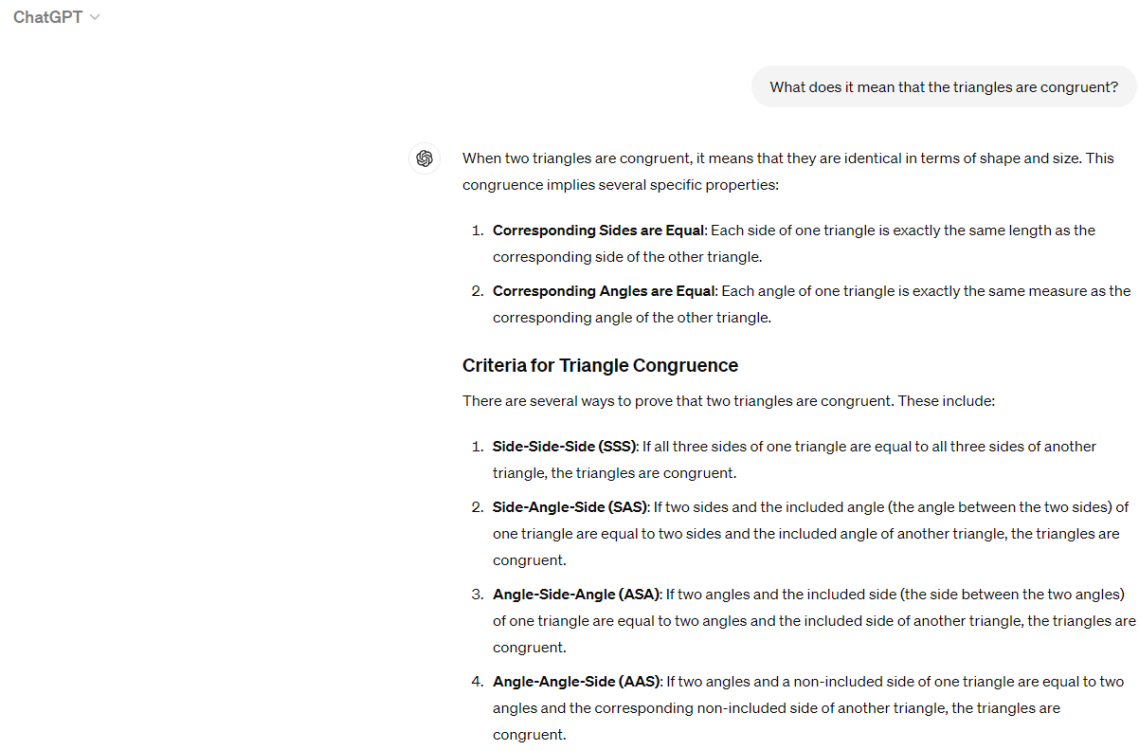


Figure 3: ChatGPT answer to the question: What does it mean that the triangles are congruent?

So, there does not seem to be a problem in this case. Copying the problem specification into the query is possible, and ChatGPT will solve the job correctly (see Figure 4).

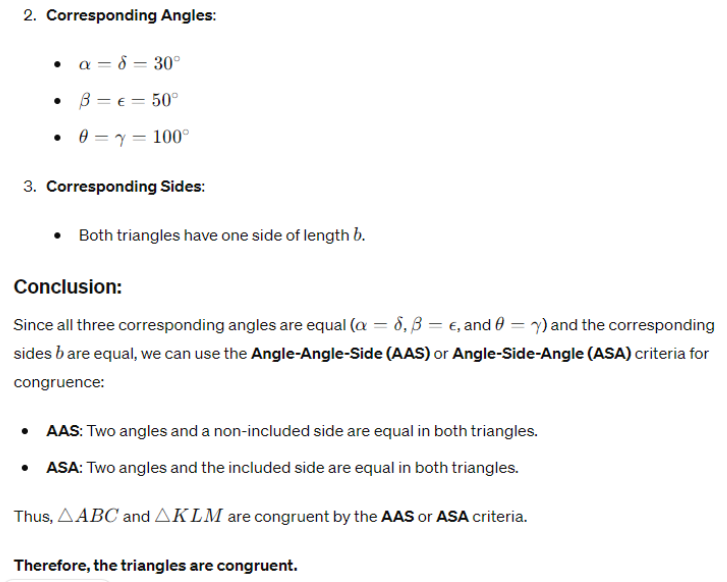
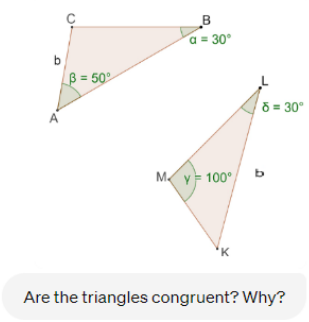


Figure 4: ChatGPT solution of the problem

However, the impression that ChatGPT is already capable of a similar task is illusory, and the hallucination problem is revealed in full if we present the same task to the application, with only a slight change in the assignment by moving the label of side b (see Figure 5). In this case, the answer is a detailed analysis of the task with the same conclusion that both triangles are identical. However, in this case, this answer is incorrect.



3. **Corresponding Sides**:

- Both triangles have one side of length b (AB in $\triangle ABC$ and KL in $\triangle KLM$).

Conclusion:

Since all three corresponding angles are equal ($\alpha = \delta = 30°, \beta = \angle M = 50°$, and $\angle C = \gamma = 100°$) and the corresponding sides $AB = KL = b$ are equal, we can use the **Angle-Side-Angle (ASA)** criterion for congruence:

- **ASA**: Two angles and the included side are equal in both triangles.

Thus, $\triangle ABC$ and $\triangle KLM$ are congruent by the **ASA** criterion.

Therefore, the triangles are congruent.

Figure 5: ChatGPT incorrect solution of the problem

The indistinguishability of correct and incorrect answers led to the need to develop a solution that would avoid confusing students. We present a description of the implemented solution below.

4. Implemented Solution of AI Hallucination in Chatbot Edu-AI

The solution implemented within the Edu-AI application is that all inputs given by the learner are analysed by the LLMs (currently Chat GPT 4) before being processed by the exerciser. The chatbot consists of a rule-based in-domain module, where individual learning exercises are implemented, and an open-domain module, which handles queries not focused on carrying out the learning exercises. The open-domain module (Fig. 1) operates in the following fashion:

1. First, all queries undergo basic preprocessing (accented character correction; Richter et al., 2012)
2. The queries are passed through an intent classifier (Section 4.1). We use five general intents: simple queries (such as "What is the time?") for handcrafted handling, returning to the in-domain module, searching for learning materials, factual questions, and chitchat.
3. A rule-based dialogue manager decides on further treatment of the input, simply depending on the intents. This includes handling the handcrafted intents and returning control to the in-domain module. Learning material search is redirected to the Czech school ministry's EMA learning materials database.
4. Question intents are passed to two question-answering (QA) modules, one for domain-related questions and another for open-domain, based on Wikipedia (Sections 4.2 and 4.3).
5. The chitchat intent is forwarded to a chitchat module (Section 4.4).

The whole open-domain module runs as a simple HTTP server. A simple keywords-based filter is included to avoid responses involving age-inappropriate or potentially offensive topics.

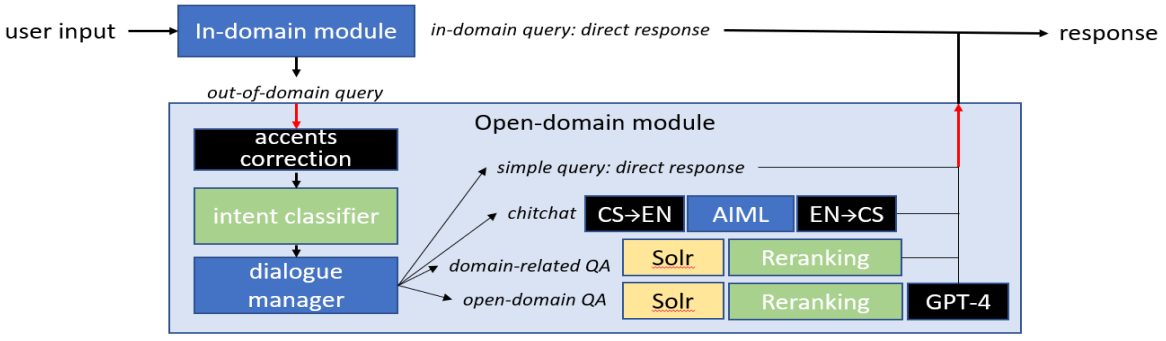


Figure 6: The overall architecture of the system.

4.1 Intent Classifier

Our intent classifier is based on the RobeCzech neural language model (Straka et al., 2021), which has been pretrained for masked language modelling (i.e., guessing masked out words from their context; Devlin et al., 2019) on vast amounts of Czech texts downloaded from the internet. We use this model as a starting point to

provide us with vector representation of Czech sentences (user inputs) and finetune (train) it using a custom dataset of ca. 5,800 utterances manually annotated with our intent labels. We can achieve >80% intent classification accuracy on a held-out test portion of our data.

4.2 Domain-Related Question Answering

For the domain-related QA, we currently support two databases, which are switched based on the source of the HTTP request on the system, i.e., depending on the website the user is looking at. This means the same underlying chatbot can show different behaviour on different websites.

The QA starts with a full-text search in a database of frequently asked questions and corresponding answers related to the domain. We use Solr (https://solr.apache.org/) for data storage and full-text search. Before the search, the user query is filtered based on part-of-speech detection (Straková et al., 2014); only nouns, adjectives, verbs and adverbs are retained. The query is further lemmatised (converted to base word forms, removing plurals, verb tense, case endings, etc.), and standard abbreviations (chosen from a manually compiled list) are expanded to their complete forms.

The Solr full-text query returns the top 10 results, which are further re-ranked to choose the one that best matches the user query. Here, we use neural vector representations of sentences (embeddings, Bengio et al., 2003) and the cosine similarity of the user query to the retrieved questions as a matching criterion. We use the Seznam RetroMAE-small model (Bednář et al., 2023), which we selected based on evaluating multiple sentence embeddings on small test queries.

4.3 Open-Domain Question Answering

The open-domain one is more complex than the domain-related QA system. It uses the exact Solr full-text search and part-of-speech query filtering. However, this time, the user query is not compared to questions from a database but to Wikipedia article titles and excerpts (paragraphs). Article title matches are prioritised. In this case, the reranking uses a multilingual SBERT sentence embedding model (Reimers and Gurevych, 2019), as we found it more accurate in comparing the similarity (relatedness) of questions to text paragraphs.

Unlike the domain-related QA, where the database already contains ready-made answers, the Solr search and reranking result is a Wikipedia paragraph, which, in an ideal case, contains the reply. The reply must first be extracted and passed to the user. We use GPT4-turbo (OpenAI, 2023) for this task. We prompt the model to respond to the user question given the extracted paragraph and give it the option to indicate that the extracted paragraph is, in fact, not relevant. If the extracted paragraph is irrelevant, we pass GPT4 the question without additional data and ask for an answer. In this case, the chatbot output indicates lower confidence ("I am not sure, but I think…").

4.4 Chitchat

For chitchat, we use a pipeline based on machine translation into English and back and the AIML pattern-matching chatbot engine (Wallace, 2009). We opted to use a rule-based chatbot over a neural trainable system to retain complete control of the responses. We previously experimented with the BlenderBot neural chatbot (Roller et al., 2021) and found that it would often steer the conversation towards inappropriate topics. Having decided on AIML, we customised the patterns of the existing ALICE chatbot (Wallace, 2009) for our purposes. We opted for pattern matching in English as this avoids the morphological complexities of Czech, and we used machine translation (Popel et al., 2020) to achieve this. The translation of the AIML output back into Czech is post-processed by syntax-based rules built on top of the UDPipe syntactic parser (Straka, 2018) to ensure the chatbot shows a consistent gender in its responses.

5. Conclusion

We know that LLMs are undergoing a rapid evolution, including minimising AI hallucinations. The progress in this area is evident. Problems that we used to demonstrate problems with math tasks last year or the year before are now very often solved correctly. It is equally likely that the problem used as a demonstration in this paper will no longer be current by the time of the conference presentation. However, the hallucination problem is much deeper and is not likely to be solved anytime soon. In addition, there will always be a need to provide a link to specific information or relevant, pre-prepared resources instead of a general answer within the chat.

While the solution we present in this paper was developed for the needs of one Czech tutoring application, it is generally portable and applicable in a broader context. The procedure can be used whenever there are guaranteed sources of information. In our case, these were proven sources of educational material provided by

one of the project partners. We are also aware that operator redirection can reduce system efficiency. We can consider replacing it with an automatic response that the chatbot cannot find a verified answer to the query.

Further research will focus on the solution's reliability and user feedback, including mapping how much users use the given links and how they perceive them compared to the text-based response.

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Flipped Classroom in the Czech Republic

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Abstract: The Flipped Classroom approach, advocated since the 1990s by scholars such as Alison King, Eric Mazur, Maureen J. Lage, Glenn J. Platt, and Michael Treglia, involves students independently learning theoretical content before class via e-learning resources like video recordings and self-directed programmes. This allows educators to use class time for discussions and scaffolding as students engage in problem-solving tasks individually and in groups. Notable milestones include the establishment of Khan Academy in 2004, MEF University's adoption of flipped teaching in 2011, the founding of the Flipped Learning Network in 2016, and the extensive use of e-learning during the COVID-19 pandemic. This paper examines implementing a flipped classroom project in environmental education in the Czech Republic. In 2018, three academics from different universities initiated the flipping of environmental education courses. The research, framed as combined action research, employed a questionnaire as the primary tool. Data were collected twice: in 2021, at the end of mandatory online teaching due to the COVID-19 pandemic, and in 2024, after three years of regular education. Responses from 288 students were analysed using standard statistical methods, while open-ended responses from 82 students and interviews with four university lecturers were qualitatively assessed. The findings underscore the benefits of electronic materials, particularly students' appreciation for interactive elements, time flexibility, and the ability to review content multiple times. Students' willingness to watch digital lectures at home decreased post-pandemic, and the perceived efficacy of this method was higher among students during the pandemic. Although students find the flipped classroom method effective, they favour its combination with traditional teaching methods. Educators, cognisant of the method's potential, interpret these results as indicative of "virtual environment fatigue", noting students' reluctance to prepare in advance as a significant barrier. They advocate for the widespread implementation of the flipped classroom model across faculties to optimise instruction and eliminate the need for switching between traditional and flipped approaches. This study offers a practical example and insights for educators seeking to integrate the flipped classroom methodology with e-learning tools into their teaching practices.

Keywords: COVID-19 impact on education, Digital learning tools, Higher education, Flipped classroom, e-Learning resources

1. Introduction

The Flipped Classroom has emerged as a transformative pedagogical approach since the 1990s. The approach was expressed as a concept in its present form in 2000, championed by academics such as Eric Mazur (1997), Alison King (2017), Maureen J. Lage, Glenn J. Platt, and Michael Treglia (2020), Wesley J. Baker (2000), etc. With the advancement and proliferation of educational technologies, interest in the Flipped Classroom model has grown in the last years.

This method involves students independently learning theoretical content before class, utilising various e-learning resources like video recordings, self-learning programs, and chatbots. Consequently, class time is dedicated to discussions and providing support, or scaffolding, as students engage in problem-solving tasks independently or in groups.

Over the years, the Flipped Classroom model has gained significant milestones. The establishment of Khan Academy in 2004 marked a turning point by providing accessible, high-quality educational videos. In 2011, MEF University became the first higher education institution to fully adopt the flipped teaching method. In 2012

the book Flip Your Classroom: Reach Every Student in Every Class Every Day (Bergmann, Sams, 2012) was published. The founding of the Flipped Learning Network in 2016 further solidified this approach, and the global shift to e-learning during the COVID-19 pandemic underscored the importance and effectiveness of digital learning resources. A comprehensive research study on the subject was provided by Ağırman and Ercoşkun (2022), who focused on questions such as: *What was the historical development of the FC model? What are the different uses of the FC concept in the literature? What is the frequency of use of the FC concept in the literature?*

This paper presents a research study on using the flipped classroom in higher education. It aims to present experiences with the flipped classroom method in several universities in the Czech Republic, one of the European post-communist countries. The technique's use in teaching affected by the pandemic (in emergency remote teaching) and in regular teaching (after the COVID-19 pandemic) is compared.

2. Characterization of the Czech Republic Focused on Higher Education in a Historical Context

The Czech Republic has a long and rich tradition of higher education, dating back to the Middle Ages. The oldest university in Central Europe is Charles University, founded in 1348 by Emperor Charles IV in Prague.

Higher education in the Czech lands expanded during the 19th and early 20th centuries. New universities and technical schools were established. These institutions contributed to the industrialisation and modernisation of the Czech lands. During the Second World War (1939–1945), all ten universities existing at that time were shut down by the Nazis. Academics found themselves unemployed, and nearly all students were deprived of the opportunity to pursue their studies. Only in exceptional cases were students able to continue their education abroad. After the Second World War, Czech universities were reopened. Students were allowed to complete their studies in an accelerated mode. During the communist regime (1948–1989), the state strictly controlled higher education in Czechoslovakia and emphasised ideological education and political loyalty. The faculties of education, philosophy and theology were under the most significant control. Contact with foreigners was minimal, and literature was censored. After the Velvet Revolution of 1989, universities were gradually reformed.

Today, higher education in the Czech Republic is characterised by high quality, a wide range of study programs, and a solid scientific and research foundation. Czech universities collaborate with international partners, participate in exchange programs, and contribute to developing European and global scientific knowledge. Czech academics were allowed to explore, experiment with, and implement modern methods of university pedagogy, including the flipped classroom method (Conelly, Gruttner, 2005; Greger, Walterová, 2007).

In March 2020, Czech universities were closed due to the COVID-19 pandemic. Emergency remote teaching lasted for four semesters in 2020 and 2021. This provided a strong incentive to create video lectures. Many of these videos were made in amateur settings using tools like Camtasia.

From June to July 2021, the Czech Ministry of Education, Youth and Sports surveyed 23,256 students and 4,597 academic staff from universities. Most respondents indicated that universities responded flexibly to this crisis and adapted well. For two-thirds of the students, studying during the pandemic was more time-consuming than in the previous period. Physical health deteriorated for 45% of students, while mental health declined for 55% of them. The financial situation worsened for 27% of students.

Three-quarters of academic staff felt better prepared for distance learning during the pandemic than at its beginning. Over 50% of academic staff assessed students' work within distance learning as worse than the previous in-person format. Academic staff felt support from the university mainly in providing technical equipment or courses on using technology and programs and, to a large extent, adjusting working conditions. Conversely, they perceived that they needed to improve in psychological and financial support, recognition for proactive approaches, or support in the didactics of distance learning and methods of motivating students. The results were presented at the Higher Education Teaching Days conference (see https://msmt.gov.cz/dopady-pandemie-covid-19-na-studenty-vs).

3. The Flipped Classroom Method in the Czech Republic

The first information about the flipped classroom method reached the Czech universities around 2008. In a year in which, according to an interview with Aaron Sams, 15% of teachers in the USA used this method routinely, Czech teachers are just learning about it and are being introduced into the classroom by several innovative individuals (Sudíková, 2017).

In 2018, three academics from three different Czech universities (Masaryk University in Brno, Purkyně University in Ústí nad Labem and Charles University) agreed on the project “Application of the Flipped Classroom model for teaching Environmental Education courses at universities”. It aimed to produce video lectures for environmental education courses for their lectures and use in the broader community. Together, they prepared and published 26 video lectures with a total length of 20 hours. The NGO BEZK provided

technical implementation as part of follow-up projects. All materials are freely available and can be used by academics and students from other universities (see https://evvoprednasky.cz/).

This proved very useful during university closures due to the COVID-19 pandemic.

4. Research Methodology

The research was conducted as action research (Elliott, 1981) using the combined (mixed) method QUAN—> qual (Morse, Niehaus, 2016).

The monitored teaching using the flipped classroom method took place from 2020 to 2024, which includes two years of emergency remote learning due to the COVID-19 pandemic and two years of standard teaching.

During this period, two questionnaire surveys were conducted in May 2021 and May 2024 (Table 1).

Table 1: Number of respondents to the questionnaire survey

	Total number of students	Completed questionnaires (percentages)
2021	180	75 (42%)
2024	108	39 (36%)
Both	288	114 (40%)

The data were processed using standard statistical methods. The evaluation primarily focused on descriptive statistics of individual variables (mainly absolute and relative frequencies). Due to the nature of the data (categorical or discrete values), normality was not tested. A test of equality of proportions and the chi-square test on a contingency table was used to determine the relationships between variables across different years. The significance level for all tests was set at 0.05. Responses to the open-ended questions of the questionnaire were evaluated using qualitative methods, with sentiment analysis being the primary method used. The data processing was carried out using R 4.4.0 and Microsoft Excel 2019.

Although the main findings were quantitative, a sub-qualitative investigation was also conducted. This was based on

a) students' answers to open-ended questions (“Name the advantages of the flipped classroom method” and “Name the disadvantages of the flipped classroom method”) and

b) open-ended interviews with four academics.

The obtained data were evaluated using the Grounded Theory method, namely concept searching and categorisation (Strauss, Corbin, 1998).

5. Results

5.1 Characteristics of the Respondents

Teacher students were respondents to the questionnaires. In 2021, there were 73 students in the Faculty of Education, 90% of whom were women. In 2024, 39 students completed the questionnaire, 2/3 from the Faculty of Education and 1/3 from the Faculty of Science – almost (97%) all women.

Four academics from four different Czech universities were interviewed, and the results showed that they regularly used the flipped classroom method.

5.2 Where Were Students Introduced to the Flipped Classroom Method?

In this course, most students were first introduced to the flipped classroom method in both periods studied (Table 2).

Table 2: You learned about the 'flipped classroom' method – answers from the years 2021 and 2024

	2021	2024
In this subject	74% (54)	73% (27)
Earlier	26% (19)	27% (10)

The proportion of students who had previously learned about the flipped classroom method mostly stayed the same from one year to the next. This is confirmed by a test of equality of proportions ($p > 0.05$). Thus, the method may have grown little after reverting to its standard state.

5.3 How Many Other Subjects Using the Flipped Classroom Method did the Students Have?

In 2024, the proportion of students who did not use the flipped classroom method in any course is significantly higher than in 2021 ($\chi^2(1, 112) = 4.203$, $p = 0.045$). Notably, in 2021, nearly a quarter of students used the method in three or more courses, whereas in 2024, only 5% of students used the technique in such a number of courses. Also surprising is the number of students who used the method in five or more courses.

Suppose we test on a contingency table with merged categories (see Table 3). In that case, we conclude that there was a statistically significant difference between 2021 and 2024 in the number of individual courses students reported learning using the flipped classroom method ($\chi^2(3, 112) = 9.405$, $p = 0.024$).

Table 3: How many other subjects have you studied using the 'flipped classroom' method? – answers from the years 2021 and 2024

Number of subjects	2021	2024
0	23 (32%)	20 (51%)
1	16 (22%)	12 (31%)
2	16 (22%)	5 (13%)
Three and more	17 (24%)	2 (5%)

5.4 Did the Students use Digital Lectures for Your Preparation?

In 2024, students were far less likely to use digital lectures (over 90% if we take the Yes + Rather Yes categories) than in 2021 (where the two categories combined are around two-thirds of the total). However, this is due to the course itself, where in 2024, students had digitised lectures only as a supplement (see Figures 1 and 2).

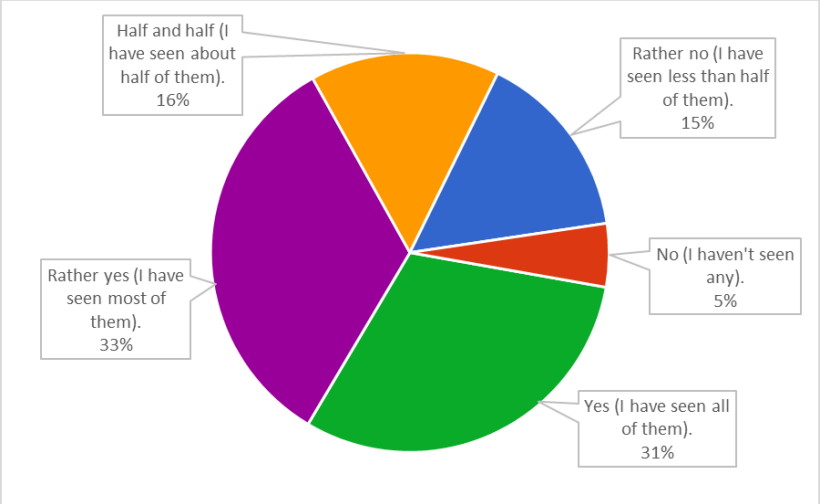

Figure 1: Did you use digitalised lectures for your preparation? – answers from the year 2021

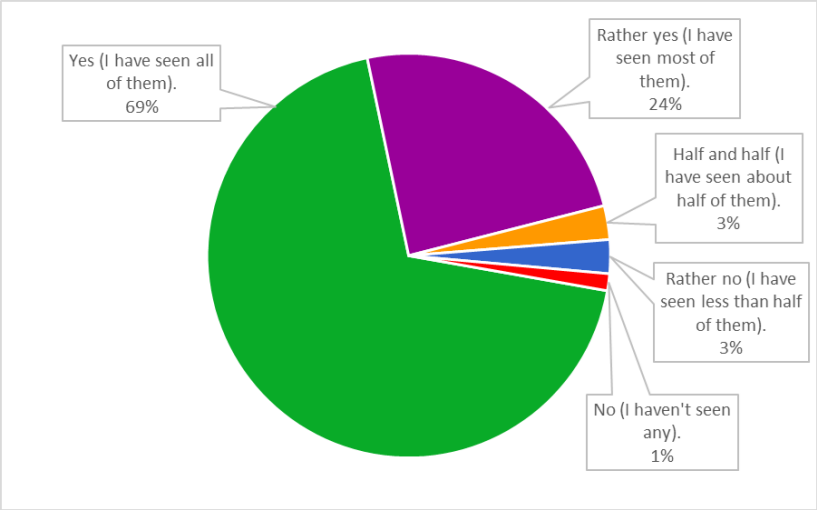

Figure 2: Did you use digitalised lectures for your preparation? – answers from the year 2024

5.5 How does the Student Evaluate the Digitised Lectures and Time Allocation of the Course?

In general, digitised lectures were rated very useful in both years (97% in 2021 and 90% in 2024). Regarding the evaluation of the level of lecture processing, students were more critical in 2024 than in 2021. In 2024, 72% of students rated the level as high or relatively high, compared to 85% in 2021. The remaining proportions fall, for the most part, into the neither high nor low category. This could be interpreted as the fact that 2024 online lectures were already standard, whereas, in 2021, this way of teaching was relatively new. In both years, students agreed that the sound quality could be improved. Other suggestions for improvement were to shorten the lectures (i.e. to split a long lecture into several shorter ones) or to provide additional study materials (answers from the year 2021).

The majority of students rated the course as time-adequate, with the percentage rating it as such being higher in 2024. Conversely, in 2021, we found more students who spent less time studying the course than its time allotment—more than a fifth compared to eight per cent in 2021. Around the same proportion of students said they spent more time studying the course than its time allotment (Table 4).

Students evaluated whether the time they spent on the course, i.e. watching lectures, online meetings, or even completing assignments in Moodle and consultations, corresponded to the credits (the time allocation is about 30 hours for one credit).

Table 4: Evaluation of course time allocation – answers from the years 2021 and 2024

Evaluation of course time allocation	2021	2024
Adequate	61 %	69 %
Inadequate, I managed in less time	22 %	8 %
Inadequate - I needed more time	11 %	18 %
Other Answers	6 %	5 %

5.6 How do the Students Evaluate the Flipped Classroom Methods?

Most respondents see the potential of the flipped classroom method. In 2021, over 80% of students saw potential in the flipped classroom method, with a drop of about ten percentage points in 2024. However, this decline has been in favour of the 'don't know' response. Interestingly and positively, only individuals do not see potential with this method—four students in 2021, with no students expressing this view in 2024 (see Figures 3 and 4).

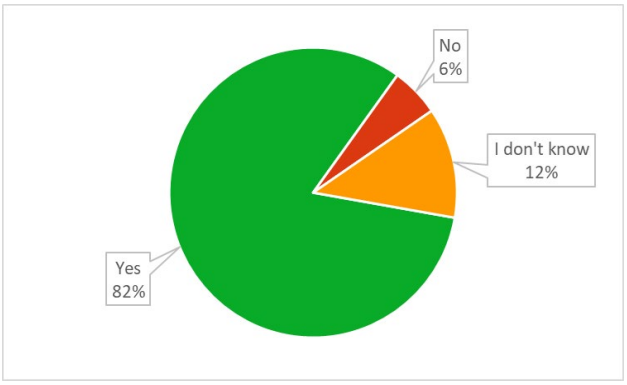

Figure 3: Do you see the potential of the 'flipped classroom' method? – answers from the year 2021

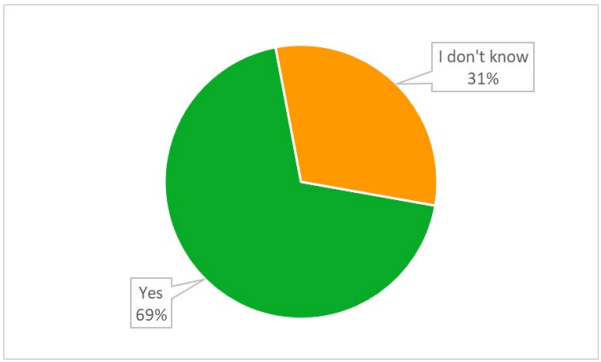

Figure 4: Do you see the potential of the 'flipped classroom' method? – answers from the year 2024

In 2021, nearly three-quarters of students would like to continue studying using the flipped classroom method. In 2024, just under 40% of these students will be in the flipped classroom, half in 2021 (Figures 5 and 6). We do not presume to assess the reasons for these responses, but the number of 'yes' responses has decreased in favour of neutral 'don't know' responses. The number of students who do not wish to study further by this method is low in both years, with seven students (10% of respondents) in 2021 and just one student (3% of respondents) in 2024.

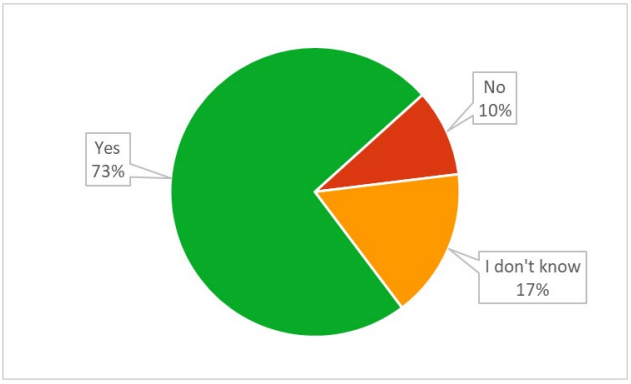

Figure 5: Would you like to continue studying using the 'flipped classroom' method? – answers from the year 2021

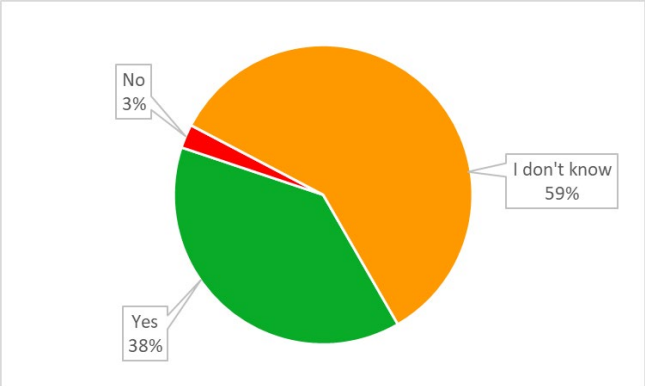

Figure 6: Would you like to continue studying using the 'flipped classroom' method? – answers from the year 2024

It is interesting to compare the relationships between the answers to the last two questions (see Tables 5 and 6. In 2021, most of those who see potential in the flipped learning method want to continue studying with this method (52/60 = 87%). In 2024, only half of such students are already there (13/27 = 48%). In the case of the other answers, the students are already relatively consistent - if they do not see the potential in the method, they do not want to use it to study; the same is usually valid for the answer "don't know".

Table 5: Contingency table for the questions: Do you see the potential of the 'flipped classroom' method? Would you like to continue studying using the 'flipped classroom' method? – answers from the year 2021

Do you see the potential of the 'flipped classroom' method?	**Would you like to continue studying using the 'flipped classroom' method?**			
	Yes	No	I don't know	**Total**
Yes	52	1	6	**60**
No	0	4	0	**4**
I don't know	1	2	6	**9**
Total	**53**	**7**	**12**	**72**

Table 6: Contingency table for the questions: Do you see the potential of the 'flipped classroom' method? Would you like to continue studying using the 'flipped classroom' method? – answers from the year 2024

Do you see the potential of the 'flipped classroom' method?	**Would you like to continue studying using the 'flipped classroom' method?**			
	Yes	No	I don't know	**Total**
Yes	13	0	14	**27**
No	0	0	0	**0**
I don't know	2	1	9	**12**
Total	**15**	**1**	**23**	**39**

5.7 A Qualitative Analysis of Open-Ended Questions

We processed responses from 82 students, 57 (75%) from 2021 and 25 (64%) from 2024.

Students' responses to the open-ended questions were very similar in both surveys. They see the disadvantage in the time required for home preparation and the limited contact with the teacher, including the impossibility of asking about uncertainties immediately.

The most frequently mentioned positives were time flexibility (the ability to listen to the lecture at any time) and the ability to play the lecture repeatedly, stop, rewind, return to more complex content, or play it again during the exam period. Approximately a quarter of the responses (totalling 23) demonstrated an understanding of the flipped classroom method, highlighting aspects such as the freedom to learn, the ability to study at one's own pace, coming to class prepared, and spending class time on activities. The ability to learn from home and avoid travel or a better fit with employment were less frequent responses.

The most frequently mentioned disadvantages included the absence of social contact (only in 2021), the time-consuming nature of preparation, concerns about the ability to understand more complex topics, such as photosynthesis, without the instructor's presence, and the acknowledgement that internal motivation is necessary. One respondent would welcome the flipped classroom method in all subjects taught at the university. Four respondents recommended introducing it partially. No respondent spoke against using an inverted classroom (see Tables 7 and 8).

Table 7: Analysis of open-ended questions – advantages of the flipped classroom method

Answers	2021	2024
time flexibility (I can start the lecture at any time)	25	11
possibility to stop the lecture and start again	16	12
learn from home/no need to travel to higher learning	9	2
the efficiency of the flipped classroom (I will learn more, freedom of learning, responsibility for learning, the opportunity to come equipped with concepts and theoretical knowledge and to actively participate)	14	8

Table 8: Analysis of open-ended questions – disadvantages of the flipped classroom method

Answers	2021	2024
absence of social contact	7	0
time-consuming home preparation	2	5
concerns about whether they will correctly understand complex subjects such as photosynthesis without the presence of a teacher	2	4
lack of motivation	3	0

5.8 A Qualitative Analysis of Short Interviews With Teachers

All four university teachers consider the flipped classroom method an effective and modern approach and are “fans” of it. They began using it before or shortly after compulsory distance learning was implemented due to the Covid-19 pandemic and the resulting closure of colleges.

They see the positives and strengths of this method in the fact that students come to class prepared with knowledge of theory and terminology. This allows class time for developmental activities such as discussions, excursions, walks, didactic games, nature observation, experiments, and project work.

The most significant area for improvement is the requirement that students do homework. Students who do not prepare at home and feel disoriented during class threaten learning effectiveness. All four respondents encountered situations where students disagreed with homework. One of them even received critical feedback from several students for requiring them to prepare at home.

All respondents interspersed the flipped classroom method with conventional teaching methods (lectures), although they believed in and were fully prepared to adopt the flipped classroom approach. Two respondents felt it would be helpful if all faculty teachers switched to the flipped classroom method, making it a conventional mode of teaching rather than an alternative one. Digital lectures are used more by part-time students than by full-time students. They also serve as a resource for absences due to illness, etc.

Three respondents interpreted the survey results as indicating “online fatigue”. Students who have been taught remotely for two years welcome face-to-face contact with their teacher. Overall, respondents still see potential in the flipped classroom method and are determined to continue using it in their undergraduate teaching.

6. Conclusion

This study examined the implementation and reception of the flipped classroom method at several Czech universities. The technique, which focuses on pre-class independent learning and in-class interactive activities, saw increased use during the COVID-19 pandemic.

In 2021, many students engaged with the flipped classroom method across multiple courses.

By 2024, engagement decreased, possibly due to online fatigue and a return to traditional teaching preferences.

Digital lectures were widely used and appreciated, though students in 2024 were more critical of their quality than in year 2021.

Regarding the advantages and disadvantages of the flipped classroom method, students from both samples agree that the main benefits they most often cited are the flexibility of studying and the possibility of repeating the lecture. They also mention the more efficient use of time during the "contact" part of the class (2024) and that they can think through the concepts/content thoroughly beforehand (2021). Students cite the need for more personal contact with the teacher and classmates and needing immediate feedback as a major shortcoming. They also mention the need to spend more time on home preparation, which sometimes clashes with other study obligations or the motivation to "force" themselves to study. Even though students find this teaching appropriate in their courses, they are concerned that the risk of not understanding the material is relatively high (e.g. photosynthesis is mentioned) for the more difficult parts.

While enthusiasm for the method remained high, perceived potential slightly declined from 2021 to 2024.

Teachers found the method effective and appreciated the preparedness it fostered in students.

A key challenge was ensuring students completed their preparatory work.

Other Czech colleagues are also achieving similar results (Pšenáková, Pšenák and Szőköl, 2024).

The flipped classroom method has significant potential but – in the Czech Republic now – requires balanced integration with traditional teaching methods and robust support for student preparation. Future research should focus on long-term outcomes and ways to optimise the flipped classroom method for broader use.

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Industry Mentoring Program: Empowering External Degree Students for Career Success: Case Study from University of Moratuwa, Sri Lanka

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Abstract: In today's interconnected world, open distance education has become widespread, granting students the flexibility and accessibility to pursue higher education through external degree programmes. Despite the increasing feasibility of delivering knowledge and skills online, a significant hurdle remains in ensuring that participants are adequately equipped for the demands of the professional world of work. Traditionally, exposure to industry standards and practical experiences is gained through activities like industry visits, guest talks, meetups, and workshops, which are often absent in online distance education programs due to their remote nature. This dearth of industry-preparedness and practical skills presents a formidable obstacle for graduates as they transition into the workforce. Thus, bridging the gap between academic learning and industry expectations becomes imperative to enhance students' employability and career readiness, ultimately fostering their success in the workforce. This case study delves into the solution to this challenge through a meticulously crafted programme aimed at cultivating industry-ready graduates. Leveraging available technology, the program provides immersive experiences within the online learning environment. The paper details the Industry Mentoring Program (IMP), which employs technology to simulate real-world experiences, assesses stakeholder perceptions of the programme's value, and offers insights for future enhancements. This programme was conducted targeting the final year students of the Bachelor of Information Technology (BIT) External Degree programme of the University of Moratuwa. This study investigates the experiences and viewpoints of students taking part in the IMP using surveys, interviews, and focus group discussions. Four student cohorts who have undergone the programme have provided their feedback both quantitatively and qualitatively. Across all groups the student satisfaction was totally positive with over 80% of the participants indicating their satisfaction at 4 or 5 on a Lickert Scale of 5 indicating very satisfied. Students' perception of their preparedness for the workforce after participating in the IMP also is extremely positive. The findings indicates that the IMP significantly improves the career opportunities of BIT students. Feedback obtained from other stakeholders such as potential employers, resource persons and administrators also validate the effectiveness of the programme. The feedback and suggestions are incorporated to enhance the programme. University has decided to incorporate this programme into the curriculum with the 2024 curriculum revision of this open distance degree programme of BIT.

Keywords: Industry ready graduate, Skills enhancement, Industry mentoring programme, Future workforce

1. Introduction

The distance education programs enable students to pursue education in a flexible and accessible manner, allowing them to continue their education regardless of geographic location or time constraints. Students can use online platforms to access lecture videos, lecture notes, assignments, and other materials, as well as interact with instructors and peers, from anywhere with an internet connection. This flexibility is especially useful for people who have family responsibilities, or who may not have access to traditional educational institutions. However, distance education can be challenging due to several factors that impact both students and educators. Distance education often struggles to replicate the hands-on, practical experiences that are crucial in many fields, leaving students less prepared for real-world applications. Lack of interaction with other students and feelings of isolation of these students can negatively impact student motivation and engagement, leading to higher dropout rates compared to traditional education settings. These challenges together with other technical and social issues make distance education a demanding endeavour for many learners.

It is also important that the students are given an opportunity to acquire and enhance the skills that their chosen field of work requires upon graduation. In synchronous face to face learning programmes these are achieved through various physical sessions and carefully crafted internship programmes. Providing opportunities for

distance mode students to acquire these skills are challenging due the nature of the curriculum and may be due to the size of the cohorts. The pseudo-synchronised nature of many open distance courses with no time-tabled slots for each class makes it a real challenge to provide interaction with the industry professionals who are willing to share their experiences and advice with the undergraduate students.

Understanding the value of this exchange of knowledge and experience, the Centre for Open and Distance Learning (CODL) at the University of Moratuwa introduced the industry mentoring program to address the evolving needs of students and enhance their preparedness for the professional world. Industry mentoring programs play a vital role in preparing the workforce of tomorrow, ensuring that graduates are well-equipped to thrive in their chosen fields. Recognizing the significant gap between academic education and industry demands, the IMP aims to provide students with practical insights, guidance, and support from experienced professionals in relevant fields. By partnering with industry experts through mentoring, the university seeks to supplement theoretical knowledge with real-world experiences, ensuring that students acquire the skills, knowledge, and confidence needed to succeed in their chosen careers. Moreover, the IMP serves as a platform for students to establish valuable connections with professionals in their respective industries, expanding their professional networks and enhancing their career prospects. This initiative will be providing holistic education that not only equips students with academic excellence but also prepares them for the challenges and opportunities of the professional world, ultimately contributing to their overall success and employability.

The IMP serves to bridge the gap between academic learning and practical workplace requirements. A carefully crafted program is used to provide students with invaluable insights, guidance, and support from expert industry professionals. Industry experts offer first-hand knowledge of industry trends, best practices, and real-world challenges, supplementing theoretical education with practical know-how. Moreover, mentoring fosters the development of essential soft skills, such as communication, teamwork, and problem-solving, which are often overlooked in traditional academic settings but are crucial for success in the workplace. Additionally, these resource persons from the industry serve as valuable role models and sources of inspiration, helping mentees navigate their career paths, set meaningful goals, and build professional networks.

This paper presents and shares the good practices of this program that lead to enhanced career readiness in the workforce for the graduates of an open distance mode Information Technology degree program. The Industry Mentoring Programme [IMP] was introduced in BIT (external) degree programme in 2020. Four programs were successfully introduced to students with the improving the activities in each programme. This program was conducted online every Tuesday from 19:00 – 20:00hrs for 15 weeks period. By matching students with experienced experts in their respective professions, the program provides targeted assistance and guidance, improves students' employability skills, and build a culture of lifelong learning and professional progress. Through this effort, the Centre for Open and Distance Learning, University of Moratuwa (UoM) seeks to provide its students with the knowledge, skills, and networks they require to succeed in the ever-changing workforce landscape.

The below table (Table 1) illustrates the evolution of the program over different cohorts, showcasing the growth in the number of students, the expansion of tools and resources used, and the introduction of new features to enhance the learning experience. Each row represents a different cohort, denoted by the semester code (e.g. 20S1, 21S2 etc.).

Table 1: Evolution of IMP in BIT Curriculum

Semester	Student Nos	Tools Used	Newly Added Feature(s)
20S2	117	Zoom Sessions	
21S2	179	Zoom Sessions	Mock Interviews
22S2	230	Zoom Sessions + Mock interviews	Panel Discussion
23S1	189	Zoom Sessions + Mock Interviews + Panel Discussion	Industry Visits

This research paper outlines the implementation of the IMP, which leverages technology to replicate authentic industry experiences, evaluates stakeholder perceptions of the program's efficacy, and provides recommendations for its improvement.

1.1 Aim of the Study

The study reported on in this paper is aimed at investigating good practices and perceptions of IMP by seeking to answer the following research questions:

- What are the perceptions of students, potential employers, stakeholders regarding the value and effectiveness of the IMP?
- What are the findings regarding the impact of the IMP on enhancing students' career opportunities?
- What specific feedback and suggestions have been provided by stakeholders to enhance the IMP?
- How the programme can be improved based on the feedback?

2. Literature Review

Universities have the responsibility of assisting the students' soft skills development during their degree programmes and graduates perceive that obtaining a degree it will enable them to secure good positions in the workforce and thus have bright careers ahead (Noah and Abdul Aziz, 2020). Thus, it is essential and important even for the distance mode external degree programmes to pay attention to enhance students' skills development. Singh Dubey, R., Paul, J. and Tewari, V. (2022) identified critical soft skills in IT sector and the perception gap between professionals and students regarding the importance of soft skills. The study suggested how the partnership between educational institutions and the IT industry can address the gap benefitting all stakeholders. Cimatti (2016) also suggested that universities can partner with industries to provide students with direct exposure to the professional environment. Activities such as visits, internships, and joint programs can help students understand the significance of skills for their careers, which may in turn motivate them to continually enhance these essential skills.

Juneby (2008) indicated that online degree programmes have a higher attrition rate and explained how attrition in distance education can be reduced through carefully crafted mentoring programs. Pradhan and Kreglicki (2020) discussed the use of mentoring as a tool to bridge the gap between industry and academia for undergraduate students. The study further identified how mentorship is an effective way for undergraduate students to learn new skills, with access to industry mentors to enhance classroom activities and providing valuable industry experience. They further described how industry mentors provide undergraduate students with professional insights and real-world workplace understanding, bridging the knowledge gap between academia and industry. Allen et al. (2004) conducted a comprehensive meta-analysis examining the career benefits associated with mentoring for protégés. Their findings highlighted the significant positive impact of mentoring programs on various aspects of protégés' careers. Specifically, they found that individuals who participate in mentoring relationships experience greater career success, including higher job satisfaction, organizational commitment, and salary growth, compared to those who do not have mentors. Mentoring offers students customized direction, advice, and encouragement from experienced professionals, assisting them in navigating career paths, setting objectives, and building important skills and abilities. According to Allen et al.(2006) formal mentoring programs continue to gain popularity within organizations despite limited empirical research regarding how these programs should be designed to achieve maximum effectiveness. The recent studies such as Hong V and Glass C (2024) highlights the importance of Industry Mentor Programs in related degree programs.

With the evolution of ICT based tools in education many studies have shown that such tools can be used to enhance the soft skills of the students. Caeiro-Rodríguez et al (2021) discussed the ICT-based services that have been developed to support the teaching of soft skills in higher education. Cherbonnier et al. (2024) analysed 18 studies on the development of collaborative skills using digital tools. This systematic review highlighted the need for further research on the use of digital tools and the functionalities they offer. The study further indicated that future studies should focus on the impact of automatic feedback on self-assessment and the use of instruments to develop collaborative skills. Weng, C. et al. (2024) analysed 31 papers from the Web of Science database to examine the impact of online learning environments (OLE) on acquiring transferable skills (TS). The study indicated that Learning Management Systems (LMS) and online platforms are widely used for teaching TS, impacting TS development, contributing to a more knowledgeable society, improved education, lifelong learning, personal empowerment, enhanced employee skills, and entrepreneurial outcomes fostering economic development. The negative aspects of using OLEs such as challenges in communication skill development, prolonged adjustment periods, and increased challenge for learners are indicated in the study with recommendations to teachers, educators, curriculum designers, and researchers obtain the effective use of OLEs.

The key learnings from literature on importance of soft (or transferable) skills and impact of digital tools in assisting the enhancement of such skills were considered in the design of IMP. The value addition that will be brought in by using industry professionals as resource persons as well as enhanced outcomes due to close industry rapport in designing and developing a program also contributed immensely to the improvement of IMP.

3. Methodology

To share the best practices of crafting a useful programme to expose distance mode learners in a three-year Information Technology degree programme this paper will outline the programme and then delve into analysing the perceptions of the outcome of the programme.

3.1 Programme Design

The programme was designed to provide the learner the exposure to the world of work they will be stepping into with the help of industry professionals. The degree programme students were following was delivered in a pseudo-synchronised manner with all the content required for a given week been made available via the LMS with no time-tabled class hours for any synchronized interaction. Students can use forums or emails to interact with their module coordinators. In designing the IMP, the importance of the need for a synchronized session was emphasized and it was agreed to have these sessions as online webinars with prior registrations, However, to provide more regularity and continuity it was decided to use one regular time slot which was deemed feasible for both the learners and resources persons. A mid-week (Tuesday) 19:00 – 20:00 hrs local time was selected for the sessions to facilitate most of the participants. Even though a specific time slot has been allocated for this programme to make it beneficial to the students who may have challenges of network connectivity and inability to attend due to other commitments students requested the recording of the sessions. Therefore, all recordings have been uploaded to the LMS course the student cohorts were using.

The programme was originally aimed for third (final) year students; however, it was subsequently made available for all students as this will give students the opportunity to enhance their skills from the time they start the degree programme. Every week the session details were displayed as a poster with a registration link enabling students to participate in the sessions via the Zoom meetings/webinar.

The original version of the programme was designed to highlight the need for enhancing soft skills. A list of topics and resource persons were identified with support from the local industry and industry consortia. During the sessions and subsequent feedback sessions with the learners, it was identified that the learners would benefit from exposure to the different types of industries and job roles available for them to work in. This led to programme been modified to add sessions on different categories of companies, and different job categories and roles. Resources persons from large scale international level companies present in the country to startups were invited while sessions on multiple job roles such as software engineers, quality assurance professionals, web developers, network engineers, and security professionals were added. Outside of the programme the CODL was conducting weekly 30-minute segments with the National Television Network which included few sessions on showcasing the work environment of local IT companies and the participants of the IMP programme were encouraged to watch the relevant episodes of the TV series. Participants while appreciating the exposure were requesting to incorporate the physical visits to some companies to gain firsthand experience of the world of work. While the feasibility of such visits needs to be evaluated for long-term sustainability few visits are incorporated in the latest version of the IMP programme. While the students were given instructions on how to prepare an effective curriculum vita, the need for giving them an opportunity to face an interview was highlighted by both the learners and the industry resource personnel. The students who participated in sessions were given the opportunity to face a mock interview conducted by professionals from the local IT industry. It is encouraging to see the successful conduct of the interviews and feedback sessions happening entirely online. A sample listing of the sessions conducted are given below in Table 2.

Table 2: Sessions of the IMP

Week No	Session Description
1	Introduction of the programme
2	Industry Expectations of a New Graduate
3	Attitude + Skills + Mind: The Motivational Training
4	Navigating the Ocean of Information
5	How to join a small-Scale IT company
6	How to become a professional in a large IT Company
7	How to ensure IT undergraduates are industry-ready?
8	Wake the Business Analyst in you

Week No	Session Description
9	How to identify your passion for becoming a Quality Assurance engineer?
10	Discussion about computer networking career advancement
11	Introduction to Career Paths in Web Development
12	The day in life of a Software Engineer
13	How to write an Effective CV?
14	Delivering business value through good project Management
15	Your Success as an IT Professional: Do Ethics Matter?
16	How to find a good internship as an intern
17	Mock Interviews and Closing Remarks

3.2 Research Design

This study conducted a survey that enabled the collection of both qualitative and quantitative data. These methods were selected with the purpose to answer the identified research questions.

This initiative specifically targeted final-year students enrolled in the Bachelor of Information Technology (BIT) External Degree program at the University of Moratuwa. The four successive student cohorts who registered for the IMP programme were invited to participate in this study. The total of four student cohorts were 715 students and 173 respondents participated in this study.

3.3 Data Collection Process

The primary data were collected through various methods, including questionnaires, focus-group discussions, and interviews. Questionnaires provided a structured format for gathering quantitative data, allowing participants to respond to standardized questions. Focus-group discussions offered a dynamic environment for exploring shared experiences and opinions among small groups of participants, fostering in-depth conversations, and uncovering nuanced perspectives. Interviews provided a more individualized approach, allowing researchers to delve deeper into participants' thoughts, experiences, and insights, there by enriching the qualitative data collected. By employing this multi-faceted approach, the study obtained a comprehensive understanding of the participants' viewpoints and experiences within the context of the IMP. The duration of the data collection was one to two months' period.

To obtain more personalized insights on how the participants perceived the outcomes of the program, online interviews were conducted with the students. These interviews provided an opportunity for students to share their experiences, feedback, and perspectives in a detailed and personal manner. These structured interviews were conducted using the following question categories; Introduction, Program Experience, Skills Development, Impact on Career Readiness, Program Enhancement, Future Engagement, and Conclusions. Table 3 provides the details of the questions used in the interviews for one such category.

Table 3: Questions used for the interviews in the Programme Experience category.

Category	Question
Program Experience	What specific aspects of the IMP did you find most beneficial or valuable?
	Can you elaborate on any challenges or obstacles you encountered while participating in the program?
	How did the program contribute to your understanding of industry standards and practical skills relevant to your study?

4. Analysis of Result

Overall satisfaction of the IMP as answered by the students are depicted in Figure 1 for the four different cohorts. It is encouraging to notice the higher percentages of satisfaction with the perceived satisfaction increasing with the newer cohorts. This increase in positive perception could be linked to improvements in many aspects of the IMP.

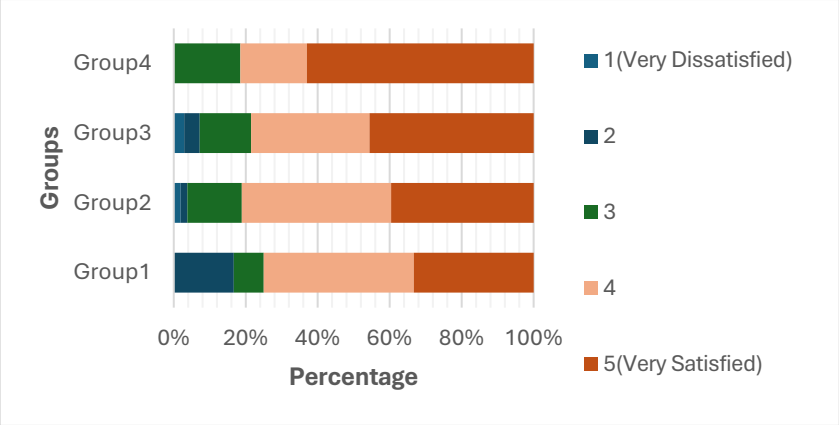

Figure 1: Overall Satisfaction of IMP

The overall responses on how the IMP has helped in developing transferable skills and preparedness for the workforce are summarised in Figure 2. Their answers to the questions; Q1: Rate to what extent do you believe the IMP has helped you develop industry-relevant skills and Q2: Rate how confident do you feel about preparedness for the workforce after participating in the IMP? are shown below in Figure 2.

It is encouraging to see most students have rated the 4 and 5 which depicts they have gained the skills that are required to face the workforce by participating in the programme. This positive feedback suggests that the program is effective in enhancing students' readiness for their professional careers.

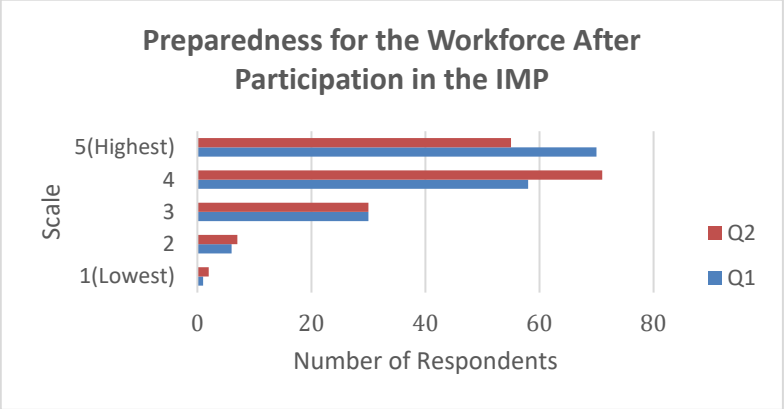

Figure 2: Preparedness for the Workforce After Participation in the IMP

Majority of the students perceived that IMP would greatly improve their employment prospects. Figure 3: Rating of the Career Prospects of the students depicts an overwhelming higher percentage of positive responses. IMP provides opportunities for gaining practical experience, developing industry-relevant skills, and building a professional network with the industry. Building upon these skills led to finding of placement in the industry.

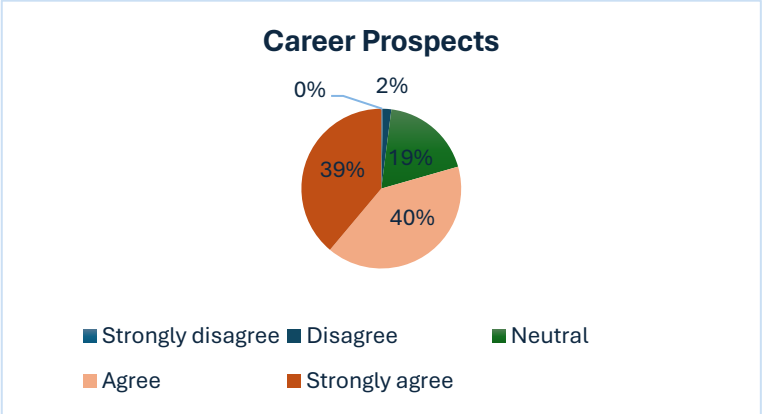

Figure 3: Rating of the Career Prospects of the students

IMP was aimed at assisting students improving their soft skills as well. The survey carried a question asking students about the improvement of their soft skills such as communication skills, self-confidence, problem-solving skills, real-world exposure, and teamwork, etc. Figure 4 indicates that the program is effective across all evaluated attributes, with many students experiencing substantial improvement. As shown in figure 4 students perceive a significant positive impact across all aspects of soft skills from the program.

Attributes such as communication skills and exposure to the real-world stand out with particularly high ratings, indicating these areas may be the most impactful elements of the program. The relatively low number of responses in the lower scales (1 and 2) further emphasizes the program's effectiveness, as only a small fraction of students reported minimal improvement.

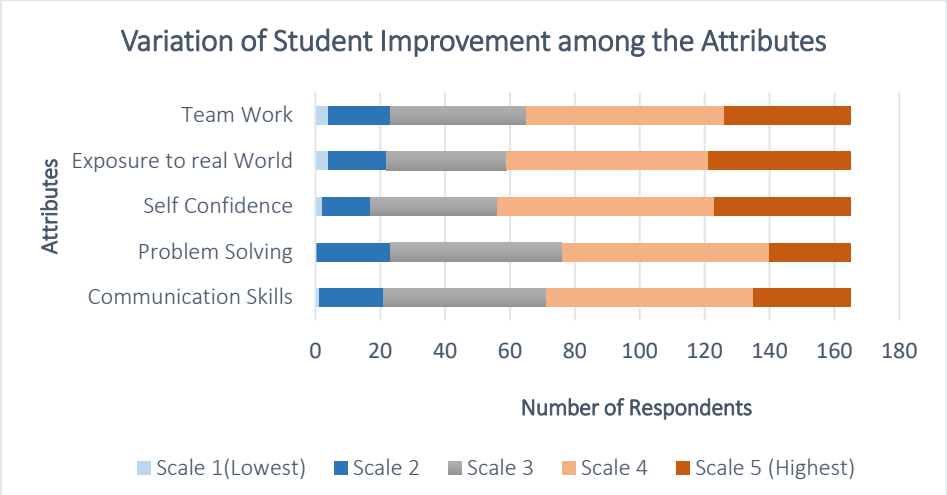

Figure 4: Variation of the student improvement among the attributes

Apart from the questionnaire, the data were gathered using the in-person interviews. The interviews facilitated a relaxed environment, enabling participants to express their thoughts and feelings in a way that might not be captured through a structured questionnaire alone.

During interviews participants indicated the most beneficial session for them. Figure 5 displays the popularity of various topics covered in the program based on student interest. Finding that different students valued different topics highlighted the value of topic selection for the entire population. The participants being non-native English speakers found the session on “How to write an effective CV” as most beneficial. The CVs prepared after this session were subsequently used in the session for mock interviews.

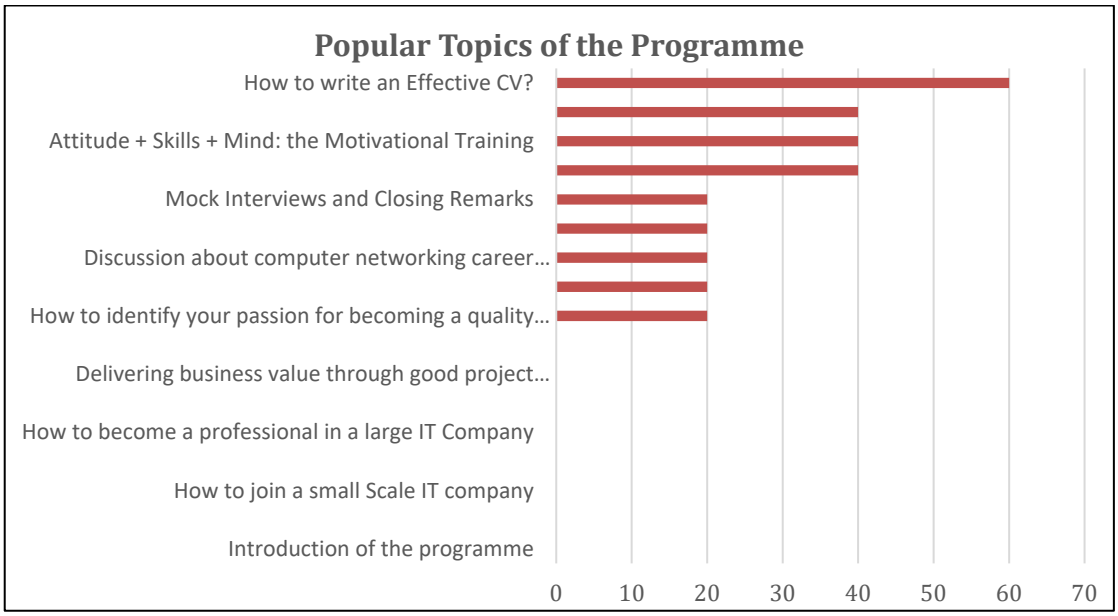

Figure 5: The popular topics of the programme

A sample answer from an interview respondent is summarized in Table 4 to illustrate the importance of "Programme Experience".

Table 4: Summarized answer of a respondent on "Programme Experience"

Answer to Question 1 (Table 3):	Created awareness of the job roles in the industry and understood the importance of soft skills
Answer to Question 2 (Table 3):	The timing of the session was the only difficult thing to manage
Answer to Question 3 (Table 3):	The programme helped to identify the preferred job role and required skills

Similarly, most respondents provided positive comments on the programme which highlighted the importance to them. The feedback received from resource persons who contributed to various sessions were encouraging. They appreciated the opportunity to directly interact with the students via an online platform and many of them invited students for further collaborations by sharing their contact details and social media contacts. Many of the invited resource persons encouraged by the active student participation offered to do more sessions if needed. The IMP was planned to be an entirely online programme, however as the resource persons were willing to give a face to face exposure to the students of their companies, multiple industry visits could be arranged to give students personal exposure to a real-world work environment, which improves their understanding of industry expectations and procedures.

The initiative not only encourages students but also enhances the connection between academia and the industry, encouraging a mutually beneficial collaboration. Dean of the faculty responsible for the BIT degree program who is a strong proponent of IMP often took time out of his busy schedule to be part of the programme even by participating in industry visits. His feedback on the impact that this programme has in naturing the undergraduates to be industry-ready professionals has impacted in including the programme into the curriculum in 2024 curriculum revision.

5. Discussion and Conclusion

Students, potential employers, and stakeholders usually believe that an industry mentoring program is valuable and beneficial, although their opinions differ depending on their own experiences and expectations. Students often believe industry mentorship programs as valuable for career development and insights into company processes, and they value the opportunity to learn from experienced experts. This program is seen as critical for creating professional networks, which can help with future job chances.

All stakeholders believe that this initiative considerably improves the overall educational experience by combining practical industry insights with academic knowledge, resulting in a more comprehensive learning environment. Furthermore, at the end of every session, there is a question-and-answer session which creates a feedback loop that creates a bond between the resource person and the student. Industry resource persons were very appreciative of the opportunity given to obtain feedback and opportunities for developing better industry connections.

Overall students' experiences and viewpoints of the IMP do not vary significantly across different cohorts as they generally hold positive perceptions about the program. However, individual expectations do vary with the type of sessions conducted. Interviewed participants mentioned various session types they found most beneficial, reflecting diverse preferences and needs. This depicts that it is of importance to address topics from multiple areas to help the entire group as the diversity of interests and backgrounds vary. Despite these individual differences, the overall design of the mentoring programs has been successful and well-aligned with students' expectations, ensuring that the sessions cater to a wide range of interests and professional development goals. This specific planning improves program effectiveness and assures overall student satisfaction.

Industry resource persons have provided several specific feedback and suggestions to enhance the program. They recommend initiating a pool of mentors and assigning a few students to one mentor. Initially, such a program should be designed with clearly stated objectives and outcomes for both mentors and mentees. Further, it was also suggested that the mentor pool be expanded to cover more sectors and career phases. CODL already provides an industry supervisor for the capstone project done by the students and perhaps the same can be combined for mentoring.

Stakeholders emphasized the need to offer a variety of session types, including personalized one-on-one mentoring, group sessions, practical workshops at the companies, and industry visits or shadowing opportunities. Some of these may be bit challenging in an online environment. However, with the experience of running the IMP programme a hybrid mechanism may be used to facilitate all the requirements of making industry ready graduates.

Regular feedback systems and long-term follow-up were recommended for tracking progress and making required adjustments. Other suggestions included establishing networking events and incorporating career days or career fairs to improve interactions.

Preliminary findings regarding the impact of the IMP on students' career opportunities indicate a significant positive influence. Students participating in the program have reported enhanced employability skills, including improved communication, problem-solving, and industry-specific technical abilities. Further, the program provided valuable networking opportunities, leading to increased access to internships, job placements, and professional connections. Many students have noted an improvement in their confidence and clarity by participating to the programme. Additionally, the real-world exposure and practical insights gained through the program have helped students better align their academic pursuits with industry demands, making them more competitive candidates in the job market. Overall, the IMP has been instrumental in bridging the gap between academic learning and professional practice, thereby substantially improving students' career prospects.

The university has decided to incorporate a new course module on Industry Mentoring into the curriculum as part of the 2024 curriculum revision for BIT. This will make it mandatory for all students to participate in the programme which will enable them to understand and evaluate the necessary skills and attitudes. The new module will be based on the IMP which had voluntary participation from the students. The lessons learnt by conducting four successful programmes will be incorporated to strengthen the new module.

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Factors Affecting the e-Learning Implementation in UAE Public Sector Organizations

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Abstract: There is an increasing recognition among organizations that investment in learning and development interventions is necessary for a sustained improvement in organizational performance and excellence. E-Learning is becoming a popular delivery method across public sector organizations in the United Arab Emirates (UAE). Organizations often consider developing the skills and knowledge of their employees by using advanced technologies and approaches. The present study aims to examine factors affecting E-Learning implementation among public sector organizations in the UAE. The review shows that the use of E-Learning has spread among organizations faster than any other method, particularly within the public sector organizations of the UAE. Therefore, this research aims to shed light on the current status of E-Learning implementation in the public sector organizations in the UAE. Moreover, the study explores different E-Learning technologies and approaches that are used in organizations. It also addresses the advantages and disadvantages of using E-Learning. In addition, it examines the barriers and challenges of using E-Learning methods in organizations and offers several recommendations to develop strategies and to improve policy and practice of E-Learning.

Keywords: E-Learning, Public sector, Learning and development, Technologies, Workplace

1. Introduction

In the 21st century, the communication technology explosion has increased the use of digital devices for many reasons in the world of work and education (Kumar, Wotto and Bélanger, 2018). There is increasing recognition among organizations that investment in learning and development interventions is necessary for sustained organizational performance and excellence (Kamali, 2018). Specifically, E-Learning has seen a continued upward trend with both government and private sector continuing to invest in learning and development (Giannakos, Mikalefand Pappas, 2022). E-learning has also become a fundamental topic in most studies over the past few years (Gros and García-Peñalvo, 2023). Yet, studies have confirmed that organizations are facing many barriers and challenges in implementing the E-Learning among organizations (Ellis and Kuznia, 2014). Currently, most organizations in the public sector organizations in the UAE are focusing on E-Learning, but there are not many details about the extent to which factors are affecting the implementation of E-Learning (Qurotul Aini, et al., 2020) In the context of the UAE, and particularly in public sector organizations, this study addresses the following research question: "What factors are affecting the E-Learning implementation in the UAE public sector organizations?" The present study is a conceptual paper that aims to examine factors affecting the E-Learning implementation among public sector organizations in the UAE. The review shows that E-Learning has spread out among organizations faster than any other method, particularly within public sector organizations. Therefore, this research aims to shed light on the current status of E-Learning implementation in the public sector organizations in the UAE. Moreover, the study explores different E-Learning technologies and approaches that are used in organizations. It also addresses the advantages and disadvantages of using E-Learning. It also addresses the barriers and challenges of using E-Learning methods in organizations. Understanding the factors affecting the E-Learning implementation in the UAE public sector organizations is critically important, as the existing literature tends to focus on E-Learning methods and practices, rather than the drivers. The purpose of this study is to examine factors affecting the E-Learning implementation among public sector organizations in the UAE and also to suggest some ideas that can contribute to the solutions of these problems facing employees. Today, technology is considered to be an essential material in the future of learning and development. Thus, we find some employees who are facing difficulties in using the technology.

2. Context of the Study

Nowadays, the pace of technological change is unbelievable as the internet becomes the most popular source of information and the channel of communication (Kumar, Wotto and Bélanger, 2018). The current rapid development of information technology has received positive feedback from the community. Currently, the public sector view E-Learning as an essential instrument for obtaining skill-based organizational outcomes (Giannakos, Mikalefand Pappas, 2022). With its state-of-the-art digital infrastructure, Dubai has set the stage for rapid advances in E-Learning. The focus of this study is Dubai government organizations because recently there has been an increased emphasis on E-Learning in the public sector. Today, many organizations are aware of the importance of E-Learning and are developing plans to improve the competences of the workforce and their

professional skills (Gros and García-Peñalvo, 2023). Dubai's Government has presented its forward thinking-prowess with the launch of a 50-year plan known as The UAE Centennial 2071 Project, the year which will be the nation's 100th anniversary. The main purpose of launching this plan is to put in place a vision that extends to five decades, thereby preparing the nation for future generations. It also aims to have a clear map for long-term government work in order to make the United Arab Emirates the best country in the world. The plan consists of four aspects: economy, education, government development and community cohesion. Currently, Dubai government organizations are using a Learning Management System (LMS) which provides a learning platform that can enable interactive learning anywhere and at any time as long as the users are connected to the system via the internet (Turnbull, Chugh and Luck, 2020). As E-Learning played an increasingly critical role during the pandemic, the heavy reliance on the use of E-Learning became a challenge in public sector organizations. Successful implementation of E-Learning systems hinges upon addressing the challenges faced by the learners and the instructors. Whilst there have been many studies which have attempted to address the challenges that are faced in implementing an E-Learning system (Tarus, Gichoya and Muumbo, 2015), there have been limited studies that focused on exploring the barriers and challenges of implementing E-Learning in the context of the public sector. This study seeks to explore the factors impacting the implementation of an E-Learning system in the public sector in the UAE.

3. E-Learning Definition

The main process of E-Learning starts with learning, so it is important to understand the meaning of learning. Learning is defined as a process whereby individuals obtain new skills in order to increase their knowledge and improve their productivity and performance (Kok, 2013). The main purpose of learning is to improve the performance of employees in order that organizations can meet their goals (Kok, 2013). E-Learning is defined as an innovative way to enhance education and learning (Kok, 2013). According to Hoppe, et al. (2003), E-Learning is the learning that is supported by digital-electronic tools and media. There are different definition terminologies of E-Learning based on the field in which it is used (eg. Education, Military, etc.). Different authors have defined E-Learning, for example, the term E- Learning refers to all training activities that use electronic media or information technology where it is used to support the learning process (Effendi and Zhuang, 2005). Also, it is described as a computer-based environment having relatively open systems which permit interaction encounters with other participants and providing access to a wide range of resources (Piccoli, Ahmed, and Lves, 2001). Another author stated that E-Learning is the process of learning facilitated by mobile devices (Kearney, et al., 2012).

4. E-Learning Technologies and Approaches

There are different approaches to E-Learning and most of the discussion concerning E-Learning is focused on educational courses. Today, there are different types of E-Learning that organizations can choose from based on their specific goals and needs. The following section presents different E-Learning approaches.

4.1 Blended Learning

Blended learning is an educational approach that includes framing the teaching learning process that incorporates both traditional face-to-face classroom methods with online learning activities. It has scope for constructive learning; collaborative learning and computer assisted learning. Learners usually engage in both in-person and online activities. This method creates a flexible and personalized learning experience (Dangwal, 2017).

4.2 Microlearning

Microlearning is an educational approach that is characterized by its bite-sized and easily digestible units (Dolasinski and Reynolds, 2020). It is one of the most powerful tools for learners, enabling complex information to be broken down into brief chunks. Microlearning is appropriate for quick learning and the reinforcement of knowledge where learners need specific information or skills. This method is designed to enhance learning and performance in the most effective manner via short pieces of contents (Taylor and Hung, 2022)

4.3 Gamification

Gamification refers to the integration of game mechanics into the educational environment in order to enhance motivation, engagement and learning outcomes (Argote and Hora, 2017). Gamification can be implemented in different organizational processes and it intends to leverage the motivational power of games to make learning more effective and compelling (Bozkurt and Durak, 2018).

4.4 Social Learning

Social learning is a type of learning that occurs via social interactions and experiences where learners can develop their knowledge and skills. It emphasizes the idea that people can learn effectively by engaging with each other and sharing knowledge and experiences in order to retain information. There are different key components and features of social learning such as discussion forums, social media integration, group chats and messaging, peer review and feedback and learning communities.

4.5 Distance Learning

Distance learning is known as distance education or remote learning, often using technology where instructors and learners can interact with each other from different geographical locations (Anderson, 2008). It permits the learners to participate and engage with course materials, providing flexibility in terms of place and time. Distance learning utilizes different digital platforms, such as Learning Management Systems (LMS), video conferencing tools and online resources, offering flexible scheduling to access the course materials. Distance learning, is a form of didactic information transfer reaching dispersed listeners, using different forms of media. This form does not require direct contact between the instructor and the learners (Bradley, 2021).

4.6 Virtual Reality and Augmented Reality

Virtual reality (VR) is a technology that creates a simulated environment which allows learners to be in a computer-generated world which can be an entirely imaginary universe. The experience can be visual and auditory, and it enables humans to directly interact with a computer-generated environment. It also can create a sense of presence, making the learners feel that they are inside the virtual world. Virtual reality is used as an aid for learning and practice in different fields such as medicine, engineering, design, architecture and education and training (Abdelaziz, Alaa El Din and Senousy, 2014). Augmented Reality (AR) is a technology that deals with the combination of real world and computer-generated data (Alam, et al., 2019). It is unlike virtual reality where the learner is completely immersed in a virtual environment. Augmented Reality allows users to interact with the virtual images and can enhance the collaboration between learners and instructors, thus maximizing the learning process (Alam, et al., 2019).

4.7 E-Learning Platform

An E-Learning platform is an electronic learning platform using communication technologies to facilitate learning and teaching (Alseelawi et al., 2020). An E-Learning platform can be used to deliver training programs, online courses, webinars, video conferencing and virtual workshops. Learners can access the platform anywhere and anytime allowing them to adjust their learning based on their own schedule and pace (Aixia and Wang, 2011). One type of E-Learning platform is Learning Management System (LMS) which is a software-based platform or web-based technology that helps to automate employee training. By using LMS, learners can have the flexibility to study at their own pace and can access course materials and assignments at their convenience.

These are just numerous examples of E-Learning technologies and approaches that are you used in education and a wide range of organizations. Currently, the public sector organizations are benefiting a lot from the Learning Management System which is used to improve the learning experience and develop the employees' knowledge consistently. A well-designed LMS can help organizations to set a structured learning environment and save time and money. The field of E-Learning continues to grow with advanced technology and new approaches that are constantly being developed to improve the learning experience. The future of E-Learning looks promising as technology continues to grow at a rapid pace. It is clear that E-Learning plays a crucial role in education and professional development.

5. Advantages and Disadvantages of E-Learning

5.1 Advantages of E-Learning

There are several advantages of E-Learning. First, organizations do not have to hire instructors to develop learning materials because it can be done online (Sitnikov, et al., 2010). Also, one the biggest advantages of E-Learning is that it can have the ability to cover distances, particularly important for organizations that are spread across multiple locations. Learners and instructors do not have to attend classes physically as they can study and learn in their comfort zone or at their workplace (Ellis and Kuznia, 2014). In addition, E-Learning can also help in fulfilling the needs of some learners with special needs (Quadri, et al., 2017). Moreover, organizations can save costs because some training courses are conducted in different locations which can be far for learners to travel to, resulting in organizations paying for accommodation, transport, and meals. E-Learning will help in minimizing

the cost (Ellis and Kuznia, 2014). Additionally, there is some flexibility in completion of the training course as E-Learning is self-paced and it can be completed at the learner's pace. Also, the contents of the training course can be repeated until it is understood by the learners (Ellis and Kuznia, 2014).

5.2 Disadvantages of E-Learning

There are several disadvantages with E-Learning and some participants can be technologically challenged and are hesitant to enroll in training courses (Ellis and Kuznia, 2014). Also, some employees might not be fully equipped technologically making it hard to implement E-Learning as some learners in organizations can come from different generations and are not used to the E-Learning method (Ahmad and Tarmudi, 2012). Some employees might have some resistance to change and it is difficult to deal with them and convince them to try the E-Learning method (Ellis and Kuznia, 2014). One of the common disadvantages of E-Learning is language as some learners might face difficulty in communication as English is not their native language. Another disadvantage is that it promotes the tendency of isolation as some learners spend most of their time completing online learning and avoiding the company of others (Akhter, et al., 2021). E-Learning cannot replace traditional learning as both of them should be blended together in order to achieve better results, better service delivery and skilled employees (Sitnikov, et al., 2010).

6. Factors Affecting the E-Learning Implementation

Various studies have highlighted factors that are affecting E-learning implementation (Sitnikov, et al., 2010; Ellis and Kuznia, 2014) and each of these studies has a different explanation and perspective for each factor. Al-Balas, et al., (2020) mentioned that E-Learning requires technological skills as it is usually conducted using electronic devices. Any lack of skill will make it difficult to benefit from the advantages of E-Learning. For example, a lecturer's competencies are one of the important factors that can impact on E-Learning implementation. Another study by Ellis and Kuznia (2014) added that the lecturer and the learners might not be committed to use the E-Learning system as they do not have the motivation to do it and because they have never been involved in the process. In addition, the rapid development of the future technology might change considerably, and some instructors might not keep up with new E-Learning trends and approaches (Cheng, et al., 2011). Instructors are also one of the important factors of an E-Learning system because any lack of skills will impact significantly on the confidence of the instructor in the use of technology. Also, the interaction between the learners and instructors when using online learning is more difficult than with traditional teaching, which might be one of the factors that can impact the E-Learning implementation. Furthermore, the infrastructure and technology play a major role in E-Learning implementation. It requires a huge budget to ensure the appropriate software, hardware, internet connection and Technical Support system is available. Therefore, infrastructure and technology are considered one of the most significant factors that can impact E-Learning implementation (Quadri, et al., 2017).

7. Challenges of Using E-Learning Methods in Organizations

Implementing E-Learning methods can offer various benefits (Ellis and Kuznia, 2014). Yet, many studies have revealed that there are numerous challenges of using E-Learning methods in organizations (Sitnikov, et al., 2010; Ellis and Kuznia, 2014). According to Giannakos, Mikalefand Pappas,(2022), the E-Learning environment is relatively new, and its technologies are developing and changing rapidly. Wu et al., (2022) views the transition into E-Learning as difficult as it involves converting the physical teaching materials into E-Learning materials which can be time consuming to complete. In addition, there are three factors that determine the successful implementation of E-Learning system such as, the perception of the users, their competencies, and computer use knowledge (Lee, Hsieh and Chen, 2013). Moreover, employees should have the acceptance and motivation to learn as it is an essential key to success in any E-Learning implementation (Almaiah, Al-Khasawneh and Althunibat, 2020). According to Almaiah, Al-Khasawneh and Althunibat (2020), there are several methods that can be utilized to enrich the employees' motivation to learn, such as having a positive and energetic learning environment. Choosing the best E-Learning platform for organizations is one of the keys to making sure the trainees have a successful and positive learning experience (Chen and Tseng, 2012). Quality is another factor that has been found to impact the acceptance of E-Learning technology. The learners will be reluctant to use the E-Learning platform if its quality is poor and this will lead to them refusing to accept the platform (Chou, et al., 2012). A lot of studies (Mahmodi, 2017; Dreheeb, Basir and Fabil, 2016) agreed that the quality attributes of the system have a critical role in providing user satisfaction to keep on using the E-learning system. A lack of consideration for factors that impact user acceptance of E-Learning may also prove to be a challenge in E-Learning (Qurotul Aini, et al., 2020). As E-Learning plays a critical role in organizations, the reliance on the use

of E-Learning also becomes a challenge not only for organizations but also for employees and the lecturers (Dreheeb, Basir and Fabil, 2016). Successful implementation of E-Learning in organizations mainly depends on addressing the challenges faced by user (Tarus, Gichoya and Muumbo, 2015). Therefore, examining the challenges may guide policy makers to fulfill the needs of E-Learning users in order to effectively implement E-Learning in organizations (Qurotul Aini, et al., 2020).

8. Conclusions

This study examines factors affecting the E-Learning implementation among public sector organizations in the UAE. Despite the robust global research interest in the role of E-Learning implementation in organizations, there is not enough research looking at how different factors impact the implementation of E-Learning in organizations, especially within Dubai government organizations. Previous research has often focused on E-Learning learning in schools and universities (Salloum, et al., 2019) but has rarely examined E-Learning in the public sector.

Several studies consider the challenges faced in implementing E-Learning in universities, while there are limited studies examining the implementation in the public sector. Therefore, more studies are required as future research. Dubai government organizations have already started applying E-Learning for their employees and there are a lot of challenges in implementing the digital technology in the learning system, yet there has been no research done to highlight the challenges in the context of the public sector organizations. Most of the researchers consider the challenges faced in the education system for students not for employees. Researchers should apply a collaborative effort to study how to implement E-Learning successfully in the learning process of organizations.

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The Effect of the BYOD Model in Comparison with the Traditional use of ICT In Primary Schools

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Abstract: It is often today claimed in the media and literature that we are in a time of tremendous technological growth, with everything in society being modernised and the dominance of digital technologies on the horizon. In contrast, digital technologies can result in changes in society and greatly affect interpersonal relationships and communication between people. Digital technologies affect all generations, and especially children in primary school. It seems that the use of these devices in education could be beneficial for both parties, schools and pupils. Thanks to their flexibility there is the possibility of using different didactic approaches that directly respond to the specific learning styles and diverse needs of pupils, from the slowest to the most gifted. The aim of this paper is to describe the effect of the Bring Your Own Device (BYOD) model in comparison to the traditional concept of digital technology in the higher primary school classroom. The aim of the research was to compare the effect of the BYOD model on teaching compared to the traditional use of digital technology using a questionnaire and a didactic test. The research was conducted in Czech Republic and utilized pupils smartphones and Ipads. For this finding, thematically identical teaching units were designed and implemented for two groups of pupils. The two experimental groups differed from each other only in the way they used digital technologies. This experiment was conducted in the context of teaching two tribal classes of children 11-12 years old. A total of 42 children participated in the research, of which 18 formed the research group and 24 formed the control group. The design of the thematic units was oriented to one of the modules of the computer science subject. Specifically, the lessons focused on hardware and software. The Nearpod web application was chosen for the BYOD model intervention in teaching, mainly because of its availability, accessibility and ease of orientation in the application. The research results suggest that the BYOD model may not always be effective; however, factors that caused or otherwise influenced this are discussed.

Keywords: ICT, BYOD, Education, Digital technology

1. Introduction

It is often today claimed in the media and literature that we are in a period of tremendous technological growth, with everything in society being modernised and the dominance of digital technologies looming on the horizon. In contrast, digital technologies can result in changes in society and greatly affect interpersonal relationships and communication between people. Digital technologies affect all generations, and especially children in primary school. According to statistics from the Czech Statistical Office in 2023, more than 99% of young people have a mobile phone, with some surveys reporting that parents purchase mobile phones for their children as early as when they start primary school (Pavlicová, 2018).

It seems that the use of these devices could be mutually beneficial for both schools and pupils. The use of mobile technology brings many benefits. Pupils use their phones almost every day, so there is no need to invest time in familiarising themselves with a new device. Using their own device allows pupils to work outside school. Besides, they take better care of their devices than they would of borrowed school equipment. Schools therefore save on expenses such as tablets and can invest the money elsewhere. As the use of mobile technology grows, so does the requirement to modernise the school network.

The benefits of the BYOD model can be applied in all educational areas. Its flexibility offers the opportunity to use different didactic approaches that directly match specific learning styles and the diverse needs of pupils from the slower to the gifted. Being able to work on one's own device, which the user knows well, can increase productivity and activity in the classroom.

The aim of our research is to investigate the effect of the BYOD model in comparison to the traditional concept of ICT in higher primary school education. In the BYOD model intervention, we chose the hardware and software computer topic, which will be the same for both experimental and control groups. To analyse the issue of BYOD in education through the eyes of pupils, we used a questionnaire survey and a didactic test. For our study we set the following research questions:

RQ1: What are the attitudes of higher primary school pupils towards the use of the BYOD model in education?

RQ2: What are the most common concerns in implementing the BYOD model in higher primary school education?

RQ3: What is the impact of using the BYOD model on pupils' learning outcomes and activity in the classroom compared to traditional ICT methods?

RQ4: What are the advantages and disadvantages of using the BYOD model in higher primary school education?

2. Theoretical Background

BYOD, or Bring Your Own Device, is a trend that was originally applied and used in the corporate environment of various companies, but has gradually moved into the field of education, where it has taken root and has been gaining increasing popularity in recent years, and its benefits are unquestionable(Disterer & Kleiner, 2013).

We understand the BYOD model in education as a certain model of an approach to learning, a concept or school policy where pupils or students bring their own mobile devices to school. Such devices include laptops, netbooks, tablets or smartphones. They are used to access school information, applications, services or directly in the classroom as part of the educational process. The development of new mobile devices and their decreasing price, fast internet connection and general digitisation are aspects that lead to an ideal opportunity to use the BYOD model in education(Dixon & Tierney, 2012).

The emergence of the BYOD model in education was preceded in the early 1990s by the 1:1 (one-to-one) model, in which schools tried to provide one PC per pupil. At the root of the models was the substitution of paper and pens with computers and digitisation(Dixon & Tierney, 2012).

Although the 1:1 approach or concept initially primarily concerned desktop computers, the term itself primarily took root with the advent of laptops and is now understood more in relation to mobile digital devices. The typical model for the introduction of the 1:1 approach was that of the school purchasing the equipment, acting as both the provider and security administrator of the equipment, taking care of licences, software and updates, local area network connectivity, maintenance, repairs, insurance or replacement of the equipment when it became obsolete. In the early days this was mainly a matter of equipping the IT classroom to provide one piece of hardware per pupil. Over time, desktop computers were replaced by mobile devices – laptops, tablets, mobile phones. With the development of new types of mobile digital devices, it became clear that pupils preferred different types of devices for different types of tasks, and so the focus on one type of these devices proved inconvenient, giving rise to a phenomenon that replaced one-to-one with a one-to-many approach (Šupicová, 2019).

The BYOD model addresses this issue by integrating both of these models. Above all, the pupil's or student's familiarity with the device itself seems to be most crucial. With the increasing expansion of smartphones owned by most pupils today, their inclusion in education seems vital. Compared to the common use of smartphones by pupils, their inclusion in the educational process aims at harnessing a completely different potential. Within the concept of BYOD, smartphones and other mobile digital devices are used for educational purposes, and thus for acquiring certain skills and competencies that are a prerequisite for both academic and later professional growth, but also for fully-fledged civic employment (Šupicová, 2019).

Advantages of the BYOD model

A well-planned application of the BYOD model in the classroom provides pupils with a whole new experience of using their own devices. At home and outside school, pupils mainly use mobile devices for leisure activities, but implementing them in the classroom can teach pupils to use their own devices for other activities that help them develop and learn new skills. These are usually activities that systematically increase their digital literacy, encourage online collaboration, teach them to critically assess various information sources, communicate purposefully, grammatically and typographically correctly in digital media, and create imaginative multimedia works using their own creativity. All this happens while respecting ethical standards and safety rules. Thus, a leisure device becomes an educational device (Neumajer, 2016).

Another interesting advantage is the economic factor. Buying computer systems or equipping IT classrooms on an already tight school budget is taxing. Of course, it does not end with the purchase of equipment, as these school devices need to be managed, secured, maintained, the software updated, licences purchased and obsolete equipment replaced. The BYOD model solves all of this, as it can save considerable amounts of money or time spent on various organisational matters around IT classrooms.

The variety of devices may seem like a disadvantage, but modern cloud computing allows us to use various services and programs stored on Internet servers to which pupils connect via the school network. Cloud computing also supports connectivity for pupils, teachers and parents by allowing access anywhere, any time.

Disadvantages of the BYOD model

The main disadvantages of this model include security and data protection. What belongs among the drawbacks is the necessary training of teaching staff or even their refusal to implement this model in teaching. The school's expenditure on boosting the internet connection may also fall under the downsides. In practice it might happen that a pupil forgets their device, but this can be solved by borrowing a school device such as a tablet.

According to the official project (Ministry of Education, 2020) called 'Individualisation of teaching and development of digital literacy using mobile devices', the main objective is to train teaching staff, participating partner schools and model schools and spread examples of good practice of model schools in the use of digital technologies in teaching in order to develop digital literacy of children and pupils using mobile technologies. The practices imparted include methods of individualisation in the conventional classroom using mobile devices and the application of the BYOD model.

The project was implemented from January 2020 to December 2021 and consisted of two key activities. The main outputs of the project were professionally supported teachers of partner schools and model schools, model lessons for each participating teacher, methodological materials, video recordings of good practice examples and improvement of technical equipment of schools through the purchase of new digital technologies.

This project has increased the effectiveness of education in terms of measurable outcomes. Mobile devices have been shown to increase the measurable effectiveness of pupils' learning, particularly through the possibility of adaptability, individualisation, time optimisation and immediate feedback. It provided support to the fixation phase of learning. The supported schools were equipped with a mobile device classroom, which allowed them to apply the skills acquired without major changes in teaching organisation and building modifications. The schools also received a basic kit to provide wireless network coverage in selected classrooms, which they can expand at will. Thanks to this project, pupils are able to tap into the potential of their mobile devices. What was particularly innovative in this project was the natural integration of mobile devices into the functioning organisation of the school and the development of pupils' digital literacy. From the perspective of the teachers, there has been a simplification of lesson preparation procedures, an active integration of digital technologies and mobile devices into teaching, and easier support to pupils with special educational needs. Teachers have also seen a significant increase in their own digital literacy and digital competencies.

According to Silva (2020), who applied the BYOD model in teaching in Portuguese schools, an overall SWOT analysis of this model was created using questionnaires, in which 95.65% of the students responded that they would like to continue using mobile devices in learning and that they worked well during the BYOD model intervention. The majority of the students (60%) would welcome this method as a helper in daily education or other activities. The author's conclusion mentions an increase in activity in the classroom with improved results.

According to Attewell (2015), it is estimated that up to one-third of Australian schools encourage pupils to bring their own digital devices. The Softlink organisation concluded that pupils want to learn with digital technologies they are familiar with and use at home, forcing schools to implement the BYOD policy. In 2013 they reported great progress in upgrading the school network and equipping schools to support e-learning and improve access to resources through digital devices. Laptops for schools will likely mean a mass application of the BYOD model across the country, as was reported by ZDNet. In 2013 the NSW Department of Education also released the 'BYOD Policy' and 'BYOD Implementation Guidelines' for schools.

Alberta Ministry of Education (Canada) released a 'BYOD Concept Guide for Schools' in 2012, stating that schools in Alberta had applied BYOD for over five years and that schools currently using the BYOD model had found the system beneficial. They see the application of the BYOD model as providing immediate access to digital technology to fully meet the educational needs of pupils (Attewell, 2015).

Due to the organisation of the American school system at the school district level, it is difficult to ascertain the current situation in all districts; however, it is true that mobile devices or even the BYOD concept are being utilised by a growing number of districts. In 2011 US mobile learning experts found that the successful application of the BYOD model in elementary and high schools, given the sophistication, prevalence and accessibility, should make up a large part of US education by 2015. They estimated that a pupil would have a mobile device available for educational purposes. For most schools, the 1:1 ratio would be achieved as they

applied a BYOD policy to help relieve the financial strain on public schools as they could not afford to purchase digital devices for every pupil (Attewell, 2015).

3. Methods

We chose a quantitative strategy for our research. To analyse the issue of BYOD in education through the eyes of pupils, we used a questionnaire and a didactic test as the research tools. In our research we observed several factors such as the opinions about the use of BYOD model in the educational process, the pupils' attitudes, the impact of the BYOD model on the pupils' results and activity and the advantages and disadvantages perceived by the pupils when using this model. A specially designed satisfaction questionnaire was tailored to the needs of this research. The questionnaire contained a total of 12 questions, scaled as 1 = yes, 2 = probably yes, 3 = do not know, 4 = probably no, 5 = no. The scale was replaced by 'emoticons', which were circled by the pupils to make it more suitable for the selected age group. The didactic test created was adapted to the needs of this research and contained 10 questions based on the material covered. The test and the questionnaire were anonymous. The main target group of the questionnaire was sixth-grade pupils in primary school. Responses were collected from 42 pupils.

To carry out our research we used Computer Science lessons, where we discussed the topic of 'Hardware and Software' with the pupils. The aim of the teaching unit was to fulfil the expected outcomes of the Framework Curriculum for Primary Education of Czech Republic, namely:

I-9-4-01 describe how a computer works in terms of hardware and operating system; discuss the functioning of digital technologies that set trends in the world;

I-9-4-04 deal with typical computer malfunctions and error conditions.

Teaching unit without using the BYOD model – Group A

The teaching unit without using the BYOD model consisted of several parts. We started with a lecture, which was supported by a presentation created in the internet application prezi.com. This was followed by a fixation activity where pupils matched pictures of components to their names in the presentation. During the lesson the pupils were provided with disassembled computer kits (including individual components such as a processor, RAM, etc.), which we showed and described. In the next part of the lesson, we assigned each pupil one term from the topic discussed, about which they had to find one or two pieces of information on the Internet that had not been mentioned so far. During the lesson there was lively communication and interaction with the pupils. At the end of the lesson the pupils took a didactic test and an evaluation questionnaire.

Teaching unit with BYOD intervention – Group B

The teaching unit with the BYOD intervention itself also consisted of several parts, with the introductory activities identical to Group A. It was based on a lecture, which was supported by a presentation created in the web application prezi.com. This was followed by a fixation activity where pupils matched pictures of components to their names in the presentation. During the lesson the pupils were provided with disassembled computer kits (including individual components such as a processor, RAM, etc.), which we showed and described.

For the BYOD model intervention in the classroom, we chose the web application Nearpod, mainly because of its availability, accessibility and ease of navigation. The Nearpod app is accessible from any device whether it is Android, iOS or any other device platform. It is a free web app that does not need to be pre-installed on the device. The teacher can observe the entire course as an observer and can directly formatively evaluate or correct.

The pupils took out their mobile phones and scanned the prepared QR code to access the Nearpod web app. Several activities awaited them in the app, such as matching correct pairs, drawing information into a picture and answering a quiz. The main activity was a gamified 'Time To Climb' task, in which pupils used the correct answers to progress towards the goal.

During the Nearpod activities, the pupils were informed of what was going to happen and what the next task was. During the lesson there was lively communication and interaction with the pupils. At the end of the lesson the pupils took a didactic test and an evaluation questionnaire.

4. Results

The research asked several key questions regarding pupils' perceptions and attitudes towards the BYOD model and its use in the classroom. The results can be used to discuss the modernisation of the educational process, to adapt to new technological trends in the field of pedagogy and especially information technology. In the research part we focused both on the overall perspective of the pupils and on the subgroups, which were divided according to the following criteria.

The research was carried out with pupils of the sixth year of primary school. Group A was used as a control group in which we did not apply the BYOD model. The class consisted of twelve boys and twelve girls. Group B was the class with the BYOD model intervention. The class consisted of eight boys and ten girls.

Didactic test results

In this section we will discuss the results of the didactic test from different perspectives. We will compare the test results between Group A and Group B and also take the gender aspect into account.

First, we will look at the scores in both groups. The total score in Group A was 177 out of 240 possible points; in Group B, it was 120 out of 180 possible points.

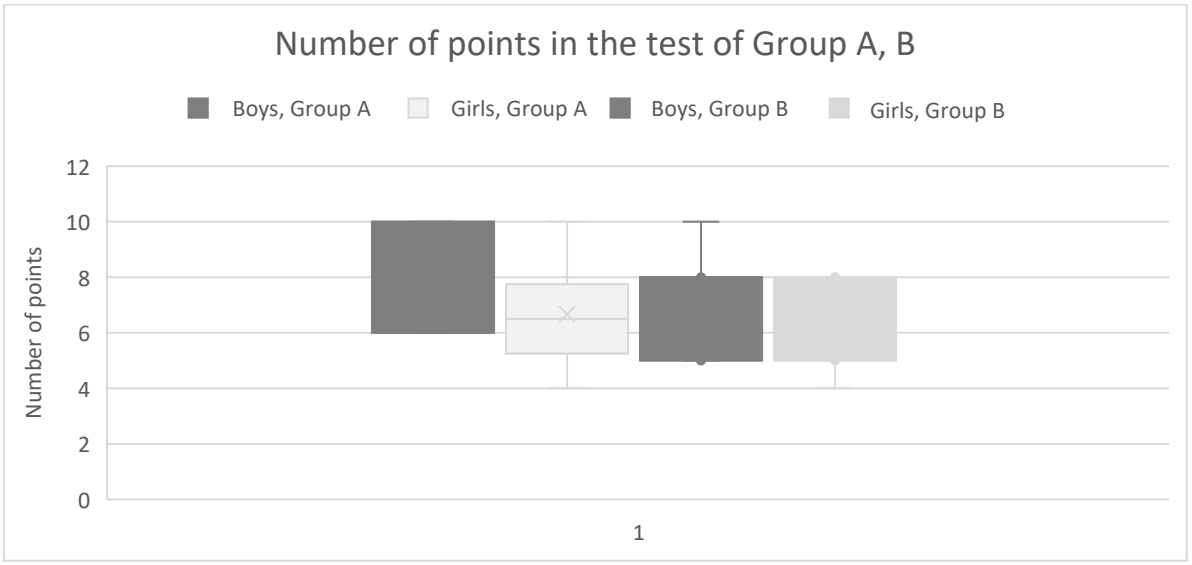

Figure 1: Didactic test scores of Group A, B, divided by gender

In the comparison of the test success rates, Group A was in the forefront with a 73.75% success rate compared to Group B, which was 66.66% successful.

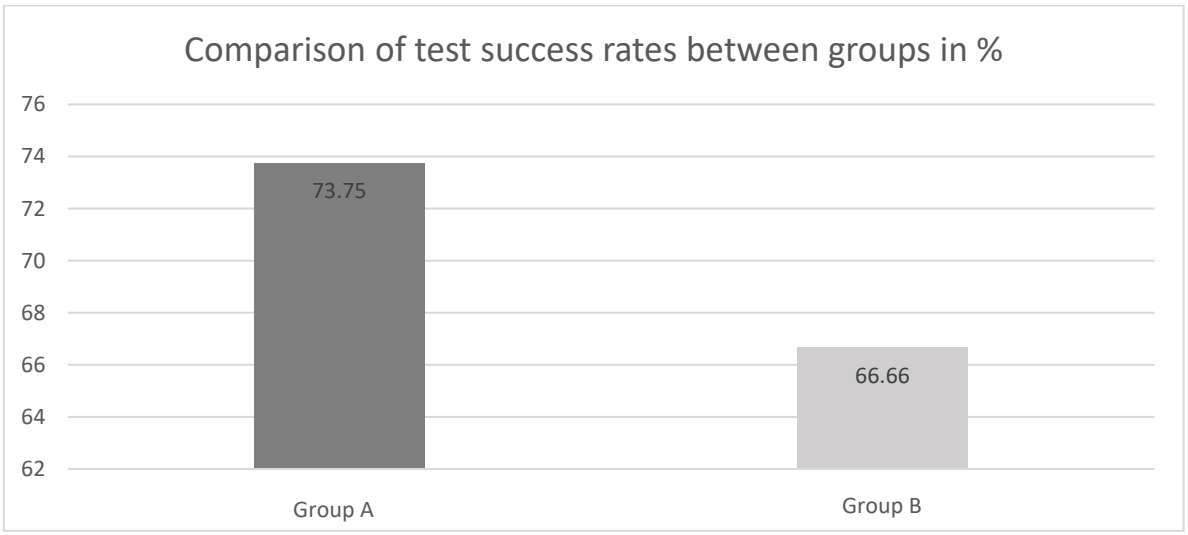

Figure 2: Overall didactic test success rate between the groups

As far as the comparison of the success rate of girls and boys in each group is concerned, the boys in Group A were better overall in the didactic test, achieving a success rate of 80.83%. The girls managed to pass the test with a success rate of 66.66%. In Group B, boys were better oriented in the test overall, with a 71.25% success rate. The girls managed to pass the test with a success rate of 63%.

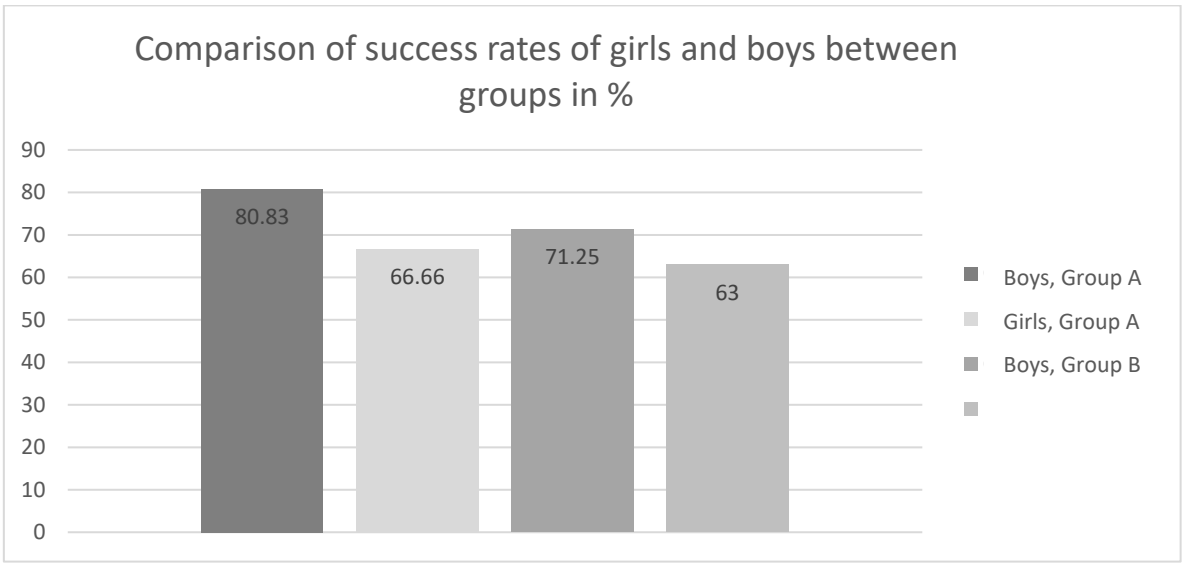

Figure 3: Comparison of success rates between Groups A, B, divided by gender

Questionnaire results

In this section we discuss the responses collected in the evaluation questionnaire. For statistical processing of the data, we converted the five different emoticons into verbal expressions of the type 'yes', 'rather yes', 'do not know', 'rather no', 'no'. Closed questions are shown in the chart, open questions are labelled and discussed in words.

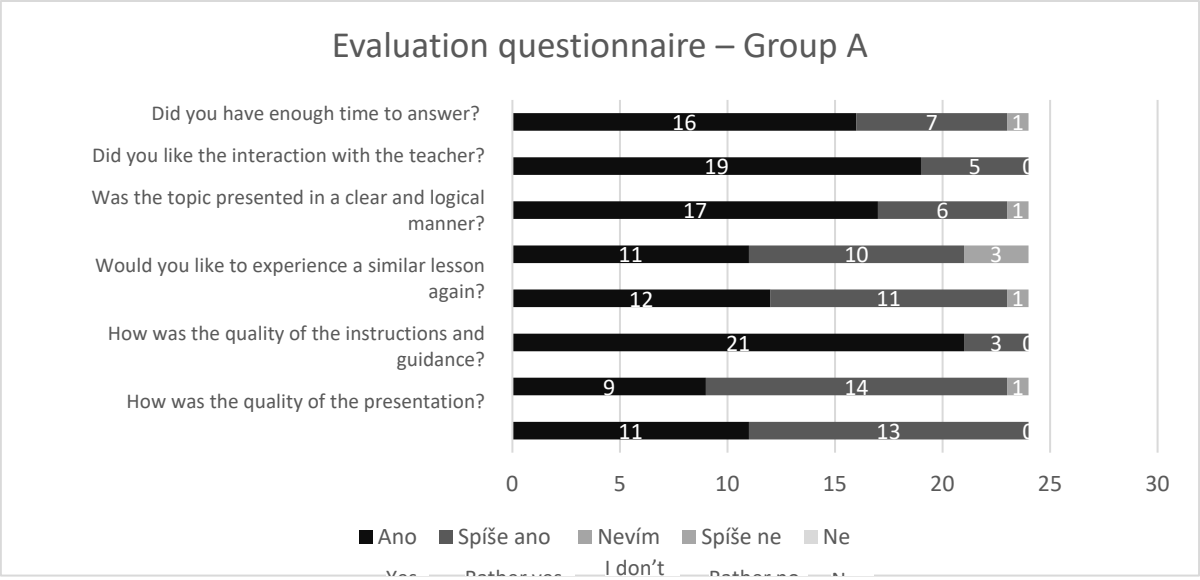

Figure 4: Responses to the questionnaire questions in Group A (without using the BYOD model)

Is there anything you would like to change about the lesson?

- The pupils answered almost unequivocally 'no' to this question. One pupil answered that he would like to try assembling a PC and one answered that he would like me to speak louder.

What did you like most about this lesson?

- The most repeated term was 'prezi', or a new style of presentation that they were unfamiliar with. They also liked the introduction of the PC and the individual components, and the work itself.

What did you like least about this lesson?

- Most pupils here answered 'no, nothing', but individuals answered, for example, that they did not like the 'frontal teaching', the 'information search', or the 'test' itself.

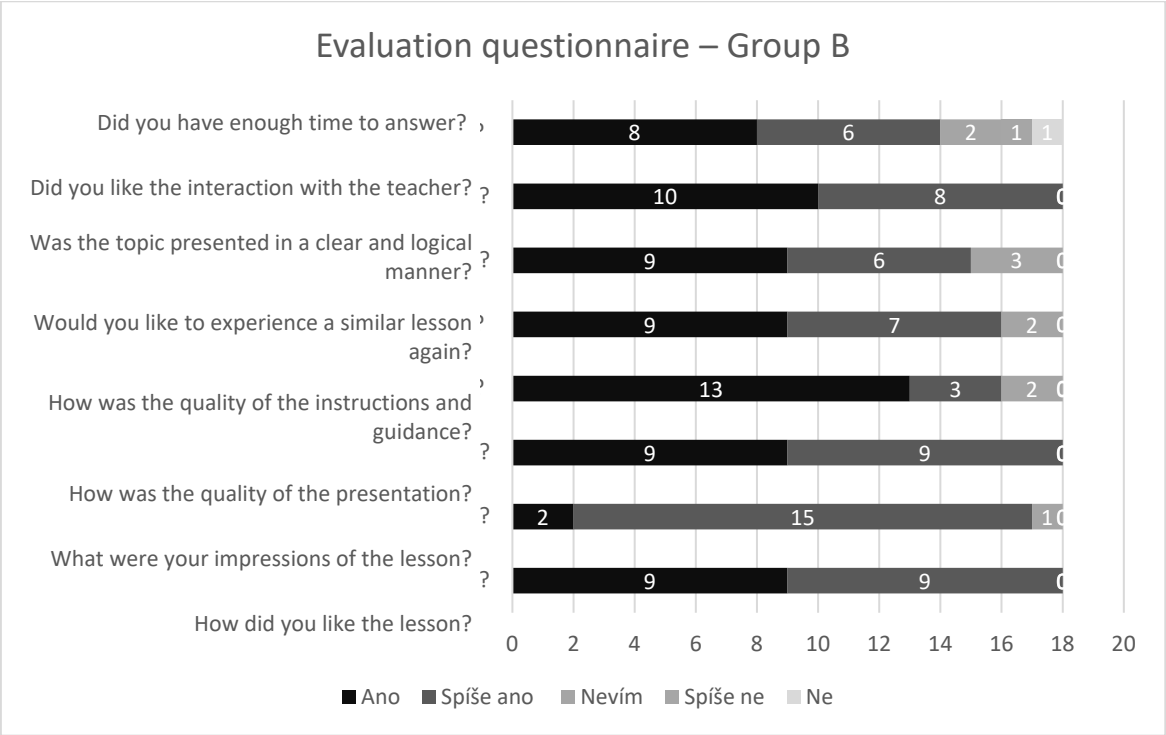

Figure 5: Responses to questionnaire questions in Group B (using the BYOD model)

Is there anything you would like to change about the lesson?

- The majority of pupils answered 'no'.

What did you like most about this lesson?

- Here the answer 'game' was clearly predominant – this term was mentioned in half of the answers. Other answers were 'nearpod', 'quiz', 'communication', 'prezi'.

What did you like least about this lesson?

- Most pupils here answered 'no, nothing', but some mentioned 'working with terms' or 'questionnaire'.

5. Discussion

Given the research results, which do not correlate with professional studies, we might wonder why Group B, the group in which BYOD was used, did not show a higher success rate in the test or why their subjective impression of the lesson was weaker than Group A, which did not use BYOD. Group B is objectively weaker. They are generally not as interested in information technology and generally the subject of ICT in education is not one of their favourites.

I would attribute the fact that boys were more successful than girls in both groups in the test to the boys' interest in computer games, as this was a lesson that was not very engaging for the girls; the boys were significantly more active in both classes and were interested in the different components or workings of computers.

Group A is very active, altruistic and calm. They enjoyed the class itself very much and were active throughout, raising their hands when I asked a question and answering correctly.

Group B, on the other hand, seemed 'tired' and inactive. We had to repeat all the questions and motivation to work often and get the correct answers from them with extra help. Group B also includes one pupil with special educational needs, so a teaching assistant was present during the whole lesson. The pupil did not have the

slightest problem to complete the whole lesson without any limitations, so we can say that the BYOD model is also suitable for pupils with special educational needs.

As a limitation in the research, we would mention the insufficient number of pupils to whom the BYOD model was applied in the lesson. As there were only two classes with a total of 42 pupils – 24 as control and 18 with the BYOD model intervention. Another was the length of the lesson, 45 minutes, in which we had to fit in the teaching, the questions, the actual application of the BYOD model, and even the final 15 minutes set aside for the completion of the test and questionnaire.

Risks of the BYOD model in practice

We registered some risks associated with this model. The pupils were informed in advance of the lesson to bring their mobile phones; however, three pupils had left their mobile phones at home. Thanks to the excellent resources of the primary school, we were able to provide these pupils with school iPads, and so the problem was relatively easily solved.

Furthermore, we noticed that for some Android device users, the Nearpod app did not display well, with the diacritics in the sentences particularly displayed with errors, and the pupils thereby had to often puzzle out what the assignment was.

6. Conclusion

The aim of the research was to determine the effect of the BYOD model compared to the traditional concept of ICT in higher primary school education. We established four research questions, which we successfully answered. We determined the pupils' attitudes towards the use of the BYOD model in education, which was rather positive. When the BYOD model was implemented, the concerns related to forgetting one's own device were confirmed. The impact of the BYOD model on pupils' performance and activity was rather negative. In the use of the BYOD model, the undeniable benefits of the model were confirmed, but so were the challenges associated with its use. We applied the BYOD model in a lesson designed in correlation with a control lesson with the traditional use of ICT in education. On the basis of the developed evaluation questionnaire and didactic test, we analysed the results of the use of the BYOD model in the teaching of sixth grades in primary school.

We analysed the results using charts. The research turned out negatively for the BYOD model, but in the discussion we mention factors that caused or otherwise influenced the research. Studies on the application of the BYOD model in the classroom show positive effects on pupils in classes using the model.

Given the limitations of our research in terms of class size or teaching hours, we would like to follow up on this issue in future research.

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A Probability-Based Model for Course Completion Prediction in Online Asynchronous Learning

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Abstract: The sheer scale of Massive Open Online Courses (MOOCs), presents a significant challenge in delivering personalized learning experiences and effective student support. With vast participation numbers, it becomes difficult for instructors to track individual progress, pinpoint specific areas where students struggle, and understand the underlying reasons for failure to complete the course. This lack of individualized attention can lead to disengagement and higher dropout rates. A probability-based analysis offers a solution by generating student-specific predictions about their likelihood of completion. This empowers educators to proactively identify those at risk, tailor interventions, optimize resource allocation, and potentially improve the overall learning experience within the MOOC environment. This study focuses on developing a robust predictive framework to accurately estimate the probability of students completing an introductory programming course offered on the Open Learning Platform of the University of Moratuwa, Sri Lanka. The approach began with a classification model to determine the likelihood of course completion. Building upon this, a regression model was developed to generate a specific probability percentage representing the chance of a student successfully completing the course within a designated time frame. Initial findings suggested that predictions from the classification model achieved the highest accuracy when students have completed approximately 42.8% of the course materials. It is anticipated that further refinements to the methodology will improve the reliability of the predictions. A crucial aspect of this research involves determining the optimal percentage of course progress needed to yield reliable probability predictions. This is investigated through systematic analysis and experimentations including incremental model testing. The dataset encompasses diverse demographic and educational variables, enabling the identification of influential factors affecting course completion. This study provides insights on developing personalized learning strategies, intervention tactics and academic planning within online asynchronous education.

Keywords: Online asynchronous learning, Predictive analytics, Predictive models, Course completion rate

1. Introduction

In recent years, Massive Open Online Courses (MOOCs) have gained immense popularity as a means of delivering education to a vast audience. However, with the unprecedented scale of participation in MOOCs, ensuring personalized learning experiences and effective student support has become a significant challenge. The sheer volume of participants makes it difficult for instructors to monitor individual progress, identify areas of difficulty, and provide tailored interventions. Consequently, high dropout rates and disengagement among students have emerged as pressing issues within the MOOC environment. To solve this issue, using learning analytics becomes crucial in MOOCs, offering insights into student behavior and performance to provide assistance on time for students and personalize the support strategies .

1.1 Background

1.1.1 Introduction to MOOCs and challenge

Massive Open Online Courses (MOOCs) have revolutionized access to education, offering opportunities for learners globally to engage with high-quality courses from renowned institutions. However, despite their potential, MOOCs face significant challenges, particularly concerning student retention and engagement. High dropout rates are a persistent issue, with many students failing to complete courses they enroll in. This literature review explores existing research on the challenges faced by MOOCs, particularly focusing on dropout rates, and reviews various predictive models and intervention strategies that have been developed to address these issues.

1.1.2 Student retention and engagement in MOOCs

Research indicates that MOOC dropout rates are alarmingly high, often exceeding 90% in some courses (Reich, 2014). Factors contributing to these dropout rates include lack of motivation, insufficient prior knowledge, and the absence of personalized support (Kizilcec et al., 2013). MOOCs typically attract a diverse learner population, ranging from high school students to working professionals, each with different learning needs and challenges (Hansen & Reich, 2015).

1.1.3 Predictive models and factors influencing dropout rates

Predictive modeling has been widely applied in educational research to identify at-risk students and improve retention rates. Various machine learning techniques, including decision trees, logistic regression, support vector machines, and neural networks, have been employed to predict student performance and dropout risks (Luan, 2002).

Decision Trees and Logistic Regression

Decision trees are valued for their interpretability and ease of use. They provide clear rules that educators can follow to classify students based on their risk levels. Studies have shown that decision trees can effectively identify students at risk of dropping out by analyzing factors such as course interaction data and performance metrics (Feng et al., 2019). Logistic regression, a robust statistical method used for binary classification problems, is particularly useful in educational settings for predicting the probability of student dropout based on various predictors. Its simplicity and effectiveness make it a popular choice for educational researchers (Zimmerman, 2012).

Advanced Techniques

Advanced techniques such as neural networks and ensemble models have shown promise in improving prediction accuracy. However, their complexity and the need for large datasets often limit their practical application in educational contexts (Xing et al., 2016).

Factors Influencing Dropout Rates

Several studies have identified key factors influencing dropout rates in MOOCs, including demographic variables, course interaction patterns, and performance metrics. Age, gender, educational background, and employment status are significant predictors of student success in MOOCs. Younger students and those with prior experience in the subject matter tend to have lower dropout rates (Jiang et al., 2014). Engagement with course materials, participation in discussion forums, and regular logins are strong indicators of student commitment. Higher levels of interaction often correlate with higher completion rates (Gillani & Eynon, 2014). Early performance in assignments and quizzes can serve as an early warning system for potential dropouts. Students who perform well initially are more likely to complete the course (Greene et al., 2015).

1.1.4 Intervention strategies and generalizability

To mitigate high dropout rates, various strategies have been tested. Personalized feedback, tailored to individual performance and interaction data, improves engagement and reduces dropouts (Tanes et al., 2011). Gamification elements like badges, leaderboards, and rewards enhance motivation and sustain interest (Hew et al., 2020). Identifying at-risk students early allows educators to allocate additional resources and support efficiently (Fritz, 2017).

Ensuring predictive models' generalizability across courses and student populations is essential, with cross-course validation aiding their applicability (Nguyen et al., 2020). Ethical considerations, especially regarding data privacy and potential biases in predictive modeling, are also crucial (Slade & Prinsloo, 2013).

1.1.5 Conclusion

The literature highlights the significant challenges MOOCs face in terms of student retention and engagement. Predictive models, particularly those using decision trees and logistic regression, offer promising solutions for identifying at-risk students. By leveraging these models and implementing targeted intervention strategies, educators can enhance student support and improve completion rates. Future research should focus on refining these models, ensuring their generalizability, and addressing ethical considerations to maximize their effectiveness in diverse learning environments.

1.2 Study Focus

High dropout rates and student disengagement in MOOCs is a significant challenge to educational institutions, particularly in identifying and supporting at-risk students. This study is based on developing a predictive framework using 2 machine learning models for the Full Stack Developer course on the Open Learning Platform of the University of Moratuwa using classification and regression models to identify and predict dropout risks.

2. Methodology

2.1 Research Design

This study uses a quantitative research design to develop and validate a predictive framework for identifying students at risk of dropping out from the Full Stack Developer certificate course offered on the Open Learning Platform of the University of Moratuwa. To personalize the learning experience, this study uses the Python for Beginners module as a foundation to identify students on time (Before dropout).

Why choose the Python for Beginners module out of six modules?

When new students register, they can only have access to 2 modules namely the Python For Beginners module and Web Design for Beginners but most students choose the Python for Beginners module as the first module so because of that the highest data volume can also be found in this Python for Beginners module.

2.2 Classification Model Design

Purpose: The classification model aims to categorize students into distinct risk groups based on their likelihood of dropping out. This initial classification provides a broad segmentation that helps in identifying at-risk students early in the course.

Model Selection: A decision tree classifier was selected for its interpretability and ability to handle complex, non-linear relationships between features. Decision trees are particularly useful for this study because they provide clear rules for classifying students into risk groups.

Model Features

The features used for the classification model include:

- Demographic Information: Age, gender, educational background, and employment status.
- Course Interaction Data: Number of logins, time spent on the platform, participation in discussion forums, and frequency of accessing course materials.
- Performance Metrics: Assignment scores, quiz scores, and the percentage of course materials completed.

Training and Validation

The dataset was divided into a training set (70%) and a validation set (30%). The training set was used to build the model, while the validation set was used to test its accuracy. Cross-validation techniques were employed to tune the model's hyperparameters and to avoid overfitting. Performance metrics such as accuracy, precision, recall, and F1-score were used to evaluate the model's effectiveness.

Table 1: Risk Groups

Group 1	Group 2	Group 3	Group 4
High risk	Moderate risk	Low risk	Likely to complete

Group 4: Students who are likely to complete the course, typically those who are pursuing or have completed a degree in IT, or are working in an IT-related job.

2.3 Regression Model Design

Purpose: This study goes beyond just identifying students at risk of dropping out. The model only evaluates the students in group 1. This model utilizes a unique model to uncover patterns in student data that correlate with dropout risk. This empowers educators to more readily focus their support on students who might benefit from additional help throughout the Full Stack Developer program on time..

Model Selection: A logistic regression model was chosen due to its robustness and ability to provide probability estimates for binary outcomes (dropout vs. non-dropout). Logistic regression is particularly suited for understanding the impact of various predictors on the likelihood of a student dropping out.

Model Features: The features used for the regression model include all those used in the classification model, with additional emphasis on time-varying factors and student engagement metrics.

Training and Validation: Similar to the classification model, the logistic regression model was trained using the training set and validated using the validation set. The performance was measured using metrics such as R-squared, Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE).

Incremental Model Testing: The regression model was tested at various points of course progress (e.g., 25%, 50%, 75%) to determine the optimal progress threshold for accurate predictions. This involved systematically increasing the amount of completed course material used as input and analyzing the impact on prediction accuracy.

2.4 Data Collection

2.4.1 Data sources

Data was collected from the Open Learning Platform of the University of Moratuwa. The dataset includes demographic information, educational background, course interaction logs, and performance metrics of students enrolled in the introductory programming course.

2.4.2 Variables

Key variables extracted from the dataset include:

- Demographic Information: Age, gender, educational background, current employment status.
- Course Interaction Data: Number of logins, time spent on the platform, participation in discussion forums.
- Performance Metrics: Assignment scores, quiz scores, percentage of course materials completed.

2.5 Data Preprocessing

2.5.1 Data cleaning

Missing values were handled by using appropriate imputation techniques, and outliers were identified and treated to minimize their impact on the models.

2.5.2 Feature engineering

Relevant features were engineered from the raw data. This included creating new variables such as the rate of assignment completion, frequency of forum participation, and cumulative time spent on the platform.

2.6 Evaluation and Refinement

2.6.1 Model evaluation

Both models were evaluated for their predictive accuracy and generalizability. The classification model's performance was measured using metrics such as accuracy, precision, recall, and F1-score. The logistic regression model was assessed using R-squared, Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE). These evaluation metrics helped in understanding the strengths and limitations of each model in predicting dropout risks.

2.6.2 Model refinement

Based on the evaluation results, models were refined by adjusting hyperparameters, incorporating additional features, and addressing any identified biases. The goal was to enhance the predictive power and reliability of the models, ensuring they provide actionable insights for educators.

2.7 Generalizability Assessment

2.7.1 Cross-Course validation

The predictive framework was tested on 2 courses within the Open Learning Platform to assess its generalizability across various subjects and student populations. This helped in understanding whether the model’s performance was consistent across different educational contexts.

2.7.2 Demographic analysis

The impact of demographic and educational variables on model performance was analyzed to ensure the robustness and applicability of the predictive framework to diverse learner groups. This involved examining how different demographic factors (such as age, gender, and educational background) influenced the model's predictions and adjusting the model to account for any biases or discrepancies.

2.8 Ethical Considerations

All data collection and analysis procedures adhered to ethical guidelines. Informed consent was obtained from all participants, and data was anonymized to protect student privacy.

3. Results

3.1 Classification Model Performance

The classification model was designed to categorize students into four distinct risk groups based on their likelihood of dropping out. The decision tree classifier performed well, providing clear and interpretable rules for classifying students.

3.1.1 Model accuracy

The decision tree classifier achieved an accuracy of 85%, indicating a high level of precision in categorizing students correctly. The model's precision (the proportion of true positives out of all positive results) and recall (the proportion of true positives out of all actual positives) were also high, with precision at 83% and recall at 80%.

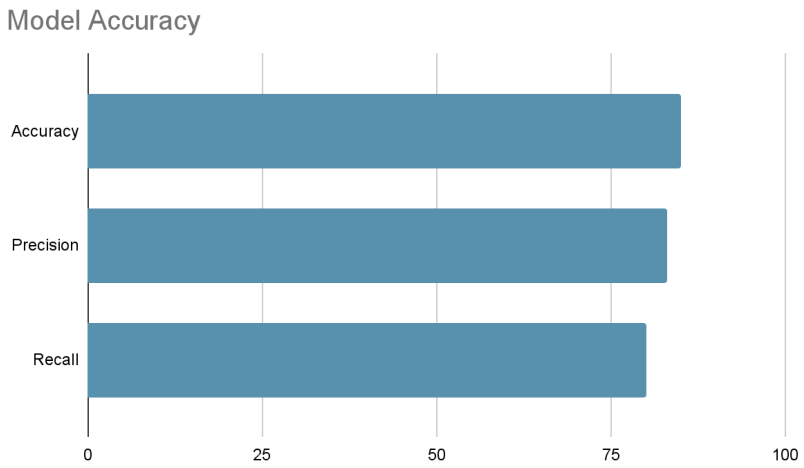

Figure 1: Model Accuracy

3.1.2 Risk group distribution

- Group 1 (High Risk): 26% of students were classified as high risk, requiring immediate intervention.
- Group 2 (Moderate Risk): 20% of students were classified as moderate risk.
- Group 3 (Low Risk): 32% of students were classified as low risk.
- Group 4 (Likely to Complete): 22% of students were classified as likely to complete the course.

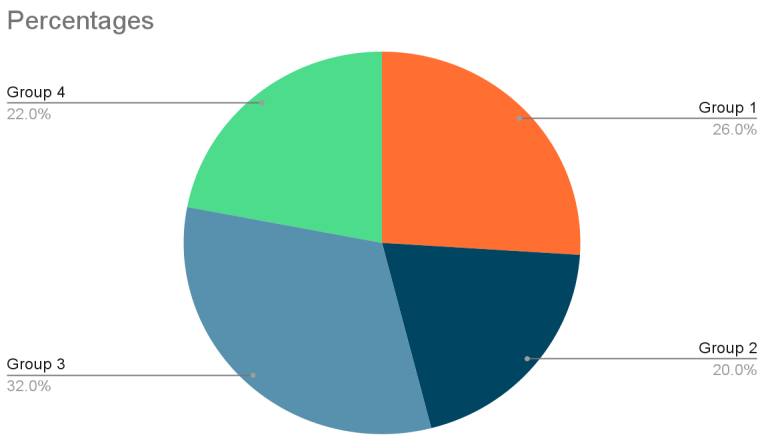

Figure 2: Risk Group Distribution

These risk groups helped in prioritizing students for tailored interventions. Notably, Group 4 included students pursuing or having completed a degree in IT or those working in IT-related jobs, which corroborated with their lower dropout likelihood.

3.2 Regression Model Performance

The logistic regression model aimed to provide a detailed and precise assessment of each student's dropout risk by estimating individual risk percentages. The model's output is a probability score for each student, indicating their likelihood of dropping out.

3.2.1 Model accuracy and reliability

The logistic regression model demonstrated strong performance, with the following metrics:

- R-squared**:** 0.78, indicating that 78% of the variance in dropout risk could be explained by the model.
- Mean Absolute Error (MAE)**:** 0.15, reflecting a low average error in the probability estimates.
- Root Mean Squared Error (RMSE)**:** 0.20, indicating a low level of prediction error.

3.2.2 Key predictors

Analysis of the model's coefficients revealed several significant predictors of dropout risk:

- Course Interaction Data**:** Higher frequency of logins and greater time spent on the platform were associated with lower dropout risk.
- Performance Metrics: Higher assignment and quiz scores correlated with lower dropout probabilities.
- Demographic Information: Students with an educational background in IT or those currently employed in IT-related jobs exhibited significantly lower dropout risks.

3.2.3 Incremental model testing

The regression model's accuracy was assessed at various points of course progress:

- At 25% Completion: The model's accuracy was moderate, with an R-squared of 0.65.
- At 50% Completion: Accuracy improved significantly, with an R-squared of 0.72.
- At 75% Completion: The highest accuracy was achieved, with an R-squared of 0.78.

This analysis indicated that the optimal prediction accuracy was achieved when students had completed approximately 42.8% of the course materials, balancing early identification of at-risk students with the availability of sufficient data for reliable predictions.

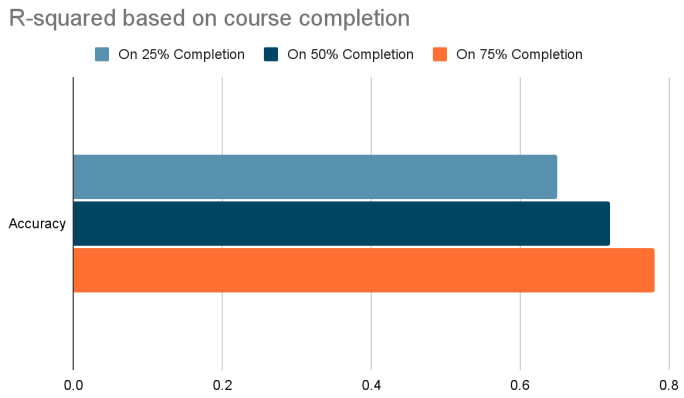

Figure 3: R - squared based on course completion

3.3 Implications for Personalized Learning and Interventions

The insights gained from the predictive models were used to develop targeted intervention strategies:

- Personalized Feedback: High-risk students received tailored feedback and additional resources to address their specific challenges.
- Motivational Activities: Engagement strategies such as gamification and peer support were implemented to maintain student interest and motivation.
- Resource Allocation: Educators could efficiently allocate resources by focusing on students with the highest dropout probabilities, optimizing support efforts.

By integrating classification and logistic regression models, the study provided a comprehensive framework for identifying and supporting at-risk students in MOOCs. The systematic approach ensured effective and generalizable predictions, offering valuable guidance for enhancing student engagement and success in online learning environments.

4. Generalizability Assessment

4.1 Cross-Course Validation

The predictive framework was tested on two distinct modules within the Full Stack Developer course. This validation aimed to evaluate the model's generalizability across different subject areas and student populations.

4.1.1 Introductory programming module (Python for beginners)

The implemented model demonstrates promising results in identifying students at risk of dropping out of the Full Stack Developer program. It achieved an accuracy of 84%, meaning it correctly classified most students in terms of dropout risk. Furthermore, the model exhibited strong performance in pinpointing at-risk students, with a precision of 82% indicating a low rate of false positives (identifying non-dropouts as at-risk). While some at-risk students might be missed (reflected in the 78% recall), the overall effectiveness in distinguishing dropouts from non-dropouts is further solidified by the AUC score of 0.86. This high AUC suggests the model's strong ability to differentiate between the two groups.

4.1.2 Advanced Programming Module (Web Design)

The model performed well in the Web Design for Beginners module, achieving an accuracy of 82%. While precision (80%) and recall (76%) were slightly lower than the introductory course, the model still demonstrates good ability to identify at-risk students (AUC: 0.83).

4.1.3 Comparison across courses

The model's performance remained consistent (accuracy, precision, recall) across both courses, requiring only minor adjustments for course-specific factors (e.g., weighting participation metrics). This consistency suggests the model's potential for wider application in different programming courses.

4.2 Demographic Analysis

The demographic analysis evaluated the model's performance across different demographic and educational groups to ensure fairness and applicability.

4.2.1 Age

Analyzing by age, the model showed younger students (18-24) performing better (accuracy: 86%, precision: 84%, recall: 79%) compared to older students (25+) (accuracy: 80%, precision: 78%, recall: 74%). This suggests potential differences in engagement or learning behaviors between age groups.

4.2.2 Gender

The model achieved an accuracy of 83% for male students, with a precision of 81% and recall of 77%. For female students, it had an accuracy of 84%, precision of 82%, and recall of 78%. The minimal differences indicate the model performed well across genders.

4.2.3 Educational background

The model's accuracy was highest for students with an IT background at 88%, with a precision of 86% and recall of 83%. For students without an IT background, the accuracy was 81%, with a precision of 79% and recall of 75%, indicating a lower dropout risk for those with IT familiarity.

4.2.4 Overall findings

The model was generally robust across different demographic groups, with slight performance variations. Detected biases, like lower accuracy for older students, were mitigated by rebalancing the training data and adding features to improve fairness. The analysis highlighted the need for tailored interventions, suggesting that older students or those without an IT background might benefit from extra support and resources.

By conducting cross-course validation and demographic analysis, the study ensured the predictive framework's robustness, fairness, and broad applicability across different educational contexts and learner demographics.

5. Conclusion

This study successfully developed and validated a predictive framework to identify students at risk of dropping out from an introductory programming course offered on the Open Learning Platform of the University of Moratuwa, Sri Lanka. The framework incorporated both classification and logistic regression models to provide a comprehensive assessment of dropout risks, thereby offering valuable insights for personalized interventions.

5.1 Key Findings

5.1.1 Classification model performance

The decision tree classifier effectively categorized students into four distinct risk groups, achieving an accuracy of 85%. This high level of precision and recall facilitated the early identification of at-risk students, enabling targeted interventions. The classification model's performance was consistent across different courses, demonstrating its adaptability to various educational contexts.

5.1.2 Regression model insights

The logistic regression model provided detailed probability scores for each student's dropout risk, with an R-squared value of 0.78, indicating strong explanatory power. Key predictors of dropout risk included course interaction data, performance metrics, and demographic information. These insights can guide the development of tailored support strategies to enhance student retention.

5.1.3 Generalizability and robustness

Cross-course validation confirmed the model's high accuracy across multiple courses, underscoring its generalizability. Demographic analysis revealed that the model performed robustly across different age groups, genders, and educational backgrounds, though minor variations highlighted the need for demographic-specific interventions.

5.1.4 Optimal course progress threshold

The study found that the optimal prediction accuracy for identifying potential dropouts was achieved when students had completed approximately 42.8% of the course materials. However, this threshold may vary slightly when the predictive framework is generalized across different courses and student populations. This balance between early identification and data sufficiency is crucial for timely and effective interventions.

5.1.5 Implications for practice

The predictive framework enables personalized feedback and resources for students based on their specific risk profiles, enhancing the overall learning experience. By identifying at-risk students early, educators can implement motivational activities, additional support, and engagement strategies to reduce dropout rates. Additionally, the model helps optimize resource allocation by focusing efforts on students with the highest dropout probabilities, ensuring efficient use of educational resources.

5.1.6 Future directions

- Refinement of Predictive Models: Further research could explore the integration of additional features and advanced machine learning techniques to enhance prediction accuracy and robustness.
- Scalability Across Platforms: Extending the study to include a broader range of courses and platforms can validate the framework's scalability and adaptability in diverse educational settings.
- Longitudinal Studies: Long-term studies tracking student outcomes post-intervention can provide deeper insights into the effectiveness of predictive modeling and personalized support strategies.

In conclusion, this study demonstrates the potential of leveraging learning analytics and predictive modeling to address the challenges of high dropout rates and disengagement in MOOCs. By providing a robust and generalizable framework for identifying at-risk students, it paves the way for more effective and personalized educational interventions, ultimately contributing to improved student success and retention in online learning environments.

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Utilising Blended Learning for Large Classes to Deliver an Introductory Programming Course

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Abstract: Higher education institutions are constantly pushed to increase the student intake and produce industry-ready graduates. The pressure generally arises from the governing bodies, originating from socio-political factors. It is particularly evident in the field of Information Communication Technology (ICT) where there is a growing need for quality graduates. Undergraduate programmes in the field of ICT generally offer introductory computer programming courses that are mandatory at early stages of the degree programme. Consequently, the number of students registering for such courses can increase drastically. The students are coming from diversified backgrounds. While some students may have prior experience in computer programming, a larger majority may not have any prior knowledge or experience. Increased class size meets the constraint of the limited availability of physical classroom space and would require the class to be separated into smaller groups for face-to-face activities. Large classes are also challenged with the increased man-power requirement in terms of lecturers, instructors, and teaching assistants. Maintaining student engagement and interactivity becomes increasingly difficult in a large class. Grading of assessments becomes time-consuming and needs and requires increased manpower. Based on the observations and learning from an ongoing introductory programming course, this study evaluates the procedure for overcoming the challenges faced by the teaching staff, especially with a class size exceeding 1000. To cover the theoretical components, recorded video lectures are provided. The class is divided into groups consisting of approximately 100 students and live, online, interactive group discussions are conducted. The live, online smaller group discussions allow students to clarify doubts regarding the content. This also allows the distribution of the limited teaching and assistant staff. Students who need further assistance are encouraged to meet the teaching assistants physically. Thus, the workload is distributed effectively, and it helps ensure the dedicated support and attention is provided to the students. Auto graded programming assignments are effectively employed for formative and summative assessments, which reduces the grading workload significantly. The findings of this study provide insights on course design to effectively deliver the content and conduct assessments overcoming the challenges presented by increased class size.

Keywords: Blended learning, Large class, Programming course, Auto-grading

1. Introduction

The field of ICT is continuously growing and the demand for skilful individuals in various sub-domains has also been in the rise. Computer programming, software engineering, web development, quality assurance engineering, cloud computing, user interface/user experience (UI/UX) design, and information security are some of the highly sought after subcategories in the field of ICT. Around the globe, a large number of students sign up and get enrolled for study programmes that aim to transform them as individuals with knowledge, skills and attitudes expected by the respective industries.

In general, any study programme in the field of ICT would expect the students to have at least a fundamental knowledge in computer programming. This is generally done by allowing the students to take an elementary programming module at the early stages of the programme, as early as in the very first semester.

At present, engineering schools are also pressing towards requiring their students to be familiar with fundamentals of computer programming. As all branches in engineering now use computers and computer-based methodologies undergraduate students that belong to all engineering disciplines are taught programming in most universities (Peteranetz et al., 2018). Even though for may engineering disciplines may not directly involve computer programming at their core work, programming knowledge is identified as a considerable advantage for such students to successfully continue with their studies. Computer programming and scripting knowledge can be vastly helpful in conducting data analysis, developing models and simulations, and to automate tasks in useful ways which otherwise can be exceedingly time-consuming. Therefore, it should be noted that for any of the non-ICT engineering disciplines, solid knowledge in programming fundamentals with hands-on experience will be vastly useful. Liu, 2014 stated that undergraduate programmes in computer science may include several programming-related courses of varying difficulty level. Other engineering disciplines may include at least one introductory programming course in the undergraduate curriculum (Wang et al., 2017).

Effectively delivering a module in programming fundamentals can be challenging in many ways. Most students may have no prior experience in any kind of computer programming. Some students may not even have a good understanding in basic mathematical concepts. The students will be from diverse backgrounds, skill levels and they will be placed in a class to learn programming from scratch. Learning programming is not just about learning theory. Hands-on exercises and practice play a vital part in teaching and learning programming. Therefore, it is not just a case of delivering lectures and requiring the students to do assessments and examinations. It may require a considerable amount of individual attention towards the students so that they can catch up with the flow and experience an efficient learning journey.

The task becomes more challenging with increased number of students and limited resources in terms of teaching staff and infrastructure. With the increasing student intake, the teaching staff is burdened with delivering programming fundamental modules for large classes often without appropriate number of manpower to cater to such scale. Especially when the class size exceeds 1000, the teaching staff find it difficult to manage the time and resources in expectation to deliver the course content effectively.

This study identifies the situation, analyses, and attempts to provide recommendations based on a real case-study on an existing programming fundamentals course in an engineering school. The findings would be largely helpful to the teaching staff as well as the administrators to take necessary steps and adopt accordingly to maintain required standards in the module delivery.

2. Literature Review

2.1 Introductory Programming Courses

Kanika et al., 2020 identified the main reasons for teaching introductory programming course in the early stage of an undergraduate engineering program. The study emphasized that exposure to terminology and fundamental programming concepts, enhancing computation thinking and problem-solving abilities, teaching to design, implement, test, and debug a program and teaching good practices in programming were of importance for the students. Such course is typically taught using a particular programming language. In a typical introductory course, students are provided with details on data types, variable declaration, operators and expressions, input and output statements, conditional and iterative statements, arrays and strings, pointers, user-defined data types, functions and recursion, and file handling (Yuan et al., 2015). C++, Java, and Python are identified as some of the popular programming languages used in most universities (Kunkle & Allen, 2016).

The history of teaching introductory and advanced modules in computer programming dates back to mid-20th century. The programming languages have largely evolved since then and hence the teaching methodologies have also evolved. Koulouri et al., 2014 identified the complexity of teaching a programming course and the challenges faced by the educators. The teachers take up the task of teaching students how to analyse a problem logically and translate the identified solution into a computer program.

Kanika et al., 2020 went on to identify approaches used in teaching programming and clustered into visual programming, game-based learning, pair and collaborative learning, robot programming and assessment systems. The study further reviewed the efficiency of the approaches by comparing multiple studies that had been conducted. The study went on to recommend that suitably designed tools help in motivating students to learn programming. Especially the interactive programming tools have shown to help students in getting familiar with programming in a short period of time.

Prensky, 2007 identified key factors for maintaining interest levels of the modern students. The study stated that the students preferred constant interaction with technology, inductive reasoning, frequent and quick interactions with content, and good visual literacy skills were preferred by students. It went on to say that these are not easy to offer through traditional instructional methods.

Bogdanovych, A. and Trescak (2016) showed that by including game-like visual examples, the students' motivation to learn programming significantly improved. The study further implied that, even though the student started with a visual framework to learn programming, they successfully went on to learn programming language like Java, which required extensive coding.

2.2 Teaching and Learning Methods for Introductory Programming Modules

Blended learning as defined in Graham (2006) as learning systems "that combine face-to-face instruction with computer-mediated instruction" has received increasing attention in recent times. Garrison and Kanuka (2004)

identified blended learning as “the thoughtful integration of classroom face-to-face learning experiences with online learning experiences”. The method is widely adopted in higher education and has been referred to as the “new traditional model” (Ross and Gage, 2006) and the “new normal” in course delivery (Norberg et al., 2011).

Blended learning has gained significant popularity in recent years, as it offers a flexible and engaging learning environment that combines the benefits of both traditional classroom instruction and online learning (Kizilcec & Kambhampaty, 2020). The hybrid-delivery model described in one of the sources allows participants to access graduate degrees while remaining in their current positions, providing them with opportunities for professional advancement (Cable et al., 2014).

lended learning offers a variety of benefits for teaching programming fundamentals. It facilitates flexible learning, access to rich resources, and collaboration among learners and educators. With the potential to transform education, this system provides a comprehensive and interactive approach that improves comprehension, retention, and overall learning outcomes (Monika et al., 2023). Blended learning also allows for a personalized learning experience, as students can progress at their own pace and receive individualized feedback and support (Cable et al., 2014). Furthermore, the use of multimedia elements such as text, images, audio, video, and interactive content in blended learning can enhance the teaching and learning process and make programming fundamentals more engaging and accessible to students (Monika et al., 2023).

3. Problem Statement

The challenges faced by educators in efficiently delivering introductory programming course in undergraduate engineering study programmes is identified. Multiple studies have investigated how these challenges can be overcome by employing modern teaching and learning methodologies. However, it is a complicated problem for which the solution may have to take different combinations of actions to provide a sophisticated and customized overall solution.

4. Methodology

This study documents the methods adopted in delivering an introductory programming module for an engineering undergraduate programme in a state university in Sri Lanka.

4.1 The Overview of the Module

The introductory programming module which used Python as the programming language for teaching, targeted at training the students to design and develop algorithms to solve simple computational problems. Using the high-level programming language Python, it further trains the students to develop simple control applications using embedded software platforms.

The most recent offering of the module, which will be of focus in this study, comprised of more than 1000 registered students who were in their first semester of the engineering degree programme. Most of these students were yet to select their specific engineering discipline and they were required to take this module at the first semester of the programme.

The students were divided into 12 groups with each group comprising of 80-90 students and one full-time teaching assistant.

4.2 Delivery of Lectures

The panel of lectures comprised of five senior academic staff. The content of the module was distributed among the panel, and they delivered their respective parts in recorded lecture videos. The respective lecture notes and other supporting material including lecture slides, labs sheets, Jupyter Notebooks (Project Jupyter), and online quizzes were made available on the learning management system, Moodle (Moodle.org).

4.3 Live Discussions

Weekly group live online discussions were conducted by the respective lecturer. The teaching assistant in-charge of the group also participated the session. The students were expected to refer to the material, including the recorded lecture for that week, prior to joining the live discussion. The students were encouraged to come prepared with questions to be discussed during the session. The lecturer would actively take examples from the lesson and explain the content. All these sessions were conducted on the video conferencing platform, Zoom (Zoom.us).

4.4 One-on-one Support

Those students who needed further assistance were given the opportunity to meet a teaching assistant during a specified time. Each week teaching assistants would allocate few hours for one-on-one meetings with students depending on the requirement. This helped the weaker students to catch-up with the flow during the semester.

4.5 Teaching Assistant Support

Twelve full-time teaching assistants were deployed for this module. Each teaching assistant had the responsibility of managing a group of students. They were the students primary contact regarding anything related to the module. Apart from providing help with the content of the module, they also kept track of the student participation and engagement. In the case of any abnormality, they would report during the weekly meeting of the teaching staff.

4.6 Continuous Assessments (CA)

The continuous assessments comprised of lab exercises and online quizzes on Moodle. In these activities students would apply the programming knowledge into hands-on work to solve programming problems of varying difficulty levels. CodeRunner (Lobb and Harlow, 2016) which is an open-source question-type plugin for Moodle was vastly useful in conducting the continuous assessments. CodeRunner made it possible to provide auto-graded programming questions which assessed the students answer based on pre-defined test cases. A significant portion of the continuous assessments were conducted using CodeRunner type questions, which reduced the grading load by a great margin.

4.7 Final Assessment

The final assessment was conducted in a face-to-face proctored mode. Multiple choice questions (MCQ) were mainly used. Since there were over 1000 students to take the examination, this was a procedure with high physical space and human resource demands. Due to the unavailability of such a large number of computing workstations, the examination had to be given on printed paper. A large number of supervisors, invigilators, and other staff personnel had to be deployed for the examination.

4.8 Grading Management

The final examination had the highest grading load with over 1000 papers to mark. Even though only MCQs were given, since the examination was paper-based, it took a considerable amount of time to complete with the participation of the lecturers and the teaching assistants.

4.9 Teaching Manpower Management

This module had one of the largest dedicated teaching staff involved. Apart from the lecturers and full-time teaching assistants, few part-time teaching assistants were also employed. The part-time teaching assistants mainly comprised of final year students in the same undergraduate programme. All the teaching staff regularly met in a weekly meeting to discuss the weekly updates and planning for the next stages of the module. In addition to that, sub-group meetings were also arranged where necessary to discuss specific events such as continuous assessment components.

4.10 Building Question Pools

The questions pools for the continuous assessments were mainly contributed by the teaching assistants. The lecturers would join the meetings to provide guidance and review the questions. By developing a large pool of questions, it was possible to randomize the questions presented to the students during the continuous assessments.

5. Analysis and Discussion

5.1 Student Composition

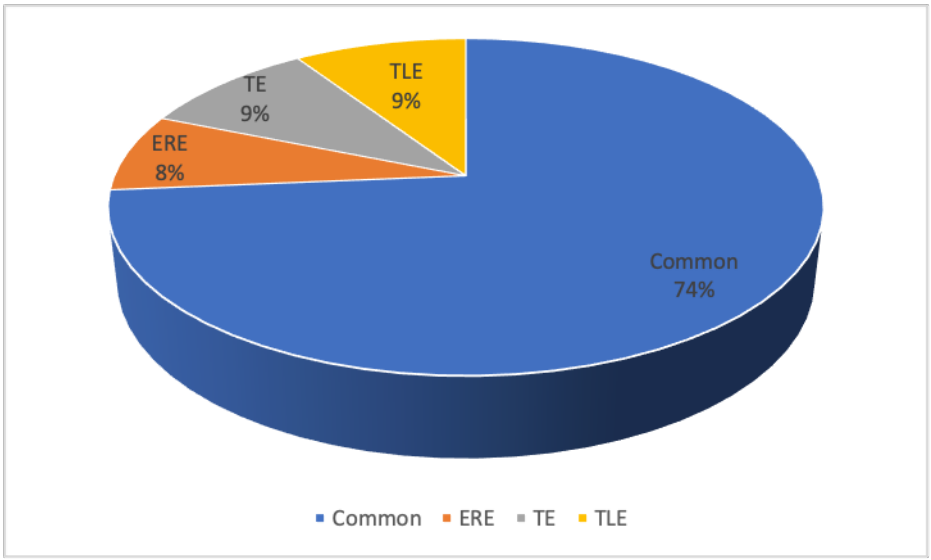

Figure 1: Enrolled students' distribution among engineering disciplines

Majority of the students (74%) were in a common group, who were yet to decide on their engineering discipline. For these students, the grade to be obtained from the introductory programming module was also countable towards the competitive score in selecting a discipline. On the other hand, student who had already included in specified disciplines, Earth Resources (ERE), Textile Engineering (TE) and Transport and Logistics (TLE) were taking the module as per the mandatory requirement.

5.2 Performance in Continuous Assessments

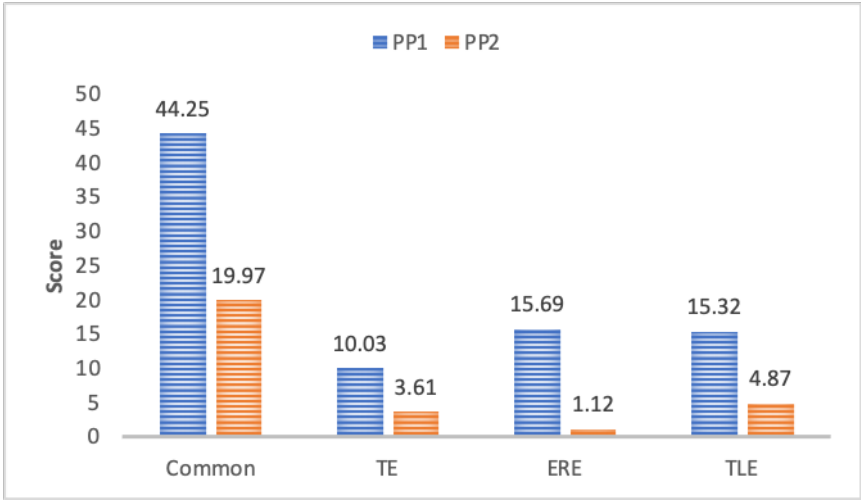

Figure 2: Average scores obtained in CA components.

Figure 2 presents the average scores (out of 100) for the two major continuous assessment components, Programming Problems 1 and 2. Bothe PP1 and PP2 presented students with programming exercises based on CodeRunner using Python. The students physically attended the lab and attempted the questions on the computer. This was conducted group-wise on different dates, as the number of workstations available in the computer lab was not sufficient for the whole class to be accommodated at the same time. Therefore, a large pool of questions was developed for this purpose as introduced in Section 4.10.

Observing Figure 2, a significant difference between the scores of the common group and the other groups can be identified. All groups found PP2 harder than PP1. Students in the common group performed significantly better in both PP1 and PP2. The need to obtain a competitive grade for the module can be considered as one

of the main reasons for the difference. The students in TE, ERE and TLE groups did not have to push for higher grades as their engineering discipline selection had already been done.

However, this should be discussed as a matter of developing appropriate attitude towards learning programming. Students tend to take the module merely as a requirement, but do not see the importance of learning programming and successful completion. Awareness should be made on the advantage of taking the course and learning programming.

5.3 Interactive Auto-Graded Assignments

One of the key aspects of the process was pushing for automatically graded programming assignments. To do a meaningful assessment in a programming course, hands-on programming components should be included. Grading of programming assignments is generally time consuming. For large classes, grading assignments individually and providing feedback becomes increasingly challenging. This is where the importance of auto-graded programming assignments is highlighted.

Figure 3 illustrates an example of using CodeRunner on Moodle for an interactive auto-graded programming assignment in Python. The student is provided with details on the expected behaviour of the program, and they can use the available space to write their code. The "Check" button can be used to test whether the program works as expected. The instructor can set-up several test cases while preparing the question. Test cases can either be specified as 'hidden' or 'visible'. The program must pass all test cases to be given full marks. It can be set-up to penalise the students based on the number of times they use the "Check" button which may lead to partial marks being given to the answer at the end. If there are errors in the code, or if some test cases fail, the CodeRunner interface will display alert messages accordingly. The student can consider such information and further refine their answer.

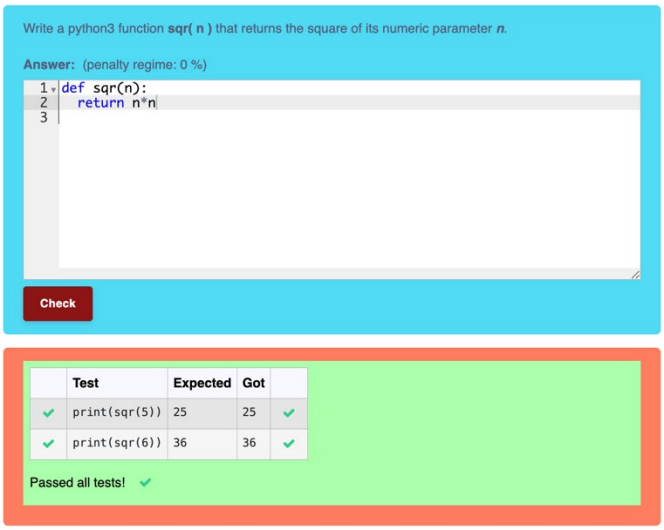

Figure 3: Example of an interactive auto-graded programming question using CodeRunner on Moodle

5.4 Utilizing Blended Learning

The delivery of the module included both face-to-face interactions as well as computer-mediated activities in the balance. Live interactive discussion sessions and one-on-one sessions with the teaching assistants maintained the level of face-to-face interactions. Recorded video lectures, text content, tutorials, lab sheets and other resources made available via Moodle encouraged self-study and helped prepare in advanced for the face-to-face sessions. Interactive, auto-graded programming assignments with feedback provided the means of conducting effective assessments for an introductory programming module.

6. Conclusion

The current study identified the applicability of blended learning for the delivery of an introductory programming course for an undergraduate degree programme. The delivery of the module faced multiple challenges due to the large number of student enrolments. Maintaining the level of face-to-face interactions became increasingly difficult and thus the teaching staff had to look for alternate and innovative ways to deliver the module efficiently. Adversities connected with limited availability of manpower as well as

infrastructure was countered by the introduction of computer-mediated interactions. The time constraints associated with grading assessments were balanced by the introduction of auto-graded assignments with the use of tools available in the learning management system. The findings of this study will be useful for institutions and academic staff in designing and delivering similar modules.

7. Limitations

The notable limitation of the approach is the conventional methods used for the final assessment. The papers had to be manually marked, in the expense of a considerable amount of time and human resources, even though it only contained MCQs. The best possible alternative is to move to computer-based examination, which can be facilitated by a quiz on Moodle. For MCQs, the quiz can be auto graded, taking out the grading burden completely. The only reason which prevented that was the unavailability of sufficient number of computer workstations for all students to attempt the examination at the same time.

A further suggestion would be to conduct the examination group-wise. Assuming that there is a lab facility with 200 usable computers, it can be suggested to prepare five distinct versions of the examination paper and let groups of 200 take the examination at different times. This would indeed require a considerable attention in preparing the questions so that fairness is maintained.

8. Future Work

The procedures described in this study should be subject to change and continuous evolvement. Some of the methods described here are purely experimental and it will take repetitive usage to determine the effectiveness. Continuously improving tools and technologies support educators to experiment with novel methods and combinations. Tools like CodeRunner thus far have been effectively deployed and the educators should look forward for better and enhanced tools and methods which will provide a better teaching and learning experience. Furthermore, online interactive coding tools like Trinket (Trinket) can be utilized for improved interactivity in programming courses.

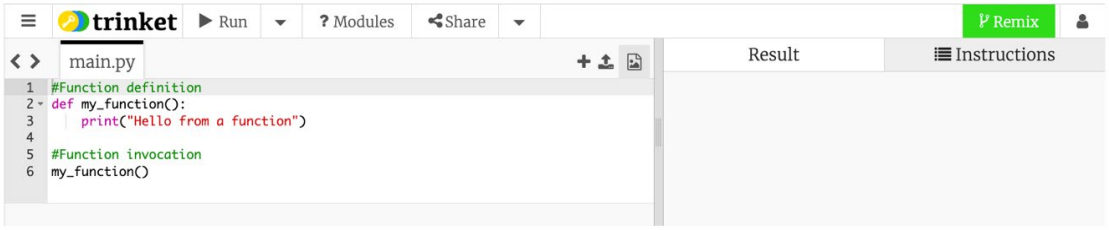

Figure 4: Online interactive coding tool, Trinket

Tools like Trinket can be seamlessly integrated to the learning management system, Moodle, to provide an uninterrupted and complete learning experience to the students.

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AI Literacy in Teacher Education in the Czech Republic

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Abstract: The development of artificial intelligence is rapidly transforming education systems worldwide, including those in the Czech Republic. This paper assesses the level of AI literacy among teachers and its integration into the Czech education system. The aim is to determine how well teachers are equipped with knowledge, skills, and understanding of AI, and how effectively they can integrate AI and AI awareness into their teaching. The methodology entails gathering data via a questionnaire survey distributed to teachers across various educational levels. The survey comprises questions that concentrate on AI literacy aspects, such as basic AI principles, the capacity to apply AI to teaching, discussing ethical issues related to AI use in the school environment, and critical thinking abilities. The questionnaire analyses the current state and challenges teachers face when integrating AI into teaching and learning practices. The results will be evaluated to identify areas where teachers' AI literacy needs strengthening and to propose strategies and recommendations for improving teacher training programmes and support. These strategies comprise teacher training, the provision of resources and support for integrating AI into the classroom, and reflection on the ethical and societal aspects of AI. It is equally important to invest in the long-term development of AI literacy among teachers as a fundamental step towards effectively harnessing the potential of AI in education and preparing students for the digital future. This article presents strategies and recommendations for the further development of AI literacy among teachers in the Czech Republic. The objective is to enhance their capacity and facilitate the more effective utilisation of AI in education.

Keywords: AI literacy, Digital competencies, Czech education system, AI integration to education, Critical thinking

1. Introduction

Artificial intelligence (AI) is regarded as one of the most significant technological developments of the past few decades. It is regarded as one of the most significant technological revolutions in history and has the potential to transform various sectors and aspects of our lives. This revolution is not only affecting the industrial sphere. At a global level, it is becoming a key element for innovation, economic growth and improving quality of life. A study by the McKinsey Global Institute (2018) indicates that AI could contribute up to $13 trillion to the global economy by 2030, representing approximately 1.2% annual GDP growth. This growth is driven by productivity gains, innovation and the emergence of new industries. AI enables the automation of routine tasks, freeing up human resources for more creative and complex activities that deliver greater value. AI also has significant potential in healthcare. For instance, AI algorithms can analyse vast quantities of health data and assist doctors in diagnosing diseases with greater accuracy than traditional methods. Studies have demonstrated that AI can enhance the detection of diseases such as cancer and enable personalised medicine that is tailored to the individual needs of patients.

The advent of artificial intelligence (AI) has opened up new avenues for educational advancement. These can significantly enhance the quality and efficiency of teaching, but they also present challenges that must be addressed. The growing importance of AI in education is evident in the increasing use of AI-based platforms and solutions to enhance the learning experience (Negoiţă, 2023). The potential of AI in education is considerable, encompassing precision teaching and improvements in student-teacher interaction. Consequently, it is vital to address ethical considerations and integrate AI responsibly into education (Negoiţă, 2023). In order to achieve effective and responsible integration of AI into the education system, it is essential to develop AI literacy. This encompasses an understanding of AI systems, their use, including applications that utilise AI principles, and evaluation in terms of transparency, safety, ethics, and impact on society. This paper presents a pilot study that assesses the level of AI literacy among teachers and its integration into the Czech education system. The objective of this study is to ascertain the extent to which teachers possess the requisite knowledge, skills and understanding of AI, as well as their capacity to integrate AI and AI awareness into their teaching.

1.1 The Potential of Artificial Intelligence in Education

The advent of artificial intelligence (AI) has the capacity to revolutionize the way we learn and educate others. The utilisation of AI technologies, such as adaptive systems, personalised learning programmes, and intelligent tutoring systems, enables the creation of learning environments that can adapt to the individual needs and abilities of students. This, according to Zhang & Aslan (2021) and Harry (2023), promotes more effective learning outcomes. This is achieved using technologies that analyse data to identify learning patterns and adapt educational content accordingly. Ahmad and his collective (2021) posit that artificial intelligence can facilitate greater accessibility to education for students with disabilities by providing them with tailored support and interfaces that can adapt to the learning styles and needs of diverse learners. Zheng and He (2021) posit that the utilisation of data-driven insights enables educators to gain deeper insights into student performance and learning processes. This, in turn, facilitates the implementation of data-driven decision-making, which in turn improves educational strategies and outcomes. In conclusion, artificial intelligence is of paramount importance in education, primarily due to its capacity to personalise learning, enhance teaching effectiveness, improve accessibility and provide invaluable insights into educational practices. Furthermore, AI tools can assist teachers in reducing their workload, allowing them to focus on more valuable tasks such as grading tests and tracking student progress. This allows for a greater allocation of time for direct instruction and individualised student support.

Nevertheless, the advent of AI has brought about several significant ethical and societal challenges. It is of the utmost importance to guarantee that AI systems are transparent, impartial and answerable. The issues of privacy, security and the ethical use of AI are the subject of intense debate. Organisations and governments around the world are engaged in the creation of regulations and standards with the objective of ensuring that the development of AI benefits society. The significance of AI development in a global context is considerable. Artificial intelligence has the potential to contribute significantly to economic growth, and to improve and address some of the greatest challenges facing humanity. Nevertheless, it is of the utmost importance that this development is conducted in a responsible manner, with due consideration for the ethical and societal implications.

1.2 The State of AI in Education in the Czech Republic

The education system in the Czech Republic is undergoing a transformation because of the influence of new technologies. In 2021, the first significant revision of the Framework Educational Programme for Primary Education in the field of digital technologies was implemented, which included the introduction of a new key competence, Digital, and modifications to the educational content of the educational area Informatics. The new digital competency is designed to ensure that by the end of primary education, pupils will have acquired the following skills:

- operate commonly used digital devices, applications and services; use them for learning and for engaging in school and community life; decide independently which technologies to use for which activities or problems,
- acquire, retrieve, critically assess, manage and share data, information and digital content, choosing processes, methods and means appropriate to the specific situation and purpose,
- creating and editing digital content, combining different formats, expressing themselves using digital means,
- use digital technologies to facilitate work, automate routine activities, streamline or simplify their workflows and improve the quality of their work,
- understand the importance of digital technologies for human society, become familiar with new technologies, critically evaluate their benefits and reflect on the risks of their use,
- avoid situations threatening the security of equipment and data, situations with a negative impact on his/her physical and mental health and the health of others; act ethically when collaborating, communicating and sharing information in the digital environment (RVP ZV, 2021).

In the Czech Republic, there are several initiatives and projects aimed at the promotion of AI in education. This is part of a broader global phenomenon where AI is creating new opportunities and challenges in the field of education. The objective of these projects is to increase awareness of AI among teachers and students, provide training in AI-related subjects, and create AI-focused educational materials.

To illustrate, the Edu AI chat assistant was developed by the Association for Better ICT Solutions, the National Pedagogical Institute of the Czech Republic and Charles University within the Edu AI project. The Edu AI

assistant provides guidance to students undertaking online preparation for the mathematics and Czech language entrance examinations for secondary schools. Furthermore, the website www.aidoskol.cz serves as a convenient gateway for schools, teachers, and students, directing them to a plethora of courses, training, workshops, and educational materials. The signpost is divided into three sections: training offers, materials and resources, and recommended tools. Nevertheless, the most prominent initiative in the field of AI education in the Czech Republic is the AI for Kids project, which encourages creativity, critical thinking and social responsibility in the context of a technology-driven world. The AI for Kids project provides educators with a range of educational materials, including a general introduction to AI for adults, the interactive story William & Meriwether, a translated textbook on machine learning for children, and AI Methodologies. Furthermore, they maintain an up-to-date awareness of new AI applications on their blog, and produce a diverse range of educational resources, not only for teachers but also for children. The organization is currently engaged in the development of an AI curriculum with the objective of facilitating the integration of AI into curriculum documents. In addition to the overview of these projects and their offerings, it is also of great importance to consider the level of AI literacy among teachers. This is a crucial factor in determining the successful integration of AI in education.

1.3 AI Literacy for Teachers

Although AI literacy has not yet received significant attention in the Czech Republic, there are several initiatives aimed at developing this area worldwide, particularly in the field of education. The importance of AI literacy in education is underscored by the multidisciplinary framework proposed by Allen (2023), which emphasises understanding AI systems, critically evaluating their implications, and fostering collaboration. A key question is how teacher education programmes can empower both future and current teachers to become competent in working with AI and to effectively guide their students in an increasingly AI-influenced environment. To analyse the current state and the challenges teachers face in incorporating AI into the classroom, a questionnaire survey was conducted. To identify the key concepts, themes and competencies that are considered essential for AI literacy in teacher education programmes, a literature search was conducted on how AI literacy is conceptualised in this context.

2. Methodology

The objective of the pilot research is to assess the level of AI literacy of teachers across different levels of education in the Czech Republic and to identify the main barriers and challenges associated with the integration of AI into teaching. In setting the objectives of this pilot research, we therefore posed the following two research questions:

RQ1. To what extent are teachers equipped with knowledge, skills and understanding about AI?

RQ2. What are the main barriers and challenges teachers face in integrating AI into teaching?

A questionnaire survey was employed to elicit responses. The questionnaire comprised five main sections: demographics, which sought to ascertain teachers' age, number of years of experience, and level of education; AI knowledge and skills, which assessed their level and frequency of use of AI tools; integrating AI into teaching, which sought to identify the barriers teachers face and ascertain whether there is support from the school and the resources needed; ethical and social issues; and promoting critical thinking. The questionnaire was distributed electronically to primary, secondary and university teachers in the Czech Republic. The data collected was analysed using descriptive statistics and the results presented in the following chapter.

3. Results

In order to obtain basic information about the respondents, the first part of the questionnaire was devoted to the collection of basic demographic data. Firstly, the distribution of respondents at different levels of the education system was of interest. The largest proportion of respondents (34.83%) indicated that they work at the second level of primary schools, while 21.72% stated that they work at secondary schools. A further 17.42% of respondents indicated that they work at the first level of primary schools, 8.71% at higher vocational schools, and 17.32% at universities. This distribution demonstrates a comprehensive representation of teachers at different levels of education, providing a comprehensive view of AI literacy.

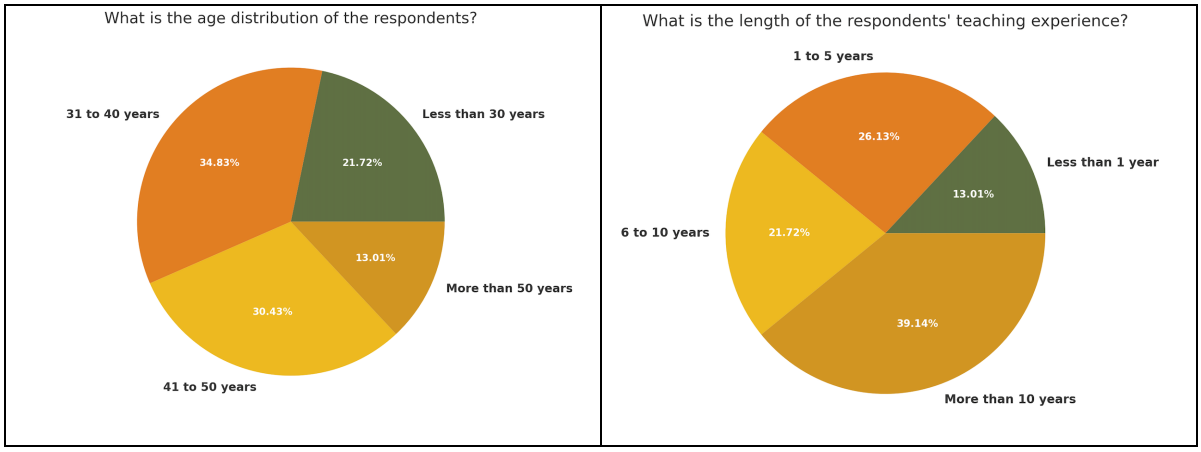

Figure 1 The charts illustrate the age of respondents and their teaching experience

The initial pie chart illustrates the age distribution of respondents to the pilot survey. A notable proportion of respondents, 34.83%, are within the age range of 31 to 40. The next largest group is respondents aged 41 to 50 years, who make up 30.43% of respondents. The next largest group is those under the age of 30, with a proportion of 21.72%. In contrast, those over the age of 50 represent the smallest segment, with a proportion of 13.01%.

The second chart illustrates the length of teaching experience of the respondents. The largest group, comprising 39.14% of respondents, has accumulated more than ten years of teaching experience. This indicates a significant proportion of educators with extensive experience. The proportion of educators with one to five years of experience is 26.13%, while 21.72% have been teaching for six to ten years. The smallest group, comprising 13.01% of respondents, is that of teachers with less than one year of experience. The data indicate a balanced proportion of experienced and relatively new teachers interviewed, which could reflect different levels of familiarity with the incorporation of AI into teaching.

These results collectively provide valuable insights into the demographics and professional backgrounds of the respondents. The diversity of age and teaching experience, along with the wide range of education levels represented, suggests that the view of AI literacy is multifaceted. It is possible that educators who are older and more experienced may encounter different challenges and levels of acceptance than their younger and less experienced colleagues.

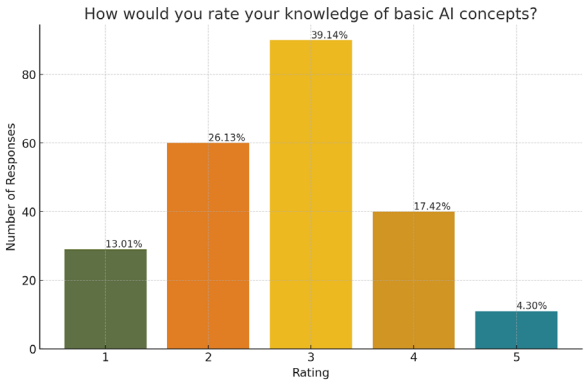

Figure 2: The chart shows how respondents rate their level of basic AI concepts

The chart illustrates the respondents' self-assessed level of understanding of fundamental AI concepts. The largest proportion of respondents (39.10%) indicated that they rated their knowledge as average (3). A smaller percentage of respondents, namely 17.40%, consider their knowledge to be above average (4), while only 4.30% consider their knowledge to be excellent (5). A notable proportion of respondents (26.10%) indicate that their knowledge is below average (2), while 13.00% rate their knowledge as very low (1). This discrepancy indicates that most respondents possess at least a rudimentary comprehension of AI, although a minority self-identify as experts in this field.

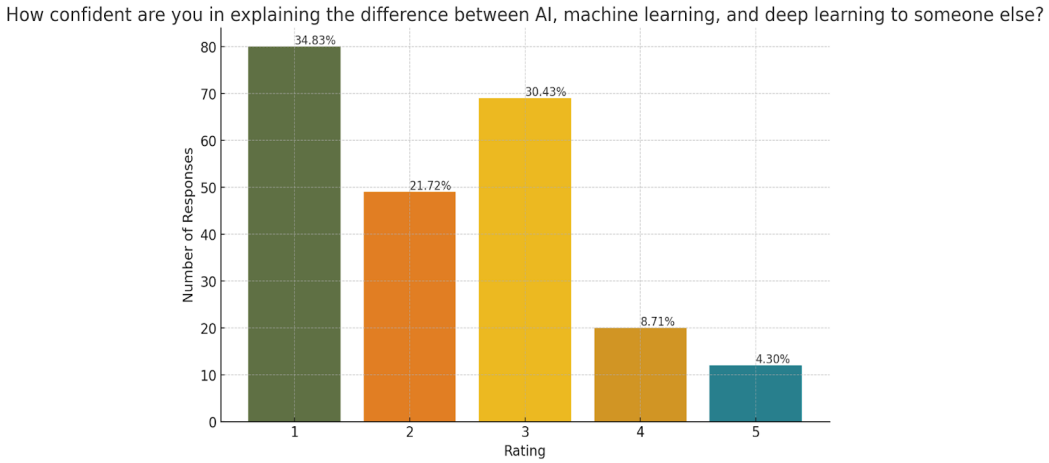

Figure 3: The chart shows how confident respondents are in their ability to explain the difference between AI, machine learning and deep learning

The chart above illustrates the respondents' level of confidence in their ability to differentiate between AI, machine learning and deep learning. A total of 34.80% of respondents indicated that they were unsure of their abilities (rating themselves as 1), while 30.40% expressed a moderate level of confidence (rating themselves as 3). A total of 21.70% of respondents indicated a lack of confidence (rating themselves as 2), while 8.70% expressed a moderate level of confidence (rating themselves as 4) and only 4.30% indicated a high level of confidence (rating themselves as 5). This dispersion indicates that a significant proportion of respondents lack the requisite confidence to comprehend and articulate these pivotal concepts.

To gain a deeper insight into the relationship between self-assessment and the level of knowledge of these key concepts among our respondents, we proceeded to pose questions pertaining to the distinction between artificial intelligence, machine learning and deep learning. The objective of these inquiries was not only to ascertain how respondents define and differentiate between these concepts, but also to determine their level of knowledge about each technology.

The results showed that 56.52% of respondents view AI as the ability of machines to perform tasks that typically require human intelligence. 65.22% of respondents see machine learning as algorithms that learn and improve based on data. 39.13% of respondents see deep learning as the fundamental level of AI, and the same proportion, 39.13%, associate it with training neural networks with many layers. It is clear from the previous graphs that most respondents feel less confident in explaining the differences between AI, machine learning and deep learning. This self-assessment correlates with the results of the questions, which show that while respondents have a basic understanding of these concepts, they often lack a deeper understanding and the ability to clearly explain these concepts. For example, most respondents correctly identify the applications and principles of machine learning, but fewer can describe deep learning in detail. It is also important to note that respondents could only guess the correct answer, which could explain the relatively high percentage of correct answers without necessarily implying a deep understanding of the concepts.

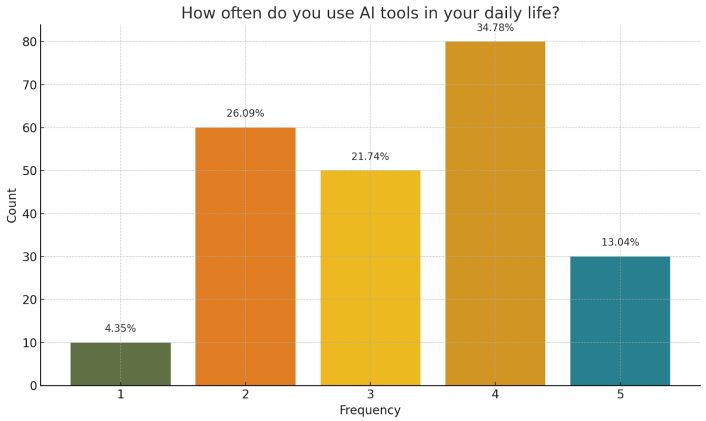

Figure 4: The chart showing frequency of using AI tools in respondents' daily lives

This chart shows the frequency with which respondents use AI tools in their daily lives. The survey, conducted among 230 participants, revealed that a significant proportion (34.78%) use AI tools frequently. 26.09% of respondents said they use AI tools to a moderate extent, while 21.74% use them occasionally. Only 13.04% of respondents use these tools very often, and a minimal number of 4.35% said they rarely use AI tools. This data highlights the increasing integration and reliance on AI technologies in everyday activities.

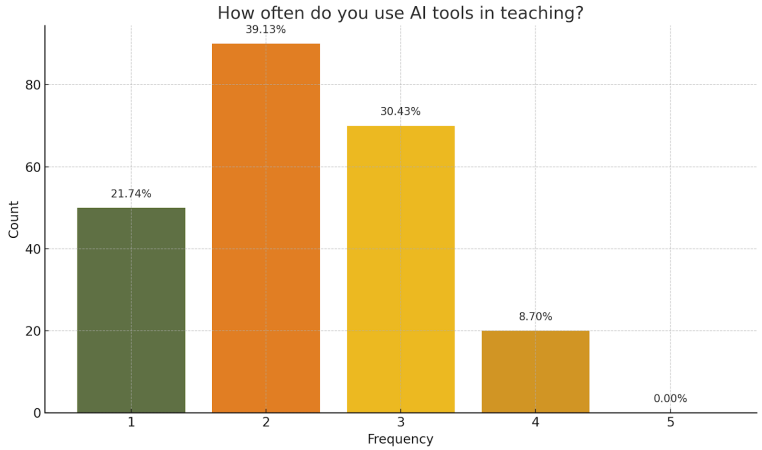

Figure 5: The chart shows the frequency of respondents' use of AI tools in their teaching

In pedagogical practice, the frequency of use varies widely, as we can see above. The results show that the majority of respondents (39.13%) use AI tools in teaching occasionally, another significant group (30.43%) reported a moderate level of use, while 21.74% of respondents do not use these tools at all.The following graph shows how often respondents use AI tools for teaching or for administrative tasks. The pilot study found that 39.13% of respondents use AI tools occasionally, a further 30.43% plan to start using AI tools, and 21.74% of respondents said they use these tools frequently. Only 8.70% of respondents are not interested in using AI tools.

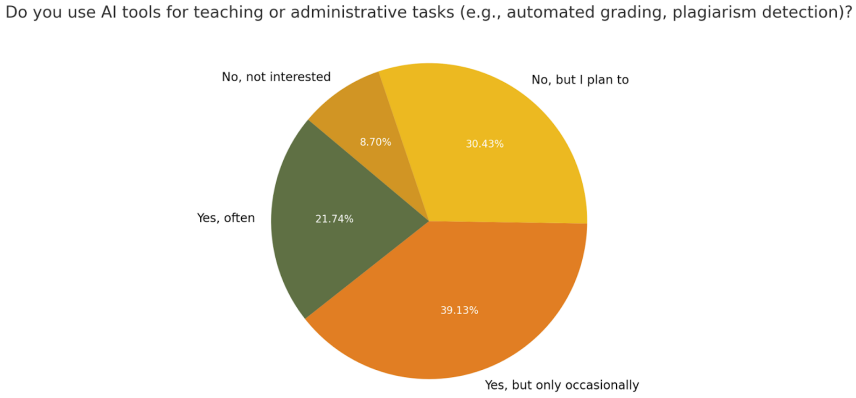

Figure 6: The chart shows how often respondents use AI tools for teaching or administrative tasks

In the following question, we asked what specific AI tools they had used in their teaching practice. 60.87% of respondents have used AI tools to generate text, for example to create exercises or teaching materials. Chatbots were used by 43.48%, making them the second most used tool. Speech recognition, e.g. for transcribing lectures, and data analysis, e.g. for assessing student performance, were used equally by 21.74% of respondents. Personalised learning tools were the least used, with only 13.04% of respondents using them. 34.78% of respondents said they had never used AI tools in their teaching. This data shows the different ways in which AI technologies are being integrated into educational processes, with some tools, such as text generation and chatbots, being used significantly more than others.

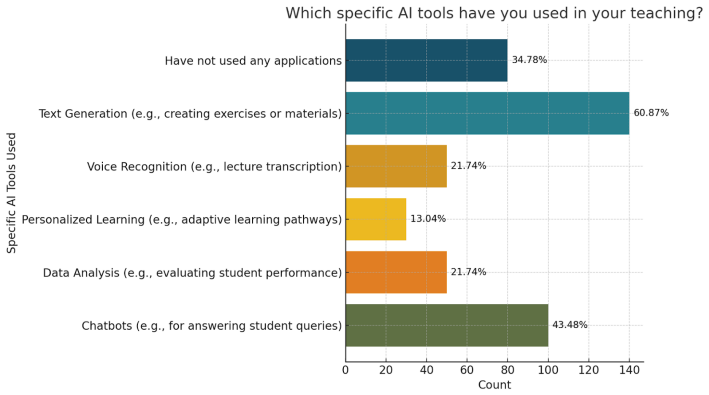

Figure 7: The chart shows what tools respondents used in their teaching

Respondents were also asked to rate the level of support from their school for integrating AI into the curriculum. The graph below shows that the largest proportion of respondents, 39.13%, rate their school's support as moderate, meaning that they perceive some support, but not very substantial. The second largest group (30.43%) rate the support at level 2, indicating that the support is rather weak. 17.39% of respondents said that support was at level 4, which is above average. 13.04% of the respondents rate the support as very weak, while no respondents rate the support of their school as excellent.

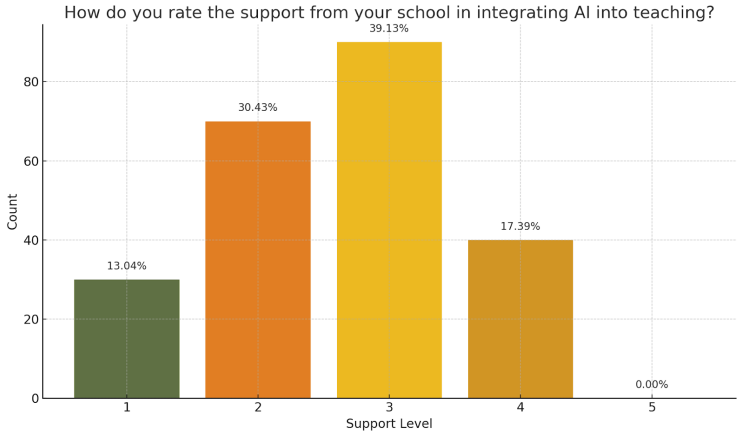

Figure 8: This graph shows how respondents rated the level of support from the school in integrating AI into the curriculum

Technical problems are seen as the biggest obstacle, with the highest number of respondents (82.61%). 65.22% of respondents identified insufficient teacher training and professional development as a significant barrier. 43.38% of respondents indicated that financial resources were insufficient to support the integration of AI into the educational process. 21.74% of respondents encountered resistance to change, indicating cultural and psychological barriers to adapting to new technologies. These data show that while technical and financial aspects are important, it is also essential to focus on teacher training and overcoming resistance to innovation to successfully integrate AI tools into the curriculum.

While teachers face several barriers to integrating AI into the classroom, we were interested in teachers' perceptions of the importance of teaching students about AI. The largest group of respondents (39.13%) consider teaching students about AI to be moderately important, while the second largest group of respondents (30.43%) consider it to be above average. 26.09% of respondents consider teaching students about AI to be very important, indicating a strong interest in the topic. Only 4.35% of respondents indicated that they considered this topic to be of low importance. This trend indicates a growing awareness and interest in integrating AI knowledge into educational programmes.

Concurrently, the majority of respondents (30.43%) concurred with the assertion that AI can be biased and thus necessitates critical evaluation. A further 26.09% of respondents expressed a moderate degree of agreement with this assertion. A total of 17.39% of respondents indicated that they agreed with the level of bias at levels 2 and 5. This response indicates a divergence of opinion between those who view critical

evaluation as moderate and those who view it as maximum. Conversely, 8.70% of respondents disagreed with the necessity of critical evaluation of AI due to bias. Nevertheless, the data indicate that most respondents perceive a risk of AI bias and consider it important that AI technology be subjected to critical evaluation. This awareness is crucial for ensuring the fair and objective use of AI in educational and other processes.

In addition to critical evaluations of AI, teachers also have some concerns that warrant further examination. The majority of respondents (82.6%) identified ethical issues as their primary concern. A significant proportion of respondents (56.5%) expressed concern about the potential impact of AI on the quality of education. Additionally, 39.1% of respondents indicated concern about the potential loss of jobs, while 26.1% expressed concern about the potential loss of student privacy. Notably, only 13.00% of respondents expressed concern about the safety implications of AI. Nevertheless, teachers discuss the ethical implications of AI to a similar extent, with 30.4% discussing it frequently and 30.4% discussing it not at all. It is alarming that none of the teachers surveyed discuss ethical issues with their students daily, even though 56.5% of respondents rate the importance of ethical considerations in the use of AI as important or very important. A mere 17.3% of educators consider the importance of ethical considerations in the use of AI to be low or very low. Similarly, the capacity to guarantee data security and protection when utilising AI tools is also rated at a low level. A total of 47.8% of respondents rated their ability as moderate, with no respondents considering themselves experts in this area. Additionally, 43.5% rated their ability as low or very low.

Nevertheless, it is encouraging to observe that, despite the low ratings, teachers demonstrate a willingness to provide students with explanations regarding the error and how to identify it when presented with distorted or incorrect AI information (52.2%). A total of 34.8% of respondents indicated that they would cease using the tool in the event of an error, while 13.00% stated that they would inform the tool developer of the error. Fortunately, none of the respondents would ignore this fact, as evidenced by the following graph.

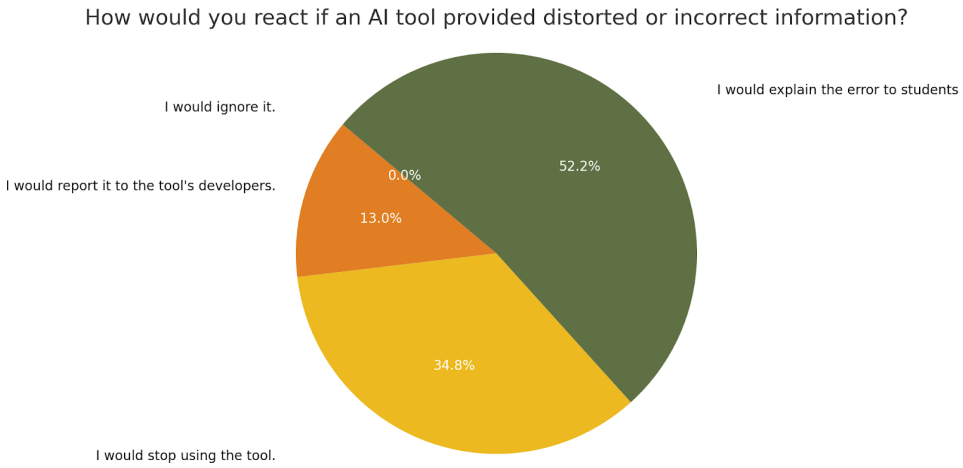

Figure 9: The chart shows the response to biased or incorrect information provided by the AI tool

4. Discussion

The results of this study indicate a diverse level of AI literacy among teachers in the Czech Republic, with significant implications for the integration of AI into the educational system. A majority of respondents demonstrate basic knowledge of AI, but a smaller percentage exhibit confidence and expertise in more advanced AI concepts such as machine learning and deep learning. This indicates a need for targeted professional development to enhance teachers' understanding of these crucial technologies.

The data indicate that AI tools are moderately used in daily life and teaching practices, with text generation tools and chatbots being the most employed. This suggests a growing familiarity with AI technologies, yet the infrequent use of personalized learning tools highlights potential areas for further adoption and integration.

The most significant barriers to AI integration are predominantly technical, with insufficient training and professional development also identified as significant challenges. These barriers indicate that to effectively integrate AI into education, there needs to be a concerted effort to provide robust technical support and

comprehensive training programmes. Financial constraints and resistance to change are additional obstacles that must be addressed through strategic planning and resource allocation.

The ethical and societal implications of AI are a critical concern for educators. The majority of respondents recognise the importance of addressing AI bias and the ethical use of AI, yet discussions on these topics with students are infrequent. This discrepancy indicates a necessity for curricular modifications to integrate ethics and critical thinking about AI technologies into pedagogical methodologies.

5. Conclusion

The study highlights the necessity of enhancing AI literacy among teachers in the Czech Republic to facilitate the effective integration of AI into the educational system. While there is a foundational understanding of AI among educators, there is a pressing need for targeted professional development to deepen their knowledge and confidence in advanced AI concepts. Addressing technical barriers and providing adequate training and support are essential steps towards successful AI integration.

Furthermore, the ethical implications of AI must be prioritized in educational discourse to prepare students for the challenges and opportunities presented by AI technologies. By fostering a comprehensive understanding of AI and its ethical considerations, educators can better equip students for the digital future.

Strategic recommendations include:

- Developing comprehensive AI training programmes for teachers at all educational levels.
- Ensuring adequate technical support and resources to facilitate AI integration.
- Incorporating AI ethics and critical thinking into the curriculum.

Promoting collaborative initiatives to facilitate the sharing of best practices and resources among educators. The implementation of these strategies will enable the Czech education system to fully utilize the potential of AI, thereby enhancing the quality of education and preparing students for a technology-driven world.

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Augmented Reality for Exploring Solids: A Study on Improving Pre-Service Teachers

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Abstract: Applications of augmented reality are gradually being integrated into teaching at various levels and types of schools. Augmented reality has the potential to transform the training of future teachers in the context of developing their mathematical knowledge, digital skills, and teaching competencies. The paper focuses on researching the impact of augmented reality on the learning of future primary teachers. The aim was to investigate the impact of AR applications on the development of cognitive and psychomotor skills and on students' motivation to learn. The study had a mixed research design. Using a pedagogical experiment, we investigated the effectiveness of an educational intervention based on the use of applications Augmented Reality in combination with hands on activities in the training of future teachers. The educational intervention was a set of activities that were carried out in a mixed reality environment using the 3D solids construction kit, the Polyedres augmentes and GeoGebra applications. The content of the educational intervention was the exploration of significant elements and properties of solids. We tested students' knowledge and abilities in the following areas: identification of simple solids from a picture; identification of significant elements of solids (vertices, edges and faces); identification of the shapes of faces of solids; nets of solids; simple metric tasks with solids. The study was conducted in 2024 with 152 primary education students as part of geometry courses. In line with the results of previous research in this area, we found that AR has the potential to improve understanding of geometric concepts, increase interactivity and student motivation. Augmented reality opens up new possibilities for exploring solids and their properties, as it allows for transfer between planar and spatial representation of solids and helps to develop spatial imagination.

Keywords: Augmented reality in education, app AR Polyedres Augmentes, app AR GeoGebra, Solids in geometry education, Primary education, Primary education, Teacher training

1. Introduction

1.1 Background and Context

Augmented Reality (AR) has emerged as a transformative tool in educational settings, capable of enhancing the learning experience by integrating digital information with the physical world. AR applications provide interactive and immersive learning environments that make abstract concepts more tangible and understandable. This capability is particularly beneficial in the field of mathematics education, where spatial reasoning and the visualization of geometric solids are critical skills.

Recent advancements in AR technology have led to its gradual integration into various levels of education, from primary schools to higher education institutions. The potential of AR to revolutionize teaching and learning processes is supported by numerous studies that demonstrate significant improvements in student engagement, motivation, and academic performance. For pre-service teachers, AR offers unique opportunities to develop their pedagogical skills, digital literacy, and content knowledge in innovative ways.

1.2 Importance of AR in Education

The importance of AR in education cannot be overstated. AR provides a dynamic and interactive platform that bridges the gap between theoretical knowledge and practical application. By overlaying digital content onto real-world environments, AR enables students to interact with learning materials in new and meaningful ways. This interaction enhances cognitive processes and supports the development of critical thinking and problem-solving skills.

In the context of teacher training, AR is particularly valuable. It allows pre-service teachers to experience realistic classroom scenarios and practice their teaching strategies in a controlled environment. This hands-on approach helps future educators to refine their skills and become more confident in their teaching abilities. Moreover, AR tools can simulate diverse classroom settings, including the management of student behavior and the adaptation of lessons for different learning styles.

Studies have shown that AR can significantly improve students' understanding of complex subjects. For example, research by Moro et al. (2017) demonstrated that AR-enhanced lessons in medical education improved students' spatial understanding and retention of complex anatomical structures. Similarly, in mathematics education, AR applications have been found to enhance students' spatial reasoning and comprehension of geometric properties (Lin et al., 2015).

1.3 Objectives of the Study

The primary objective of this study was to investigate the impact of AR applications on the cognitive and psychomotor skills of pre-service teachers, as well as their motivation to learn. Specifically, the study aimed to:

- Evaluate the effectiveness of AR-based educational interventions in improving pre-service teachers' understanding of geometric solids.
- Assess the development of spatial reasoning and geometric visualization skills through the use of AR tools.
- Explore the potential of AR applications to enhance student engagement and motivation in learning mathematics.
- Determine the applicability of AR tools in primary education settings, particularly in teaching geometry.

To achieve these objectives, a mixed-methods research design was employed, combining quantitative assessments (pretests and posttests) with evaluative feedback from participants. The study focused on a set of AR activities involving the 3D Solids Construction Kit, the Polyedres Augmentes application, and the GeoGebra application. Through these activities, pre-service teachers were provided with opportunities to explore and manipulate 3D geometric shapes, thereby enhancing their understanding and teaching competencies.

By examining the impact of AR on pre-service teachers, this study aims to contribute to the growing body of research on the use of AR in education and provide insights into the potential benefits and challenges of integrating AR into teacher training programs.

2. Literature review and theoretical background

2.1 Augmented Reality in Educational Settings

Augmented Reality (AR) is emerging as a powerful tool in educational environments, demonstrating its potential to significantly increase student motivation and engagement. AR's capacity to create dynamic and interactive learning experiences bridges the gap between theoretical knowledge and practical application, making abstract concepts more tangible and understandable.

AR applications are increasingly being utilized in higher education to create immersive learning environments that engage students and enhance their understanding. Prodromou (2020) discusses the transformative impact of AR on higher education, emphasizing how AR can make learning more interactive and personalized. According to Prodromou, AR can support diverse learning styles by offering multimodal content that includes visual, auditory, and kinesthetic elements. For instance, the chapter by Ferko, Berger-Haladová, and Bohdal (2020) highlights the use of AR in enhancing collaborative learning experiences in STEM education, noting improvements in student engagement and knowledge retention.

One notable application of AR in higher education is its use in medical training. AR simulations provide medical students with realistic, hands-on experience without the risks associated with real-life procedures. A study by Moro et al. (2017) demonstrated that AR-enhanced anatomy lessons significantly improved students' spatial understanding and retention of complex anatomical structures. The immersive nature of AR allowed students to visualize and manipulate 3D models of the human body, leading to better comprehension and skill acquisition.

The use of AR in teaching mathematics and geometry has garnered considerable attention due to its ability to make abstract concepts tangible. AR tools enable students to interact with geometric shapes in a 3D space, thereby enhancing their spatial reasoning and understanding of geometric properties. Research by Lin et al. (2015) explored the effectiveness of AR in improving the geometric thinking of undergraduate students. Their study found that students who used AR applications to study geometric transformations and spatial relationships performed better in assessments compared to those who relied solely on traditional teaching methods. The interactive and visual nature of AR helped students grasp complex geometric concepts more effectively.

AR not only supports cognitive development but also enhances psychomotor skills by providing interactive, hands-on learning experiences. Dünser et al. (2012) conducted a study that showed how AR applications could improve students' ability to visualize and manipulate 3D objects. This is particularly beneficial in fields such as engineering and architecture, where spatial awareness and the ability to understand and create 3D models are crucial. In the context of teacher training, AR has been shown to enhance both digital literacy and teaching competencies. Bower et al. (2014) highlighted that pre-service teachers who engaged with AR technologies during their training developed a better understanding of how to integrate digital tools into their teaching practices. This is critical in preparing future educators to use innovative technologies to improve student learning outcomes.

Several case studies have demonstrated the practical benefits of AR in educational settings. For example, a study by Garzón and Acevedo (2019) investigated the use of AR in a university-level geometry course. The study found that AR applications significantly improved students' motivation and engagement, leading to better academic performance. Students reported that the ability to interact with 3D geometric shapes in real-time helped them understand complex concepts and retain information more effectively. Moreover, a study by Fuchsová, Adamková, and Lapšanská (2020) examined the use of AR in biology education, finding that it significantly enhanced students' understanding of biological processes and structures. Additionally, the work of Dillingerová, Babinská, and Koreňová (2020) on AR and future mathematics teachers showed that AR tools effectively prepared students for teaching complex mathematical concepts.

Despite the numerous benefits of AR, its implementation in educational settings is not without challenges. Technical issues, such as the need for advanced hardware and reliable software, can hinder the widespread adoption of AR technologies. Professional development and training are essential to ensure that teachers can effectively integrate AR into their teaching practices. Future research should focus on addressing these challenges and exploring new ways to leverage AR's potential in education. This includes developing cost-effective AR solutions, creating comprehensive training programs for educators, and conducting longitudinal studies to assess the long-term impact of AR on student learning outcomes.

2.2 AR and Teacher Training

AR is not only transforming student learning but also revolutionizing teacher training by enhancing pre-service teachers' skills and competencies. AR tools provide an immersive and interactive environment where future educators can develop their teaching strategies, digital literacy, and classroom management skills. This innovative approach shows significant potential for increasing student motivation and engagement in learning.

The integration of AR into teacher training programs has been shown to significantly improve the preparedness of pre-service teachers. According to Prodromou (2020), AR-based training allows teachers to experience realistic classroom scenarios in a controlled environment. This hands-on approach helps them practice and refine their teaching methods without the pressures of a real classroom. For example, AR can simulate diverse classroom settings, including managing student behavior, adapting lessons for different learning styles, and integrating technology into teaching practices.

Ferko, Berger Haladová, and Bohdal (2020) discuss how AR applications can enhance collaborative learning among pre-service teachers. By working together in an AR environment, future teachers can develop their communication and teamwork skills. These collaborative experiences are crucial for fostering a supportive professional community and preparing teachers for the collaborative nature of modern educational environments.

Furthermore, AR in teacher training supports the development of digital competencies, which are essential for integrating technology into education effectively. Bower et al. (2014) highlighted that pre-service teachers who engaged with AR technologies during their training developed a better understanding of how to use digital tools in their teaching practices. This includes creating interactive lessons, using AR to visualize complex concepts, and enhancing student engagement through technology.

The work of Kaufmann and Schmalstieg (2003) demonstrated how AR applications in educational training could significantly enhance spatial abilities and problem-solving skills. Their research focused on the use of AR for geometry education, where pre-service teachers could interact with 3D models, improving their understanding and ability to teach these concepts.

Several studies have demonstrated the positive impact of AR on teacher training. For instance, Garzón and Acevedo (2019) found that AR applications in teacher education programs increased pre-service teachers'

motivation and engagement. The study reported that the interactive nature of AR made learning more enjoyable and meaningful, which in turn enhanced the overall training experience. Additionally, research by Dillingerová, Babinská, and Koreňová (2020) on AR and future mathematics teachers showed that AR tools effectively prepared students for teaching complex mathematical concepts, thereby increasing their confidence and competence in the subject.

Despite the evident benefits, implementing AR in teacher training also presents challenges. These include the need for advanced hardware and reliable software, as well as the necessity for professional development to ensure that educators can effectively use AR technologies. Addressing these challenges requires a strategic approach, including investing in infrastructure, providing continuous training, and developing a supportive community of practice among educators.

Future research should focus on exploring new ways to leverage AR's potential in teacher training. This includes developing cost-effective AR solutions, creating comprehensive training programs that incorporate AR, and conducting longitudinal studies to assess the long-term impact of AR on teacher effectiveness and student outcomes. By doing so, we can better understand how AR can be used to prepare future educators to meet the demands of 21st-century classrooms.

2.3 Previous Studies on AR in Mathematics Education and Research Gaps

The application of Augmented Reality (AR) in mathematics education has been a growing field of study, demonstrating significant potential in enhancing students' understanding of complex mathematical concepts. Various studies have explored how AR can improve learning outcomes, spatial abilities, and engagement in mathematics.

One of the seminal works in this area is by Kaufmann and Schmalstieg (2003), who investigated the use of collaborative AR in teaching geometry. Their study demonstrated that AR could significantly enhance students' spatial visualization skills and their ability to comprehend geometric concepts through interactive 3D models. The immersive environment provided by AR allowed students to manipulate geometric shapes, which led to a deeper understanding of the subject matter.

Lin et al. (2015) further explored the effectiveness of AR in improving the geometric thinking of undergraduate students. Their research found that students who used AR applications to study geometric transformations and spatial relationships performed better in assessments compared to those who relied on traditional teaching methods. The interactive and visual nature of AR helped students grasp complex geometric concepts more effectively, highlighting the benefits of incorporating AR into the mathematics curriculum.

In a study focused on pre-service teachers, Ferko, Berger Haladová, and Bohdal (2020) examined how AR applications could be used to enhance collaborative learning in STEM education. They found that AR tools not only improved the pre-service teachers' understanding of mathematical concepts but also fostered a collaborative learning environment that encouraged communication and teamwork.

Moreover, Bower et al. (2014) highlighted the role of AR in making abstract mathematical concepts more concrete. By visualizing and interacting with mathematical models, students were able to develop a better conceptual understanding, which is often challenging to achieve through traditional methods. This study emphasized the importance of integrating AR into mathematics education to make learning more engaging and effective.

Despite these positive findings, several research gaps remain in the field of AR in mathematics education. One major gap is the need for longitudinal studies that examine the long-term effects of AR on students' learning outcomes and retention of mathematical concepts. Most existing studies have focused on short-term interventions, and there is limited understanding of how sustained use of AR impacts students' mathematical abilities over time.

Another gap is the lack of comprehensive studies that explore the integration of AR in diverse educational settings. Much of the existing research has been conducted in controlled environments, such as university labs or specific classroom settings. There is a need for more studies that investigate the practical implementation of AR in a variety of educational contexts, including under-resourced schools and different cultural settings.

3. Research Methodology

3.1 Research Design

The research design employed in this study was a mixed-methods approach, integrating both quantitative and qualitative (evaluative) methodologies to comprehensively investigate the impact of augmented reality (AR) applications on pre-service teachers' knowledge and skills in geometry. Mixed-methods research combines elements of qualitative and quantitative research approaches for the broad purposes of breadth and depth of understanding and corroboration (Creswell & Plano Clark, 2011).

The quantitative component consisted of a pretest-posttest design, which is effective in measuring the changes in participants' knowledge or skills before and after an intervention (Campbell & Stanley, 1963). The pretest assessed students' initial understanding of geometric solids, while the posttest, administered after the AR intervention, measured the same parameters to determine any cognitive gains.

The evaluative component involved the use of semi-structured questionnaires with open-ended questions. This method is beneficial for exploring participants' attitudes, experiences, and perceptions in depth (Patton, 2002). The evaluative data provided insights into students' experiences with AR and their views on its applicability in primary school teaching.

3.2 Participants

The study involved 152 primary education students from Comenius University in Bratislava, Faculty of Education. These students were enrolled in one of seven courses focusing on mathematics, geometry, and the teaching of geometry. The participants were selected to evaluate the effectiveness of AR tools in their professional preparation, as future primary school teachers need a strong foundation in these areas to effectively teach young learners.

3.3 Instruments and Tools

The quantitative instruments included pretest and posttest designed to evaluate students' knowledge of geometric solids. The pretest consisted of six questions, each requiring students to identify a geometric solid based on an image and describe at least five properties. The geometric solids included a cuboid, a triangular prism positioned on its side, a regular square pyramid, a regular hexagonal prism, and a non-traditionally oriented cylinder. Additionally, students were asked to identify solids from their nets, including the nets of a cube, a cuboid, a regular square pyramid with equilateral triangle faces, another variant of a regular square pyramid, and a regular hexagonal prism.

For the evaulative component, semi-structured questionnaires were used. These questionnaires included open-ended questions designed to capture students' opinions on the AR intervention and their views on the use of AR applications (Augmented Polyhedrons - Mirage, AR GeoGebra) in primary school teaching. This method is effective in collecting detailed and nuanced data, as it allows participants to express their thoughts in their own words (Silverman, 2000).

3.4 Data Collection Procedures

The quantitative data were collected in two phases. The pretest was administered at the beginning of the activity to establish a baseline of students' knowledge of geometric solids. After the educational intervention, which involved the use of AR applications and hands-on activities, the posttest was administered. The posttest was identical to the pretest to ensure comparability of results.

In our research, we conducted an evaluative approach based on students' opinion surveys.

This data collection method is effective in understanding the subjective experiences and attitudes of participants (Bryman, 2016; Kostrub et al., 2017).

3.5 Data Analysis Techniques

The quantitative data from the pretests and posttests were analyzed using descriptive and inferential statistics. Descriptive statistics, including mean scores and standard deviations, were used to summarize the data. A paired sample t-test was conducted to compare the pretest and posttest scores, assessing the cognitive gains made by the students (Field, 2013). The analysis focused on three key areas: the initial level of knowledge about geometric solids, the level of knowledge after the intervention, and the cognitive gain achieved through the AR-based learning activities.

The pretest was administered at the beginning of the activity to establish a baseline of students' knowledge of geometric solids. After the educational intervention, which involved the use of AR applications and hands-on activities, the posttest was administered. The posttest was identical to the pretest to ensure comparability of results.

In our research, we conducted an evaluative approach based on students' opinion surveys. The feedback collected from these questionnaires was analyzed to assess students' perceptions regarding the effectiveness of AR in their learning process and its potential application in primary education. This evaluative approach provided a structured method for interpreting students' opinions and drawing conclusions about their experiences with AR in educational settings.

4. Educational Intervention

4.1 Description of AR Applications Used

The educational intervention aimed to enhance the understanding of geometric solids among pre-service teachers by incorporating various augmented reality (AR) applications. These applications provided an interactive and immersive learning experience, enabling students to visualize and manipulate 3D shapes effectively. The primary AR tools used in this study were the 3D Solids Construction Kit, the Polyedres Augmentes application, and the GeoGebra application. Each tool offered unique features and capabilities that contributed to the overall learning objectives of the intervention.

4.2 The 3D Solids Construction Kit

The 3D Solids Construction Kit, also known as the 4D Frame Educational Kit, allowed students to physically construct geometric shapes. This hands-on approach helped students understand the properties and structures of various solids by building and manipulating physical models. The kit included various components such as rods and connectors, which could be assembled to form different geometric shapes, including cubes, pyramids, prisms, and more. By constructing these models, students could explore the number of faces, edges, and vertices, enhancing their spatial reasoning and comprehension of geometric properties.

4.3 Polyedres Augmentes Application

The Polyedres Augmentes application, developed by Mirage, provided an AR environment where students could visualize and interact with 3D geometric solids. Using a set of 12 markers (QR codes), each corresponding to a different solid, students could view the augmented models on their smartphones or tablets. The application allowed students to rotate and manipulate the solids in real-time, providing a comprehensive understanding of each shape's properties. The activity involved identifying and documenting the name and characteristics of each solid, such as the number of faces, edges, and vertices.

4.4 GeoGebra Application

The GeoGebra 3D Calculator application was another crucial tool in the intervention. GeoGebra is a versatile mathematical software that enables the visualization and exploration of geometric concepts in a dynamic environment. Students used the GeoGebra 3D Calculator to view and compare virtual models of geometric solids with their physical counterparts constructed using the 3D Solids Construction Kit. The application also allowed students to sketch the nets of the solids and explore their properties interactively.

4.5 Structure of the Augmented Reality Activities

The educational intervention was structured around a series of mixed reality activities that integrated the use of AR applications and physical construction kits. Students worked in groups of 4 to 6 to complete the following tasks:

1. Installation and Setup:

- Students installed the Polyedres Augmentes application on their smartphones or tablets.

- They used the application to view and interact with 12 geometric solids, each associated with a specific AR marker.

- Students documented the name and properties of each solid, filling out a provided table.

2. Physical Modeling:

- Using the 4D Frame Educational Kit, students constructed at least four geometric solids from the list provided.

- They took photos of their constructed models alongside the AR images from the Polyedres Augmentes application for comparison.

- Students also sketched the nets of the constructed solids.

3. GeoGebra Activities:

- Students installed the GeoGebra 3D Calculator application and opened specific 3D models using provided search codes.

- They compared the virtual models in GeoGebra with their physical constructions.

- The AR feature in GeoGebra was used to overlay virtual models onto physical ones for detailed comparison.

4. Project Creation:

- Students summarized their findings and learning experiences in a project report or presentation.

- The project included photos, sketches, and descriptions of the methods and results.

- Students submitted their projects via MS Teams or Moodle as per the instructor's guidelines.

These activities were designed to provide a comprehensive learning experience, combining theoretical understanding with practical application through the use of AR technologies and hands-on construction. The intervention aimed to enhance students' spatial reasoning, understanding of geometric properties, and ability to integrate technology into their future teaching practices.

5. Findings and Results

5.1 Evaluative Findings

The quantitative analysis was conducted to measure the cognitive gains in understanding geometric solids among pre-service teachers before and after the intervention using augmented reality (AR) applications. The analysis was based on pretest and posttest scores obtained from 185 participants.

5.1.1 Pretest and posttest scores

The pretest and posttest consisted of six tasks where students identified geometric solids and described their properties. The total possible score for each test was 20 points. The following results summarize the findings:

1. Mean Pretest Score:

- The average pretest score was 10.95 points.

2. Mean Posttest Score:

- The average posttest score was 13.84 points.

3. Score Improvement:

- The mean difference between posttest and pretest scores was 2.89 points, indicating a significant improvement.

5.1.2 Statistical analysis

A paired sample t-test was conducted to determine whether the improvement in scores was statistically significant.

- t-Statistic: 14.23

- p-Value: < 0.001

The p-value of less than 0.001 indicates that the improvement in scores is statistically significant, suggesting that the AR intervention had a positive impact on students' understanding of geometric solids.

5.2 Evaluative Findings

The evaluative data were gathered through semi-structured questionnaires, which captured students' feedback on the AR intervention. The responses were analyzed using thematic coding to identify recurring themes and patterns.

5.2.1 Increased engagement and motivation

Many students reported that the AR applications made the learning process more engaging and interactive. The ability to visualize and manipulate 3D models helped them better understand the geometric concepts.

> *"The application was interesting and easy to use, and it was colorfully well-designed."*

> *"We enjoyed it very much, but we missed having the names of the solids."*

5.2.2 Improved understanding

Students expressed that the AR tools facilitated a deeper understanding of geometric properties and relationships. The interactive nature of the applications allowed them to explore the shapes and their characteristics more thoroughly.

> *"Yes, it enhanced my understanding because visual aids help me the most in learning."*

> *"The application simplified spatial orientation."*

5.2.3 Future application in teaching

Several students highlighted the potential of using AR applications in their future teaching careers. They believed that these tools could significantly enhance the learning experience for primary school students by making abstract concepts more concrete and accessible.

> *"As a group, we think the application could be a motivating element in the educational process for children."*

> *"This application also provided inspiration that we can use in the educational process."*

5.2.4 Connection between theory and practice

Students appreciated that the AR activities connected theoretical knowledge with practical application, enhancing their spatial awareness and understanding.

> *"As future teachers, we need to have a better understanding of solids; this activity connected theory with practice within visual awareness."*

> *"Thanks to teamwork and the use of digital technologies, the application increased our motivation to learn geometry due to the interaction with the application and among us."*

5.3 Discussion

The findings from both the quantitative and evaluative analyses indicate that the AR intervention was effective in improving pre-service teachers' knowledge of geometric solids. The significant increase in posttest scores demonstrates the cognitive benefits of using AR in geometry education. Additionally, the positive feedback from students suggests that AR applications can enhance engagement and understanding, making them valuable tools for teaching complex concepts.

6. Conclusion

This study demonstrates the potential of augmented reality to transform the teaching and learning of geometry. By providing an interactive and immersive learning experience, AR can help pre-service teachers develop a stronger understanding of geometric solids and prepare them to use innovative teaching methods in their future classrooms. The positive impact on both cognitive gains and student motivation underscores the value of integrating AR applications into teacher education programs.

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Digital Technologies in Primary Mathematics Education: Insights from Future Teachers' Portfolios

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Abstract: The integration of digital technology in education has become an essential competency for primary school teachers, particularly in mathematics education, where innovative tools can enhance learning outcomes and student engagement. This paper investigates the extent and nature of digital technology utilization among future mathematics teachers, focusing on tools like dynamic geometry software (GeoGebra), e-testing platforms (e.g., Kahoot), learning applications (e.g., Learning Apps), and immersive technologies such as augmented and virtual reality. Our research centers on the analysis of final portfolios submitted by graduating students from the Faculty of Education at the University of Ostrava in 2024. These portfolios, which are a culmination of the students' educational strategies and experiences, offer a unique lens through which to assess the preparedness and innovation potential of future educators. Additionally, we surveyed the views of these students through questionnaires on the use of digital technologies in mathematics teaching. We specifically examined how these candidates plan to integrate digital technologies into their teaching practices and the innovative methods they propose to engage primary school students in mathematics. Through a qualitative study of 24 portfolios and a questionnaire survey of 15 students, we identified prevalent trends and inventive approaches in the use of digital tools. Our analysis highlights not only the variety of digital technologies incorporated into teaching strategies but also the depth of pedagogical integration, reflecting a sophisticated understanding of how to enhance learning environments effectively. The findings underscore the importance of digital literacy in teacher education and suggest that current training programs are effective in equipping future educators with the necessary skills to implement advanced technological tools. This study contributes to the ongoing discussion about digital competence in education, providing evidence of emerging trends and the transformative potential of digital technologies in primary mathematics education.

Keywords: Digital technologies, Mathematics education, Teacher education, Student engagement, Digital literacy

1. Introduction

The integration of digital technologies into education has increasingly become a focal point for modern teaching practices, particularly in mathematics education. As educational paradigms shift towards more interactive and student-centered learning environments, the role of digital tools in facilitating these changes cannot be overstated. Digital technologies such as dynamic geometry software, online testing platforms, and interactive learning applications have shown great potential in enhancing both learning outcomes and student engagement.

Future mathematics teachers are now being trained in an era where digital literacy is as crucial as traditional pedagogical skills. At the Faculty of Education at the University of Ostrava, teacher education programs are designed to equip future educators with the necessary skills to integrate digital technologies effectively into their teaching practices. The curriculum includes comprehensive training in various digital tools such as GeoGebra for dynamic geometry, Kahoot for interactive assessments, and Learning Apps for personalized learning experiences. Additionally, immersive technologies like augmented and virtual reality are also introduced to provide students with innovative ways to visualize and interact with mathematical concepts.

Digital technologies offer several advantages in the realm of mathematics education. They allow for the visualization of abstract concepts, making them more accessible and understandable for students. Tools like GeoGebra enable students to manipulate geometric figures dynamically, providing a deeper understanding of geometric properties and relationships. Online platforms like Kahoot facilitate real-time feedback and engagement through gamified learning experiences, which can significantly enhance motivation and participation.

Furthermore, digital tools support differentiated instruction, catering to the diverse needs of students. They provide opportunities for self-paced learning, where students can engage with content at their own speed, review difficult concepts, and practice problem-solving in a supportive environment. This flexibility is particularly beneficial in mathematics education, where students often need varying amounts of time and practice to master complex topics.

The research presented in this paper is situated within the context of the final portfolios submitted by graduating students from the Faculty of Education at the University of Ostrava in 2024. These portfolios are a culmination of the student's educational strategies, lesson plans, and reflections on their teaching practices. By analyzing these portfolios, this study aims to assess the extent and nature of digital technology utilization among future mathematics teachers.

Specifically, the research seeks to answer the following questions:

- What types of digital technologies do future mathematics teachers integrate into their lesson plans?
- What teaching methods are employed when using these digital technologies?
- What mathematical topics are taught using digital technologies?
- How do future mathematics teachers reflect and self-reflect on their teaching experiences with digital technologies?

Understanding how future mathematics teachers utilize digital technologies is critical for several reasons. Firstly, it provides insights into the current state of digital literacy and readiness among upcoming educators. Secondly, it highlights the innovative approaches and best practices that can be shared and implemented more broadly. Thirdly, it identifies potential challenges and areas for improvement, informing teacher education programs on how to better prepare future educators.

The findings of this study contribute to the ongoing discourse on digital competence in education. They provide evidence of emerging trends and the transformative potential of digital technologies in primary mathematics education. By documenting and analyzing the experiences and reflections of future teachers, this research offers valuable guidance for enhancing teacher education programs and ultimately improving student learning outcomes in mathematics.

2. Literature Review

The integration of digital technologies into mathematics education has garnered significant attention from researchers and educators alike. The ability of digital tools to enhance learning outcomes, increase student engagement, and support differentiated instruction has been well-documented. This literature review examines the current state of research on the use of digital technologies in mathematics education, focusing on the tools and methods that have proven effective, the challenges encountered, and the implications for teacher education.

Dynamic geometry software, such as GeoGebra, has been widely recognized for its ability to facilitate the visualization of geometric concepts. According to Hohenwarter and Fuchs (2004), GeoGebra allows students to manipulate geometric figures dynamically, providing a deeper understanding of geometric properties and relationships. Studies have shown that using such software can lead to improved spatial reasoning and problem-solving skills (Jones, 2000).

Online testing platforms like Kahoot have revolutionized the way assessments are conducted in the classroom. These platforms offer real-time feedback and engage students through gamified learning experiences. Wang (2015) found that the use of Kahoot in mathematics education significantly enhances student motivation and participation, leading to better retention of mathematical concepts.

Interactive learning applications, such as Learning Apps, provide personalized learning experiences that cater to the diverse needs of students. These applications support self-paced learning, allowing students to engage with content at their own speed and review difficult concepts as needed. Research by Kim and Chang (2010) highlights the effectiveness of interactive applications in improving mathematical performance and fostering a positive attitude towards learning.

Immersive technologies, including augmented reality (AR) and virtual reality (VR), offer innovative ways to visualize and interact with mathematical concepts. Dunleavy, Dede, and Mitchell (2009) note that AR and VR can create immersive learning environments that enhance conceptual understanding and engagement. These technologies are particularly effective in making abstract mathematical concepts more concrete and accessible.

The integration of digital technologies in teaching requires a shift in pedagogical strategies. Interactive methods, such as games and quizzes, have been shown to increase student engagement and understanding (Prensky, 2001). Collaborative methods, including group work facilitated by digital tools, promote active learning and peer interaction (Johnson & Johnson, 1999). Moreover, traditional direct instruction can be

enhanced with digital tools to create a blended learning environment that supports varied learning styles (Means et al., 2010).

One of the primary challenges in integrating digital technologies is technical issues, such as connectivity problems and device malfunctions. These issues can disrupt the learning process and create frustration for both teachers and students (Ertmer & Ottenbreit-Leftwich, 2010). Ensuring reliable access to technology and providing robust technical support are essential to overcoming these challenges.

Varying levels of digital literacy among students and teachers can hinder the effective use of digital technologies. According to Voogt and Knezek (2008), targeted training is necessary to improve digital competencies. Teacher education programs should include comprehensive digital literacy training to ensure that educators are equipped to support their students effectively.

Teacher education programs must focus on developing both technical proficiency and pedagogical integration skills. As Koehler and Mishra (2009) suggest, effective integration of technology in teaching requires a combination of technological, pedagogical, and content knowledge (TPACK). Training programs should aim to balance these components to prepare future teachers adequately.

Providing opportunities for future teachers to experiment with various digital tools and reflect on their experiences is crucial. Reflective practice allows teachers to critically evaluate their use of technology and continuously improve their teaching strategies (Schon, 1983). Teacher education programs should facilitate such opportunities to foster a culture of continuous improvement.

Longitudinal studies examining the long-term impacts of digital technology integration on student learning outcomes and teacher development are needed. Such studies would provide a comprehensive understanding of the sustained effects of these tools and inform best practices in technology integration.

Comparative research exploring differences in digital technology use across various educational contexts, such as urban versus rural schools or different educational levels, can help identify specific needs and tailor support accordingly (Warschauer, Knobel, & Stone, 2004).

Further research is needed to investigate how digital technologies affect different groups of students, such as those with special educational needs or from diverse socio-economic backgrounds. Understanding these impacts would inform more inclusive and equitable teaching practices (Black & Wiliam, 1998).

The integration of digital technologies in mathematics education offers significant potential for enhancing learning outcomes and student engagement. However, challenges such as technical issues and digital literacy must be addressed to realize this potential fully. Teacher education programs play a critical role in preparing future educators to integrate digital tools effectively, emphasizing the need for balanced training in technological, pedagogical, and content knowledge. Future research should continue to explore the long-term impacts and contextual differences in digital technology use, contributing to a more comprehensive understanding of its role in education.

3. Research Design

This research employs a qualitative approach to understand how future mathematics teachers integrate digital technologies into their teaching practices. Qualitative research is chosen because it allows for a deep exploration of the experiences, practices, and reflections of the participants, providing rich, detailed data that can reveal insights into the complexities of teaching with digital technologies.

3.1 Methodology

The participants in this study are future mathematics teachers who have completed their teaching practice as part of their teacher education program at the Faculty of Education at the University of Ostrava. These individuals have created portfolios that document their lesson planning, teaching methods, the use of digital technologies, and their reflections on their teaching experiences. Data was collected from seven student portfolios.

These documents were chosen because they provide comprehensive information on the participants' teaching practices, including lesson plans, descriptions of digital tools used, teaching methods, topics taught, and reflections on their teaching experiences (Merriam, 2009; Creswell, 2013).

Data Analysis

The data was analyzed using qualitative content analysis, which involves systematically coding and categorizing textual data to identify patterns, themes, and insights (Glaser & Strauss, 1967; Strauss & Corbin, 1998; Kostrub, 2016; Severini & Kostrub, 2018).

Open Coding

Open coding is the initial phase of the coding process, where the data is broken down into discrete parts and examined closely. The steps include:

1. Reading and Familiarization: Each portfolio was read thoroughly to understand the overall content and context.

2. Highlighting and Initial Coding: Relevant segments of text related to digital technologies, teaching methods, topics taught, and reflections were highlighted. Descriptive labels, or codes, were assigned to these segments to capture the essence of the information Strauss & Corbin, 1998; Kostrub, 2016).

3. Creating Initial Codes: A list of initial codes was developed based on the highlighted text. These codes were kept broad to encompass various aspects of the data (Merriam, 2009; Kostrub, 2016).

Axial Coding

Axial coding involves reassembling the data by finding connections between the codes identified during open coding. The steps include:

1. Grouping Similar Codes: The initial codes were grouped into categories that represent broader themes. This step helps in understanding how different codes relate to each other (Strauss & Corbin, 1998; Severini & Kostrub, 2018).

2. Developing Subcategories: Within each broad category, subcategories were created to provide more detailed insights. For example, under the category "Digital Technologies Used," subcategories such as "iPads," "Online Platforms," and "QR Codes" were developed (Merriam, 2009; Kostrub & Severini, 2018).

3. Refining Codes: The data was revisited to refine the codes and ensure that all relevant information was captured accurately. This iterative process helps in making the coding more precise and comprehensive (Creswell, 2013; Kostrub, 2016).

Themes and Categories

The analysis led to the identification of several key themes and categories:

1. Digital Technologies Used:
    - Types of technologies: iPads, online platforms (e.g., Kahoot, Wordwall), QR codes.
    - Purpose of technologies: enhancing student engagement, facilitating assessments, providing interactive learning experiences.
2. Teaching Methods:
    - Interactive methods: games, quizzes, interactive presentations.
    - Collaborative methods: group work, pair activities.
    - Direct instruction: traditional teaching methods supplemented by digital tools.
3. Mathematical Topics Taught:
    - Specific topics: fractions, angles, algebra, linear equations.
    - Integration with digital tools: how digital tools were used to teach these topics.
4. Reflections and Self-Reflections:
    - Positive outcomes: increased student engagement, improved understanding of concepts.
    - Challenges: technical issues, varying levels of digital literacy among students.
    - Suggestions for improvement: better planning, need for technical support, continuous training.

3.2 Conclusion

This study offers a detailed exploration into the integration of digital technologies by future mathematics teachers, providing insights into their lesson planning, teaching methods, topics covered, and reflective practices. The findings from the analysis of seven student portfolios reveal several key themes and offer significant implications for teacher education programs.

Summary of Findings

The analysis identified several key insights into how future mathematics teachers utilize digital technologies:

1. Digital Technologies Used:

- Types of Technologies: The portfolios demonstrated a wide range of digital tools such as iPads, online platforms like Kahoot and Wordwall, and QR codes. These tools were employed for different purposes, including engaging students, facilitating assessments, and providing interactive learning experiences.

2. Teaching Methods:

- Interactive Methods: Many teachers incorporated interactive methods like games, quizzes, and interactive presentations to enhance student engagement and understanding.
- Collaborative Methods: Group work and pair activities were commonly used, leveraging digital tools to facilitate collaboration among students.
- Direct Instruction: Traditional teaching methods were supplemented with digital tools to create a blended learning environment.

3. Mathematical Topics Taught:

- Specific Topics: The use of digital technologies was applied across various mathematical topics such as fractions, angles, algebra, and linear equations. These tools helped make abstract concepts more concrete and accessible through visual and interactive representations.

4. Reflections and Self-Reflections:

- Positive Outcomes: The use of digital technologies generally led to increased student engagement and improved understanding of mathematical concepts. The interactive nature of these tools helped maintain student interest and motivation.
- Challenges Faced: Technical issues were a common challenge, including connectivity problems and device malfunctions. Additionally, varying levels of digital literacy among students posed difficulties for some teachers.
- Suggestions for Improvement: Reflections included valuable suggestions for future practice, such as better planning for technical contingencies, the need for more comprehensive digital literacy training for both teachers and students and continuous professional development.

Implications for Teacher Education

The findings have important implications for the design and implementation of teacher education programs. These programs should focus on the following areas:

1. Technical Proficiency and Pedagogical Integration:

- Teacher education programs must ensure that future teachers are not only technically proficient in using digital tools but also skilled in integrating these tools into their pedagogical practices effectively. This dual focus will enable teachers to create engaging and effective learning environments.

2. Opportunities for Practice and Reflection:

- Providing opportunities for future teachers to experiment with various digital tools and reflect on their experiences is crucial. Reflective practice allows teachers to critically evaluate their use of technology and continuously improve their teaching strategies.

3. Support for Digital Literacy:

- Given the challenges related to digital literacy, teacher education programs should include comprehensive training on digital skills. This training should address both the technical and pedagogical aspects of digital tool use, ensuring that teachers can support their students effectively.

Addressing Challenges

The study highlights several challenges that need to be addressed to enhance the integration of digital technologies in teaching:

1. Technical Support:

- Schools and teacher education programs must ensure reliable access to technology and provide robust technical support to teachers. This support can help mitigate issues related to device malfunctions and connectivity problems.

2. Digital Literacy Development:

- Both teachers and students need targeted training to improve their digital literacy. Teacher education programs should offer courses and workshops focused on developing these skills, ensuring that all participants are comfortable and proficient with the required technologies.

3. Time Management and Classroom Management:

- Effective time management is essential when integrating digital tools into lessons. Future teachers should be trained in classroom management strategies that allow for the seamless incorporation of technology without disrupting the lesson flow. Providing practical tips and best practices can help teachers manage their time more effectively.

Future Research Directions

While this study provides valuable insights, several areas warrant further investigation:

1. Longitudinal Studies:

- Longitudinal studies could examine the long-term impacts of digital technology integration on student learning outcomes and teacher development. Such studies would provide a more comprehensive understanding of the sustained effects of these tools.

2. Comparative Studies:

- Comparative research could explore differences in digital technology use across various educational contexts, such as urban versus rural schools or different educational levels. This would help identify specific needs and tailor support accordingly.

3. Impact on Diverse Student Groups:

- Further research could investigate how digital technologies affect different groups of students, such as those with special educational needs or from diverse socio-economic backgrounds. Understanding these impacts would inform more inclusive and equitable teaching practices.

In conclusion, this study underscores the potential of digital technologies to transform mathematics education when effectively integrated into teaching practices. By addressing the challenges identified and leveraging the benefits of these technologies, future mathematics teachers can create dynamic and engaging learning environments that enhance student understanding and motivation. Teacher education programs play a critical role in preparing future teachers for this task, ensuring they are equipped with the necessary skills and knowledge to thrive in a digital age. Through comprehensive training and support, we can foster a new generation of educators who are adept at using digital tools to enrich their teaching and improve student learning outcomes.

4. Survey. Questionary

4.1 Survey

As part of a questionnaire survey, we compared the experience of using digital technologies in the teaching of mathematics between students of the 1st and 2nd year of the follow-up master's program Teaching for the 2nd grade of elementary school - combination with mathematics. We investigated the experiences of these

students with digital technologies at primary and secondary schools, then during their studies at higher education institutions, during practical experience at higher education institutions and whether they would like to use digital technologies as part of their work as mathematics teachers at primary schools.

15 students took part in the research, including 8 second-year students and 7 first-year students. Women slightly predominate: 9 women and 6 men. Regarding the secondary school completed, among the students there are only 3 students who graduated from the gymnasium, 11 students graduated from the vocational secondary school and 1 student is a graduate of the vocational secondary school in the field with a high school diploma.

4.2 Analysis of the Questionnaire

From the questionnaire survey, we found that among the 4th and 5th grade students, the majority (40%) stated that they had never encountered the use of digital technologies in teaching mathematics during their studies at primary or secondary school, even 2/3 had never or almost never encountered it. Only 1 student stated that he encountered the use of digital technologies often.

Of the 11 students, approximately 36% reported that digital technologies were more likely to help them in their learning, a similar proportion of students said that digital technologies were more likely not to help them, and the remaining number was in the middle on a Likert scale.

Of the 15 students, approximately 88% confirmed the use of digital technologies at the university within the mathematics courses. Only one student stated that she hardly used digital technologies while studying mathematics at the university.

Regarding the use of digital technologies in the completed internships, out of 15 students, only two students did not encounter the use of digital technologies in the teaching of mathematics during their listening experience. 9 of the interviewed students took part in teaching as part of their practice, 6 of them stated that they often or occasionally used digital technologies in their practice, 3 students used digital technologies on average.

All 14 students who answered the above question confirmed that they want to use digital technologies in their mathematics education. They most often mentioned an interactive whiteboard or panel, and tablets. From the applications, GeoGebra, Kahoot, and Blooket. TEAMs, Nearpod, Geoboard online, Wordwall, Únikovka, Pattern Shapes applications appeared among others.

The conducted questionnaire survey revealed that although students encountered digital technologies minimally during their studies at primary and secondary schools, at universities they were already exposed to digital technologies much more in preparation for their profession. Students rarely used digital technologies during their internships, which, after discussion with them, mostly resulted in limited opportunities for use in primary schools. Mostly it was a limited number of tablets and limited access to computer labs. Nevertheless, they mostly want to improve this situation in the future and include digital technologies in the teaching of mathematics at elementary schools to a greater extent so that it is beneficial and not counterproductive.

4.3 Method of Statistical Processing

In the frame of the quantitative research, the statistical method (Stockemer, 2019) of multidimensional regression analysis has been selected with regard to the focus of the proposed analysis. The dependent and independent variables have been determined for further clarification, of whether statistically significant interactions have appeared.

Hypotheses. Based on the goal and tasks of the contribution, we created hypotheses, which we approach in the results of the work.

Hypotheses Proposal

The following items were considered in the frame of the quantitative research (Table 1):

Table 1: Description of Questions' Variables

Question Code	Description
Q9	Efficiency
Q1	Gender
Q3	Using digital technologies at Elementary or Middle School
Q5	Using digital technologies at the University
Q7	Using digital technologies at practices with students
Q12	Future implementation of digital technologies in teacher job

The following hypotheses were proposed and tested in the software PAST Statistics (Hammer, 2001) as the multi-regression approach.

H_0: There is not statistically significant interaction between item Q9 and {Q1, Q3, Q5, Q7, Q12} on the significance level.

H_A: There are statistically significant interactions between item Q9 and {Q1, Q3, Q5, Q7, Q12} on the significance level.

H_0-Q1: There are no statistically significant interactions between items Q9 and Q1 on the significance level.

H_A-Q1: There are statistically significant interactions between items Q9 and Q1 on the significance level.

H_0-Q3: There are no statistically significant interactions between items Q9 and Q3 on the significance level.

H_A-Q3: There are statistically significant interactions between items Q9 and Q3 on the significance level.

H_0-Q5: There are no statistically significant interactions between items Q9 and Q5 on the significance level.

H_A-Q5: There are statistically significant interactions between items Q9 and Q5 on the significance level.

H_0-Q7: There are no statistically significant interactions between items Q9 and Q7 on the significance level.

H_A-Q7: There are statistically significant interactions between items Q9 and Q7 on the significance level.

H_0-Q12: There are no statistically significant interactions between items Q9 and Q12 on the significance level.

H_A-Q12: There are statistically significant interactions between items Q9 and Q12 on the significance level.

Results of Testing Hypotheses

Sample size *N* is equal to 15 with non-parametrical behavior tested using the Shapiro-Wilk method.

The multidimensional regression analysis (Table 2) is bounded on the principle of *p* values with complementation of effect sizes supporting a case of rejecting a zero hypothesis in favor of an alternative hypothesis. Results of occurred *p* values are being corresponded as: $p < .001$, $p < .01$, $p < .05$. Across the independent variables, the nominal and cardinal types of variables have appeared. For each independent variable, the influence of each independent variable is denoted also using by *p*-value. The following effect sizes are considered as the Cohens' *f*: small > .02, moderate > .15 and large > .35; as the *r*: small < .3, medium from .3 to .5, large > .5 An adjusted multiple R^2 has been strengthened by consideration of the size of sample size inside the computations.

Table 2: Obtained Results of Multi-Regression Dependences Analyses

Related Hypothesis	
y Dependent Variable of Model	Q9
H: *p*-value for Multiregression	**1**
Effect Size Cohen's f^2	**Non**
Adjusted Multiple R^2	-461.720
Independent Variable	
H-Q1:	.959
H-Q3:	.975
H-Q5:	.981
H-Q7:	.958
H-Q12:	1.000

$p < .001$, $p < .01$, $p < .05$

Conclusion of Testing Hypotheses

According to Table 2, the statistically significant influence on the variable Q3(Efficiency) doesn't have variables Q1, Q3, Q5, Q7, and Q12.

H_0: There is not statistically significant interaction between item Q9 and {Q1, Q3, Q5, Q7, Q12} on the significance level.

H_0-Q1: There are no statistically significant interactions between items Q9 and Q1 on the significance level.

H_0-Q3: There are no statistically significant interactions between items Q9 and Q3 on the significance level.

H_0-Q5: There are no statistically significant interactions between items Q9 and Q5 on the significance level.

H_0-Q7: There are no statistically significant interactions between items Q9 and Q7 on the significance level.

H_0-Q12: There are no statistically significant interactions between items Q9 and Q12 on the significance level.

5. Conclusion and Discussion

5.1 Summary of Results

This study explored the integration of digital technologies in mathematics education among future mathematics teachers, using a combination of qualitative and quantitative research methods. The qualitative analysis of seven student portfolios and the quantitative questionnaire survey of 15 students provided comprehensive insights into the use of digital tools in teaching practices.

Qualitative Findings:

1. Digital Technologies Used:

- Future mathematics teachers employed a variety of digital tools, including iPads, online platforms like Kahoot and Wordwall, and QR codes.
- These tools were used for enhancing student engagement, facilitating assessments, and providing interactive learning experiences.

2. Teaching Methods:

- Interactive methods (e.g., games, quizzes, interactive presentations) were commonly used to boost student engagement and understanding.

- Collaborative methods (e.g., group work, pair activities) facilitated by digital tools promoted active learning and peer interaction.
- Direct instruction was often supplemented with digital tools, creating a blended learning environment.

3. Mathematical Topics Taught:

- Digital technologies were applied to various mathematical topics, including fractions, angles, algebra, and linear equations.
- These tools helped make abstract concepts more concrete and accessible through visual and interactive representations.

4. Reflections and Self-Reflections:

- Positive outcomes included increased student engagement and improved understanding of mathematical concepts.
- Challenges included technical issues and varying levels of digital literacy among students.
- Suggestions for improvement focused on better planning, technical support, and continuous training.

Quantitative Findings:

1. Exposure to Digital Technologies:

- The majority of students had minimal exposure to digital technologies during their primary and secondary education. However, at the university level, they experienced a significant increase in the use of digital tools in their training.

2. Current Use of Digital Technologies:

- During internships, the use of digital technologies varied, with most students encountering limited opportunities due to resource constraints in primary schools.

3. Future Intentions:

- All surveyed students expressed a desire to use digital technologies in their future teaching practices, highlighting tools like interactive whiteboards, tablets, and applications such as GeoGebra, Kahoot, and Nearpod.

5.2 Statistical Analysis

The multidimensional regression analysis revealed no statistically significant interactions between the efficiency of digital technologies (Q9) and the variables Q1 (gender), Q3 (use of digital technologies in primary/secondary school), Q5 (use of digital technologies at the university), Q7 (use of digital technologies during internships), and Q12 (future implementation of digital technologies).

Comparison with Literature Review

The findings from this study align with existing literature on the use of digital technologies in mathematics education. According to the literature review:

1. Enhanced Learning Outcomes and Engagement:

- Tools like GeoGebra facilitate the visualization of geometric concepts, leading to improved spatial reasoning and problem-solving skills (Hohenwarter & Fuchs, 2004; Jones, 2000). Similarly, our study found that digital tools helped make abstract concepts more concrete and accessible.

2. Gamified Learning Experiences:

- Platforms like Kahoot provide real-time feedback and engage students through gamified learning experiences, significantly enhancing motivation and participation (Wang, 2015). The use of interactive methods in our study, such as quizzes and games, echoed these benefits.

3. Personalized Learning:

- Interactive applications like Learning Apps support self-paced learning and improve mathematical performance (Kim & Chang, 2010). Our findings also highlighted the role of digital tools in providing interactive learning experiences and facilitating differentiated instruction.

4. Challenges:

- Technical issues and varying levels of digital literacy are common challenges (Ertmer & Ottenbreit-Leftwich, 2010; Voogt & Knezek, 2008). These challenges were also evident in our study, emphasizing the need for robust technical support and comprehensive digital literacy training.

Implications for Teacher Education

The study underscores the need for teacher education programs to focus on both technical proficiency and pedagogical integration of digital tools. Key recommendations include:

1. Comprehensive Training:

- Teacher education programs should provide extensive training on the use of digital tools, ensuring that future educators are proficient in both the technical and pedagogical aspects.

2. Opportunities for Practice and Reflection:

- Programs should offer opportunities for future teachers to experiment with digital tools and reflect on their experiences, fostering a culture of continuous improvement.

3. Support for Digital Literacy:

- Targeted training to improve digital literacy among both teachers and students is essential to overcome the challenges related to varying levels of digital skills.

Future Research Directions

To build on these findings, future research should explore:

1. Longitudinal Studies:

- Investigating the long-term impacts of digital technology integration on student learning outcomes and teacher development.

2. Comparative Studies:

- Examining differences in digital technology use across various educational contexts, such as urban versus rural schools or different educational levels.

3. Impact on Diverse Student Groups:

- Studying how digital technologies affect different groups of students, including those with special educational needs or from diverse socio-economic backgrounds, to inform more inclusive and equitable teaching practices.

Limitations of the Study

Despite the valuable insights provided by this study, there are several limitations that need to be acknowledged:

1. Sample Size:

- The study involved a small number of participants (seven portfolios analyzed qualitatively and 15 students surveyed quantitatively). This limited sample size may not fully represent the broader population of future mathematics teachers and may affect the generalizability of the findings.

2. Self-Reported Data:

- The data collected through portfolios and questionnaires relied on self-reported information, which could be subject to biases such as social desirability or recall bias.

3. Contextual Factors:

- The study was conducted within a specific educational context (the Faculty of Education at the University of Ostrava), which may limit the applicability of the findings to other settings with different resources, curricula, and student demographics.

4. Technical and Logistical Constraints:

- The study highlighted challenges related to limited access to digital resources during internships. These constraints may have influenced the extent to which participants could experiment with and reflect on the use of digital technologies.

In conclusion, this study highlights the transformative potential of digital technologies in primary mathematics education. By addressing the challenges identified and leveraging the benefits of these tools, future mathematics teachers can create dynamic and engaging learning environments that enhance student understanding and motivation. Teacher education programs play a critical role in preparing educators for this task, ensuring they are equipped with the necessary skills and knowledge to thrive in a digital age. Through comprehensive training and support, we can foster a new generation of educators who are adept at using digital tools to enrich their teaching and improve student learning outcomes.

Acknowledgement

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GREENCOOL: Case Study of an International MOOC Course's Green and Communication Content Development

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Abstract: Sustainability and green matters are emerging issues among youth in the 21st century. The European Union (EU) emphasises youth discourse on greener thinking and lifestyle, which aims to build an open-minded, green, and digital future. Therefore, it is crucial to provide appropriate education and shape attitudes towards green issues. Regarding this scope, four universities of the European Capitals of Cultures (ECoC), the University of Pannonia (Veszprém, Hungary), University of Tartu (Estonia) Vytautas Magnus University (Kaunas, Lithuania), and West University of Timisoara (Romania), allied to develop a MOOC course interconnecting green related topics and communication skills and methods. The case study summarizes the main findings of the questionnaire (with 701 youth between 18-25 age), the desktop and focus group interviews research that gave the bases of developing the MOOC course material of GreenCool Erasmus projects. First the primary data, reflecting aspects of the involvement of young people in fighting climate crisis was analysed. The ultimate goal was to come up with a well-documented profile of students in tertiary education, reflecting their 'green' and 'communication' profiles as agents in fighting climate change. Second, taking the outcomes into consideration, the 4 universities carried out focus group interviews with 27 participants: influencers, green and communication experts and university students. As a result the green and communication topics were identified. This led to those methodological tools that were appropriate and effective in developing the GreenCool MOOC material and the corresponding blended Greenfluencer course with the provisional title: 'Attitudes shaping communication techniques and green related topics in the 21st Century'. The case study describes the process and the results.

Keywords: MOOC course, Green, Communication, University students, Case study

1. Introduction

Despite the widespread recognition of sustainability and green practices, there is a need to develop new innovative and creative solutions. Education has the key in this role in this development. Furthermore to reach out youth the power of online such as MOOC courses have vital impact. Within the GreenColol project four European Capitals of Culture universities and a Greek agency have developed the Grennflunecer MOOC course that is now piloted as bended university seminars. The case study describes the research before developing the online course syllabus and materials.

2. Literature Review

2.1 Sustainablity and Environmental Education

As Adam Tooze (2022) puts it, when our coping strategies and abilities to deal with problems become stuck, they become a crisis. The problem is that in recent years people have been hit by a number of shocks and crises (such as climate change, various natural disasters, COVID-19, the energy crisis, food and commodity problems, inflation, the Russian-Ukrainian war, the escalation of the Palestinian-Israeli conflict into war), the severity of which lies in their interaction with each other. According to the Eurobarometer 2023 survey, the five most important challenges currently facing the European Union are immigration, the war in Ukraine, the international situation, inflation and the environment and climate change. In the survey, 45% of respondents identified peace, 35% human rights and 31% respect for human life as the most important values. The World Economic Forum's Global Risks Report 2024 tops the list of risks, including extreme weather, misinformation and disinformation caused by artificial intelligence, social and societal polarisation, livelihood crisis and cyber-attacks.

The environmental, social and economic problems listed can all be classified under the key pillars of sustainable development and sustainability.

The impact of humanity on the environment is not a problem that has been identified today, as the first report of the Club of Rome (1972) already stated that the exploitation of natural resources and supplies must be slowed down and population stabilized. If humanity fails to do this, and consumption patterns and growth rates increase

exponentially in the 21st century, their model-based projections predict that by 2100 our world as we know it today will collapse (Meadows et al., 1972).

The term sustainable development as a policy term first appeared shortly afterwards in the Brundtland Report (Brundtland et al., 1987), which focused on the relationship between natural limits and human well-being, the quest for balance. The basic concept of sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainability therefore means the long-term maintenance of well-being, a process that is not synonymous with the environment. Although we are consuming natural resources and supplies at the expense of future generations, we are also producing knowledge that will serve to achieve future well-being (Kuhlman and Farrington, 2010).

Sustainability envisages a fair life between generations in time, on the one hand, and between humans and nature in space, on the other. As early as 1977, at an intergovernmental conference in Tbilisi, world leaders recognised the importance of environmental education for the preservation and improvement of the world environment and for the healthy and balanced development of the world's communities. Environmental education is seen as a lifelong process, regardless of cultural, social or economic group. The Tbilisi Declaration (1977) identifies five environmental education objectives: 1. environmental awareness, 2. environmental knowledge, 3. environmental attitudes, 4. skills and 5. Participation. UNESCO carried out several surveys and studies (1985, 1987) on environmental education in the 1980s. It defines environmental education as a complex learning process consisting of the following elements:

- expanding people's knowledge and understanding of the environment,
- develops the skills needed to cope with environmental challenges,
- develops skills and competences to deal with environmental challenges, shapes attitudes, motivation and commitment,
- encourages responsible action.

According to Boca and Saracli (2019), the aim of environmental education is to teach and educate the public about the functioning of the terrestrial environment and the role of humans in the natural ecosystem, as well as their norms of behaviour and conduct.

> *"ESD is a lifelong learning process and an integral part of quality education that enhances cognitive, social and emotional and behavioural dimensions of learning. It is holistic and transformational and encompasses learning content and outcomes, pedagogy and the learning environment itself." (ESD Roadmap, UNESCO, 2020, p.8.)*

2.2 MOOC Method

The development of the Massive Open Online Courses (MOOCs) methodology dates back to 2008, when it was created in cooperation between companies and universities with the aim of providing a credit-free learning opportunity for anyone interested and willing to learn in an online environment, without a limit on the number of participants and without a formal admission procedure (Gaebel, 2013). The biggest MOOCs platforms are Coursera, edX, Udemy, Udacity, Futurelearn. MOOCs have the power of technology to trigger learning to massively scale without global limits (Bayne, 2023).

MOOCs are an option to traditional higher education, a popular form of blended learning today (De Moura et al.,2021). Higher education institutions, especially in developing countries, need to find solutions to challenges related to teaching quality, training costs and educational equity in order to ensure the sustainability of the education system (Gulati, 2008). MOOC-based blended learning can enhance personal participation and involvement in the classroom and develop the student's development as an active learner (De Moura et al., 2021).

2.3 Green Skills and Competences

The European Commission has developed the GreenComp sustainability competences reference framework, which "responds to the growing need for people to develop and acquire the knowledge, skills and attitudes needed to live, work and act sustainably." It also defines the concept of sustainability literacy (…). Sustainability competence applies to all aspects of life - both personal and collective."

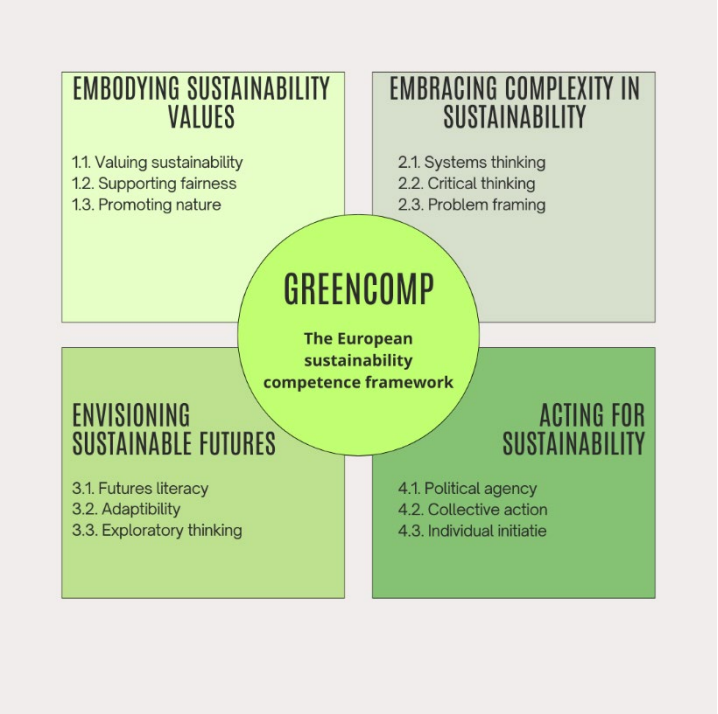


Figure 1: GreenComp identifies 4 key areas with 3-3 key competences based on the European Commission GreenComp, Bianchi et al. 2022, own editing

The European Union framework was preceded by several studies on sustainability-related competences between 2012 and 2020, which aim to understand sustainability education (SE) and education for sustainable development (ESD) by defining key competences.

2.4 Green Attitudes

An EU-wide survey conducted by the European Commission in December 2019 found that 53% of respondents consider the environment to be a very important issue, with 1) climate change, 2) increasing waste and 3) air pollution as the most important issues. The main concerns are the impact of microplastics, plastic products and chemicals on the environment. The most effective ways to address environmental problems, according to respondents, are 1. consumption, 2. changing the way we produce and trade, 3. research and development, 4. more education. 66% of respondents collect a significant proportion of their waste separately in order to reuse it. There is a perception that neither big business and industry, nor citizens and national governments are doing enough to protect the environment (Eurobarometer 501, 2019). Other research in different disciplines shows that the public is becoming increasingly sensitive to environmental issues at the individual level, particularly in wealthier countries. Green attitudes are reinforced by economic prosperity, as it provides greater opportunities for environmental education and facilitates green consumption (Ott and Soretz, 2018).

Zsóka and colleagues (2013) clustered the students surveyed according to their attitudes towards environmental issues:

1. *Active cluster:* mainly university students and showing active pro-environmental behaviour in their daily life. They are aware of environmental issues, are aware of the elements and benefits of sustainability.
2. *Familiar cluster*: mainly teenagers, aware of environmental problems and concerned about them, but less committed than the active cluster.
3. *Techno-optimist cluster:* a group of teenagers, students, young adults who believe that technological progress will solve environmental problems.
4. *Hedonist cluster*: a cluster of highly hedonistic consumers.
5. *Careless cluster:* not involved in environmental education programmes, not involved in environmental actions, often answer "don't know".

The clusters clearly show differences in behaviour and environmental awareness. The study shows that there is a significant correlation between environmental knowledge and skills, pro-environmental behaviour,

consumption and everyday behaviour (Zsóka et al., 2013.). Another study revealed that youth consider nature as a higher power than humans, and therefore people have to adapt the limits of nature (Kővári et al. 2023).

2.5 Green Universities

Since the 1970s, an increasing number of higher education institutions have been offering courses aimed at raising environmental awareness, increasing knowledge, skills and attitudes towards sustainability (Balcerak - Wozniak, 2022). Higher education institutions have a significant impact on training and preparing the next generation to become green societies. Universities need to place equal emphasis on the different dimensions of environmental education (Boca - Saracli, 2019). Young people can be agents of change. Therefore their involvement in different programmes and decision making is key for the successful implementation of environmental protection (Ramirez, 2017). Appropriate communication can influence people's behaviour, initiate dialogue and promote understanding. Continued visibility of sustainability efforts at universities is key to attitude formation and engagement (Franz-Balsen - Heinrichs, 2007).

3. Case Study of the Development of the GreenCool MOOC Course

3.1 Background

The GreenCool – 'Let me influence your green self! – skill development in the encouragement of mind-set towards environmental awareness and sustainable development has been implemented in partnership between 4 European Capitals of Culture Universities such as the University of Pannonia (coordinator), Vytautas Magnus University, the West University of Timisoara and the University of Tartu and Militos Consulting S.A. The general goal of the project is to develop environmental awareness among university students and to spread the thought of sustainable development among the widest possible age groups at events that attract large audience. The partners have been committed to develop an innovative online course material and to mainstream sustainable development in all curricula for higher education students. Furthermore, the goal is to equip students with communication tools and sustainable attitude to become effective advocates for advancing EU green economy and culture. This objective encompasses the following specific objectives:

- ***Greenfluence Practice Collection and Research***: methodological framework for implementation by exploring influencer tools and techniques and communication channels through youth can be approached in the 21st century.
- ***Developing the Massive Online Open Course***: course curriculum-design and development of material in two platforms.
- ***Blended ECoC Greenfluencer Pilot Course on national level***: the outcome of the course is a participation in an ECoC event/festival, where students can try and test their knowledge and influence audience offline.
- ***Blended ECoC Greenfluencer International Course***: mixed nationality students groups present at the final GreenCool ECoC event
- ***Online Interactive Platform:*** the MOOC material will also be available on an interactive platform where students, academics, influencers, green experts can access it.
- ***Professional Content and Guidelines*** for international online workshop for stakeholders to give suggestions how to integrate these techniques into subjects from any disciplines in order to provide the knowledge for any universities.

The present paper focuses on the first objective that includes the exploring the green issues and communication methods, tool to develop the Greenfluencer MOOC course material. In the following we introduce the case study which is an exploratory result that contains both a survey with university students and focus group interviews. The case study describes the topic elements which were important to implement into the MOOC material, while the focus group interviews aim were to see the communication channels and method as well as the green attitude in order to organize the style, structure and activates of the MOOC and blended course.

4. Analyses and Results

The secondary and primary analyses aim was to gather information about youth knowledge and attitude on two main issues: social media (following and using) especial focusing on influencers and green-related topics. The data collection and analyses period was between 28 February and 31 August 2022. The primary research included questionnaire (701 students) and focus group interviews (27 participants). The secondary research was a desk top analysis looking at articles, best practices, past and ongoing projects nationally and internationally to examine the similarities and differences among the 4 countries. The data were analysed with qualitative and

quantitative data methods. The aim of the desktop research as secondary data analyse was two-folded: firstly to examine the best practices, previous results and literate on and about youth attitude towards 'green', 'influencer' and 'communication' issues. Secondly, to provide a solid bases in order to develop a questionnaire and focus group questions to exploring the targeted 4 countries' youth attitudes in the previously mentioned topics. In the following the outcomes of the focus group interviews and questionnaire are summaries in reflection and connection to the secondary data analysee research outcomes gave the base of the MOOC material for ECoC Greenfluencer course.

5. The Questionnaire Survey Results

5.1 Outcomes on Communication Platform and Attitude

The majority of the respondents use the following social media platforms for communication to get information, post their thoughts and feeling and to follow opinion leaders, friends and influences on various topics. Instagram is the most preferred platform, followed by *Facebook, You Tube and TikTok* though the last two varies between countries. Interestingly WhatsApp, Telegram and Twitter are country specific. As *for communication techniques Instagram considered creative, TikTok considered funny but very powerful if it comes to specific videos (such as green topics), You Tube is perfect for storytelling that is relevant and give audience instantly what they want.* Subgroups on FB are for information and event sharing that would take place offline in an action. Snapchat is used by younger kids and mainly in Lithuania, while LinkedIn and Pinterest are rarely used.

5.2 Outcomes on Green Issues

The exploratory research did not want to limit the definitions of 'green' to just environmental topics, in order not to limit but broader the online teaching material varieties. Therefore the young people identified different kinds of green issues and approaches. Issues such as: *nutrition, responsible consumption, urban lifestyles, urban mobility, sustainability of public spaces, small household habits, energy saving, air quality, carbon footprint, critical recycling techniques, circular economy, zero waste/waste management, climate-phobia and anxiety, greenwashing, ethical thinking, green mobility and collective social responsibility*. About green education and communication youth want to feel these relevant, important, trendy and sexy. *"Small steps, big results"* and *"be pro-active" and "take social responsibility"* what green influencers emphasised. The *negative side of 'green'* was also considered: company using green as marketing and also pay influencers to do that, misinterpretation of labels (bio, but what it is really?). The concept of *green guilt* appeared, meaning that young people are afraid to be green as the majority might mock them. Also there are lots of misinformation on green topics, so 'grey zone', a kind of skill to filter green information is needed. Influencers should be simple and authentic on green issues to convey the right information and attract people to pay attention and act.

5.3 Communication and Green Topics to the ECoC Greenfluencer MOOC Course

Based on the previous research outcomes the following 12 communication techniques and 10 green issues are suggested to be included in the ECoC Greenfluencer MOOC course (Table 1)

Table 1: Communication and green topics (own editing)

Communication techniques and structure of discourse:	Green topics:
Storytelling on and offline	Nutrition and food-waste
Blogging/glossary writing	Sustainable fashion
Short film, video (You Tube, TikTok)	Urban lifestyles, sustainable public living
Instagram, TikTok techniques offline-acting	Responsible consumption: small household habits, individual's responsibility
How to create powerful picture content	Energy saving and alternative energy: air and water quality and quantity
Elevator pitch	Collective social responsibility: individuals, companies and institutions
Pecha Kucha	Critical recycling techniques, waste management and circular economy,
Oxford debate	Climate-phobia and anxiety,
TED talk	Greenwashing and ethical thinking
Gamification	Green mobility
Communication with art and music	
Round-table discussion	

These topics made up the main core of the MOOC course syllabus and materials.

6. Focus Group Interview Results

For the data analysis was employed applied thematic analysis to structure the data. The result is a rich, analytical description of the data that is accessible to interpretation. Themes are being actively generated by the researcher as it was chosen to conduct an inductive analysis, which led to an analysis driven by data rather than theory. The thematic analysis data have been derived from focus groups interviews made in four countries with young people, aged between 18 and 25: Hungary (6 participants), Romania (8 participants), Estonia (7 participants), Lithuania (6 participants), totally – 27 participants, (Figure 2).

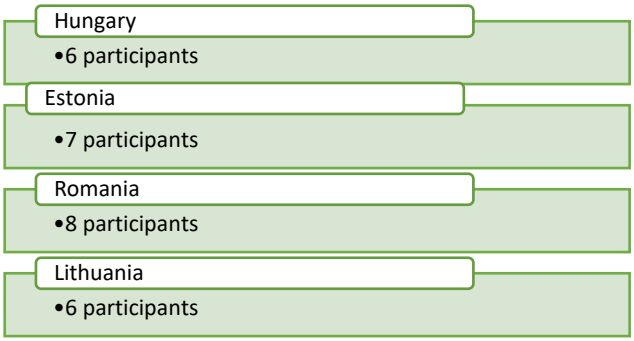


Figure 2: Focus group participants per country (own editing)

The Focus group thematic analysis is structured in two levels of depth. The first level defines fundamental analysis themes, linked to "What about" questions: What about profile of the participants?, What about influencing?, What about communication channels and techniques?, What about the content?, What about favourite influencers for young people?, What about young people and green attitudes?, What about dark side of green communication?, themes are presented in Figure 3.

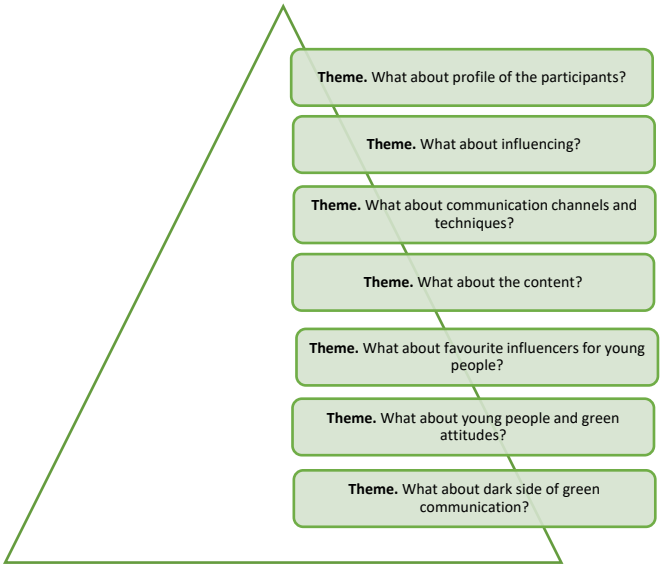


Figure 3: Themes of focus group thematic analysis (own editing)

Summarising focus group data thematic analysis derived from focus groups interviews there is not noticeable very big difference among the participants' opinions per countries. When discussing communication channels and techniques, it could be noted that all group participants are active sharing their ideas and experiences in various platforms such as: Tik Tok, Instagram, Youtube, Facebook, WhatsApp, LinkedIn, etc., and noticing that "platforms are changing by time to time". When discussing the content, participants of all groups share their ideas about visual content as well as the content using various storytelling tools and inspirations, noticing that: "people really like simplicity and authenticity". And when discussing the role of young people to green attitudes, it could be seen more active participants from Hungary and Romania, noticing that "reflecting green topics is of

real interest to young people in a heterogeneous approach". However, it can be noted, when discussing the dark side of green communication, more critical opinions emerge among Estonian and Lithuanian participants. Thus, summing up the experiences of the research participants, it is noticeable, that the research participants revealed as active and creative young members of nowadays society, paying attention not only to green communication, but also seeking to be active participants, changing the public's attitudes to climate change issues. When survey outcomes were discussed the participants agreed with the green topics and communication tools and method to be included in the MOOC course, furthermore 20 mentioned that these issues are vital to be taught regardless of the field of study of the university students. Drawing our initial conclusions from the findings at this research phase of the GreenCool project, we will try to outline the 'green' and 'communication' persona of our target group, which consists of young people at the age of 18-25, summing up key-characteristics that seem to be valid across the four project countries (Hungary, Estonia, Lithuania, and Romania), as well as across digital identities as constructed in the online world and are rather border-free.

7. Conclusion

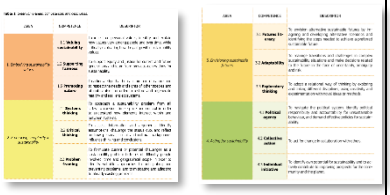
In the table below we summarise the findings of the primary and secondary data research as demonstrated in this document across two axes:

- In the left column of the table we provide 'statements' on the 'green' and 'communication' profile of young people (focusing on the age group 18-25) as drawn from the findings (what young people think, feel, do).
- In the middle column we provide recommendations (what should be amplified, moderated, eliminated, transformed towards making young people becoming knowledgeable and actively engaged in fighting against climate change?).
- In the left column we provide challenges (which are the challenges for the GreenCool partnership in turning the suggested recommendations into a methodological approach for the development of the GreenCool MOOC material and the corresponding ECoC Greenfluencer course)

It should be noted, that 'Recommendations' and 'Challenges' should here be considered as complementary to each other towards indicating and suggesting educational material as planned, in the sense of both its direction and scope, as well as the considerations in the process of fleshing out this direction in the form of educational/pedagogical content (challenges).

Table 2: Empowering the 'green self's' of young people as agents and influencers in fighting climate crisis (own editing)

'Green' and 'communication' self of young people	Recommendations	Challenges
Extremely worried, amplified by feelings of fear, sadness, anxiety, angriness, helplessness, powerlessness.	Channelling depressive feelings and emotions towards agency at personal and collective level – Making them conscious of their determining role as a distinct social group.	Identifying the correct discursive means, that can overcome the feelings of 'nothing can be done' vis-a-vis 'a damage done'.
Higher levels of involvement at the individual (activism at home), rather than collective level.	Encouraging 'activism at home', but however, endowing it with the notion of a collective life-style that can be communicated through actions that have a collective impact themselves (making individual life-style publicly known by promoting it through digital and not only means).	Infusing the responsibility of the individual towards society. How impactful practices and everyday activities fighting climate change in own micro-world should be communicated and promoted - to schoolmates, friends, family, irrespective of the result.

'Green' and 'communication' self of young people	**Recommendations**	**Challenges**
Pronounced, real-life exposure and experiences to climate crisis consequences, that go beyond the scientific discourse discussing the issue.	Provide young people with skills that can transform scientific, journalistic, expert discourse about climate crisis into creative communication discourse (e.g. drawing connections between climate crisis topics and future planning, professional and personal aspirations which initially seem to be disconnected from 'today's' climate crisis discussion)	Development of meaningful examples. Explaining the processes of abstract thinking, that connect the future agency of a young person with climate change. Building on selected skills according to EU GreenComp 
Active participation in worldwide impactful activities and movements (e.g. FFF, Extinction Rebellion etc.) is not massive and consistent, and also varies across countries.	Identification and demonstration of the reasons for that, as well as the outcome, the impact of those movements (what is/was attractive and what not?). Connecting young people with collective action and movements of the past – creating an intergenerational community through time, that is, from the past, to the present and into the future	Overcoming methodological difficulties in approaching and making the recommendation meaningful and presentable (i.e. attending the respective socio-cultural contexts and intergenerational tensions in their own historical contexts)
Blaming the older generations for climate crisis but not explicitly. Higher trust and hopes for fighting against climate change are invested in NGOs, local communities, rather than governments, the leaders in economy and industry.	Promoting the concept of intergenerational equity rather than intergenerational conflict Promoting intergenerational learning through climate communication (e.g. climate communication as intergenerational or cross-generational as for example from persons at the upper cohort of the age group 18-25 to them at the lower cohort i.e. 18 or less) Deploying methodologies like for example role-playing workshops where participants represent past, present and future generations, taking responsibility and being accountable to each other.	Developing inspirational material (preferably visual and scenario-based, rather than narrative) that promotes climate change as an urgency of today, while at the same time transcends into the long duration (past and future).
Easily influenced by social media influencers Prefer credible and entertaining content Prefer visual, short but meaningful content rather than narrative Co-creation of content The wide outreach (followers) of an influencer doesn't always work in a positive way Spend much time online and on social media in particular, running the risk of FOMO and the related anxiety issues (Fear-Of-Missing-Out)	Allowing for high levels of co-creation of content (i.e. not instructional, top-down approach). Ensuring credibility of content. Promoting visual elements and short to medium duration in topics integration. Promoting 'influence' on the basis of valid and verifiable arguments, rather than the influencer as agent and authority	Adjust content, style, and discourse used on the issue and goal of promoting 'greenfluencing' to several socioeconomic profiles of young persons within the age group 18-25 (e.g. gender, educational background, national identity, relationship with social media etc.)

'Green' and 'communication' self of young people	Recommendations	Challenges
Can become confused and eventually neutral, disengaged, or worse, negative, when they can't relate to or understand the climate change jargon	Avoiding scientific jargon as a means of communication climate change and crisis (discourse), while deploying at the same time scientific jargon as a means of validation (i.e. as a way to explain why rather than what)	Need of glossary and conceptual guidance that should be tested and validated as effective
Credibility, trust worthiness, sympathy, originality, uniqueness are the 'winning' qualities of an influencer Quality of communicated material or opinion matters more than quantity of followers and audience	Development of skills that allow credibility, worthiness, sympathy, originality, uniqueness to be expressed in written discourse (online, social media), but also in visual, audio or other means of communication	The mentioned skills that have to do with the recommendation as provided might be hard to be formed, as well as 'taught' within the scope of educational material, as they touch upon interpersonal as well as intrapersonal skills, which can be challenging for the particular age group (18-25)
Having to deal with scattered, unstructured and often not well-documented information Lack critical assessment and thinking skills Having to deal with misinformation which can be hard identifiable as such	Developing skills for the creation, communication, as well as the critical assessment of 'what is written online' and especially social media	The recommendation can have a very wide scope and touch upon various areas (e.g. use of emotive and rational language, assessing credibility and validity of information by cross-examination of multiple sources, assessing credibility and validity from the visual, narrative or other context that complements the information etc.)

The Greenfluencer course has been piloted both at national and international level and the educators and students involved in the project are giving feedback and analyses to professionalize the open platform to be available soon to everyone.

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Didactic Innovation in Mathematics Using Technologies

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Abstract: The continuous progress of society requires all the actors to be dynamic and constantly updated, both in terms of monitoring as well as in the need to adapt. Regarding education, no matter how updated we are in relation to the contents, didactic strategies, and technological resources, we are still inevitably forced to adapt to new paradigms, leading us to reformulate traditional teaching methods. In this context, the contribution of e-learning platforms emerges, where teachers and students have at their disposal new means of empowering the teaching and learning process, since these platforms can be defined as a virtual teaching support environments. Currently, our students, in general, have many difficulties in problem-solving and mathematical reasoning, which often reflects in the performance of very simple tasks, with a growing disinterest towards Mathematics. It is also possible to argue that our students' "poor preparation" is a contributing factor in their failure (many did not attend Mathematics in Secondary Education and/or have not studied for several years, as is the case of those who entered through special contingents, as the "aged 23 and over"). In order to promote a distinct, alternative and supportive pathway that may help to solve this issue, a project on the Moodle learning management system (LMS) platform has been developed with the goal of assisting students in their study and the development of their skills in a way that is directly related to the curricular units (CU) in the scientific field of Mathematics, in an online learning environment. To increase students' engagement into their learning process in a collaborative environment, a flipped model was employed into a Financial Mathematics/Financial Calculus Course (FCC). This paper's primary goal is to examine the effects of implementing the flipped classroom paradigm on students' performance, learning, and classroom instruction. The results from employing this approach have indicated a beneficial effect on the overall academic progress of students.

Keywords: Flipped classroom, Distance education, Higher education, Didactic innovation, Online learning, Mathematics education

1. Introduction

The rapid evolution of technology and the unstoppable shifting of societal needs, demand continuous adaptation and learning across multiple sectors, with education being a primary focus. In this case, it means embracing new paradigms and integrating technological advancements into traditional teaching methods (Crowley et al., 2023; Means et al., 2009; Shea & Bidjerano, 2013). Traditional classrooms, often limited by time and space, are being supplemented and even replaced by e-learning platforms that facilitate a more dynamic and flexible learning environment. One outstanding example of such platforms is Moodle, an open-source Learning Management System (LMS) that supports a wide range of educational activities. Moodle provides a versatile environment for enhancing the educational process by offering several tools and resources that support both teaching and learning (Lopes, 2011, 2014). These tools include discussion forums, quizzes, and assignments, which can be tailored to meet the specific needs of different courses and student populations Dougiamas & Taylor (2003). Research has shown that the use of Moodle can lead to improved student engagement and learning outcomes, as it encourages active participation and provides immediate feedback (Al-Ajlan & Zedan, 2008; Lopes & Soares, 2018b).

Moreover, the adaptability of e-learning platforms like Moodle allows for the implementation of diverse teaching strategies, such as the flipped classroom model. In this model, traditional lectures are replaced with online instructional videos and other support material that students can watch and use at their own pace, freeing up classroom time for interactive, hands-on activities. This approach has been shown to enhance students' understanding and retention of material, as it allows them to engage with the content more deeply and actively(Fung et al., 2021; Han et al., 2024; Lowell Bishop & Verleger, 2013; Nja et al., 2022; Rahmat et al., 2024; Walsh, 2024).

Even today, one of the most significant challenges in education continues to be the widespread difficulty students face in problem-solving and mathematical reasoning (OECD, 2019; Seepiwsiw & Seehamongkon, 2023; Szabo et al., 2024). This is particularly evident in their performance on simple tasks and their increasing

disinterest in Mathematics. Additionally, the inadequate preparation of many students, especially those who have been out of formal education for extended periods, exacerbates this issue. Research indicates that students often struggle with problem-solving and mathematical reasoning, which are critical skills for success in many fields, such for instance Financial Calculus (Indefenso & Yazon, 2020; Janicek Pavelova et al., 2023; Lopes & Soares, 2018a; Vilenius-Tuohimaa et al., 2008; Wangsa et al., 2023).

The main objective of this study is to explore the effects of implementing a flipped classroom model in a Financial Calculus Course (FCC) on student performance, learning outcomes, and classroom dynamics.

2. Methodology

2.1 The Flipped Classroom Model

The flipped classroom model represents a significant shift in traditional teaching methodologies. In this approach, instructional content is delivered outside of the classroom, often through online videos, readings, and other digital resources. The flipped classroom concept incorporates theories such as constructivism, active learning, and peer-assisted learning. In a flipped classroom, the instructor serves as a guide and facilitator, motivating students to construct their own knowledge, supporting them, and closely monitoring their learning outcomes. This model reserves in-class time for interactive, hands-on activities that promote active learning and deeper understanding of the subjects. Students could engage with the content at their own pace before class, allowing them to come prepared for more collaborative and application-based activities during class time (Akçayır & Akçayır, 2018; Jensen et al., 2015; Lopes & Soares, 2017; Sopamena et al., 2023).

Several studies have highlighted the impacts of the flipped classroom model. Lowell Bishop & Verleger (2013), conducted a comprehensive review of flipped classroom research and found that students in flipped classrooms performed better academically and reported higher satisfaction compared to traditional classroom settings. Lage et al. (2000), observed that students in a flipped classroom showed improved engagement and performance in economics courses, attributing this to the increased opportunity for active learning during class time. O'Flaherty & Phillips (2015), reviewed diverse studies and concluded that the flipped classroom model enhances student learning outcomes, engagement, and satisfaction across diverse educational contexts. Setren et al. (2021), conducted a randomized controlled trial at West Point to investigate the impact of the flipped classroom. They found that the flipped classroom produced short-term gains in math but had no effect in economics. Interestingly, the flipped model broadened the achievement gap, with effects driven by white, male, and higher-achieving students. While short-term gains were observed, the long-term average effects on student learning were not significant. Nouri (2016), studied students' perceptions of flipped classroom education in a university course on research methods. The results indicated that a large majority of students had a positive attitude toward the flipped classroom. Positive attitudes were strongly correlated with increased motivation, engagement, and effective learning. Notably, low achievers reported more positive perceptions compared to high achievers. Cabi (2018), investigated the impact of the Flipped Classroom (FC) Model on students' academic achievement. The results indicated that there were no statistically significant differences between the scores of the experimental group that included students learning through the FC Model, and the control group that included participants taught through traditional blended learning. The findings showed that the use of the FC Model does not yield significant impacts on increasing the students' academic achievement.

2.2 Implementation in Financial Calculus Course

The project was implemented using the Project MatActiva in Moodle LMS platform (see Figure 1), which provided a structured and interactive environment for the FCC. Video lectures, interactive lessons (see Figure 2), quizzes and tests (all with a proposed step-by step solution) were made available online for students to study independently. In-class time was dedicated to problem-solving sessions, discussions, and collaborative activities.

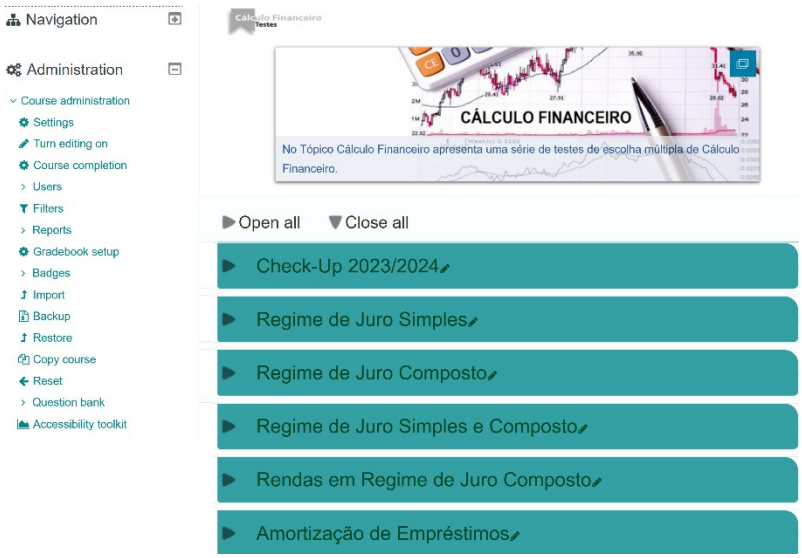

Figure 1: Print screen from the Main Page of FCC in MatActiva Project Moodle

Figure 2: Print screen of an interactive lesson about Discount at Simple Interest

A question pool, with more than 300 questions, based on the material covered in the FCC was built from scratch (see Figure 3) and afterwards organized into categories and subcategories. Each category's question combinations are chosen at random, creating a huge variety of online tests (quizzes) that students can solve whenever and wherever it is most convenient for them. The assessments facilitate many efforts, yielding automatically quantifiable outcomes, and promptly rectify each attempt. To assist students in understanding about their answer and with the underlying reasoning, the feedback provides a step-by-step proposed solution for each answer, encouraging self-evaluation and skills development.

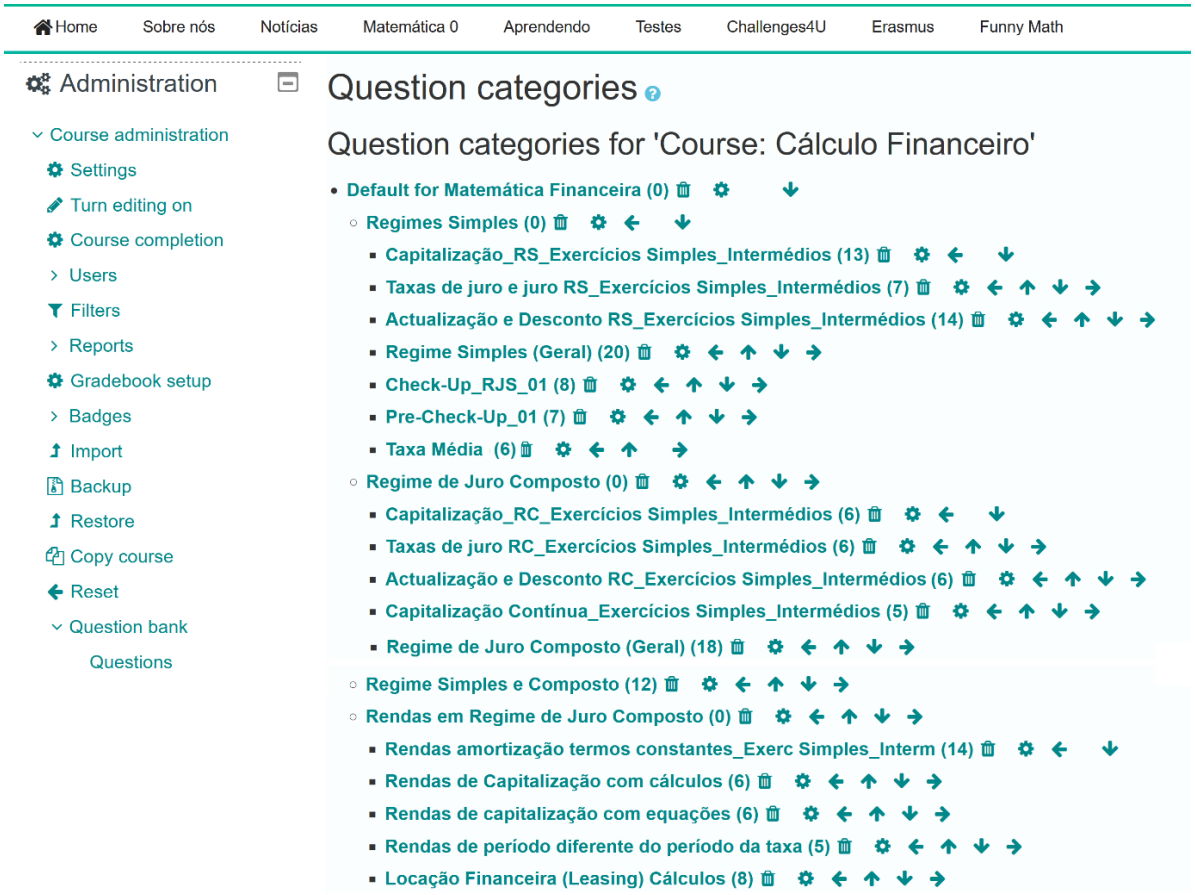

Figure 3: Print screen of some of the categories and sub-categories of the Question Bank (Question Pool)

2.3 Data Collection and Analysis

The sample for our study, conducted during the second Semester of the FCC at the Porto Accounting and Business School (ISCAP), which belongs to one of Portugal's largest and most prestigious public Polytechnic Institutes, the Polytechnic Institute of Porto (P.PORTO), in the 2022/2023 academic year, comprised 732 students. These students were divided into two groups: a flipped classroom group, included 64 students and a traditional teaching group. In both groups, around 80% of the students were attending the classes for the first time. The course covered four topics (Simple Interest, Compound Interest, Annuities and Loan Amortization) throughout the semester. Participants from flipped group could access to the Project Course Moodle (www.matactiva.com) where they can find video lectures, interactive lessons (see Figure 2), online exercises and quizzes related to each topic.

Accessing the Project Course Moodle (www.matactiva.com), participants could access all the available sections and they have at their disposal video lectures, interactive lessons, sets of online exercises and online quizzes, related with each topic.

Two classes each week, lasting one hour and thirty minutes, were part of the flipped classroom approach. Before this class period, students could study at their own pace using a set of interactive lessons (SCORMS) and quizzes that covered the course topics and were posted to Project Moodle. During the first twenty minutes of class, students' queries about any issues they were having trouble with were answered while skimming through the interactive lessons. The rest of the class period was allocated to working through the material through PowerPoint presentations, followed by individual or group work projects and problem-solving exercises. Every week students had a series of online tasks called "Financial Check-Up", deeply connected with the subjets they had learned, that should be completed outside of class. Therefore, online quizzes and activities were integrated to “test” what students have learnt. By receiving immediate quiz feedback and the possibility to repeat lecture segments enabled them to clarify some “grey” points in their thinking. These quizzes can also enhance learning because if students are “tested” before the class time, instructors have the additional opportunity to use feedback from these to tailor the content addressed in class.

The course performance data was collected and the results from both groups (flipped and traditional) were examined and compared. To further investigate the impact of the flipped classroom paradigm on the training, comprehension, and performance of FCC students, we have also created a survey. At the end of the semester, this survey was given to participants to analyze their overall opinions regarding the implementation of the flipped model in their classes.

3. Results/Discussion

For instructors, evaluating students' performance is always a difficult and demanding activity, especially in online learning contexts. Teachers that use online learning platforms often must modify and enhance their courses to ensure that their students do well and are able to learn. Access to learning analytics regarding students' quiz results and lesson completions should help educators gain a better understanding of, for instance: students' contributions to the course and their ability to follow and understand the materials, issues that students found challenging, students' knowledge transfer, as well as several other insights. The Moodle platform gives educators and administrators access to a variety of learning analytics tools that offer a wealth of information reports on the many activities that students complete in each subject, these can be very useful in enhancing and changing the subject matter Mwalumbwe & Mtebe (2017).

The grades chart in Moodle displays grade distribution for selected activities that helps both, teachers and students visualize performance, track progress, and identify areas needing improvement.

This chart (see Figure 4) tabulates grade results from assignments, quizzes, databases, forums, and other gradable activities from FCC. All tasks in which grades have already been awarded are listed below the chart and can be added to or removed from display in the chart. The chart displays the distribution of grades in the selected activities as a box plot.

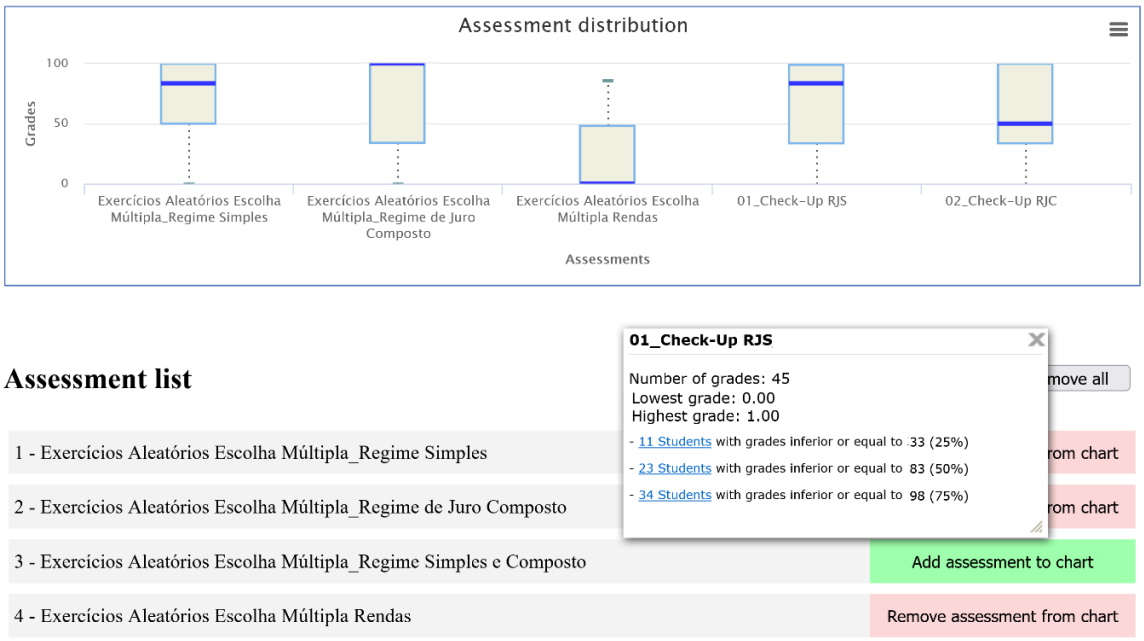

Figure 4: Print screen of the grades chart of FCC students in Moodle

When we click on the box plot for an activity, for instance first Check-Up about Simple Interest (see Figure 4), we can see a numerical breakdown of the grades, including the number of students below the quartiles and the highest and lowest grades. In this case, clicking the highlighted student numbers allows the direct message editing to be send to students who are below the quartiles in that group. A popup will appear, enabling to personalize the subject and text of the message. The default subject will include the unit's name and the assignment title. Additionally, we can choose to share the email with other teachers in the Moodle Course. It is very important to recognize students work and effort in a respectful and welcoming manner, since this will encourage positive self-esteem and motivation. This can be achieved by using their names, affirming their accomplishments, and tailoring comments based on our understanding of the individual performance. When students feel supported and respected, they are more likely to be receptive to feedback and motivated to act on it (Henderson & Phillips, 2015).

From Moodle Learning Analytics, the analysis revealed a significant improvement in students' problem-solving skills and overall performance in the FCC.

The final exam results have been used to measure the success of the flipped classroom model.

Table 1: Measuring the success of Flipped and the Traditional Classroom Groups

	2022/2023
Flipped Classroom Group success rate	73,6%
Traditional Classroom Group success rate	42,2%

Source: Own elaboration

Table 1 shows the results of the 2022/2023 FCC, in the traditional classroom group and flipped classroom group and it illustrates that the flipped classroom's success rate is higher than the traditional classroom's success rate in FCC.

Additionally, the average grade received by successful flipped students was greater than the average grade received by successful traditional class participants. In Financial Calculus, the average grade for students in flipped classrooms was 14.1, while the average grade for the students from traditional class was 12.6 (in a 0 to 20 scale).

The survey conducted at the end of the course showed a high level of student satisfaction with the flipped classroom model.

A big percentage (92,2%) of the students who took part in the experience said that the Interactive Lessons improved their understanding of the FCC subjects (see Table 2). No participants expressed any disapproval of the flipped classroom interactive lessons.

Table 2: Interactive lessons and students' preparation

Interactive lessons helped me understand the concepts studied in FCC	Number	Percentage
Strongly agree	37	57,8%
Agree	22	34,4%
Neither agree nor disagree	5	7,8%
Disagree	0	0%
Strongly disagree	0	0%

Source: Own elaboration

It's remarkable that nearly all of students (96,9%) who responded to the question "Online exercises enabled me to improve my Financial Calculus Course knowledge and skills" said that they performed better as a result of the randomly quizzes and detailed solution offered by all the online exercises.

Just 3.1% of participants had no opinion, were neutral, regarding the advantages of the flipped classroom's online exercises in terms of improving their performance (see Table 3).

Table 3: Students' Academic Achievement and Online Exercises

Online exercises enabled me to improve my FCC knowledge and skills	Number	Percentage
Strongly agree	44	68,8%
Agree	18	28,1%
Neither agree nor disagree	2	3,1%
Disagree	0	0%
Strongly disagree	0	0%

Source: Own elaboration

When asked about their preferences on the flipped classroom, 70,3% of the students in this study said they were in accordance with it. Of the participants, 12,5% preferred the traditional classroom, whereas 17,2% were neutral about their choices about the flipped classroom (see Table 4).

Table 4: Students' preferences in relation to the flipped classroom

A flipped classroom course is more attractive to me than a traditional classroom course.	Number	Percentage
Strongly agree	29	45,3%
Agree	16	25,0%
Neither agree nor disagree	11	17,2%
Disagree	8	12,5%
Strongly disagree	0	0%

Source: Own elaboration

In general, students reported feeling more engaged and motivated, citing the interactive and collaborative nature of the classroom sessions as particularly beneficial.

4. Conclusion

The development and implementation of a project, called MatActiva, on the Moodle platform has shown promising results in addressing students' weak skills in Mathematics. By directly aligning with the curricular unit of Financial Calculus Course in the scientific field of Mathematics, this project provides a structured and supportive online learning environment that enhances students' study practices and skill development.

The adoption of the flipped classroom model in this course has yielded significant improvements in student performance, engagement, and classroom dynamics. This innovative approach leverages e-learning technologies to deliver instructional content outside the classroom, thereby optimizing in-class time for interactive and applied learning activities. The flipped classroom model not only seems to foster a deeper understanding of mathematical concepts but also cultivates essential critical thinking and problem-solving abilities.

The positive outcomes observed in this project underscore the potential of e-learning platforms like Moodle to transform traditional Mathematics education. These platforms offer flexible and adaptive solutions that provide diverse learning needs and styles, thereby enhancing the overall educational experience.

Further research and development in this area can continue to improve educational methodologies and addressing the dynamic needs of students and society. Future studies should focus on exploring additional e-learning tools, refining the flipped classroom model, and integrating new technological advancements to sustain and enhance the efficacy of education.

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From Traditional to Challenge-Based Learning: A Case Study

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Abstract: The rapid evolution of the information technology sector necessitates innovative educational methods not only addressing current industry needs but also anticipating future challenges. This study aims to explore the transition from traditional pedagogical approaches to challenge-based learning (CBL) within the context of an undergraduate course, "Ethical, Social and Professional Aspects of IT" (120 participants). It investigates how this methodological shift influences the development strategies of the course and the pedagogical outcomes for students, particularly first-year IT administration and development students engaging in practical group work. Employing a mixed research design, the study gathers data through reflections of the course staff, empirical study with students and analysis of the didactic changes within the course. It evaluates the effectiveness of problem-based learning (PBL) and CBL methodologies in addressing real-world IT ethics, social, and professional challenges with a focus on fostering creativity, problem-solving skills, and interdisciplinary collaboration. Preliminary findings suggest that CBL not only enhances students' engagement and learning outcomes but also bridges the gap between academic knowledge and practical application in the IT sector. The collaboration students provided insights into real-world challenges, improving students' learning and administrative experiences at the university. Furthermore, the study highlights the advantages of integrating both PBL and CBL to cultivate a more dynamic and responsive educational environment. The shift towards CBL in the "Ethical, Social and Professional Aspects of IT" course at Tallinn University of Technology represents a significant step forward in aligning educational practices with the needs of the contemporary and future IT industry, preparing students for the complexities of the modern workforce, and contributing to a sustainable, innovative, and resilient economy. Further research is needed to fully understand the long-term impacts of this pedagogical shift and to refine the methodologies for broader application.

Keywords: Challenge-Based learning, Problem-Based learning, IT ethics, Pedagogical transformation, Course development strategies, Educational innovation

1. Background

Information technology (IT) is a fast-changing field that offers educational techniques both new opportunities and problems. Though fundamental, traditional educational approaches are increasingly being complemented with newer teaching strategies that predict the industry's future direction and respond to its changing needs. Challenge-Based Learning (CBL) is one such approach that has drawn interest due to its potential to completely transform processes in higher education (see Table 1 for a comparison).

Table 1: The Comparison of PBL (based on Wijnia, 2024) and CBL (based on Membrillo-Hernández, 2021)

Aspect	Problem-Based Learning (PBL)	Challenge-Based Learning (CBL)
Definition	A student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem.	An educational approach where learners use technology and inquiry to engage with real-world problems, developing solutions that make a difference in their community.
Advantages	Encourages deep understanding through problem-solving. Develops self-directed learning skills; Promotes collaborative skills.	Fosters engagement with real-world issues. Enhances critical thinking and creativity. Encourages practical application of knowledge.
Disadvantages	Can be time-consuming to implement. Requires significant facilitator expertise. Assessment can be challenging.	Can be challenging to align with curriculum standards. Requires careful planning to ensure relevance.
Effect on Motivation	Generally, has a positive effect on students' motivation, particularly in healthcare and STEM fields.	Motivates students by providing a sense of purpose and relevance, though research on its specific effects on motivation is less extensive.
Implementation	Often used in medical and health sciences education. Can be applied at both course and curriculum levels.	Commonly implemented in engineering and technology programs. Can be integrated with project-based and case-based learning.

According to Leijon (2022), it is important to understand that, compared to traditional ways, CBL has considerably enhanced student engagement, showing this method to be more participative and responsive to learners' needs. At the same time CBL also is harder to be implemented in academic settings due to enormous freedoms from students aside. This means with the flexibility it needs to arise also raise responsibilities. If there is no room to fail, then CBL might not be best to be used in traditional settings.

The course we use as an example, the Ethical, Social and Professional Aspects of IT, dates to 2001 and has since gone through several changes and additions (including course formats and languages). A pure background knowledge course for future IT professionals, its topics range from tech history to psychology to cyberculture to legal and business aspects. Its secondary aim has always been to foster the students' communication skills (depending on the course format, the emphasis can be on speaking/presenting or writing). The main goal is to provide students with the range of knowledge that often distinguishes a professional from a mere practitioner.

Regardless of the changes, the course has always had the exploratory, 'playful cleverness' spirit of classical hackerdom (as described by Himanen (2002) and several others). On a conceptual level, it is close to the concepts of the Flow and autotelic experience (originally by Csikszentmihalyi (1990), later expanded by both him and many others). The approach has also been studied in the educational contexts by e.g. Dermott et al (2016) and Oliveira et al (2023). The main tenets of the Flow - balance of challenge and skill, well-defined tasks, and immediate feedback - have been especially evident in the distance (e-learning) version of the course (surplus in the point system allowing choice, weekly feedback letter). While the connection in the earlier contact version was not this evident (it was there, though) since the last readjustment of the course in 2023 our aim has been to bring the Flow more to the surface by reviewing the task system to match the CBL approach.

Our findings also seem to confirm the conclusions from the systematic review by Doulougeri et al (2024) that while CBL is an effective approach, it requires relevant training for educators as well as sufficient time to familiarize both educators and students with the process.

The paper discusses the results of the 2023 course, but there will be significant modifications in 2024 that aim to use the models that have been learned, as well as employ even more interactive and cooperative CBL methodology and AI generative tools next year. This is just the first step; in 2024, the course will further incorporate AI tools and shift the lecture portion into automated and more asynchronous learning opportunities. This year we also want to bring in real-world panel experts from academia and industry will also engage in debates with students.

2. Methods

This study used a mixed (qualitative and quantitative) research design to investigate how challenge-based learning (CBL) has replaced traditional teaching methods in an undergraduate IT course called "Ethical, Social, and Professional Aspects of IT." There were 120 students in the course, most of whom being first-year IT administration and development majors. To evaluate the immediate effects of the new pedagogical approach in the early phase of their academic careers, the study concentrated on first-year students. We also wanted to test out some generative AI tools to complement the teaching and gather ideas on how to shift the course towards that direction in the coming years.

A variety of methods were used to gather data to examine the educational shift:

- To gather their perspectives and experiences about CBL, the teachers and facilitators provided qualitative comments over exercises used to facilitate the course. In this study the main interventions were a) Pecha Kucha and Belbin-based personal introduction to profile the students' interests; b) choosing one of the AI-generated topics for the project; c) developing personas and pilot with a real focus group (or in some cases, generative AI), d) reviews of the presentations; and e) the final exam where generative AI was used to develop the test based on lectures (which had a large variety of information society related topics).
- We also studied the reports written by students about their projects which offered in-depth insights into the students' cooperation and work process at the chosen topic. We also looked at the students' descriptive comments and reviews of each other's presentations (2), so in total, 1153 unique units of feedback were analysed for the paper.

- Finally, we studied the general end-of-the-course feedback given by the students about the course (tasks, facilitating etc).

The analysis focused on several major themes: in comparison to conventional teaching approaches, the study evaluated the effects of CBL on student engagement levels and learning outcomes. Using a focus on creativity, we assessed problem-solving abilities, potential uses of generative AI and the handling of ethical issues in professional settings, as well as effectiveness of CBL in bridging the gap between academic theories and real-world IT challenges.

3. Results

The results of the course are covered below by the stages as they occurred.

3.1 Profiling Students' Interests and Skills - Pecha Kucha Meets Belbin

At PBL courses, the team members are usually either chosen randomly, appointed by teacher, or the teams are formed by participants. The CBL approach is to allow everyone to present themselves to form a versatile team. Different methods can be used, an example is the brain dominance test developed by Ned Hermann (1987).

At this course, the initial one-hour profiling event (named the Team Member Exchange, or TME in short) involved a Pecha Kucha (McBrain, 2016) personal introduction with a one-pager document about themselves. In this, the students had to state their interests, possible traits, and their desired role in the team, according to the Belbin Team Inventory (Belbin, 1981). Team leaders were chosen among those who had opted for the leadership role - these students then had to use the remaining TME time to create a team that included as many different roles and additional qualities as possible (see Figure 1).

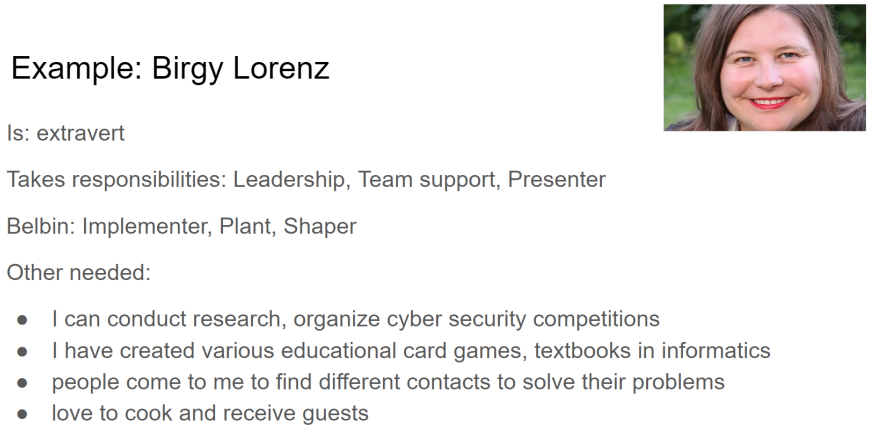

Figure 1: A sample one-pager from the profile

The feedback from students about the TME was that it made understanding the potential of each person easier, and in turn, it made everyone understand their role and responsibility in their team. At that time, they did not know the topic yet, so they could only strive to gather the best team for any possible situation. They also found it interesting that friends did not become the first choice anymore, as they were familiar, both in their potential and limitations - the students realized that this was not the best way of team building. The students claimed to have learned a lot about themselves, but also about how to hire people, present themselves, explain their values, or show themselves as trustworthy leaders to others.

3.2 Using AI for the Project Topics

The next step was providing the participants with topics based on the main content of the course - the areas included ICT history, information society, new media and social software, legal aspects of IT (intellectual property issues, patents, copyright, software licensing etc, free and open-source software, professionalism in IT, online communication, information security, privacy, censorship HCI (including assistive technology) and IT ethics.

While the role of the customer can be optional at PBL projects, it is needed for CBL. When using CBL as a methodology it is often discussed whether the customer should be present to develop the challenge or not. We decided to use a surplus of AI-generated challenges - this allowed them to interact with several customers and develop their own solution that can a) help the customer directly, b) provide the customer with a usable

service, or c) start to compete with the customer. This gave the students more freedom to develop their ideas and original solutions.

The 120 challenges were created with generative AI (Chat GPT 4.0, paid version) from which we chose 60 to be shared with the students. We found it interesting that actual, usable challenges were created by the AI within minutes using a rather simple prompt: “create a list of challenges on [topic list] for university BA level IT developers and administrators for the course [course name] using the CBL method. The idea should be possible to implement by groups of 6 in 2 months''. According to our experience so far, lecturers develop these lists of ideas by themselves, and it will take 1-2 days of work to come up with versatile challenges.

After that, the newly formed groups of students had a chance to review them and choose four most interesting ones. If the same choice was made by more than one group, the competing teams had to debate each other to find out which group was better equipped to implement the topic.

Some examples of challenges:

- How can we improve the user interfaces and user experience of autonomous vehicles to make them easier and more reliable to use?
- How can we increase the awareness of IT professionals and the public about the importance and possibilities of green IT to promote the green revolution?
- How can we effectively integrate the various IT systems and platforms used within TalTech so that they can communicate and share information effectively?

3.3 Personas and Piloting the Idea with Real Audience

These were three separate parts of a compound exercise with the same focus group. The student group needed to investigate who their product customer was and have a meeting. For developing personas, we provided some basic training and helped them develop academically sound and ethical surveys. We directed them towards developing a real product or at least a demo. The personas and piloting were using common business development tools, but the added value was in how the teams used their Belbin roles and responsibilities.

In our case, we made the transfer from traditional to CBL rather abruptly, therefore it was not clear whether a) the approach suits the first-year IT students at all, b) the students accept the Belbin roles (or will they prefer people they know, regardless of their skills and contribution) (see Figure 2). However, the project was successful - only one group out of 20 was afflicted by the common group work malady of piling all the work on just 1-2 people (this group had to be given extra tasks individually), the rest used the role distribution as designed and finished with good results. The only dropouts from the course were the 10 people (out of 120 participants) who registered but did not start. We used the ‘traffic lights’ system to monitor the progress - only 2 teams (out of 20 ever dropped into the ‘red’ zone, requiring direct help from lecturers. There were some more ‘yellow’ (needing advice) moments, e.g. one team had to change the topic during the project.

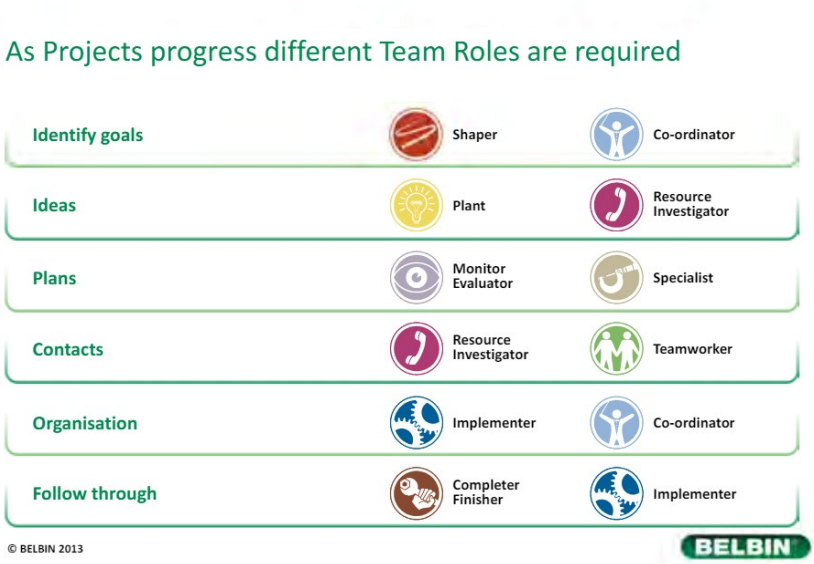

Figure 2: The Roles and Responsibilities in a Team (How to Form a Team)

Students reported that it was a challenge to develop a solution and write an academic paper about it in parallel within a limited timeframe (notably, they had trouble with proper academic writing - seems that their previous training in this section had been inadequate). The students enjoyed teamwork, pointing especially to the role of “team coherence builder” (essentially a community manager) whose responsibility was to see that everyone was contributing to time, and no one was left alone. This also helped to free the team leaders for other responsibilities (to represent the team and make final decisions). The students also pointed out that while the “writing wizard” and “presentation star” were the most competent for their respective jobs, they were used in trainer/coordinator roles instead (teaching others to do the work properly and ‘package’ the results at the end).

3.4 Presentations and Feedback to Them

We asked students for two presentations: a) explaining the idea at the beginning, and b) explaining the results at the end. Assessment was based on several criteria: clarity and sufficiency of the project title and team information, comprehension and course relevance of the project's main idea, the feasibility and clarity of the solution steps, the realism of the project timeline, and the definition and justification of the projected outcomes and finally piloting the results and outcomes. Additional evaluation provided feedback about the clarity of slides, effective use of the allotted time, the overall delivery and logic of the presentation, and the appropriateness of responses to any follow-up questions. Peer reviews focused on the understandability of the project idea, the added value compared to existing solutions, and the clarity of the project’s alignment with course objectives, also offering recommendations for improvement and noting any deficiencies in presentation length or content.

At the initial evaluation, 90% of the ideas were considered clearly understandable; 86% were deemed to add value and improve the situation; 80% of the ideas were considered realistic, and the final summary quality estimate was 95%. The main recommendations given by the peers were: a) to define the focus group (customer) well and understand the problem/needs thoroughly, b) information gathering must be selective and follow regulations, c) consider the size and limits of the task chosen (whether it is doable within the timeframe).

On a positive note, we recognized the common trend among the students - instead of competing with other teams, they helped and advised others as well. Still, when asked to provide constructive feedback, the quality of it was low - one of the reasons being the lack of previous knowledge about giving polite and useful feedback instead of mere criticism.

3.5 Exam: Stirring the Waters with Generative AI

For the exam we developed new exercises using generative AI (Chat GPT 4.0, paid version). The main prompt was “Develop a multiple-choice question about [topic] for the Bachelor-level course [course name] for the exam. Example of the question is [example]. Explain correct and incorrect answers.”. Some examples are provided in Table 2.

Table 2: Examples of the original multiple-choice questions and the AI-added narrative versions

	Original question	**AI modification**
1	In his 1968 demo (probably the first of its kind), Douglas Engelbart did NOT demonstrate. a) computer mouse b) graphical user interface c) packet communication * d) text editing by several users at the same time e) a screen presentation (like today's MS PowerPoint)	In 1968, Douglas Engelbart conducted a historic demonstration, often referred to as the "mother of all demos", which was notable for several technological innovations. During this demo, he introduced several innovative concepts and devices that are standard in computing today. Despite demonstrating several revolutionary technologies, there was one particular technology that he did not introduce at the time, even though it is an important part of digital communication and data transfer today. Which of the following was not part of Douglas Engelbart's 1968 demonstration? a) Computer mouse b) Graphical user interface c) Packet communication * d) Text editing by multiple users at the same time e) Screen presentation (like MS PowerPoint today)
2	Protocols that enable web content aggregation (pooling	The website owner wants to provide his readers with a convenient way to keep track of fresh articles and posts. He decides to integrate technology into his

	Original question	**AI modification**
	sources into one application for easier reading) are a) MariaDB b) Atom * c) RSS * d) NFT e) NTP	website that allows users to subscribe to news feeds and automatically receive notifications when new content appears. To do this, it uses two popular web standards that are specifically designed to aggregate web content and allow users to read news and blog posts from different sources in one place using the appropriate application or service. What are these two protocols? a) MariaDB b) Atom * c) RSS * d) NFT e) NTP
3	Terms that characterize the Anglo-American legal system are (a) common law * (b) civil law c) property law d) Roman law e) case law *	The Tallinn law firm "LexGlobal" specializes in international law, offering consulting services to companies operating in various legal systems around the world. The firm conducts training for young lawyers who have recently joined the team to introduce them to different legal systems. One of the main topics of the training is the Anglo-American legal system, which is significantly different from many other legal systems. What terms best describe (as a whole) the Anglo-American legal system covered in the "LexGlobal" training? Choose two correct answers. a) Common law. * b) Civil law. c) Property law. d) Roman law. e) Case law. *

We used the test questions in a mixed way, each test featuring both human-made and AI-made questions. The exam was technically yet another similar test (the exam was open book, but web search and AI tools were prohibited). As a twist, at the exam we introduced a) questions presented as graphics, making copying difficult and forcing the students to read and understand the question, and b) negative points for wrong answers, which made blindly clicking through the test a bad strategy.

The students considered the test rather interesting, in fact grasping the idea behind both 'twists' quite well. They admitted that they had to read and understand both the questions and answers, and while negative points caused some grumbling, they understood the reasons behind them.

3.6 Student Feedback to the Course

The feedback of the students was collected via comments and Likert scale questionnaires, they had to comment on both the course and their team (see Table 3). The teams were almost universally well-appreciated, also emphasizing the role distribution. They also outlined the improvement of their academic proficiency - notably the ability to provide constructive criticism - and leadership skills that were boosted by teamwork. The overall positive, inclusive and cooperative atmosphere was also praised.

Table 3: The percentages of positive reaction to various aspects at the course

Feedback to the course itself	**Yes, rather yes**
Were you able to contribute to the group work as you wished?	98%
Did you manage to use your Belbin-based skills in group work?	68%
Did everyone in the group contribute equally (giving their best according to their skills)?	84%
Did learning through the problem-solving methodology suit you?	96%
Was 3 months enough time for a PBL project to achieve the goal?	92%
Did you manage to participate in all the practicals?	92%
Would you recommend this course to other programs?	90%

Did your group work well together?	76%
Are you happy with the results of the outcome in the given time?	84%

Concerning the course, a valuable experience (besides many of the ones already covered above) mentioned by the students was the need for time management and meeting deadlines. We note that a lot of the course feedback from students suggests reaching the Flow discussed above - the course managed to balance the challenge and existing knowledge/skill rather well, provided a well-crafted set of tasks, and immediate and detailed feedback. The appreciation of teammates in student feedback also hints of reaching the autotelic experience where the activity itself becomes a reward.

4. Discussion

The findings of this study demonstrate the actual impact of the shift from traditional teaching methodologies to Challenge-Based Learning (CBL) in the "Ethical Social and Professional Aspects of IT" course at Tallinn University of Technology. A crucial element of this shift was the appreciative feedback from participants regarding their peers, reflecting a broad acknowledgment of the benefits derived from effective team collaboration and the tailored application of individual skills within these teams.

The participants notably appreciated their teammates for facilitating a supportive and dynamic learning environment. This was not only beneficial for personal growth but also instrumental in enhancing academic performance, particularly in writing, project, and time management. The transition to CBL highlighted several key areas:

- The students liked the structured approach to forming teams based on diverse skills and personality traits, which led to well-optimized team performance - this will also be needed in the future to manage complex projects. The results suggest the course being a success in preparing students for real-world challenges by simulating professional team settings.
- The development of leadership skills was frequently highlighted. The participants were grateful for the opportunity to lead and manage teams, which not only improved their leadership capabilities but also their ability to work effectively in teams under pressure. The roles such as 'team coherence builder' were particularly valued for maintaining team unity and ensuring that all members contributed equally effectively.
- The course improved the participants' abilities in academic writing and project management significantly, aligning with university standards and expectations. Students were thankful for the practical application of these skills, which are critical for their future academic and professional life.
- The emphasis on constructive feedback was another aspect that participants found extremely valuable. This process not only enhanced their learning experience but also fostered an environment of mutual respect and continuous improvement. The ability to give and receive feedback effectively is a crucial skill in both academic and professional contexts, and students acknowledged the benefits of this practice extensively throughout the course.
- The role of effective time management was another critical learning outcome from the course. The participants appreciated how the course structure and team dynamics encouraged better planning and adherence to deadlines, which are essential skills in any professional setting.

We propose that the transition to CBL has not only enriched the learning experience by connecting academic theory with practical application but has also cultivated a nurturing and productive educational environment that encourages personal and professional growth. These outcomes support broader adoption of CBL in educational settings, especially in disciplines that benefit from hands-on, collaborative learning approaches.

5. Conclusion

The shift from traditional teaching methods to Challenge-Based Learning (CBL) within the "Ethical Social and Professional Aspects of IT" course at Tallinn University of Technology has demonstrated significant positive outcomes in both academic and interpersonal domains. This study evaluated the impact of CBL on first-year IT administration and development students, revealing that the methodological shift not only enhanced student engagement and learning outcomes but also fostered a more dynamic and responsive educational environment.

Key findings from the study include the effective use of CBL to bridge the gap between academic knowledge and practical application, particularly in addressing real-world IT ethical, social, and professional challenges. Students appreciated the structured, yet flexible team dynamics encouraged by CBL, which allowed for the optimal use of diverse skills and personalities within teams. Leadership skills, responsibility, and the ability to work under pressure did improve significantly, preparing students for the future work life.

Moreover, the emphasis on cultivating the Flow (balance of skill and challenge, well-defined tasks, constructive feedback) as well as promoting proper academic writing and project management practices resulted in a rounded educational experience, equipping students with essential skills for their future careers. The appreciation for these elements among participants underscores the value of CBL in creating an engaging, supportive, and productive learning environment.

Considering these findings, the study supports the continued integration of CBL into educational curricula, particularly in fields that benefit from hands-on learning and real-world application. The success of the CBL approach in this course at Tallinn University of Technology suggests that such pedagogical strategies can significantly enhance educational outcomes, providing students with the tools they need to succeed in both academic and professional settings. Further research is recommended to explore the long-term impacts of CBL and its potential for broader application across different disciplines and educational contexts.

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E-Learning Supporting Infrastructure Investment in South Africa: Perspective of a Developing Economy

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Abstract: South Africa is one of the developing economies. Most of its provinces are in rural areas and have poor or lack of reliable critical infrastructure to enable development as in the case of urban areas. Infrastructure refers to physical structures that serve as the underlying foundation for the functioning of an economy. It includes physical facilities such as communication systems (telephone lines, broadband), and power supply systems (electrical grids, dams, etc.). The focus of the study is on information communication technological infrastructure (ICT) such as telephone and broadband networks and electricity infrastructure that support the adoption of e-learning. Many schools in South Africa are in rural areas and are attended by the majority of learners. These learners should perform the same way as learners in urban schools. Urban schools have better access to ICT infrastructure. Due to a lack of equitable ICT infrastructure, many education institutions back-tracked from the hybrid teaching mode implemented during the coronavirus (COVID-19) lockdown to the traditional class/lecture-room mode of teaching. It is revealed in the study that South Africa struggles in the area of infrastructure development. These affect the achievement of sustainable development goals (SDGs) which are heavily dependent on infrastructure, including education. E-learning offers a better advantage compared to traditional class/lecture-room-based education. ICT infrastructure that supports the provision of e-learning is not equitably distributed, and those that are available are not enough and reliable. South Africa is reported to need R4.8 trillion to achieve its critical infrastructure goals, indicating a dire need for infrastructure investment. Under-investment in infrastructure affects all sectors of the economy, including the education sector.

Keywords: Distance education, e-Learning, Infrastructure development, Infrastructure crime (theft and vandalism), Internet connectivity

1. Introduction and Background of the Study

Education is fundamental for all economies to grow and prosper. It is a tool for individuals to realise their full potential (Partner, 2022), a tool most powerful to change the world. The need for the world to change is more urgent and greater than ever. An investment in education is fundamental in paving the way to achieving sustainable developmental goals (SDGs) (Kioupi and Voulvoulis, 2019). Education allows communities to discover themselves, localise, and ultimately progress in achieving their aspiring priority SDGs (Kioupi and Voulvoulis, 2019). Education is the pillar of SDG#4, one of the 17 SDGs (Thacker et al, 2019). The purpose of education, regardless of the format it is offered (e-learning, mobile learning, face-to-face), includes servicing economies and developing and supplying human capital (making students/graduates employable) (Traxler, 2018). The United Nations (UN) 2030 agenda for sustainable development is fundamentally a universal commitment to peace and prosperity while preserving the planet. South Africa is rated in position 113th out of 161 countries on performance in the achievement or progress made towards the achievement of the SDGs. Most developing nations, including South Africa, are not doing well toward achieving SDGs (Creamer Media Reporter, 2024). The performance of most African countries is held back by spending more resources on servicing foreign debts than on investment in infrastructure that supports the achievement of SDGs, including education (Thorne, 2024). Infrastructure is at the center of support for the achievement of most of these 2030 SDGs' agenda, including education, electricity, and digital/ICT (Developmental Bank of Southern Africa (DBSA) and The World Bank, 2023). There is a dire need to invest, operate, and maintain the infrastructure required to achieve these SDGs in South Africa, including SDG#4 for education. The available public resources to close the infrastructure gap are not enough to meet the demand for infrastructure investment (Developmental Bank of Southern Africa (DBSA) and The World Bank, 2023). In South Africa, the infrastructure that should facilitate and support the provision of quality online learning (e-learning) is not enough, and those that are available are reliable or stable. For example, it is reported that load-shedding causes havoc among network service operators, especially when higher stages of multiple power outages are implemented in a day (Staff Writer, 2024). When a power outage hits the area, the internet connectivity is severely affected, both for businesses and households (Staff Writer, 2024). Quality education is at the center of the formulation of a common vision which is guided by the SDGs. It capacitates stakeholders (educators, learners, and communities) to identify constraints and enabling conditions, work together to select the needed competencies, develop appropriate curricula and pedagogies, pursue the many facets of a whole-institutional approach, and evaluate their progress made towards sustainability of well-articulated goals (Kioupi and Voulvoulis, 2019).

The future is becoming increasingly uncertain, a concern is whether the education system adequately prepares students for the world they will inherit, given the huge investment in education (Partner, 2023). The capacities of many countries in attending to uncertainty were tested during harsh Coronavirus (Covid-19) on the poorest, most vulnerable, and marginalised communities (Reddy and Mncwango, 2021). In the area of education, the transition to distance learning revealed some gaps, unjust inequities, and digital divides in the provision of quality education (Reddy and Mncwango, 2021). The future job market may look different from what it is today. Instead of trying to pre-empt how and what the future of work will look like, important skills such as resilience, critical thinking, and problem-solving should be taught and prioritised on (CambriLearn, 2023; Partner, 2023). E-learning is capable of equipping future-ready graduates, who harness these necessary life skills and tools for thriving in uncertain times (CambriLearn, 2023; Partner, 2023). Education helps countries to be forever prepared for uncertainties by investing in human resource development by capacitating people, versatile to address most of the pertinent challenges brought by the uncertainty of the future.

The infrastructure that supports the provision of quality services such as education for the future is not stable and reliable. It is due to factors such as theft, vandalism, and corruption among other factors which impede investment, operation, and maintenance of these infrastructure. Many resources are used in operating, maintaining, repairing, and replacing the stolen and vandalised infrastructure. The transition from old infrastructure has not been a smooth one, resulting in the unstable provision of the most needed commodities such as electricity among others. All these are problems that should be confronted head-on if the country wants to compete with the best in the world. Corporations are also concerned about most of these challenges. There are needs and importance of South Africa to invest in education for the youth (Parker, 2023). The world's highest failure rate of small and medium-sized enterprises (SMEs) is largely due to the failure of South Africa to invest in people at all levels of society (Parker, 2023). The failure of public education, lack of infrastructure epidemic lawlessness, and continuous failure of public health care in South Africa were lamented on (Parker, 2023), widening the gap between inequality and a high rate of unemployment (Madubela, 2022). The areas of reform such as infrastructure investment, accessible to reliable and predictable energy supply as the fourth means of production. South Africa is not poor, and Africa as a continent is not also poor but is simply poorly governed (Madubela, 2022). Many reports suggest that South Africa is struggling in the areas of infrastructure investment, operation, and maintenance. These affect the achievement of the sustainable developmental goals (SDGs) commitments with the United Nations 2030 agenda, these include education. Education is responsible for developing and supplying human resource capital capable of influencing the achievements of other sustainable development goals. The study reviewed the literature to discover the relationship between infrastructure investment, operation and maintenance, and attainment of education, as one of the pillars of sustainable development goals. In the next sections, the aspects of e-learning and infrastructure investment/development are focused on and discussed accordingly.

2. E-Learning (Theory) Principles and Practices

The concepts of electronic learning (e-learning), mobile learning (m-learning), and digital learning (d-learning) are somehow used indifferently, or in a complementary way to mean technologically supported learning (Sujit et al, 2018). E-learning is the alternative to traditional education and it also complements it (when the hybrid approach is used (online and face-to-face classroom)). On the other hand, m-learning is complementary to both traditional face-to-face classroom/lectureroom-based learning and e-learning. M-learning allows learners to interact with their learning resources while far away from normal learning environments. Through m-learning, students can easily perform certain support activities such as buying or downloading e-books to their devices. It is no longer a novelty for learners, but it is a mainstream, pervasive learning delivery medium relied upon by thousands of tertiary education institutions, including millions of workforce in various workplaces. M-learning is the subset of e-learning. E-learning is a macro concept that includes m-learning, d-learning as well as all forms of online learning environments. M-learning is e-learning through mobile computational devices, such as Palms, and even digital cell phones (Sujit et al, 2018). D-learning is a tool that addresses numerous challenges that are faced by educational institutions, community leaders as well as policymakers. It helps learners to connect in remote areas with the institution – and career-prep courses taught by a qualified instructor who does not work in the students' institution. It is helpful for instructors who are facing some barriers in meeting student's learning needs. The use of these technical terms sometimes confuses users in drawing some distinctions among them (Sujit et al, 2018). E-learning or distance education is progressively chosen for students in higher education institutions for the convenience it offers both instructors and learners. It is the delivery of educational activities (all activities relevant to instructing, teaching, and learning) through various electronic media (Koohang et al, 2009). According to Rodrigues et al (2019), there is no commonly

accepted definition for e-learning, describing it as a broader approach to learning that brings new opportunities for learning and teaching in many fields of education far from the conventional traditional lecture-room environment (Rodrigues et al, 2019). Digital technologies (artificial intelligence (AI) and the Internet of Things (IoT)) are the main factors for trends for education in the public domain for meaningful lives through employment in the economy (Traxler, 2018). Distance learning exists in the wider context characterised by global technological development, economic trends, and exerted pressures against specific educational technology trends and initiatives which are fragmented and diversified (Traxler, 2018). The literature describes distance education as implying the physical separation between the student and an instructor, which is not the defining feature of e-learning. The concept of distance education has evolved into other forms of learning, such as e-learning, online, online collaborative, and virtual web-based learning (Rodrigues et al, 2019). The most common feature of all these forms is that instruction occurs between a student and an instructor at different times and/or places, using several forms of gadgets. There are four general categories proposed for the elements of e-learning, including technology-driven (emphasizing the technological aspects of e-learning); delivery-system-oriented (focusing on the accessibility of learning resources); communication-oriented (considering e-learning to be a communication, interaction, and collaboration tool); and educational par e-learning as a new way of learning or as an improvement on an existing educational paradigm) (Rodrigues et al, 2019). In the main, e-learning is commonly defined as focusing on either one or more of these four general categories. In general, the most common definition of e-learning is education supported by information communication technology (ICT) to enable access to online learning/teaching resources (Rodrigues et al, 2019). These forms of provision of education mirror the world of work, aiding in the development of human capital ready for jobs of the future as the world of work continues to evolve and increasingly uncertain.

There is another education concept referred to as homeschooling or learning from home, which is also supported by most electronic and technological gadgets, offering vast advantages and benefits such as less mandatory travel to an education institution, ownership of time, or managing one's own time by pacing with oneself's learning speed (CambriLearn, 2023). However, homeschooling has strong effects on the inequality in educational opportunities and other related challenges (Bol, 2020). South Africa would be on its way to achieving better infrastructure, but most infrastructure investment, operation, and maintenance are affected by issues of theft and vandalism, and corruption, with more resources spent on maintenance and replacing missing ones (Mputing, 2022). Some nations such as the United States of America (USA) with advanced network and broadband infrastructure, realising that the country's traditional education system was outdated, visualised and implemented a nationwide digital transformation initiative for the education sector. They created the world's biggest digital library, one that was inspired by the entire nation and would be used by all citizens to empower them for a better future (Partner, 2022). In homeschooling, parents assist learners with the process of learning, facilitated by e-learning. The South African government is at a stage of drafting the artificial intelligence (AI) policy, drawing lessons from international practices to both stimulate AI development and effectively address associated harm and ethical risks (Thorne, 2024). At this stage, other countries are making progressive strides while South Africa is still contemplating policy development on current issues such as AI. These are the trends that are defining the educational and world of work environments.

3. Investment in e-Learning Enabling Infrastructure

An analysis of the history of empires and successful nations shows that one of the primary defining features of their success was scientific discoveries and investment in technological innovations and development (Luthuli, 2023; Saidi et al, 2018). South Africa might not be in the process of building an empire but needs to build a viable economy, feed and educate its citizens, create jobs, and build, maintain, and operate infrastructure. Infrastructure plays a major role in people's lives. Infrastructure is the physical structure that serves as the underlying foundation for the well-functioning of an economy. These include physical facilities such as transportation systems (rail, roads, airports, etc.), communications systems (telephone lines, broadband), power systems (electrical grids, dams, etc.), and water provision and treatment (e.g., irrigation and sewage), and buildings that support production and human capital development, office structures, factories, schools, and hospitals (Kapsoli et al, 2023; Luthuli, 2023). The concept of infrastructure has been extended to various spheres, such as institutional infrastructure, financial infrastructure, and so forth (Kapsoli et al, 2023). There are interdependencies and complementary existence of infrastructure in various economic sectors for an integrated service provision (Creamer Media Reporter, 2024). Adequate infrastructure across all economic sectors is required and it is a necessity for achieving sustainable development goals (SDGs).

A recent global report on infrastructure needs by the World Bank concluded among others that the focus should not only be on spending more but spending better on properly managing and maintaining the existing infrastructure (Developmental Bank of Southern Africa (DBSA) and The World Bank, 2023). The amount of financial resources required for infrastructure that keeps the lights on is estimated between R200 and R350 billion over ten years. There is a challenge in raising these funds, with a proposal for the participation of the private sector (Fraser, 2024). The point is that infrastructure is intimately intertwined and interwoven for the well-being of citizens by permeating most aspects of their daily lives (Luthuli, 2023). Infrastructure can be described as a system that organises and manages complex systems of flows, movements, and exchanges of services. Infrastructure does not only provide networks of pathways, but also provides locks, gates, and valves to check, control, and regulate these flows (Saidi et al, 2018). An integrated infrastructure system can be described as a combination of two or more infrastructure systems working together with an explicit awareness of one another through combinations of spatial, physical, logical, and/or cyber connections (Saidi et al, 2018). Integration can occur at various scales (e.g. urban, rural, or regional) and across the ecosystems (e.g. social, urban, land, water, and climate) and between different structures or sectors (e.g. social, physical, health, economic, and political). Traditionally, infrastructural development was planned, designed, operated, and managed independently of the other. The integrated infrastructure systems are preferred because of the common factors/drivers, such as information and technological innovation, risk of failure due to age, economic/population growth, extreme events, and climate change (Saidi et al, 2018).

When there is no service delivery supporting infrastructure, people protest, demonstrating how infrastructure contributes to their social lives (Luthuli, 2023). Infrastructure is part of sustainable development goals (SDG#9) (industry, innovation and infrastructure). It is recognised to have much wider benefits for sustainable development goals, either directly or indirectly influencing all other 17 SDGs, including 121 of the 169 SDGs' targets (approximately 72%), including education, and energy supply among others (Thacker et al, 2019). One of the reasons infrastructure is not appreciated is because of it quiet role it plays in the background. People fully appreciate the significant value of infrastructure when something goes wrong with it. For example when there is no electricity, water, connectivity, etc (Luthuli, 2023). Some of the Johannesburg Stock Exchange (JSE)-listed company chief executive officers (CEOs) called out for the government's failure to provide solutions on an ever-increasing list of issues, including power crisis, coupled with the deteriorating logistics industry, infrastructure vandalism, record-levels of unemployment and rising poverty, policing, service delivery, among others (Dludla, 2023). Various economic industries such as the mining and automotive industries share the same sentiments about the unsustainable cost of doing business in South Africa, attributing these to load-shedding, deteriorating rail infrastructure, and inefficiency of the ports (Manyane, 2023). It is lamented that each time load shedding is implemented, approximately 1% of the gross domestic product (GDP) is wiped off the economy. This affects the future and well-being of all South Africans, with increasing job losses, economic instability, and a decline in the quality of life (Dludla, 2023; Manyane, 2023). In response to the high cost of transport logistics and ongoing load-shedding, some mining giants had to shut down their businesses, cutting many needed jobs. Domestic challenges are also coupled with global challenges, such as the global weak demands of some of the mining produce (Dludla, 2024). According to SEDA (2023), the forced roll-out of green energy projects to mitigate the impact of emission footprint may give South Africa an advantage over time. The early adopters of these frontier technologies can move ahead faster and create permanent advantages for themselves than the scepticals. South Africa is ranked 56th out of 166 countries, in these fields as per the calculated frontier technology readiness index, focusing on information communication technology (ICT) skills, research and development, industrial capacity, and finance indicators, well ahead of all its sub-Saharan African peers. The improvement of the education throughputs (science, technology, engineering, and maths field) is emphasised as one of the tools for South Africa's improved readiness (SEDA, 2023).

According to Malatji and Baloyi (2023), it's proven that unstable power supply or power outages not only affect the economy and socio-economic aspects of society but destabilise internet connectivity, which is one of the main enablers of online learning. Load shedding is described as another pandemic in the South African context. Effective online learning in South Africa is hamstrung by the frequent load-shedding, which is blamed for poor internet connectivity-related services (Malatji and Baloyi, 2023). Other factors that are contributing to the poor development of e-learning, in addition to load-shedding, are factors such as the digital literacy gaps, shortages of personal laptops, and exposure to contemporary fields such as marine studies (Malatji and Baloyi, 2023). Infrastructure should enable a reliable power supply, which is fundamental in creating an environment for effective online learning to take place. An environment that allows students to concentrate on their studies with fewer major obstacles such as lack of necessities like power supply, digital skills, and connectivity is desirable (Malatji and Baloyi, 2023). The effective transitioning of open distance learning institutions from

conventional print-based learning is leveraged by digital devices such as computers, iPods, mobile phones, and other emerging technologies, in the heart of all these is a seamless connectivity (Msekelwa, 2023). In a world driven by technology, South Africa battles with power load shedding, sending some unprecedented shockwaves against effective and efficient development in the education landscape (Mbaleki et al, 2024). Load-shedding leads both students and lecturers to only connect outside normal working hours, especially in rural areas (Mbaleki et al, 2024). The impact of these challenges could be witnessed in the unprecedented rise in unemployment, as the impact transcends to affect other economic sectors, such as the provision of quality education.

According to Cowling (2024), there were 45.34 million active internet users in South Africa as of January 2024. These numbers represent a significant growth of internet users up from 25 million in 2013. 26 million internet users in the country use social media, which is approximately 42.8% of the total population. The majority of these people, approximately 78.7% are using mobile devices to access the internet, with those aged between 25 and 34 years being the highest users (Cowling, 2024). These developments were positive as internet users in South Africa averaged 72% globally, with the Sub-Saharan averaging 36% (WorldBank, 2024). Some reports indicate that South Africa is the most internet-addicted country, with users spending a staggering average of at least 9.5 hours online per day, surpassing the world average of 3 hours (Rédaction Africanews with Agencies, 2023). The problematic use of the internet (PUI) constitutes a serious health concern among users, especially those aged between 18 and 30 years in South Africa (Van Den Berg, 2022). The percentage distribution of households with access to the Internet at home or through all means for periods between 2010–2022 is shown in Table 1 below:

Table 1: Percentage of households with access to Internet at home or mobile between 2010–2022

Connectivity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Home/fixed	10.6%	10.2%	10%	10.3%	11.1%	9.9%	9.8%	10.6%	10.4%	9.1%	8.3%	10.4%	13%
Anywhere	28%	34.4%	41%	41.3%	49.2%	54.1%	59.8%	61.8%	64.7%	63.3%	74.1%	77.5%	75.3%

Source: (StatsSA, 2024)

Connectivity in most cases is through mobile gadgets rather than at home. Home connectivity averaged 10%, with mobile connectivity high above 75% (StatsSA, 2024).

Trends in South African education highlighted steady, but insufficient progress has been made in educational attainment. The data shows significant increases since 1994 in attainment of secondary education, especially amongst black Africans. Despite all these positive reports, large inequalities between different population groups remain concerning with the transition from secondary education to the completion of a bachelor's degree. Education and other authorities have achieved a lot in increasing primary and secondary school attendance rates with interventions such as the provision of free education, free meals, free transport, social grants, and financial aid (National Student Financial Aid Scheme (NSFAS)) for students pursuing higher education. Further improvements in the quality of education are needed, through interventions such as smaller classes and better-trained teachers (StatsSA, 2024).

Unemployment has been on the steady increase with the prevailing deterioration of infrastructure as shown in Table 2 below:

Table 2: Unemployment rate by sex, Q2: 2015 to Q2: 2023

Period	2016	2017	2018	2019	2020	2021	2022	2023
	Q4	Q4	Q4	Q4	Q4	Q4	Q4	Q4
Women	28.9	29	29.5	31.3	34.3	38.2	35.5	34.4
Men	24.5	24.8	25.1	27.2	31	32.8	30.4	30.1
Below matric	31.2	31.8	32.0	34.6	37.9	39.8	38.9	38.6
Matric	27.1	27.5	28	29.7	33.9	37.7	34.4	33.7

Period	2016	2017	2018	2019	2020	2021	2022	2023
	Q4	Q4	Q4	Q4	Q4	Q4	Q4	Q4
Graduates	7	6.6	6.7	7.6	8.4	11.8	10.6	9.6
RSA	26.5	26.7	27.1	29.1	32.5	35.3	32.7	32.1

Source: (StatsSA, 2024)

In 2016, unemployment was at 26.5%, with women at 28.9% and men at 24.5%. This has since increased steadily to 32.1%, with women at 34.4% and men at 30.1% in 2023, fluctuations only focused on quarter four of every year. Women are the most affected group than their male counterparts (StatsSA, 2024). Unemployment was also severe among those with minimum education, such as fewer matriculants as compared to matriculants and graduates. However, unemployment is on the increase among all groups (graduates, matriculants, and less matriculants) (StatsSA, 2024).

4. In Conclusion

The study shows the interface between infrastructure investment, maintenance and operation, and progressive development in education. Infrastructure is at the heart of economic development, facilitating the achievement or progress towards the achievement of the SDGs, including education SDG#4. In the absence or lack of infrastructure investment, operation, and maintenance, the economy struggles to achieve or advance toward the advancements of the other SDGs. Education, which is responsible for the development and supply of human capital, also suffers when there is a lack of or under-investment in infrastructure, maintenance, and operations. These compromise the overall achievements of objectives of the universal sustainable development for peace and prosperity. The other social challenges, such as high unemployment rates reach unprecedented levels, rendering the country difficult to govern. Both the corporate and academic community, share the same sentiments that there is an urgent need for investment in infrastructure. The provision of quality education also suffers in that, the education that is provided, does not adequately prepare graduates for the future world of work. The fact that there is high unemployment among graduates, is a sign that the current education system is not adequately preparing graduates for a future-ready world of work. Unemployment is high amongst the youth, suggesting that the education that they received, does not give them more options, either to look for a job or create one for themselves and contribute to the economy.

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Deconstructing the AI Myth: Fallacies and Harms of Algorithmification

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Abstract: We are experiencing a massive and volatile expansion of AI-based products and services. The current intermeshing of digital technologies, people, and society is shaping how we live and bringing algorithms to the forefront of decision making. The *algorithmification* of society and the narratives used to make it appear inevitable serve specific interests, mostly profitable for and controlled by few actors. It is not AI in itself, but the utilitarian sophistication of optimisation mechanisms and the power structures behind them that profit from controlling all that we do, when and how we do it, our behaviours, and even ourselves. In education, this is of serious concern as academia is gradually moving to uncertain dependencies on corporate interests. This paper calls for radical changes in dealing with the AI narratives that have monopolised recent public debates and discussions. It sheds light on the key terminology surrounding today's AI algorithms and the technological background that makes them possible. It shows examples of the negative impacts and the implications of not addressing or ignoring certain issues, especially in education. This paper also suggests good practices through consistent advocacy, grounded materials, and critical work on digital literacy, particularly AI literacy.

Keywords: AI, AI hype, Critical AI literacy, AI narrative

1. Introduction

With the latest advancements in the field of Artificial Intelligence (AI), especially those concerning the growing use of "machine learning"-based techniques in many domains since 2010, it has become of utmost importance to understand and critically assess the role and impact that "intelligent"[1] algorithms have on our lives. Such a critical appraisal is incomplete without knowing their particularities (e.g. how they work), which are no longer unique to academic labs, as well as their limitations (e.g. what they cannot and likely will not ever be able to do). Knowing and critically evaluating the current and potential consequences of using them, their fundamental characteristics, and how they might affect minorities, entire cultures and the environment, are more essential than ever for a well-functioning society. Yet, misconceptions about algorithms' capabilities, the narratives used to refer to them, a new high in hype inflating narrow successes, and the unregulated and/or bad uses of AI technologies are not only affecting disempowered populations but also damaging the AI field: they distort the public's perception of AI and destroy trust. They might have far-reaching consequences that, if not addressed, generate pushback and favour lawsuits becoming the new normal (GW Law, 2024).

Where critical AI literacy[2] is inadequate or non-existent, the risks that people use AI to damage others, make wrong decisions, or complain about people addressing the issues are high. Choosing the right narratives about AI is fundamental for dealing with and understanding AI's implications whatever their type. This is also why it is insufficient to encourage its use in educational settings just because it is new or appealing: pressing issues and the actual harms, technological limitations, potential dangers, and inflated narratives about AI must *also* be part of educating people.

Digital literacy, especially AI literacy, is about the *how* and *when* (how to use the latest technology in a given context), about the *what* and *how* (what it is and how it functions). It is also about *why not* use or even develop it, and about the power structures behind AI, its limitations, and negative implications. Most of the latter are avoided in the AI discourse, are superficially discussed, or are simply not present in certain academic settings, e.g. where AI tools are promoted as solvers of major systemic problems, disregarding how the harms outweigh the benefits and overlooking how the trends of economic inequalities are exacerbated (Acemoglu and Johnson, 2023).

This paper aims to help understand why deconstructing common myths around AI is essential. The methodology used follows an analytical approach and builds upon extensive related work. The paper explores the origins and determining factors of past and present AI, critically abounds in the actual processes behind its developments

[1] They are not intelligent, for several reasons discussed in (Bishop, 2021; Larson, 2021; McDermott, 1976).
[2] I.e. questioning what AI is used for, knowing about how their techniques work, not falling for the fallacy of AI functionality (Raji et al., 2022), and taking a critical stance about its negative impact and limitations.

and limitations, and contributes to demystifying the AI hype by showing the hidden purposes and causes that hinder understanding.

2. What AI?

Much of the confusion around what AI stems from the lack of consensus on its definition (Monett et al. 2019). It has been a very controversial and contextual concept over decades, part of a "conceptual borrowing" of AI as a discipline (Floridi and Nobre, 2024). AI *is* software; no magic is behind it (Landgrebe and Smith, 2023; Larson, 2021). However, the term has been misused and abused, and its meaning rebranded depending on the concrete application at hand, particularly for corporate or individual interests or for capturing the media's attention, VC's support, or attracting potential users.

In the recently approved AI Act of the European Parliament, for instance, an *AI system* is defined (AI Act, 2024, Article 3) as "a machine-based system designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments." For regulatory purposes, this one might be a general enough definition. Other authors believe, however, that there are no truly "intelligent" artefacts (Crawford, 2021) and there probably never will be, which they explain is mathematically, computationally, evolutionarily, and neurobiologically demonstrable (Landgrebe and Smith, 2023).

A digital artefact (e.g. program, algorithm, application) has different levels of representation. Most people hyping or idealising digital artefacts or their capabilities, like those based on AI techniques or those advertised as having AI inside but have none, might lack a basic understanding of at least one of their levels of representation. Winograd and Flores (1986, 87ff) grouped those levels of representation into five categories, from the *physical machine* (its circuits and hardware components) to *high-level language representation* schemes for (symbolic) structures and *how to operate* with them. They state (p. 89) that these levels of representation and their complex interdependencies change "as new kinds of hardware are designed and as new programming concepts evolve", and suggest that "people who have not programmed computers have not generally had experiences that provide similar intuitions about [computer] systems" like those that programmers usually have and use (Winograd and Flores, 1986, p. 90). Such people normally lack a basic understanding of hardware or software breakdowns that could happen at a given point in time, how resources (e.g. memory) were or could be used, which and how higher-level operations were coded, which interdependencies between the representation levels (and even external dependencies) exist, how the problem domain was represented, and what are the implicit biases of their programmers when coding and working with it, as bias is unavoidable and history and culture-dependent.

3. Factors Conditioning the AI Momentum

Several factors have triggered the *AI momentum* or AI "spring" of recent years, in particular the one from the 2010s and early 2020s. Advances in the field of computer science have been the least contributing to it, despite the Janus-faced hype, doom-loaded with utopian and dystopian idioms (Goodlad, 2023). The reasons for the supposed AI *renaissance* have more of a technical, economic, and even socio-political character.

The following is a non-exhaustive list of conditioning factors for the AI "spring" we are in:

- Computing power and hardware, i.e. chips and micro- and multiprocessors, especially AI chips developed for parallel computations required by AI algorithms; also technology other than computer chips, like cameras, sensors, wearables, etc. that enable data collection and processing at scale;
- Data, amassed and controlled by tech corporations, often extracted without consent from the data providers or producers. Huge amounts of data in the form of text, images, video, and audio, but also derived from users' behaviour (clicks, likes, purchases, hovers, time spent, location);
- Algorithms and models, the former mostly around for a longer while, their basic characteristics dating back to the origins of neural networks and machine learning (from the 1950s to the 1980s), now revamped, tested, and developed further; the latter consolidating theoretical insights from the fields of statistics and linguistics, now powered with massive computing hardware and fed with huge amounts of data;
- Exploitation—as Crawford (2021, p. 64) writes, "The technical AI research community relies on cheap, crowd-sourced labour for many tasks that can't be done by machines." There is a massive amount of miserably paid people annotating data for the algorithms to work and moderating other data for the

companies developing such algorithms to continue extracting value from data (Castaldo, 2023; Hao, 2023; Williams et al., 2022; Zuboff, 2019);
- Investments, without it wouldn't be possible to buy technology, build huge data centres and research facilities, do research, as well as procure resources and technical infrastructure with which AI-based technology and applications can be developed;
- Courses and study programs (and also blogs, podcasts, etc.) e.g. with instructional purposes devoted to lowering the entrance level to the AI domain;
- Practitioners and self-declared instructors, i.e. people with or without professional scholarship in the AI field, also sharing, tweaking, and using algorithms for new kinds of applications and problems than ever before;
- Conferences and (open-access) publications, with a major increase in the number of papers and AI-related events (Maslej et al., 2024), written or organised by almost all types of actors, from laymen to AI insiders, and lately also including AI-generated content, directly affecting trust and review processes;
- Development platforms and tools, where (open-source) code is collaboratively produced, shared, maintained, and made accessible to novices and experts alike. These are enablers of mass consumption and of the development of new algorithms that fuel the algorithmification of society;
- Marketing and media that reverberate about the possibilities of AI algorithms and models, mostly hyping them.

Often, the creators and corporate players driving those factors redesign human activity and behaviour in the social, historical and cultural variance of its practices, intending to make AI work but not designing AI to work for humans; rather, for humans working or adapting their behaviour so that AI can work. The outcomes are models that only work in narrow scenarios. Others are rather useful for corporate profits that are silent about the AI risks and the people they harm (O'Neil, 2016), i.e. ignoring or diminishing the potential economic, political, social (Acemoglu, 2021), or environmental and planetary costs (Crawford, 2021) of the technology. Yet, those same factors conditioning the AI momentum, once abused, misused, and hyped, give rise to the so-called AI "winters," which are periods of high disappointment with major cuts in funding and field reorientation. Several works address the AI hype from different perspectives, as was the case before other AI "winters" (Floridi, 2020). Unfortunately, in the contemporary AI field local AI "winters" are *still* happening: in all those other AI subfields not in the media's attention, nor within venture capitalists' favours, and therefore devoid of the advantages of AI "spring"-conditioning growth. This is the case of almost all AI subfields other than machine learning, where major developments have occurred recently. For more on AI hype, AI "winters," AI pitfalls and stepping stones for progress, we refer the reader to the works of (Birhane, 2021; Floridi, 2020; Markelius et al., 2024; McQuillan, 2022; Mitchell, 2021; Strickland, 2021).

The optimisation promise and the machinisation of our lives

The algorithmic fabric that conditions the current development of AI has been part of a continued multi-objective optimisation process for the sake of innovation and technological progress. This is a fertile ground for hype and the optimisation fallacy, i.e. thinking that optimising complex processes and societies through their simplification and fragmentation is the best option for understanding and dealing with them. Those who control the data and the technology, a few unelected players, are increasingly optimising and affecting society's functioning through AI (Whittaker, 2021; Zuboff, 2019). The vast complexity of social interactions and life itself are reduced to abstract, limited mathematical formulations that cannot cope with novelty, are translated to machinistic (i.e. machine-dependent) and mechanistic expressions, and result in restricted and narrow mathematics-based algorithms that operate in utilitarian ways. Those algorithms are then used "to find, expand, fine-tune, and experiment with [human] processes [and activities] that unfold in time" (Hilbert, 2022, p. 4), thereby allowing for the algorithmification of humans and their behaviours and directly affecting them and their future.

Digital machine-accelerated optimisation is not neutral at any level. It is run on a social and human framework that is affected by different levels of power, where the core subjects of the optimisation, the humans producing the data, are the least served, directly affected, or forgotten (Buolamwini and Gebru, 2018; Raji et al., 2020; Zuboff, 2019). The extracted pieces of what we signalled online in the past, disregarding how they actually model or represent reality, are used for predicting future human behaviours that have still not occurred and are inherently incomplete, cannot be finalised, are biased, and are dynamic in a world that is open, uncertain, and non-determinable (Birhane, 2021; Birhane et al., 2023).

The AI optimisation promise is essentially a substrate on which societal and political decisions are technologically manipulated to serve a few and concentrate power. It is the gear of what Zuboff (2019) calls a surveillance economy and parasitic economic logic for expropriating critical human rights and people sovereignty, for deskilling and corroding human agency, and for exacerbating dependency on technology. It is the product of a covert Silicolonisation dressing of a digital soft-totalitarianism which Sadin (2020) defines as "the conjunction between territorial expansion and the advent of a 'life-industry' […] organizing the world according to self-interests, while making people believe that we have never known a 'cooler,' more 'collaborative,' and 'creative' period in history." It is an optimisation that runs ad infinitum, where, increasingly, algorithmic breakthroughs, continual technical progress, and greater corporate convenience are what matter most, usually without considering the computational costs, the ethical implications, or the impacts they have on people's lives, society, and the planet (Bender et al., 2021; Bode and Goodlad, 2023; Birhane, 2021; Buolamwini and Gebru, 2018; Crawford, 2021; Sadin, 2020; Zuboff, 2019).

4. The Machine Intelligence Fallacy: Why Changing the Narrative is Imperative

There is an urgent need for a global optimisation boost, but one that introspects and looks inward to question fundamental problems across the AI subfields and the narratives around what machine intelligence means. The machine intelligence concept is fundamentally wishful and has turned fallacious, being prone to misunderstandings about what the technology can truly achieve. In its current state, it still resembles science fiction and wishful thinking (McDermott, 1976; Mitchell, 2021). Hyping narratives and techno-solutionism still monopolise airtime and have spread out to other sectors of society, e.g. education (Bender, 2024). For example, the fear of missing out (FOMO) has become a serious problem in education. It has been undermining some educators' behaviours (Bender, 2024) who see in AI opportunities for revamping their (possibly stuck) research objectives and academic goals (Watermeyer et al., 2023). In an exercise of abundant gullibility, education and academia depend on more corporate greed than ever. With generative AI-based chatbots, for instance, the low-hanging fruits of attractive publications or visibility in an AI era rippled with hype, function like a step higher in the already deteriorated academic ladder (Lin et al., 2023; Watermeyer et al., 2023).

Similar problems, ethical dilemmas, and discussions originated in the past, actually since the beginnings of the AI field itself. Seminal works on "past" AI, its limitations, and pressing ethical implications and consequences remain seldom read or discussed (Dreyfus, 1992; Lighthill,[3] 1973; Weizenbaum, 1976; Weizenbaum and Wendt, 2015; Wiener, 1950, 1988)). For more on those and other related matters see also (Larson, 2021; Lipton and Steinhardt, 2019; McQuillan, 2022; Mitchell, 2019; Wooldridge, 2020). AI and its techniques, whatever their mathematical brightness, colourful pixelated appearance, or media and corporate furore, won't ever solve academia's structural problems. Those problems needed in the past, still need, and will remain needing in the future, human touch and agency. Avoiding or algorithmificating those problems distracts from the actual negative consequences they pose to learners, educators, entire educational institutions, and society.

If it were *only* education! Sadly, there is much more to AI and how a flawed narrative erodes or destroys trust in it. Take for example the irrational exuberance with which "new" algorithms or applications are announced ("the future is promising," "for the benefit of humanity") and how they are debunked shortly after (Mitchell, 2021; Schaeffer, Miranda and Koyejo, 2023); or the serious problems with deep fakes, mis-, and disinformation massively originated *thanks to* generative AI, fuelling data contamination and leaking, as well as malpractices like reproducibility issues (Balloccu et al., 2024); or the many intellectual property infringements and ongoing lawsuits (GW Law, 2024) curbing value creation and knowledge share by artists; or the severe privacy issues not just through data collection but also through inferences from the data collected (Bartneck et al., 2021); or the many security issues of AI models with major unsolved vulnerabilities allowing for attack vectors emerging faster than any time in history before (Vijayan, 2024); or the unsustainable and disproportionate waste of resources (rare metals, electricity, water, etc. (Crawford, 2021; Luccioni, Jernite, and Strubell, 2023)) for revamping the algorithmification of our lives and what we do to even higher levels, touched with unscientific claims becoming the norm, like machines "understanding," "reasoning," "comprehending," "thinking," "having emotions," "being sentient," "acting" and "thinking" like humans (the wish!) (McDermott, 1976), i.e. already living the *grand dream* of AI which is still very different from reality (Mitchell, 2019, 2021; Wooldridge, 2020). None of the eventually well-intended AI applications counterbalances the dangers they pose to disempowered populations and political, societal, and planetary ecosystems (Crawford, 2021; McQuillan, 2022; Zuboff, 2019). The AI field is

[3] The "Lighthill report" was commissioned by the UK's Science Research Council and summarised the limitations of its techniques and how their actual development was far away from what was promised. It led to major cuts in research funding and to the first AI "winter" in the late 1970s.

slowly imploding before everyone's eyes; trust has been eroded and the discourse around AI politicised. The next debacle or AI "winter" might be around the corner. It is time to put an end to all that nonsense once and for all.

5. Recommendations for a new Type of AI Literacy

The narratives we need about AI should focus on factual information that demystifies AI. In this regard, AI literacy based only on its functionality (i.e. what it is and how it works) is not enough. The critical components must come prominently into the AI equation. We must demand responsibility proactively when dealing with AI and through regulation. We must contest malpractices and seek accountability. We need to be sceptical, to question why, for whom, for which purposes, who is profiting from our data and why, which values and rights are eroded, and why they must be at the centre of a well-functioning society, among many other questions.

Our concrete recommendations for a much-needed new type of AI literacy are:

- Technological developments, especially digital ones, depend on much more than just AI-based algorithms (see Section 3 for details). Emphasise those other factors; demystify with factual information the magic thinking about what AI could do but still does not.
- Reclame autonomy back and make informed decisions related to technology. "You have to choose between [emphasis added] freedom or servitude to powers and systems that decide for us the course of things" (Sadin, 2020).
- Put human ethical and moral judgement into focus. If individuals or whatever the system is not ethical, we cannot have ethical outcomes. They should be more than just soft, vacuous wording to industry, academia, government, and society.
- Prioritise human rights and values. By surrendering human agency to algorithmification one bit at a time, we gradually give up our rights and values. Vulnerable populations, children, and disempowered people are the most affected. AI systems cannot be truly compatible with societal standards and will not align well with human values if part of its members are left behind.
- Learn about and try out new products, tools, and frameworks. They are skills that may be important in several fields or for using certain applications. Learn also that, other times, however, some of them do not deserve the attention they are given and are only enablers of deskilling and mediocrity. Is it the future you want to live in? Question the what, how, why, by whom, for what, etc. of AI and digital technologies. This helps to understand or even avoid the AI fog.
- Collaborate, break the siloed thinking: multidisciplinarity is key to today's AI. E.g. involve people affected directly by AI in all phases of its lifecycle; that is the best way to design, develop, test, deploy, and use, i.e. deal with AI.
- Strive for informed decisions. Replace being told what to do or what to think concerning AI, with critical AI literacy. This needs critical thinking and grounded knowledge about AI. Verify, then trust!

Critical AI-literate people with a healthy dose of scepticism, if in doubt, should stop blindly accepting uncertain decision making and start asking the hard questions. Educators play a distinctive role thereby; they should shift from FOMO and corporate will to contesting both technology and technologists; they should stop educating generations of learners on wishful futures and techno-idealised resources-burning algorithmification. Teaching and learning spaces must shift from digital swamps and human automatons to active and critical shapers of society's future. The rule of law plays an essential role in guaranteeing that technologists, VCs, and anyone deploying software systems that might be life impacting are accountable. The reader is referred to the many policies, safeguards, and regulatory frameworks that are already into force or proposed to be introduced. For example, the EU AI Act (EU, 2024), the US Blueprint for an AI Bill of Rights (US, 2022), the UK AI Regulation Bill (UK, 2023), or the preliminary draft of China's proposed AI Law (China, 2024), among others.[4] Neither AI nor the software industry are exempt from accountability. Opponents have been voicing concerns about regulation stifling innovation; however, regulation is not *de facto* a barrier to innovation. Correct regulation is actually an enabler of innovation and a guarantor of a safety baseline. Other industries and their products are strongly regulated and they continue to innovate at scale.

6. Conclusions

[4] The OECD.AI Policy Observatory is also a good referent for tracking national AI policies and strategies from around the world: https://oecd.ai/en/dashboards/overview.

Society is being algorithmificated, but not just through AI. The danger is a shift to the "just automate" mindset and over-reliance on machines leading to surrendering human agency, which, in the end, only empowers those who will make decisions for us instead of us. Digital literacy, especially critical AI literacy must be part of national education curricula at all levels, from school to higher education and to postgraduate, vocational, and corporate education. Those are core skills for life that, left unattended, will reinforce the power and serve the purposes of only a few, mostly not democratically elected players. The true purpose and essence of "modern" automation are hidden behind the algorithmification of society and encompass practices and processes that are not always obvious or easy to detect or contest (McQuillan, 2022). Only when people are affected, e.g. disadvantaged populations or those already marginalised (which are actual majorities), is the true impact of automation known or visible (these are mostly the problems that make it into press news). It is already too late to tackle them or develop countermeasures by then. At this time, the lives and future of uncountable people, especially the disempowered ones, might have been affected irreversibly. Educating ourselves and others, being aware, and understanding that the answer should not be to rush or surrender to the algorithmification of our lives, are *the* critical skills of the digital era that need urgent attention.

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Flipped Classroom Trial for Python Programming with Raspberry Pi Using Moodle

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Abstract: A flipped classroom is a pedagogical method that flips traditional lectures and homework. In the case of a flipped classroom, the traditional lecture is viewed at home before class and homework activities are completed in the classroom with the tutor present to guide students in their work. At present, the above-mentioned flipped classroom has become increasingly popular, and sometimes controversial, within higher education. In this paper, we describe the flipped classroom example for Python programming to control I/O devices with Raspberry Pi. First, the tutor uploads the lecture notes onto Moodle. Secondly, students read the lecture notes prior to the class. Students can then ask questions on the Moodle Forum if there are any questions about the class notes. Thirdly, the students attend the class. As part of the class activities, students form into 10 groups. Each group creates a Python programme based on topics related to the class note, one hour is permitted for this activity. This is an example of a group activity. Next, each group will demonstrate the Python programme they have created to the tutor and other students in a 5-minute presentation. Following this, the tutor and other students will provide comments on the demonstration. Students will then complete a self-reflection journal about the flipped classroom on Moodle after the class. The tutor evaluates each journal written by the students. In this paper, a description of the Python programmes aims to control 8 LEDs is given as an example of a flipped classroom. Finally, the tutor added a questionnaire about the flipped classroom onto Moodle at the end of the semester. Collated questionnaire responses show that students felt the flipped classroom was appealing and helped improve programming skill. Thus, the author concludes that the flipped classroom is engaging and an effective way of teaching.

Keywords: Flipped classroom, Moodle, group work, Python programming, Raspberry Pi

1. Introduction

What is a flipped classroom? A flipped classroom is a pedagogical method that flips traditional lectures and homework. In the case of the flipped classroom, the traditional lecture is viewed at home before class and homework activities are done in the classroom with the tutor present to guide the students work. (Bishop & Verleger, 2013, June).

The flipped classroom started as active learning in the 1990s. Mazur (1997) encouraged students to engage with each other to understand contents during class time rather than passively listening to lectures. This is known as peer instruction (Crouch & Mazur, 2001). Baker (2000) used the phrase "classroom flip" at an education conference for the first time. He proposed a model where students accessed instructional content outside of the classroom. As a technological integration, In 2004, Khan, a founder of Khan Academy, used videos for instructions outside of traditional class time. This contributed significantly to the flipped classroom movement (Thompson, 2011). Bergmann and Sams (2023) began recording lectures in Chemistry class for students to watch at home in 2013. This allowed class time to be used for hands-on activities and individualized instruction, formalizing the flipped classroom model in a secondary education setting.

At CST (College of Science and Technology), RUB (Royal University of Bhutan), the flipped classroom was introduced to all subjects in 2023. This was guided by Alvin Lee, a member of CST-GCBS (Gedu College of Business Studies) transformation team. The author explored how the effective flipped classroom is introduced in a programming language course. In this paper, an example of a flipped classroom using Python programming to control 8 LEDs with Raspberry Pi, is described. This was given to a third-year class of Electronics and Communication Engineering Course students at CST in the spring semester of 2023.

Section 2 is a literature review of the flipped classroom in the engineering field. The process of implementing the flipped classroom is described in section 3. In section 4, an example of our flipped classroom is given. Advantages and disadvantages of the flipped classroom are discussed in section 6. The conclusion is given in section 7.

2. Literature Review of the Flipped Classroom in the Engineering Field

Mason, Shuman and Cook (2013) compared the effectiveness of the flipped classroom to the traditional classroom in an upper-division engineering course. They considered the following three areas: 1) content coverage; 2) student performance; and 3) student observations and perception of the flipped classroom format. The results showed that: 1) the flipped classroom allowed the tutor to cover more material; 2) students

participating in the flipped classroom performed as well or better on comparable quiz and exam questions; and 3) while students initially struggled with the new style, they adapted quickly and found the flipped classroom style to be satisfactory and effective.

Bishop and Verleger (2013, October) implemented the flipped classroom in a numerical methods course for second and third-year engineering students. It combined constructivist and behaviourist learning theories, using asynchronous video lectures and in-class problem-solving. Conducted in 2013 at Utah State University, the study compared experimental and control groups on homework, exams, and conceptual tests.

Kerr (2015) investigated the impact of using a flipped classroom model in undergraduate engineering education. He reviewed a total of 24 studies, and most studies reported high student satisfaction and increased performance in a flipped classroom environment.

Karabulut-Ilgu, Jaramillo Cherrez and Jahren (2018, May) reviewed the use of flipped learning in engineering education, providing practitioner guidance by appraising existing research. A systematic review of 62 articles from 2000 to May 2015, showed that the flipped classroom gained popularity amongst engineering educators after 2012.

Focused on programming education, Çakıroğlu and Öztürk (2017) explored the development of self-regulation in a programming language course. Problem based learning activities were carried out in flipped classrooms to promote self-regulation.

Chis et al. (2018) investigated the effectiveness of combined Flipped Classroom and Problem-based Learning teaching approach in a computer programming module. The combined approach made use of learning technologies and supported authentic learning in terms of authentic context, multiple perspectives through team work and collaboration.

3. The Process of Implementing the Flipped Classroom

The process of a flipped classroom is as follows:

Step 1: The tutor uploads class notes onto Moodle, giving the students the opportunity to understand the class content notes before the class. At this point, students can ask the class tutor questions on the Moodle forum.

Step 2: The class length is 120 minutes. Whilst in class students will form 10 groups, the tutor will explain the task to each group for 10 minutes. Some tasks are the same among all groups, whilst other tasks may not be.

Step 3: Each group will have one hour to develop a Python code according to the instructions given in Step 2. The tutor will oversee the students at work, and give advice as required.

Step 4: Each group will then give a presentation on the Python code developed, to be demonstrated using a Raspberry Pi microcontroller board. A five-minute presentation time is allowed per group, including Q&As.

Step 5: When the class ends, all students fill in a self-reflection journal about the flipped classroom on Moodle. There are three purposes of the self-reflection journal - firstly, to review the experience of a flipped classroom; Secondly, students reflect on the skills they have developed; thirdly, evidence of students contribution is documented.

Step 6: Finally, the tutor evaluates the completed self-reflection journal written by the students.

4. Example of a Flipped Classroom for Python Programming using Raspberry Pi

This section shows an example of the above-mentioned flipped classroom for Python programming, using Raspberry Pi.

4.1 Upload of Class Notes to Moodle

As described in section 3, the tutor uploads the class notes onto Moodle for pre-reading by the students. Below is an example (taken from Osoyoo.com, 2017)

Chapter 12. Blinking Eight LEDs with Raspberry Pi

In this chapter, we connect eight LEDs with raspberry Pi GPIO, the program then outputs a high or low level to the GPIO to control the LEDs blink. Also used is a PWM (Pulse Width Modulation) signal to control and change LED brightness.

12.1 Connection of Eight LEDs with Raspberry Pi GPIO

Connect eights LED (anode) to Resistor (200Ω) to limit the current, cathode to B17, B18, B27, B22, B23, B24, B25, B4 respectively. B means BCM pin number, as shown in Fig. 12-1. Also, Fig.12-2 shows the connection graph of eight LEDs with GPIO extension board.

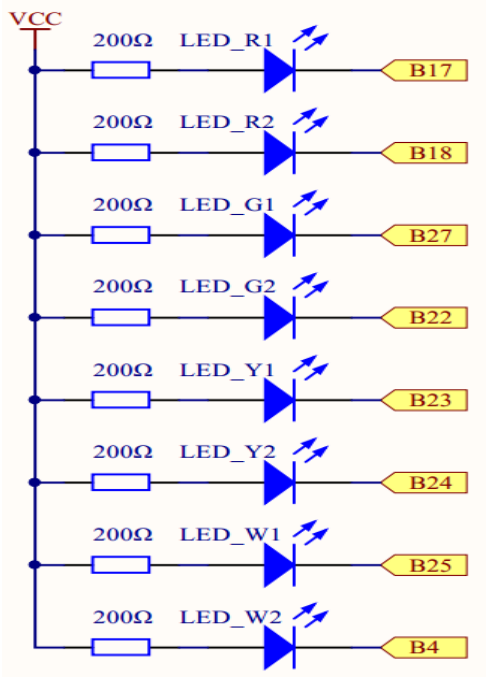

Fig. 12-1 Circuit diagram showing the connection of eight LEDs with Raspberry Pi GPIO

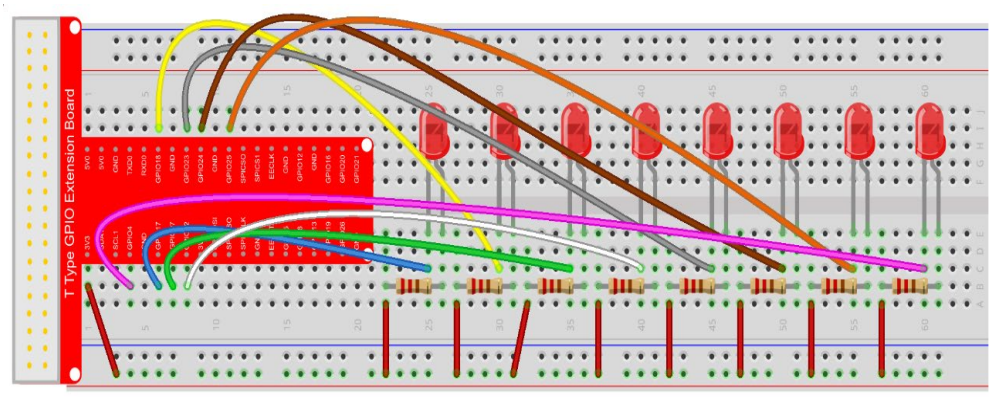

Fig. 12-2 Connection graph of eight LEDs with GPIO extension board

Figure 1: Class note instructions of how to control eight LEDs with Raspberry PiStudents read the class notes show in Figure 1, and understood how to control eight LEDs blinking, before attending the class. In addition, they had the option to ask the tutor and other students questions using the Moodle forum as shown in Figure 2

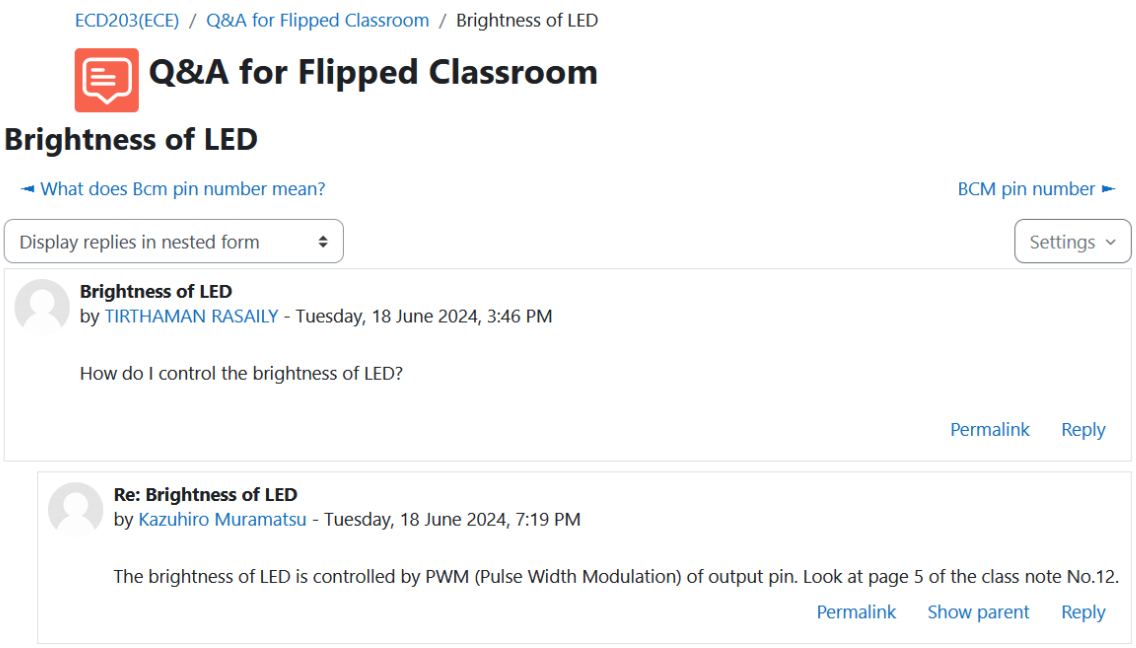

Figure 2: Example Moodle Forum questions regarding the class notes

4.2 Explanation of the task for the flipped classroom

At the beginning of the class, the tutor explains the task for the flipped classroom. In this case, the tutor explains how to control eight LEDs blinking with a projector. The method used for the task are shown in Table 1.

Table 1: Task to control eight LEDs for the flipped classroom

Week 12	
Strategy for FC	Based on Types of Learning Outcomes
Total Time for FC	2 hours. (Not including activities for usual lectures, tutorials and/or practices)
Lesson Plan for FC	2-3 students form a group (total 10 groups), the tutors give Raspberry Pi Trainer kits to each group respectively in FC. Each group develops the Python code to blink 8 LEDs on Raspberry Pi WH. The blinking patterns are originated by each group. Finally, each group explain their Python programme using a projector, and shows a demonstration of blinking 8 LEDs on Raspberry Pi WH. Following the class, each group submits the Python code, and all students complete the worksheet submitted to the tutor via Moodle. 10 mins – Explanation of topics 60 mins – Development of Python programme according to the topic 50 mins – Demonstration of Python programme on Raspberry Pi WH and Q&A (each group has 5 min.)
Expected Outcomes	Students can develop a Python programme related to blinking 8 LEDs. In addition, students will improve teamwork and independent learning.
Resources	Raspberry Pi Trainer kit, Laptop, Textbook and Class notes.

4.3 Development of the Python Code to Control Eight LEDs

As described in the task, the students develop the Python code to control eight LEDs as shown in figure 3. shows a group activity, developing the Python code.

Figure 3: Shows a group python coding development activity

4.4 Presentation and Demonstration of the Developed Python code to Control Eight LEDs

After the 60-minutes group activity developing the Python code, each group gives a 5-minute presentation demonstrating the developed Python code. Figure 4 shows the presentation, and a photo of the demonstration is shown in Figure 5.

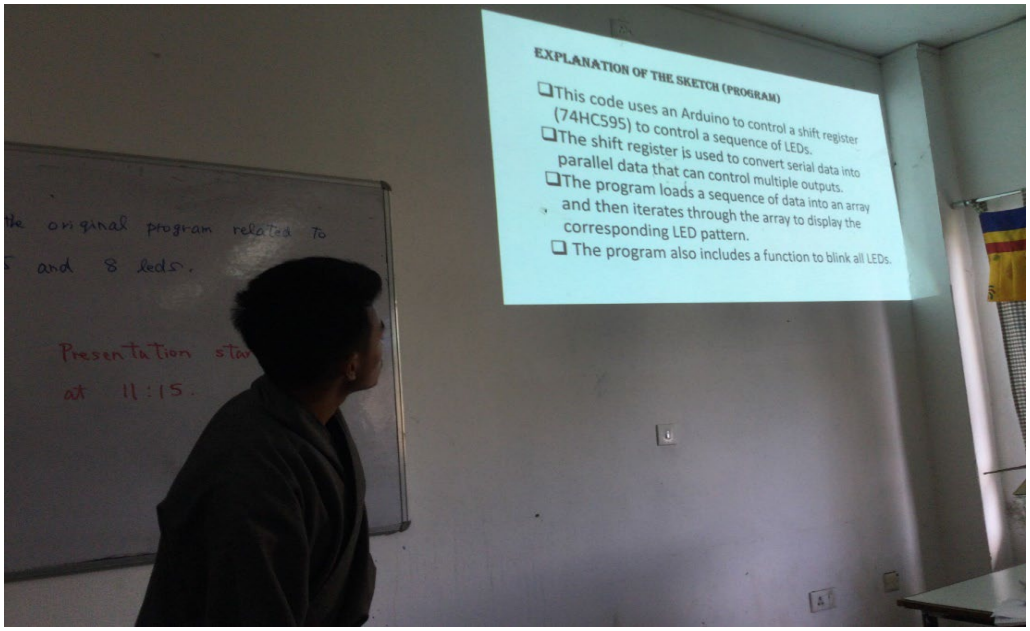

Figure 4: Presentation of the developed Python code

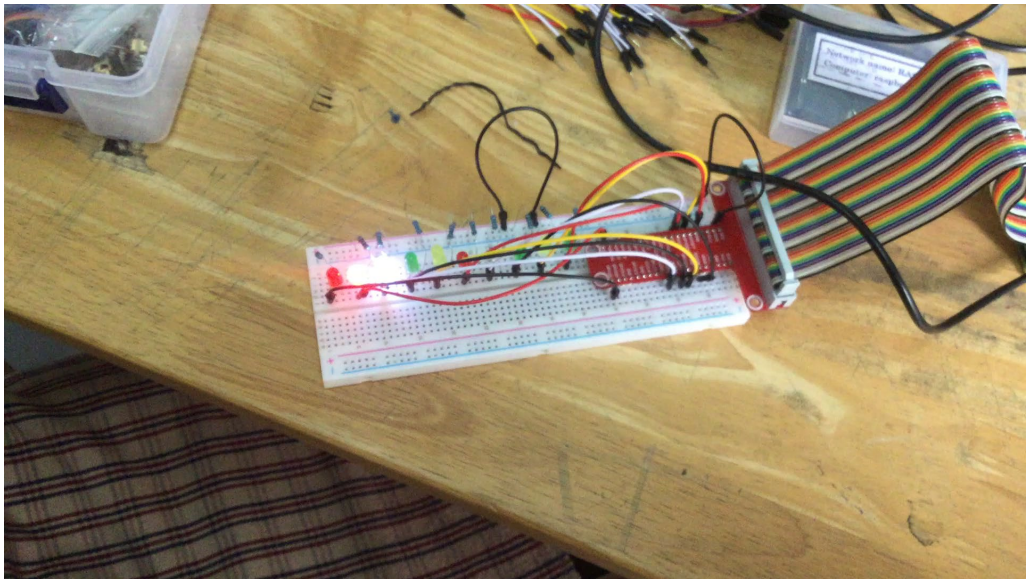

Figure 5: Demonstration of the Python code developed in the flipped classroom

4.5 Self-Reflection Journal About the Flipped Classroom

After the class, students complete the self-reflection journal about the flipped classroom. Figure 6 shows the first page of the self-reflection journal on Moodle.

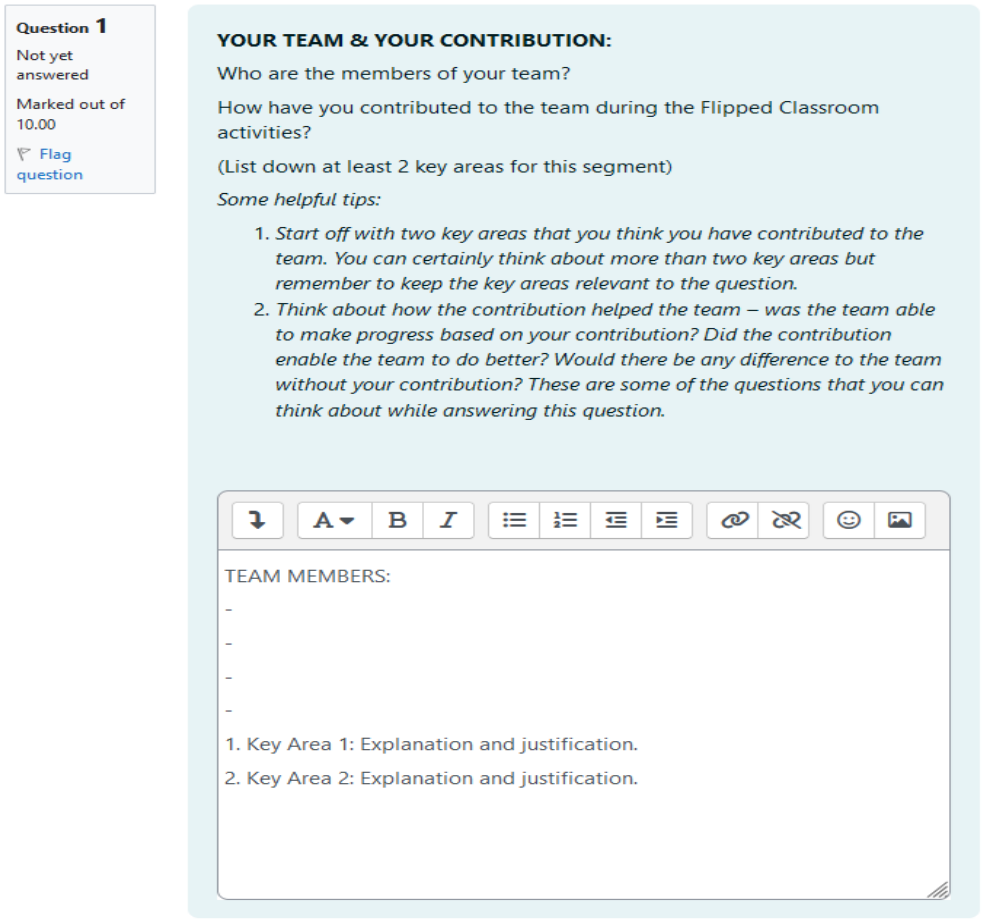

Figure 6: Self-reflection journal

4.6 Evaluation of the Self-Reflection Journal

Based on the marking rubric for the self-reflection journal, the tutor evaluates the filled self-reflection journal written by the students using Moodle. The students can view the marks given on Moodle.

5. Discussion

The author taught 15 2-hour flipped classroom sessions in the spring semester of 2023. Out of 15 flipped classrooms, 9 flipped classrooms follow the Python or Arduino programme as detailed above. The remaining 6 flipped classrooms are investigation activities which use the Internet and e-books. According to the filled self-reflection journal, the students prefer the programming activity over the investigation activity.

The full 60 minutes allocated to the programming activity was used. However, it was felt that 60-minutes was not sufficient time to complete the programming. Therefore, 90 minutes would be required to complete this activity in the flipped classroom.

The third-year class of Electronics and Communication Engineering Course comprised of 21 students. At the beginning of the semester, the class was divided into five groups. Namely, 4 or 5 students formed a group. It was found that 1 or 2 students performed most of the workload, and the other students did not contribute to the task (InnerDrive, 2024). Therefore, the tutor decided to divide the class into ten groups. This led most of the students into contributing to the task.

Finally, the tutor observed that a part of the students did not read the class content notes before the class. Thus, they could not understand the task which was given by the tutor at the beginning of the class. Therefore, the tutor had to explain the class content notes to them in the class. This situation makes the flipped classroom ineffective.

6. Conclusion

In this paper, we focused on the flipped classroom for the Python programming with Raspberry Pi, because the students feel that the flipped classroom activities for the Python and Arduino programming are better than ones for the investigation activities. The author will compare the programming activities and the investigation activities in the flipped classroom in detail.

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The author would like to thank Mr. Alvin Lee for his guidance of the flipped classroom technique. The author would also like to thank the third-year students of the Electronics and Communication Engineering Course, CST for their participation in the flipped classroom.

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Implementing Technology-Enhanced Support for First-Year Students on Blackboard: Lessons Learned

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Abstract: Technology Enhanced Learning has become one of the key components of teaching and learning in the current environment and mainly because of Covid-19, hence the introduction of the Technology Enhanced Learning Programme. The Technology Enhanced Learning Student Assistants (TeL Assistants) programme supports students in the university with Blackboard (University choice of LMS). The programme was established in 2021 since there was a need to assist students in the use of Blackboard. With Covid, the university moved to strictly online and that became a challenge to the students. With most undergraduate students coming from disadvantaged high schools and backgrounds, there was a need for the programme. The TeL student assistants undergo training by the Teaching and Learning Consultants. The aim of this study was to evaluate how the TeL student Assistants supported the students of the University of Fort Hare on how to navigate Blackboard. This study examined the benefits of TeL student Assistant's support in first-year students navigating their modules using Blackboard as an LMS. A purposive sample of undergraduate students that were trained by TeL student assistants submitted data through a qualitative survey in which they narratively conveyed their perspectives on support provided for Blackboard by the TeL Student Assistants. Data was analysed through coding, which were then assigned to themes and categories. The significant aspect of the TeL student assistants which enabled students to use Blackboard was the submission of assignments and tests, the facilitator's knowledgeability and the patience students received from the TeL student assistants. The findings of the study directly benefit the university and higher education because they will provide information upon which we can take action to improve the support, retention, and throughput of students at the University of Fort Hare (UFH).

Keywords: Blackboard, TeL students assistants, Support, Learning Management System

1. Introduction and Background

The Technology Enhanced Learning (TeL) Student Assistant Programme was introduced by the Teaching and Learning Centre at the University of Fort Hare (UFH) in 2021 as an important component of student development and support. The programme is aimed at providing support to students through trainings and consultations on issues related to the university LMS (Blackboard) of choice. Blackboard is a Learning Management System (LMS) which facilitates online teaching, learning, assessments, collaboration, and knowledge sharing in a synchronous and asynchronous manner. Bradford et al. (2007) states that Blackboard improves e-learning through a number of essential features and it offers more accessibility, enabling students to view course materials at any time and from any location. Due to the mobility that LMS offers, access is not limited to desktop, but there is an App compatible with smart phones where both students and lecturers can navigate the system.

At UFH, first-year students often face considerable difficulties with Blackboard, which can negatively impact their engagement and academic success. The university is located in rural Eastern Cape province and attracts students from underprivileged schools with limited knowledge of E-Learning technologies. The students' inexperience with technology makes it more difficult to use Blackboard which causes frustration and difficulties to engage with online learning activities. Providing individualised support to students, the TeL Student Assistant Programme seeks to close the gap and improve first-year students' overall educational experience. The increased technological expectations imposed on students can cause them to feel overwhelmed learning new educational technologies. The TeL Student Assistant Programme addresses critical issues by providing individualised support to help students navigate the complexities of Blackboard. The programme is designed to be a lifeline for students, offering them guidance and assistance they need to become proficient in using the LMS.

Providing hands-on training with immediate assistance on Blackboard, the programme assists students adapt to the LMS, improving their confidence and competence in using digital learning tools. Better academic performance is made possible by the support provided by TeL assistants, creating a more interactive and engaging learning environment for students. The availability of TeL student assistants lowers barriers to successful online learning, increases student retention at the university, and guarantees that students have access to ongoing support.

2. Literature Review

2.1 Technology-Enhanced Support in Higher Education

The use of technology to support students has been a growing focus in educational research. Studies show that technology-enhanced support can significantly improve student outcomes by offering tailored resources, interactive learning environments, and timely feedback (Alavi & Leidner, 2001; Herrington & Oliver, 2000). For first-year students, who often face challenges in adapting to university life, these technologies can be crucial in providing academic support and fostering a sense of belonging (Tinto, 1993). The implementation of technology-enhanced support for first-year students using Blackboard has revealed both benefits and challenges.

Studies highlight that Blackboard's communication tools, such as discussion boards and messaging systems, significantly enhance interaction between students and lectures, which is crucial for first-year students transitioning to university life (Garrison, Anderson, & Archer, 2001). These tools help create a supportive learning community and facilitate student engagement (Moore, 1993). Additionally, Blackboard's centralized access to academic resources, including lecture notes and gradebooks, allows students to manage their coursework efficiently and receive timely feedback, which contributes to improved academic performance and retention (Dzuiban, Hartman, & Moskal, 2004; Krause & Coates, 2008). However, the successful use of these tools depends on their effective integration into course design and the lecturers' engagement, as well as addressing issues related to digital literacy and user interface design (Beetham & Sharpe, 2013).

Despite these advantages, several challenges have been highlighted to effectively utilise Blackboard for first-year student support. Technical difficulties and the complexity of the LMS interface can hinder its effectiveness, particularly for students with limited digital skills or unreliable internet access (Seale, 2014; JISC, 2008). Effective implementation also requires strong institutional support and adequate training for both students and lecturers (Khan, 2012). Continuous feedback and interative improvements are crucial to addressing these challenges and enhancing the platform's usability (Swan, 2003). While Blackboard offers valuable tools for supporting first-year students, overcoming these obstacles is essential for ensuring that all users can fully engage with and benefit from the technology.

2.2 Benefits of Technology Enhanced Support for Student Success

Alamri, Watson, & Watson (2021) claim that there are several advantages to technology-enhanced support in higher education which have a major positive impact on student achievement. Institutions can provide more individualised and flexible learning experiences that are suited to the needs of specific students by utilising digital tools and platforms. According to Liu, Lomovtseva & Korobeynikova (2020), digital platforms offer flexibility by allowing students access learning materials and finish tasks at their own convenience and pace. Students with different schedules and responsibilities especially benefit from this flexibility, which fosters a more welcoming and accessible learning environment. As a result, incorporating technology-enhanced support not only leads to better academic results but also increases student retention and happiness.

The University of Fort Hare is subscribed to the Blackboard Learning Management System as a technological tool for student learning. According to Bradford et al. (2007), Blackboard as LMS has features that include dependable material access, prompt feedback, efficient communication channels, thorough progress tracking, and the development of critical organisational and time management skills that all work together to enhance the e-learning experience. These advantages make Blackboard an effective instrument in the field of educational technology experience, supporting both lecturers and student learning processes. Due to diverse student abilities with interaction with LMS, the university employs TeL Student Assistants to provide the needed support to assist students with navigating the LMS.

According to Johnson-Smith (2014), by establishing more dynamic and engaged learning environments, integrating technology-enhanced support programs with TeL Student Assistants can significantly boost student engagement and retention. Features such as simulations facilitated by TeL Student Assistants, make learning more engaging and enjoyable, capturing students' interest and encouraging active participation. TeL Student Assistants also play a crucial role in promoting online discussion forums and collaborative tools, which facilitate peer-to-peer interaction and foster a sense of community and belonging among students. Furthermore, early alert systems that track student performance and engagement are frequently included into the LMS which enables prompt interventions for students who are at risk of falling behind. Bradford et al. (2007) underscores that Blackboard allows for progress tracking by keeping track of student usage and performance. Additionally, Blackboard helps students effectively manage assignments and deadlines by promoting time management and organisational skills through tools like the Course Calendar.

While there are obvious advantages to technology-enhanced support, Adekola, Dale & Gardiner (2017) point out that institutions must address certain issues and problems in order to assure successful implementation. issues such as poor network connectivity, limited access to computers by students, liabilities to use computers form part of the issues witnessed by the University of Fort Hare that reduce the effectiveness of digital learning programmes. Connecting to online resources can be a challenge for both lecturers and students, which can impede learning and cause lower interest to online learning.

2.3 Theoretical Framework

The study employs the E-learning Systems framework which according to Aparicio et al (2016) is made up of three fundamental elements that make up the theoretical foundation of e-learning systems which is people, technologies, and services. Below on figure 1 is the e-learning systems framework diagram that illustrates the interrelatedness of the three components of the framework.

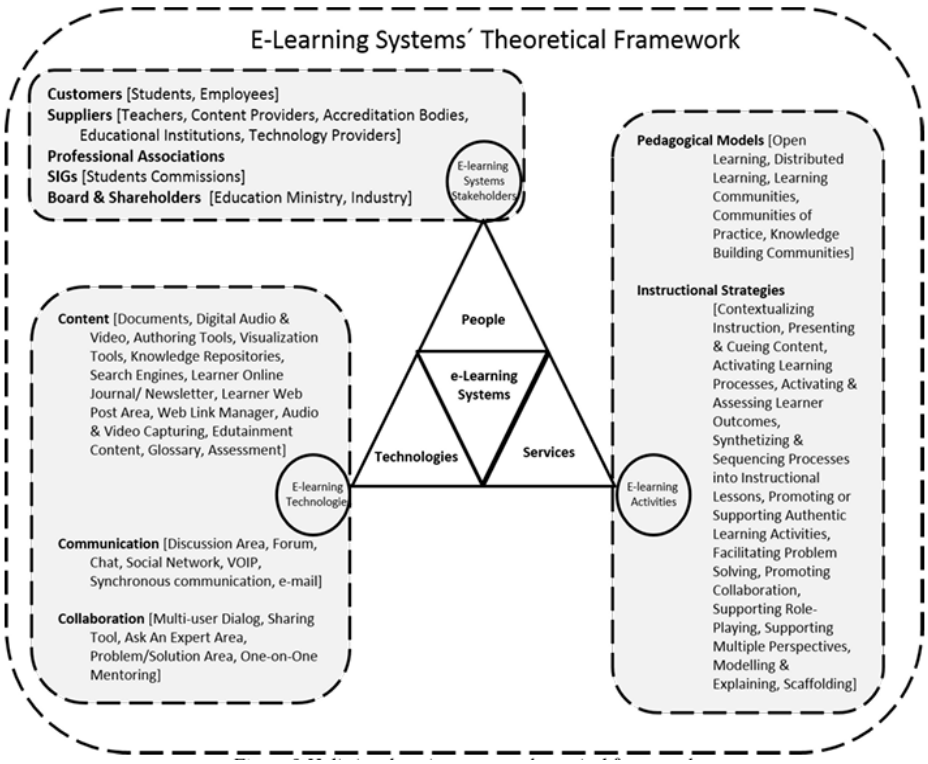


Figure 1: e-Learning systems framework

The framework deduces that technologies support user interactions, content integration, communication, and collaboration, and people interact with e-learning systems. Services include the instructional tactics and pedagogical frameworks that underpin online learning activities. E-learning theory is built on cognitive science principles that demonstrate how the use and design of educational technology can enhance effective learning.

3. Methodology

3.1 Research Design

The parallel mixed-methods design was employed in this research. This approach involves the simultaneous collection and analysis of both quantitative and qualitative data, which allows for a more holistic understanding of the research problem (Almeida, 2018). By integrating these two methodologies, the parallel mixed-methods design provides a more nuanced perspective and enhances the validity of the findings. Moreover, the parallel mixed-methods design facilitates the triangulation of data, which strengthens the credibility of the results by cross-validating findings from different sources. As Dawadi et al. (2021) highlight, this approach not only enriches the overall analysis but also helps in collaborating one set of findings with the other. Consequently, it enables researchers to draw more robust and reliable conclusions about the issue at hand, ensuring that the research outcomes are well-rounded and reflective of multiple facets of the problem. This method is particularly effective in addressing complex research questions where a single methodological approach might fall short of capturing the full scope of the issue.

3.2 Sampling

In this study, two training sessions were conducted with the goal of evaluating their effectiveness and gathering feedback from the participants. Following these training sessions, a questionnaire was distributed to the attendees through Google forms to collect their responses and insights. Out of the 68 participants who attended the trainings, 51 completed and submitted the questionnaire. This resulted in a response rate of approximately 75%. The collected responses were then used to analyse and assess the impact of the trainings, providing valuable data on participants' experiences, satisfaction, and areas for improvement.

3.3 Data Collection

The data collection process utilised both quantitative and qualitative methods to capture a comprehensive set of responses from participants. Quantitative data were gathered through numerical responses, which involved the use of structured instruments such as surveys with closed-ended questions and rating scales. This type of data provides measurable and statistically analysable results that facilitate the identification of trends, patterns, and correlations within the dataset.

In addition, qualitative data was also collected through narrative responses, which involved open-ended questions with prompts that encouraged participants to provide detailed and descriptive feedback. This approach captures the depth and richness of participants' experiences, opinions, and insights, offering context and elaboration beyond mere numerical scores. Participants shared their personal reflections on the training's impact, suggested improvements and described specific instances of how the training affected their practices. Analysing these narrative responses helps to uncover underlying nuances understanding, and address aspects of the training that may not be evident from quantitative data alone.

By combining these two types of data, the research aims to gain a well-rounded understanding of the participants' experiences and the effectiveness of the training. Quantitative data offer a broad overview and statistical validity, while qualitative data provide detailed, contextual insights, enriching the overall analysis and supporting more informed conclusions (Bandara, Furtmueller, Gorbacheva, Miskon, & Beekhuyzen, 2015).

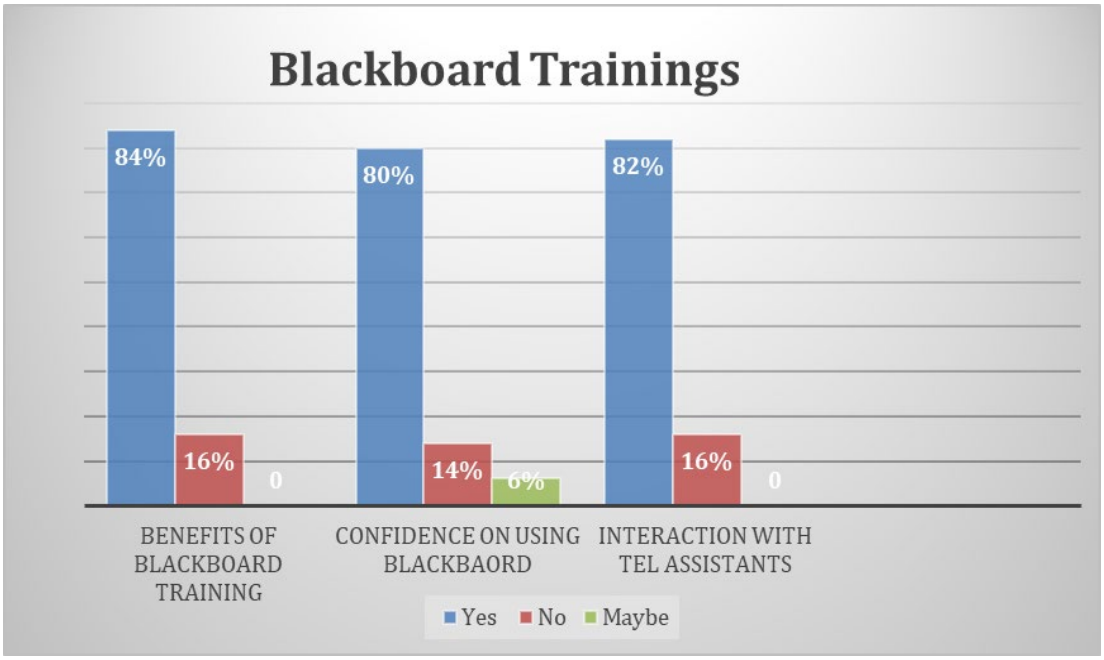
3.4 Data Analysis

In this study, the E-learning theoretical framework was employed to analyse the collected data, providing a structured lens through which the findings were interpreted. This framework encompasses various models, theories, and constructs related to the design, implementation, and effectiveness of e-learning environments. By applying this framework, the research aims to assess how well the e-learning systems used in the training sessions met the theoretical expectations and objectives that are set.

The data was clustered based on the three core areas of the E-Learning framework, which are people, technology and services. The framework helps to analyse the interaction between technological tools, the students and the services offered by the TeL Students Assistants. This examined how well the e-learning systems supported the learning objectives and acquisition of knowledge. The framework also provides criteria for assessing the usability and functionality of the e-learning platforms used, including their accessibility, user-friendliness, and technical performance.

4. Results and Discussion

The study looked at lessons learned on implementation of technology-enhanced support for first-year students on Blackboard. The results and discussion is based on the three core areas of the framework which are Service (offered by the TeL Assistants), People/ E-Learning Stakeholders (Students) and E-Learning Technologies (Blackboard LMS). The table below quantitatively tabulates the results of the study and how the training benefited the students with consideration of the framework.



The results highlight how TeL Assistants improved students' proficiency with the navigation of Blackboard. Significantly, 84% of the participants agreed that having TeL Assistants as support was helpful. The study looked at benefits of the Blackboard training for improved results. The results show that a great percentage of the students found the Blackboard training beneficial in that they are confident in using the LMS for their learning. The high degree of satisfaction emphasizes how the TeL Assistants' interactions were crucial in helping students navigate the technical and procedural aspects of the Blackboard effectively. This is shown by 82% of students acknowledging the importance of having competent and approachable support staff during the training sessions.

Students who attended the training indicated their confidence in using the LMS where 80% of them indicated that their confidence in using Blackboard increased after the training. This therefore can be assumed to be an indication that students can yield positive results with the training received from the TeL assistants as it covered how to access content, study materials and resources as well as how to write and submit assessment tasks in the Blackboard LMS. The support provided by the TeL Student Assistants has undoubtedly benefited students by enhancing their confidence and proficiency in utilizing the LMS. The knowledge acquired will be beneficial for students' lifelong learning as the knowledge covered in the training will be useful for students through their learning process. Providing early support not only helps students to actively participate in their courses but also cultivates essential independent learning abilities that are vital for their academic success. Moreover, the acquisition of digital literacy and problem-solving skills through this assistance can enhance the students' academic performance.

4.1 Service Offered by the TeL Assistants

Students stated that their comprehension and efficient use of Blackboard were much enhanced by the TeL Assistants' abilities to gently walk them through procedures and respond to their enquiries. The students expressed confidence to navigate Blackboard LMS after the training conducted. The TeL Assistants' extensive familiarity with Blackboard was another important component, the students were able to use the platform more easily and received accurate and useful guidance. Students were able to learn how to use Blackboard's services, like submitting assignments and taking tests, rapidly thanks to the assistance of this competent staff.

4.2 E-Learning Technologies - Blackboard LMS.

Students found Blackboard to be more accessible due to its built-in user-friendliness and assistance provided by the TeL Student Assistants. The results provided that the students stated that blackboard was beneficial to them. The platform's ease of use and efficient support made it possible for students to concentrate more on their academic assignments rather than battling with its technical features. The results of the study demonstrated that assisting students with the completion of assignments and tests was one of the major advantages of having TeL Assistants on staff. Due to the constant support of the TeL Assistants, these important academic activities were less complicated and demanding.

4.3 People/ E-Learning Stakeholders (Students)

The results displayed stakeholder satisfaction as positive feedback was received regarding the quality of training that TeL Student Assistants offered as the students responses indicated as such in the administered questionnaire. Students displayed confidence and the abilities to utilise Blackboard efficiently ready to take on their academic needs, as these training sessions covered a variety of platform functionalities.

5. Conclusion

The study provides insights into the success of the TeL Student Assistant Programme and emphasizes the active involvement of the intervention. The programme's success is further demonstrated by how simple it is to access and navigate the LMS. The study highlights the integration of user-friendly components which are crucial in creating an atmosphere that facilitates effortless engagement with E-Learning Technologies, by augmenting the overall learning experience. Furthermore, it has become clear that the facilitators' attributes are important to the programme's success. The TeL Assistants' patience and knowledge are key qualities that enhance the success of training sessions. Facilitators who are well-versed in the platform and exhibit patience can address students queries and concerns more efficiently, creating a supportive learning atmosphere. This approach not only aids in the immediate understanding and application of the platform's features but also instills a sense of assurance in students, encouraging them to utilise the platform confidently in their academic activities. the study concludes that Implementing technology-enhanced support for first-year students on Blackboard yields positive results that promote student engagement with the LMS through ongoing support by the TeL Student Assistants.

6. Recommendations

The study recommends the uptake of the TeL Student Assistants progromme to provide assistance to first-year students as it yields positive results. The study recommends employing the peer-to-peer interaction model of TeL Assistants to improve student engagement and learning during trainings. Peer-to-peer training fosters a more relaxed and relatable environment, where students feel more comfortable asking questions and expressing concerns. TeL Assistants are viewed as more approachable peers who foster open communication and a collaborative learning environment. This enhances learning and fosters a community of support among students, which promotes lifelong learning and aid to one another. .Here is the implementation plan we've developed:

Step	Action	Details
Needs Assessment and Goal Setting	Assess Needs	Conduct surveys or focus groups to identify challenges faced by first-year students. Review academic data and feedback
	Define Goals	Outline objectives and establish specific, measurable goals for the programme.
Programme Design	Develop Programme Structure	Define roles of TeL Assistants and interaction formats (one-on-one, group, workshops).
	Create Training Modules	Develop training materials covering communication skills, active listening, and academic support.
	Develop Support Materials	Create guides, FAQs, and tips for first-year students.
Recruitment and Selection	Recruit TeL Assistants	Advertise the programme and specify candidate qualifications.
	Select Candidates	Use applications, interviews, and peer evaluations to choose candidates.
Training and Development	Train TeL Assistants	Conduct training sessions covering programme objectives, student needs, and mentoring techniques.
	Develop Mentorship Skills	Provide resources and workshops to enhance TeL Assistants' mentorship skills.
Implementation and Rollout	Launch the Programme	Organize an introductory event and integrate the programme into orientation.
	Monitor and Evaluate	Establish feedback systems and use surveys and metrics to evaluate effectiveness.

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Smartphones: A Catalyst for Tobacco Control Training in India

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Abstract: The tobacco crisis confronting low- and middle-income countries (LMICs) requires scale-up of effective tobacco control programs, such as *Tobacco Free Teachers-Tobacco Free Society* (TFT-TFS). We previously demonstrated the efficacy of TFT-TFS in increasing tobacco use cessation among teachers and schools' adoption of tobacco control policies in Bihar, India. To scale TFT-TFS, we are now pioneering a smartphone-based mobile learning strategy to train principals (or their designees) in Madhya Pradesh to implement and monitor TFT-TFS in schools. Research underscores the transformative potential of mobile learning: a flexible, scalable, and cost-effective alternative to in-person training methods. Our study is a unique opportunity to test a training approach that could have implications for wider and more efficient delivery of other public health programs. The strategic use of gamification and digital storytelling enhances the TFT-TFS mobile training app. Gamification mechanics—including points, leaderboards, and digital badging—foster a dynamic learning environment to enhance learning outcomes. This approach propels continuous participant engagement toward understanding and implementation of TFT-TFS's six monthly themes and four program components. The TFT-TFS smartphone training program weaves in elements of Indian culture, notably the symbolic use of colors and kites. The Indian kite festival celebrates communal harmony through healthy competition. Similarly, the app employs the idea of school kites, which are divided into six blank segments corresponding to the TFT-TFS monthly themes. Participants navigate each module, engaging with animated videos, digital assessments, and interactive activities. Upon a principal's successful completion of each monthly theme's program components, the school's kite receives a new color, unlocking the subsequent theme. The TFT-TFS smartphone training showcases a unique interactive mobile learning application that integrates gamification and tests how to scale up an effective tobacco control program in schools in India and other LMICs. The TFT-TFS smartphone-based training app may also have relevance to other public health-related training efforts in resource-constrained areas.

Keywords: Smartphones, Training, Tobacco control, Gamification, Schools, Mobile learning

1. Introduction

Tobacco consumption is the world's leading cause of preventable diseases and deaths (World Health Organization, 2011). In India, the world's second-largest consumer of tobacco, 29% of people aged 15 and above smoke or use smokeless tobacco (Tata Institute of Social Sciences, 2018), with notably low cessation rates (Jindal *et al.*, 2006; International Institute for Population Sciences, 2010; Thankappan, 2014). Each year, approximately 1.2 million people in India die from tobacco-related causes (Jha *et al.*, 2008; Sinha *et al.*, 2014). India also has the highest oral cancer rate globally (Reddy and Gupta, 2004; Gupta *et al.*, 2014). Reducing tobacco-related mortality in India and other LMICs requires scale-up of effective tobacco control programs (McMichael, Waters and Volmink, 2005; Siddiqi, Newell and Robinson, 2005)—such as *Tobacco-Free Teachers, Tobacco-Free Society* (TFT-TFS) (Sorensen *et al.*, 2013)—that leverage the power of community leaders and institutions.

Traditional approaches to implement tobacco control programs in LMICs often involve in-person training (Fernandes *et al.*, 2007; Mormina and Pinder, 2018), which brings logistical challenges and variability in delivery that can affect program integrity (Hayes, 2000; Orfaly *et al.*, 2005; Baron, 2006). Smartphone-based mobile training may bridge some of these gaps (Government of India, 2020) when scaling up tobacco control programs, particularly in rural and resource-constrained settings.

Defined as "learning across multiple contexts, through social and content interactions, using personal electronic devices," (Crompton, 2013) mobile learning on smartphones offers advantages not found in traditional face-to-face educational settings, including: ready access to current content in audio and video formats (Curran *et al.*, 2017); real-time data feedback and tracking; and information sharing among participants and with community members (Anikeeva and Bywood, 2013; Curran *et al.*, 2017). Digital content can be updated and disseminated more quickly and less expensively than printed materials—a benefit particularly relevant to underserved communities (Anikeeva and Bywood, 2013; Baker, Dede and Evans, 2018).

Researchers in India and the United States previously demonstrated the success of TFT-TFS in a cluster-randomized study in Bihar, India. Tobacco use cessation rates among teachers in intervention schools were double those of teachers in control schools (Sorensen *et al.*, 2013), and all schools adopted school tobacco control policies (Pawar *et al.*, 2015). TFT-TFS engages tobacco users and non-users around six themes designed to resonate with teachers' personal experiences, and centers teachers as school and community role models. We tested an in-person training-of-trainers model, leveraging the Bihar Department of Education (DOE) infrastructure (Nagler *et al.*, 2023). However, program scalability faced resource limitations and logistical challenges. These constraints inspired the development of a smartphone-based TFT-TFS training format that could reach a broader geographic area with increased efficiency and enhanced data collection capabilities.

Grounded in the ubiquitous use of smartphones across India, the India/US research team is now examining the utility of a gamified smartphone-based training app for TFT-TFS program implementers, i.e., school principals (or their designees) in two districts of Madhya Pradesh (MP). While in MP the program implementer is referred to as the Program-In-Charge, for clarity, here we will refer simply to the "principal." We are conducting a comparative effectiveness trial using a cluster-randomized design in which principals in MP are randomly assigned to receive TFT-TFS program training in person or via smartphone. Once trained, principals in both groups implement the TFT-TFS program within their schools. Our research question is: Will implementation of the TFT-TFS program, defined as implementing a minimum standard of core program components within the school, be as good or superior (i.e., non-inferior) in the smartphone training arm compared to the in-person training arm? Our study aims are to: (1) Develop in-person and smartphone-based training models based on systematic assessment of contextual factors in MP using the Consolidated Framework for Implementation Research (CFIR)(Damschroder *et al.*, 2009); (2) Compare program implementation fidelity, effectiveness, and cost for the two training models; and (3) Identify factors affecting program implementation after in-person vs. smartphone-based training.

This case study from India describes the gamified TFT-TFS smartphone training app we are testing in MP schools. We describe the development and design of the app; challenges encountered and overcome; measurement of outcomes; and future directions. Finally, we conclude with reflections on how this technology might be adapted to train people who implement other public health-related programs in low-resource settings. We also offer practical insights into scaling up tobacco control and other social impact programs using smartphone technology in schools across India and in other LMICs—a critical step toward reducing tobacco-related diseases and other non-communicable diseases (NCDs).

2. Infrastructure

Setting: Madhya Pradesh, India's second largest state, has a population of over 72 million (Government of India, 2011). Approximately 34% of all adults (50% males, 17% females)(Tata Institute of Social Sciences, 2018) and 21% of school personnel (28% males, 8% females) (Sinha, Gupta and P, 2007) in MP smoke tobacco and/or use smokeless tobacco (Tata Memorial Centre, 2018, pp. 2016–2017). We selected these districts for their high tobacco use prevalence (60% of adult males and 7% of adult females, on average, use tobacco) (Karuppusamy *et al.*, 2021); having rural, urban, and tribal populations, proximity to our local collaborator; and safe roads.

Population: We randomly selected 200 high schools across the two districts and randomly assigned 110 to the smartphone training arm and 90 to the in-person training arm.

TFT-TFS program: TFT-TFS is a school-based program for teachers implemented during work hours for six months across an academic year. With the goal of creating a tobacco-free school environment, TFT-TFS centers on six themes, which the principal delivers one-per-month (following one initial Orientation session): i. Teachers as Role Models; ii. Health Effects of Tobacco; iii. Motivation to Quit Tobacco; iv. Skills to Quit Tobacco; v. Dealing with Withdrawal; and vi. Maintenance and Celebration. TFT-TFS has four core program components that incorporate the monthly themes:

- Theme-based group discussions with teachers, facilitated by the principal

- Cessation support, including sharing a self-help quit booklet and referrals to government resources
- Hanging six theme-based tobacco control posters
- Displaying and implementing a school tobacco control policy

The essential role of teachers in TFT-TFS—voluntary, but encouraged by the DOE—is to become tobacco-free ambassadors by conducting "bonus activities." Bonus activities include: motivating students, family, and community members to quit using tobacco; and sharing information on the harmful effects of tobacco, cessation resources, and the TFT-TFS self-help quit booklet. Recording bonus activities in the app helps the schools' kites achieve height.

Gamification: Utilizing game elements in a non-game environment (Deterding *et al.*, 2011), or gamification, increases motivation to complete tasks (Deterding *et al.*, 2011; Werbach and Hunter, 2012). Researchers have identified more than 200 game "mechanics," or elements that may be employed to engage end users (Peters and Cornetti, 2019). Gamification enhances learning outcomes by increasing motivation, engagement, and retention (Sailer *et al.*, 2017). In the context of health behavior change, gamification has been shown to encourage participation and program adherence (Cugelman, 2013).

Digital storytelling: Digital storytelling is a pedagogical approach that (Smeda, Dakich and Sharda, 2010) presents consistent themes, characters, and story arcs throughout the training. Digital storytelling allows learners to: synthesize the material into their understanding of their daily activities; draw conclusions about how to apply their knowledge; and identify thematic relationships across training materials. As a result, digital storytelling has been shown to increase participant engagement, reduce time to mastery, and dramatically reduce abandonment rates (Hunter and Hunter, 2006).

Formative research: To inform the app design, we visited 23 schools in four districts to conduct a qualitative formative research study. Formative research consisted of 13 focus groups with teachers (4 to 14 participants per group) and 17 key informant interviews with principals in June-July and November 2022. *Data collection:* Interviews and focus groups were conducted in Hindi by a trained facilitator, accompanied by note takers and digitally recorded, with questions guided by four CFIR domains: *innovation* (TFT-TFS program and training); i*nner setting* (school); *outer setting* (state/district tobacco control initiatives and the Clean India Mission); and *individual* (principals as TFT-TFS program implementers). We also explored principals' mobile usage patterns and preferences, technological familiarity, and awareness and perceptions of gamification. *Analysis:* Data from interviews and focus groups were transcribed verbatim in Hindi and translated into English. Framework Analysis informed our work, since it is well suited for multidisciplinary teams to enhance credibility and relevance of findings (Smith and Firth, 2011; Iliffe *et al.*, 2015). We followed a five-step process (Bryman and Burgess, 1994) (i) data familiarization, (ii) thematic framework identification, (iii) coding in N'Vivo,(QSR International, 2019) (iv) charting data into themes, and (v) data interpretation. A study team member in Mumbai reviewed all codes and matched them with the CFIR domains to ensure the data were interpreted appropriately. This allowed us to tailor the TFT-TFS content to MP schools and ensure contextual relevance. The Harvard T.H. Chan School of Public Health's Office of Regulatory Affairs and Research Compliance, and the Healis Sekhsaria Institute for Public Health's (Healis) Institutional Ethics Committee approved all study procedures.

Findings revealed that almost all principals and teachers interviewed had Android-based smartphones. They had grown familiar with various smartphone teaching apps during COVID-19, and preferred shorter, animated audio-visuals in Hindi. Further, they recommended the use of a leaderboard to motivate and maintain healthy competition among schools.

We also conducted the Reiss Motivational Profile with six MP principals to reveal what engages them (Reiss, 2013). Principals ranked high on curiosity, honor, idealism, order, and status. Based on these findings, we developed strategies to enhance their learning outcomes by tying game mechanics (e.g., a point system) to these specific motivations. The TFT-TFS training program thus employs a combination of gamification mechanics and digital storytelling to immerse and engage participants in the content.

Kite theme: Based on our formative research findings, we selected a kite-flying motif for our app design and gamification strategy. In Indian society, kite flying symbolizes communal harmony through friendly competition. Colorful kites symbolize a festive spirit, their height depicts achievement, and their flight depicts freedom. The ritual of preparing and flying a kite takes skill that takes time to build; thus, the kite is symbolic of schools' efforts to make their environment tobacco-free—and fosters friendly competition with other schools. In the app, each school is represented by a kite that is segmented into six parts corresponding to the six TFT-TFS monthly themes. A school's performance is gauged by gains in colors and height.

Cultural relevance: We converted in-person TFT-TFS training content into training videos using Vyond or Camtasia, which allowed the study team to design a creative, customizable, and immersive environment. Informed by our formative research, we created characters and stories in Hindi that align with local MP culture and representation.

App usability testing: We selected Nielsen's Usability Framework (Nielsen, 1993) to guide usability testing because it is a well-established, user-centered, practical framework to help us ensure the app was easy to navigate and accommodated principals' preferences that were identified through our formative research. We conducted three rounds of usability testing. The first two rounds were with the India/US study team and other Indian researchers at Healis. After revising the app based on their feedback, we conducted a third round of testing with five principals from the study districts in MP. Using a "think aloud" technique, principals performed specific tasks and provided feedback about challenges faced and potential solutions to improve the app design and functionality.

TFT-TFS training app: The app login screen (Figure 1) features the image of "*Aadarsh Vidyalaya*" (The Ideal School), emphasizing TFT-TFS's aim to help schools create a tobacco-free environment. The app is divided into three sections: (1) The "Principal's Journey" provides access to gamified training content and the four core components for each theme; (2) the "Teachers' Journey" helps teachers track their bonus activities; and (3) the "Dashboard" displays a school's progress in comparison to other schools.

Figure 1: Login screen with the idyllic school image

Principal's Journey: The home page features a map of MP (see Figure 2) with the themes plotted on it to simplify navigation. The Orientation module at the beginning of the journey map provides an overview of TFT-TFS, app features, scoring, navigation, and animated videos offering insight into tobacco use in India. To track how well principals understand the content, they are asked to take a brief three-to-five-question quiz after each video. This process of verifying participant's knowledge is repeated throughout the app. Upon completion of the Orientation, the school is awarded an outline of a kite divided into six segments, with each segment representing a TFT-TFS theme.

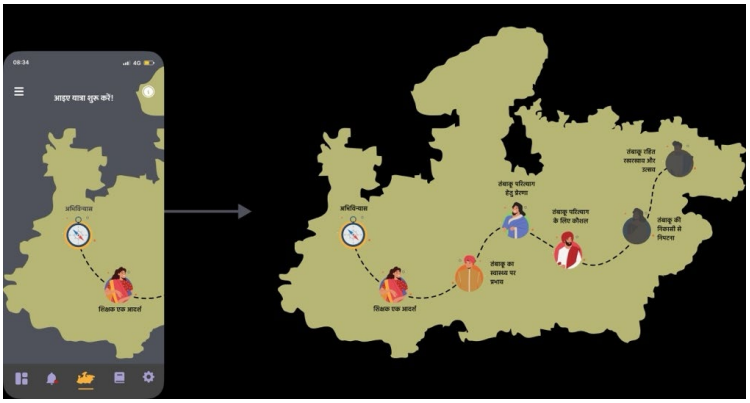

Figure 2: App home page and the full map of Madhya Pradesh when swiped

All themes are similarly structured. The principal first views training videos that explain the theme. For instance, Theme 1, titled *Shikshak ek Aadarsh* (Teacher as a Role Model), features a video narrating the story of a teacher who raises awareness about tobacco's harmful effects after a student drops out due to family circumstances related to tobacco use. After completing a quiz, principals download a guide to facilitate the first theme-based group discussion with teachers, and instructions for implementing the theme's other three program components (i.e., sharing the quit booklet, hanging the theme-based poster, and displaying the school tobacco policy). Additionally, the app guides principals in encouraging teachers to conduct bonus activities in the school, family and community.

To document component implementation, the principal completes a form and uploads a photo (e.g., of a poster on a school wall). Once a school completes Theme 1, the school kite gains the color blue. Similarly, after completion of Theme 2, the school kite gains orange, and so on, until the kite is filled in with the six colors.

Each theme's module has its own landing page. Content is organized in a carousel-style display that allows the learner to swipe and see viewed and unviewed content within the theme. Users can navigate back to previous content or activities at any time. The app also delivers weekly push notifications to motivate principals to complete their monthly activities.

Teachers' Journey: Teachers begin by watching the TFT-TFS program overview video outlining the six themes and four program components. The video illustrates how the themes are connected to the game of kite flying and how schools can score points. Upon completion of these videos, teachers are encouraged to conduct bonus activities with students, fellow teachers, friends, and community members and record their actions on their smartphones. Each bonus activity has a recording form. The bonus activities remain the same throughout the six monthly themes.

How schools score points: Implemention of the four core program components—alongside teachers' bonus activities—earns schools points and determines a school's standing in the kite flying game. Points range from two to six per activity, with a maximum of twenty-four points per theme achievable for the school. If a single teacher completes the activity, the school scores two points, while if 100% of the teachers at the school complete the activity, the school scores a maximum of six points. So, the combination of core and bonus activities within each theme offers schools opportunities to score in the game, with greater activity completion indicating greater implementation within the school and community.

Dashboard: The dashboard (Figure 3) is divided into four tabs that track the progress of every school: Kite Page, Bonus Activities Page, Leaderboard, and Scoreboard. The Kite Page offers a summary of program component completion per theme, displaying the earned colors on their kite. The Bonus Activities Page displays all bonus activities conducted by teachers. The Leaderboard displays the top five schools in the district, represented by their kites flying highest in the sky. Finally, the Scoreboard lists all district schools, ranking them based on score.

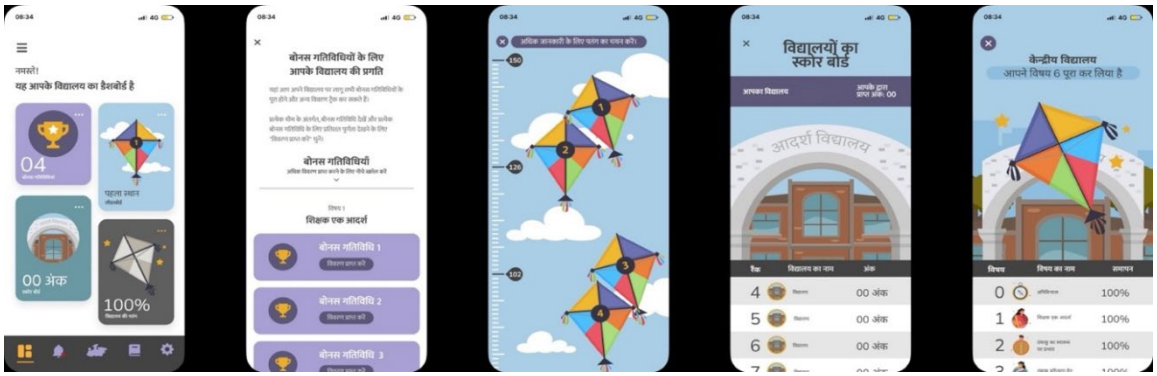

Figure 3: Dashboard with bonus activities, leaderboard, and school kite

3. Challenges

In designing the TFT-TFS smartphone training, we encountered challenges that became opportunities to improve the app's feasibility and acceptability.

For example, principals expressed concerns about the amount of space the app might take on their phones. In response, the team developed training content using highly compressed video and images to limit the amount of space the app requires. Principals also faced internet outages or lack of internet services, particularly in very

rural areas of MP. In response to this contextual challenge, the training content (videos, etc.) was built natively into the app so users can access the videos even without internet connectivity.

Users experienced the app's hiccups in the pilot phase. For example, users initially struggled with the one-time code login or could potentially get kicked out of the app and be forced to log in again. We resolved these bugs before uploading the final version to the Google Playstore.

After years of partnership, our India/US multidisciplinary team has extensive experience working across India to carry out public health research. However, our team was unfamiliar with app usage and internet constraints in rural or tribal MP. To gain contextual understanding, we conducted formative research as described earlier, which included visits to rural and tribal schools to meet with principals and conduct group discussions with teachers. We also received feedback from end users (e.g., principals) and study team members as we developed the app to ensure user-friendliness and relevance for a primarily rural/tribal audience (see ***App usability testing***). The team tailored the app in response to user feedback. This involved revising visuals and grammar to the local context; adjusting the aesthetics of the animated characters; and making app functionality more efficient. The formative research and subsequent tailoring of the training app are critical study phases required to enhance participant learning outcomes, personal and cultural relevance, and sustainability.

4. How the Initiative was Received by the Users or Participants

We will conduct a qualitative assessment of the implementation experience in Summer/Fall 2024. However, we learned anecdotally through discussions with principals and their comments to a TFT-TFS WhatsApp group that they appreciate the healthy competition the training app has generated. As one male principal said after completing Theme 3, "My school's kite is at the first position since the beginning of this program. Our teachers are very motivated with this. Thank you for bringing this program to us." Another male principal commented after completing Theme 4, "My school came at 2nd position this time, but I assure you that next theme onwards we will come in the 1st position." Participants also commented that having audio-visuals in Hindi is essential. Finally, a female principal expressed her overall satisfaction: "The app and the program are good, and the leader board is quite a motivating factor. We will keep progressing in the program."

5. Learning Outcomes

The primary learning objective of this initiative is to determine if principals can implement TFT-TFS in their schools following smartphone-based training. To document implementation, principals record on their smartphones: 1) completion of the four core program components for each theme; 2) photos displaying theme-based posters and the school tobacco-control policy; 3) quit booklet distribution; and 4) date, time and number of teachers attending each TFT-TFS group discussion. Teachers track bonus activities on their phones.

Measures*:* We will assess implementation of each program component and then examine the percentage of schools implementing all four components. Implementation will be a dichotomous measure (successfully vs. inadequately implemented). A school will be coded as having successfully implemented the program if: 1) discussions with teachers addressed at least three of the six themes; 2) cessation materials were shared with all teachers; 3) at least three of the six theme-based posters were hung; and 4) the tobacco policy was posted. We will create a summary measure; if a school did not meet these implementation criteria, it will be coded as inadequate implementation. ***Analysis:*** The school will be the unit of analysis, and all implementation measures will be assessed at the school level. Implementation will be compared by estimating the difference in successful implementation proportion for the smartphone-based vs. in-person training groups with a 90% confidence interval.

dentifying factors affecting program implementation: In August and September 2024, we will qualitatively identify factors underlying observed variations in TFT-TFS program implementation. Based on our prior research (Aghi *et al.*, 2016; Nagler *et al.*, 2020;), we selected factors expected to influence implementation of TFT-TFS that are relevant to the DOE and that can inform future scale-up efforts. These include factors related to: 1) the TFT-TFS program and smartphone training app features and functioning; 2) DOE leadership support for TFT-TFS and the smartphone training app; 3) compatibility of the TFT-TFS program and its training app with school processes; and 4) principals' ease of using and perceived effectiveness of the TFT-TFS smartphone app. This will deepen our understanding of contextual factors associated with using the TFT-TFS smartphone training app.

We will select principals from rural, urban, and tribal schools and DOE leadership to participate in interviews and focus groups. Along with the topics above, we will ask open-ended questions about their implementation experience and TFT-TFS program tracking on smartphones. Additionally, we will invite principals to propose

solutions to implementation challenges and to make recommendations for future use of this e-learning technology.

Findings: We are gathering implementation data and expect to have final results in 2025. Based on data collected in the app, preliminary findings indicate that 96/110 (87%) of the principals assigned to the smartphone training arm completed the Orientation session on the TFT-TFS training app. This indicates their ability to download the app, log in, interact with content, and complete quizzes.

6. Plans to Further Develop the Initiative

Gaps in the literature addressed by the TFT-TFS smartphone training*:* The TFT-TFS smartphone training study addresses several gaps in mobile learning literature. First, previous studies have not examined mobile apps that are culturally adapted and that use gamification to improve user engagement and effectiveness. Research by Gonzalez and colleagues (Gonzalez *et al.*, 2021) demonstrates the potential of mobile health or "mHealth" interventions, but also stresses the need for culturally-tailored and personalized content that resonates with intended users. The TFT-TFS smartphone training includes cultural elements like the Indian kite festival in its design. Second, the app focuses on training school principals to implement and monitor a tobacco control program, recognizing a need to involve school leadership in health programs (Leksy *et al.*, 2024). The TFT-TFS app meets this need by offering a scalable eLearning technology tailored specifically for principals, making it adaptable for school leaders across various regions. Finally, most mobile health research in India has concentrated on urban areas, leaving rural and tribal populations underrepresented. This is a significant oversight, as these communities often have higher tobacco use rates and distinct cultural practices (Gaidhane *et al.*, 2011; Mohan, Lando and Panneer, 2018). We addressed this gap by selecting a primarily tribal district in MP to implement the TFT-TFS smartphone training.

Future plans: Future directions to develop the initiative include expanding TFT-TFS smartphone training across MP and to other Indian states and LMICs. We expect our results may help guide schools and departments of education to tailor TFT-TFS trainings to the local context and pinpoint specific factors associated with implementation success. As India expands digital technology, this initiative will also contribute new evidence supporting smartphone-based training and learning models. Ultimately, we expect to positively impact tobacco control by evaluating how smartphone-based training can be used to scale up implementation of tobacco control programs and reduce tobacco use and related deaths in resource-constrained areas, including other LMICs.

Additionally, we will explore how smartphones can be used to train program implementers to address other pertinent health issues in LMICs, such as the rise of NCDs, including cancer, heart disease, and diabetes. More than 75% of annual deaths attributable to NCDs occur in LMICs, disproportionately affecting the people in these countries (World Health Organization, 2023).

The overall concept, design, and architecture of the smartphone app can be modified to address a broad variety of issues and audiences. Designers would need to analyze the technology needs and preferences of the intended audience to build and deliver a culturally and linguistically relevant app. They would also need to modify the app content for the language/s and health literacy of the user population (Coughlin *et al.*, 2016). For example, if the app were adapted to train implementers of an adolescent diabetes program in Mexico, designers could use a *luchador* (brightly costumed Mexican wrestler) theme. Designers could create a digital story in which the user takes on the luchador persona and engages in a series of "matches" as they progress through the training app.

7. Conclusion

The TFT-TFS smartphone training showcases a unique interactive mobile learning application that integrates gamification and shows how to scale up a tobacco control evidence-based intervention in schools across India. The smartphone-based training app can also be applied to address other pertinent health issues, as well as implement ongoing programs, such as the School Health and Wellness Program in India and in other LMICs.

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WhatsApp Support for School Experience e-Portfolio Development: A Conversational Approach

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Abstract: This paper reflects on the different ways of learning fostered by Whatsapp in the development of school experience e-Portfolios. Student teachers in one institution went through their school experience and practice teaching with an expectation to submit portfolios in an electronic format as evidence of their engagement with the theory and practice of teaching. WhatsApp interactions between student teachers, the school experience co-ordinator, and the practitioners in the Academic Development Centre, supporting the development of e-Portfolios, had to be relied on during the process of developing e-Portfolios. Informed by Laurillard's conversational framework on the six ways of learning, this study analysed the possibilities of WhatsApp support in the development of e-Portfolios by student teachers in one university. First and fourth-year education students on school experience provided qualitative data on the ways of learning that are best and least served by WhatsApp. Their accounts and evaluations of their interactions and support through WhatsApp were expressed narratively. Meaning units were extracted through content analysis and allotted to themes and categories suggested by the conversational framework. This study reports on the usefulness of the framework to evaluate WhatsApp support as well as the ways of learning that are most and least served by WhatsApp support on the development of e-Portfolios of evidence on practice teaching. Recommendations on the efficacious use of WhatsApp support for e-Portfolio development, the practices that would foster the realisation of all the six ways of learning, and enhancement of e-Portfolio development for the school experience are furnished. Suggestions are also proffered on further research about purposive use of WhatsApp and the conversational framework on e-Portfolio development.

Keywords: WhatsApp, School experience, e-Portfolio, Conversational framework, Six ways of learning

1. Background

In 2019, the portfolio development team from the Academic Development Centre at the university from which this study is conducted introduced e-Portfolios as a solution to the challenges associated with managing bulky hardcopy portfolios. Previously, the Faculty faced significant storage issues due to the volume of physical portfolios submitted by school experience students. The shift to e-Portfolios was implemented primarily to address these logistical concerns by moving portfolio development and submission to an online platform and store.

The initiative was initially piloted with the Faculty of Education's school experience students. By 2020, the rollout of e-Portfolios extended to all first and fourth-year education students, coinciding with the outbreak of the COVID-19 pandemic. This transition occurred at a time when face-to-face lectures and training sessions were suspended. Consequently, training for these students was conducted online through Blackboard Collaborate, the University's official Learning Management System (LMS). This platform facilitated interactive sessions where students could receive guidance on creating their e-Portfolios using Google Sites, thereby adapting to the new digital requirements imposed by the pandemic.

The integration of digital communication tools into educational practices has significantly transformed the way students engage with their learning experiences. This paper explores the evolving role of WhatsApp in shaping the development of school experience e-Portfolios for student teachers. At the University where the study is conducted, student teachers are required to document their school experience and practice teaching through e-Portfolios, which serve as comprehensive evidence of their theoretical knowledge and practical skills. The process of developing these e-Portfolios is increasingly reliant on digital interactions, particularly through WhatsApp support.

WhatsApp has emerged as a crucial platform for facilitating communication between student teachers, the school experience coordinator, and practitioners from the Academic Development Centre. This paper reflects on how these WhatsApp interactions have influenced the development of e-Portfolios, examining the ways in which this digital tool supports, challenges, and enriches the learning experience. By analysing these interactions, the researchers aim to understand the broader implications of WhatsApp for educational practices and the potential of social media to enhance the reflection processes in teacher education. The choice of

WhatsApp was based on its less costly data tariffs and the fact that most students use mobile phones. Another reason being that it works in remote areas with limited wifi and poor reception.

The objective of this paper is to evaluate the effectiveness of WhatsApp as a support tool in the development of e-Portfolios for practice teaching. Specifically, the study aims to assess how well WhatsApp facilitates different modes of learning and to identify which aspects of learning are most and least effectively supported by this platform. Additionally, the paper provides recommendations for optimizing the use of WhatsApp in e-Portfolio development, including strategies to ensure that all six ways of learning identified by Laurillard are adequately addressed. The ultimate goal is to enhance the overall process of e-Portfolio development for school experience by leveraging WhatsApp support more effectively.

2. Literature Review

2.1 The Role of Digital Tools in Teacher Education

Digital tools have increasingly become integral to teacher education, offering new opportunities for interaction and reflection. Messaging platforms like WhatsApp are among the tools that have gained prominence due to their user-friendly interface, affordability, and broad accessibility (Ally, 2009; Chen et al., 2020). WhatsApp facilitates instant communication and resource sharing, which can enhance collaborative learning and continuous engagement (Cobo & Moravec, 2011). Its capacity to provide timely feedback and maintain consistent interaction is particularly valuable in educational settings where traditional face-to-face contact may be limited (Dhawan, 2020).

2.2 WhatsApp as a Learning Support Tool

WhatsApp's features, including group messaging, multimedia sharing, and real-time updates, make it a versatile tool for supporting various aspects of learning. Its effectiveness in fostering collaborative environments and facilitating peer-to-peer and student-teacher interactions has been highlighted in several studies (Sánchez & Hueros, 2010). For example, WhatsApp's role in enhancing communication and feedback processes has been well-documented, showing its utility in maintaining engagement and facilitating learning outside traditional classroom settings (Ally, 2009; Cobo & Moravec, 2011).

2.3 WhatsApp in the Context of e-Portfolio Development

The development of e-Portfolios involves a multifaceted process that aligns with Laurillard's (2002) learning modes, namely: acquisition, inquiry, discussion, collaboration, practice and production. e-Portfolios are designed to showcase students' integration of theoretical knowledge and practical skills (Barrett, 2005). The role of digital tools in this context is critical, as they facilitate reflective practice, feedback, and collaborative activities (Hodge, 2011). WhatsApp's ability to provide real-time support and feedback makes it a potentially valuable tool for e-Portfolio development, though its effectiveness across all learning modes needs further exploration (Zhao, 2021). Recent research on the use of WhatsApp to enhance e-Portfolio development has revealed that it significantly affects instructional strategies. El-Masri and Naser (2022). For example, the authors demonstrated how WhatsApp can facilitate continuous communication and prompt feedback between educators and students, thereby supporting the iterative process of developing e-Portfolios. Al-Mekhlafi and Nagaratnam (2023) found that WhatsApp groups help students completing e-portfolios communicate and exchange resources more effectively, which enhances peer evaluation and group education. Additionally, WhatsApp allows for instant communication and updates that contribute to an e-Portfolio experience that is more interactive and engaging, as noted by Sadeghi and Khodabandelou (2024). These studies (Nguyen, 2022; Khan & Smith, 2021) show how effective WhatsApp is at promoting a more participatory and team-oriented e-Portfolio development process.

2.4 Empirical Evidence on WhatsApp's Effectiveness

Empirical research on WhatsApp's role in education highlights both its benefits and limitations. For instance, WhatsApp has been found to effectively support collaboration and discussion (Sweeney et al., 2013). However, its impact on more structured learning modes, such as practice and production, may be less pronounced. Qualitative research focusing on students' experiences with WhatsApp in e-Portfolio development provides insights into its strengths and areas for improvement (Goh et al., 2014). These findings emphasise the need for a nuanced understanding of how WhatsApp supports various learning modes and how it can be optimised for educational purposes.

The literature suggests that while WhatsApp offers significant advantages in fostering communication and collaboration, its role in supporting all six of Laurillard's learning modes may vary. This paper aims to build on existing research by analysing how WhatsApp supports different learning modes in the development of e-Portfolios and by providing recommendations based on student feedback. Insights such as these are essential for enhancing the use of digital tools in education and improving e-Portfolio development processes.

Through its creative features, WhatsApp has been shown in recent studies to be an effective tool for improving teaching methods. In their investigation into WhatsApp's role in supporting collaborative learning, Al-Rahmi and Othman (2013) discovered that the platform's instant messaging features greatly enhance student engagement and communication. Similar to this, Annamalai (2023) showed how WhatsApp groups promote interactive learning environments by facilitating peer support and real-time feedback, which improves the quality of the learning process overall. Furthermore, WhatsApp's multimedia features, like voice notes and video sharing, have been shown by Rahayu and Ahmad (2024) to make learning more dynamic and interesting. According to Nguyen (2022) and Khan & Smith (2021) these findings highlight WhatsApp's potential to enhance student interaction, collaboration, and learning outcomes in educational settings.

3. Laurillard's Conversational Framework and its Application

The Conversational Framework was established by examining the results of research on student learning and utilising them to establish the criteria for the teacher responsible for developing the learning process for the students they teach (Laurillard, 2002). Laurillard's Conversational Framework (2012) provides a theoretical model for analysing how learning can be supported through interactive processes. The framework explains six ways of learning: acquisition, inquiry, discussion, practice, production, and collaboration. Each mode plays a distinct role in the learning process:

- *Learning through Acquisition* involves gaining knowledge from various sources.
- *Learning through Inquiry* emphasises the exploration and questioning of information.
- *Learning through Discussion* facilitates deeper understanding through dialogue.
- *Learning through Practice* relates to the application of knowledge in practical scenarios.
- *Learning through Production* involves creating outputs based on learned concepts.
- *Learning through Collaboration* focuses on working with others to achieve learning goals.

The framework offers a useful perspective for evaluating how digital tools like WhatsApp support different aspects of the learning process, in an interactive way, particularly in the context of e-Portfolio development (Laurillard, 2012). The Conversational Framework effectively enhances student participation and engagement in learning environments, fostering strong connections between teachers, students, and technology (Neo et al., 2023).

4. Methodology

4.1 Research Design

The study employed a qualitative-interpretive approach and a narrative design to evaluate the effectiveness of WhatsApp in supporting different modes of learning in the development of e-Portfolios for first- and fourth-year education students, guided by Laurillard's conversational framework. Participants, comprising first and fourth-year education students involved in school experience programmes, provide qualitative data through their detailed narratives and reflective evaluations of WhatsApp interactions. Data collection involves gathering students' accounts of their experiences with WhatsApp, which include descriptions of how the platform supported or impeded their learning. These accounts are supplemented by evaluations reflecting on WhatsApp's effectiveness across various stages of e-Portfolio development.

4.2 Sampling

In this paper, a purposive sample was selected, comprising 51 final-year Bachelor of Education (B.Ed) students from the 2021 cohort. These students were specifically chosen for their involvement in the school experience component of their programme. The focus of this sample was on students who had been trained in portfolio development as part of their professional preparation from their first year. Additionally, these students received ongoing support through the WhatsApp platform, which facilitated communication and guidance throughout their training process. This approach aimed to assess the effectiveness of portfolio development training and the impact of digital support on the students' educational experience.

4.3 Data Collection

Data collection was conducted using a structured questionnaire featuring open-ended questions. The questionnaire was administered in a controlled group setting at a designated venue selected to facilitate an organised and focused data-gathering environment. Prior to the distribution of the questionnaires, researchers provided a comprehensive explanation of each question to ensure clarity and to facilitate accurate and thoughtful responses from participants. This explanatory session aimed to eliminate any ambiguity and to standardise understanding across all participants. Ethical considerations include obtaining informed consent, ensuring confidentiality, and ensuring voluntary participation (Zhao, 2021).

The responses were collected anonymously to protect participants' privacy and encourage candidness. Each individual completed their own questionnaire independently, and the process was designed to ensure that no personal identifying details were linked to the responses. This approach was employed to maintain the confidentiality of participant identities and to minimise potential biases that could arise from the knowledge of participants' identities.

4.4 Data Analysis

Data Analytics is the methodical examination of extensive and intricate databases to reveal concealed patterns, correlations, and useful insights (Udah et.al, 2024). To analyse the data, content analysis of phrases, meaning units, sentences and keywords was conducted on the students' narratives. These were colour-coded in accordance with the themes imposed by the framework. The datasets were extracted and classified into themes. These were categorised into themes suggested by the Conversational Framework that looks at the six ways of learning. Thus, an etic approach was used in categorising data according to themes imposed by the framework. The etic approach enables the construction of arguments using scientific frameworks that are based on supposedly objective social processes and relationships (Mostowlansky & Rota, 2020). The use of the Etic approach ensured that the themes fit the Conversational Framework which was deployed as a thinking tool. More profound representative quotes were then selected to buttress the narrative of each theme, namely: the six ways of learning. The results are reported narratively, highlighting the strengths and limitations of WhatsApp in supporting diverse learning experiences and offering recommendations for optimising its use in educational settings (Chen et al., 2020; Goh et al., 2014).

5. Results

5.1 Learning through Acquisition

This theme involved school experience students' indications that WhatsApp was a useful reminder on the processes of developing e-Portfolios. One of the students said: "*I was also able to teach through the theory I have learnt because my colleagues reminded me".* Other students suggested that WhatsApp enabled school experience students to access information and updates. This information was said to be recent and accurate and on point information. The following excerpt attests:*"I also get clarity on difficult concepts or topics that I have taught in class"*. It also fostered the understanding of topics and offered students alternative ways of getting information. For example, "T*hrough WhatsApp there was an alternative way of getting the information i.e. It can be in the form of voice notes, images and texts".* The acquisition of learning resulted from explanations for clarity that other students offered on the WhatsApp platform. For example, one of the students remarked that *"through WhatsApp, it is possibly easy to explain things through voice notes and text".* Other excerpts from the students' narratives suggest that WhatApp fostered understanding, offered explanations and helped students get others' perspectives on the various aspects of e-Portfolio development. This is captured in the following excerpt "*even if one of us didn't understand something we were able to explain using audio by listening to others' perspectives which made the look great and easier".*

5.2 Learning through Investigation

The phrases, meaning units, segments and words extracted from students' narratives suggested that WhatsApp helps with the development of critical thinking skills. Others suggested it assisted investigation and inquiry through communication of issues via the WhatsApp platform. Another important learning obtained by some of the students involved auto correct in WhatsApp which some students claim helped them with the improvement of spelling. One of the students remarked that*"I had the challenge of spelling incorrectly when writing but through this digital platform, auto-correct helped me".* An important aspect of inquiry obtained by one of the school experience students involved the use of WhatsApp as a reflection tool. The student said that *"I would go and view videos when I needed to reflect".* Other school experience students opined that WhatApp enabled them

to write properly and improved their grammar. For example, one of the students remarked: *"Because of WhatsApp I am able to write words properly which improved my grammar"* . The above quote appraised the role of language in the thinking processes involved in an inquiry as a thinking tool.

5.3 Learning through Discussion

Discussion as a way of learning is enabled by Whatsapp through interactions that it affords lecturers and school experience students, Academic Development Centre support staff, as well as amongst school experience students themselves, and between school experience students and pupils/learners in schools. This is captured in the following excerpt*"As WhatsApp helped us to interact with my colleagues and lectures it helped me on how to interact with my learners".* The student teachers also indicated instant feedback emanating from the discussions in the following way "*The feedback I would get from the peers was very instant",* Thus, WhatsApp allowed other students teachers in the WhatsApp group to be the sounding board for other school experience students in the e-Portfolio development process. It also included the sharing of resources, documents, expertise and experiences among student teachers as reflected in the following quote: *"It helped me a lot because I was able to interact and get information through sharing."* The students who were participants in the WhatsApp group for e-Portfolio formed a reference group for one another as suggested by the following quote: *"I easily referenced from WhatsApp if I had forgotten something".* This reference group served to remind and reinforce learning obtained about the e-Portfolio development process.

5.4 Learning through Practice

Practice was according to the school experience students played out through application of theory in practice facilitated by the WhatsApp platform. The student remarked that "*WhatsApp made it possible to apply and connect the knowledge gained in the coursework and meet the community needs. WhatsApp was used by our School Experience coordinators to share the required templates for school experience".* It also involved integration which was defined by the following phrases, "how to", "develop", "ability to", "practice", "doing" and "connections" as reflected in the excerpts from the school experience students' narratives. The integration is evident in the following quote: "*WhatsApp was very helpful in developing e-portfolios and in putting the theory into practice. Because I was able to get support such as ATPs and lesson templates. We got them on WhatsApp group and also other material that assisted me on developing e-portfolio and assisted me on school experience. I got them on a WhatsApp group".* A lot of practice skills and competencies were obtained by the majority of students. These included obtaining guidance from other school experience students on the development and use of tools and templates as well as the use of theory to foreground their teaching practices. This is reflected in the excerpt below: "*WhatsApp assisted me as a student teacher to receive ATPs, lesson plans template, which are essentials in the classroom, thus connecting theory and practical in my lesson"*

5.5 Learning through Collaboration

This way of learning entailed sharing documents amongst student teachers. One student opined that "WhatsApp assisted me in getting the documents that I will use in class, even the lesson notes. Sometimes we share the lesson notes if we are doing the same subjects because the content is the same. We communicated using WhatsApp to get the required documents like the templates". This help and assistance that school experience students received from one another fostered a sense of collaboration and togetherness towards the achievement of the e-Portfolio development tasks. This is captured in the following way "Yes we were able to work together as a group via WhatsApp. We would even meet up in groups at the library and do the file together as a group, even on submission day we would meet up and share the stress". This togetherness also assisted the students in terms of alleviating pressure and stress related to the submission of e-portfolios. It also includes collaborations, teamwork and cooperation with others in the cohort of school experience students who received training on e-Portfolio development. The teamwork spirit is captured in the following way: "Teamwork assisted us a lot because we were able to plan meet-ups using WhatsApp, we even met at the library to do our file together and that made it very easy to do our file". The development of multiple skills was highlighted as an important learning and a WhatsApp affordance to come out of the collaborations as reflected in one of the students' narratives. The quote below attests to the co-operation "WhatsApp allows us users to create and broadcast lists, which facilitates collaboration and communication among multiple tasks". Therefore, collaboration is promoted by WhatsApp.

5.6 Learning through Production

Production involved school experience students feeling a sense of stimulation, and enablement. This resulted in the development of multiple literacies, rekindling of interest, tapping into creative and innovative ways of

developing e-Portfolios. The school experience students were able to show uniqueness, make their e-Portfolios attractive through use of smart features. One of the student teachers maintained that WhatsApp*"allowed me to show my creativity. I use most of the features there to make it beautiful and eye-catching, I created science inspired templates, using smart features which are coded within google drive".* The result was the creation of unique, creative, eye-catching and inspirational e-Portfolios from interactions in WhatsApp. The personalisation aspect in the development of e-Portfolio was highlighted in the following way "*I was able to make my e-portfolio the way I like. The themes there were unique and attractive. I started my e-portfolio there from scratch creating each and every folder of my own"*. Similarly, another student teacher remarked that *"I was able to express my uniqueness in creating my portfolio by changing themes, fonts and images which were different from my peers, I chose designs which suited my needs, interests and reflected who I am".* Other students claimed overcoming challenges in the e-Portfolio development work. In producing e-Portfolios school experience students had to substitute and redefine aspects of their work in the e-Portfolio development process. This is evident in the customisation that some students claim is fostered by WhatsApp as suggested by the following reflection*"I was able to customise my e-portfolio to my needs and interests and also make it personal. I was able to develop, make it at my own pace, I was able to make it attractive but not express my uniqueness".*

6. Discussion

The use of Laurillard's conversational approach to interrogate and make sense of WhatsApp support in e-Portfolio development was an after-thought since neither the activities nor the facilitators' presentation were informed and shaped by the framework. The fact that WhatsApp promoted the six ways of learning in varying degrees give credence to its potential for an all-rounded learning of complex tasks with high cognitive demands. The findings also find support in the suggestion that the framework is applicable in all kinds of media and that it promotes learning across levels of schooling and study. Studies also vouch that the use of WhatsApp that is framed and focused by the conversational framework fosters connections between teachers, technology, and students (Neo, et al, 2023), as well as in a variety of contexts namely, face-to-face and online.

Using WhatsApp responsibly informed by the conversational approach helps to promote an iterative process of learning including e-Portfolio development which has a bearing on the teaching strategies (El-Masri and naser, 2022; Al-Mekhlafi and Najaratnam, 2023), as well as participatory and team-orientated modes of learning. Other affordances of the framework that are demonstrated in this particular study of the conversational framework with WhatsApp include interaction, collaboration, and achievement of learning outcomes. These findings confirm Nguyen (2022) and attest to the efficacy of the conversational framework for learning engagements and modalities of learning, teaching and learning support. Similarly, the narratives about production, collaboration and discussion support the notions expressed by participants of the study on WhatApp support for e-Portfolio development.

7. Conclusion

The results of this study suggest that WhatsApp has the potential to foster learning through the six ways of learning identified by the conversational framework. The school experience students' narratives were less and superficial on learning through investigation since the task of developing an e-Portfolio did not require them to be involved in a scientific inquiry. The few references to critical thinking and reflection by the few students suggests that it has the potential for the realisation of this manner of learning through WhatsApp. The areas of WhatsApp success for e-Portfolio development were learning through acquisition, discussion, practice and collaboration. Again, there were expressed and recorded successes with the production way of learning. However, more creative outputs were as a result of group efforts and assistance from others, but not individual efforts and endevours. These successes need to be consolidated with more effort expended on achieving these ways of learning through independent and individualised studies..

8. Recommendations

To achieve all the six ways of learning through WhatsApp, there is a need for deliberate, purposeful, and planned WhatsApp learning activities and tasks for acquisition, investigation, discussion, practice, collaboration, and production. So that the realisation of these six ways of learning through WhatsApp is not serendipitous but a calculated feat. We further recommend the replication and scaling up of WhatsApp studies using the conversational framework with data gathering tools that are designed and developed with the conversational framework in mind. Each of the six ways of learning needs to be probed further through individualised and independent studies.

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A Model for Collaborative Immersive Classroom Management Development Using Multi-User Virtual Reality

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Abstract: Classroom management has been identified as a key challenge in becoming a teacher, as newly qualified teachers are overwhelmed by the complexity of professional teaching practice. This paper explores the transformative potential of immersive technologies in fostering a collaborative reflection and problem-solving space for the continued development of newly qualified teachers' classroom management competencies – allowing newly qualified teachers to become better prepared for facing the unexpected, local, and situated challenges of becoming a teaching professional. Through iterative cycles of design-based research, we have developed a model of immersive collaborative classroom management training using multi-user Virtual Reality. The model consists of four phases: (1) 360-degree video recording, creating an immersive version of the classroom and the complex interactions that occur within it. (2) clip selection, giving teachers the ability to select clips that are relevant for them and their practice. (3) Multi-user Virtual Reality training, allowing teachers to get feedback on their selected clips and construct actionable knowledge together with local teaching supervisors (4) Debriefing, for ensuring the joint understanding and transfer of knowledge to practice. Through analysing teacher's and supervisors' meaning making processes of 18 selected video clips across five multi-user Virtual Reality training sessions, we uncover three main phases: Analysis, Abstraction, and Actionability. By being able to collaboratively watch, re-watch, and discuss selected video clips and moving between these three main phases, teachers and supervisors co-create actionable knowledge, creating an improved understanding of current practices, and supporting the ability to transform future practices. These findings contribute both theoretical insights and practical implications for educators and learning designers, emphasising the importance of creating social immersive reflective spaces in which real situations may be revisited in order to examine the intricacies of classroom practices, allowing newly qualified teachers to better engage with their profession.

Keywords: Collaborative learning, Immersive virtual reality, 360 Video, Classroom management, Teacher training, Feedback

1. Introduction

Newly qualified teachers often experience overwhelming feelings of stress and emotional exhaustion in their first job (Voss and Kunter, 2020). A common reason is the surprising amount of invisible work, which newly qualified teachers find they are untrained for, such as classroom management (Böwadt and Vaaben, 2021). To support the movement between reflecting on what happened (past actions) in the newly qualified teachers classroom practice and coming up with future classroom management strategies (future actions), we turn to video – a resource with a long history of supporting e.g., classroom management development in the teaching profession (Gaudin and Chaliès, 2015). Recently, studies have shown that the use of 360-degree video in teacher training can provide a more realistic and authentic experience, especially when using 360-degree video of teachers own teaching, which has shown to increase reflection compared to videos of others' teaching (Atal, Admiraal and Saab, 2023). In this paper, we present a novel digital learning space using 360-degree video recordings and Immersive Virtual Reality (IVR) – commonly addressed as 360VR or RealVR (Pirker and Dengel, 2021). 360VR uses 360-degree video recordings as the primary content of the virtually mediated space, paving the way for more accessible VR-learning. According to Atal, Admiraal and Saab (2023), 360-degree videos in VR further increases the likelihood of teachers ability to notice, identify, and transfer skills from VR to the classroom. The immersive affordance of 360-degree video blurs the line between reflection-in and on-action (Schön, 1983), so while the teachers are not able to make changes in practice, they are able to re-live practice, getting a feeling of being in-action, while reflecting on-action, setting the scene for this kind of training.

The digital learning space in this study is designed as a collaborative IVR environment, a space which may be conceptualised as "a shared experience in an immersive, virtually mediated space, where there is a shared goal/problem which learners must attend to collaboratively." (Paulsen et al., 2024, p. 10). In this paper, we explore: *How does multi-user Virtual Reality support the development of classroom management competencies, and how can the knowledge acquired in VR be translated into practical teaching strategies?*

2. Related Work

Most current VR solutions are aimed at pre-service teachers' training decision making in programmed environments, in order to improve their procedural knowledge (Wang & Li, 2024). When entering service, teachers find that problems are complex and locally situated (Böwadt and Vaaben, 2021). Systems aimed at

preparing for practice by training standardised procedural knowledge are then at risk of being unable to effectively support the conceptualisation and transfer of the local problems that the newly qualified are experiencing when engaging with complex, real practices. Here, we find it relevant to highlight another observation - the distinction between 360VR systems and programmed VR systems. Programmed VR systems are, as also identified by Wang and Li (2024), mostly aimed at training procedural classroom management skills. A couple of examples include: Building on generalised cases to create VR scenarios, allowing pre-service teachers to work with conflict scenarios (Kugurakova *et al.*, 2023); Using a commercial VR training solution for analysing the effect on pre-service teacher's classroom management ability (Chen, 2022); Comparing use of the same commercial VR training solution for pre-service teachers' training classroom management with 2d video on a flat screen (Seufert *et al.*, 2022). While these examples each in their own way address the complexity of classroom management, Wang and Li (2024) noted that programmed VR applications for teacher training mostly focus on recreating traditional classroom scenarios, rather than exploring the difficult situations found in the actual classroom practices that teachers engage with. A reason for this might be that the tools are mainly aimed at pre-service teachers, meaning that the student teachers are not connected to a specific practice, apart from when engaging with practice placements. 360VR allows for engaging with these specific scenarios in an accessible manner, as it allows for recording authentic practices. A recent study on 360VR for pre-service teachers also concluded "360 videos should be personalized according to PST career and professional goals." (Gandolfi, Ferdig and Kosko, 2024, p. 2), emphasising the need to connect VR-based classroom management training to actual practices that teachers can connect to.

Use-cases of 360VR in teacher training seems to be aimed at broader goals such as pre-service teachers professional noticing (Kosko, Ferdig and Zolfaghari, 2021) or reducing pre-service teachers' anxiety (Theelen, van den Beemt and Brok, 2020). We argue that this might be because using 360VR allows VR training to go beyond training procedural and operational knowledge, and move towards a more practice-oriented view of learning, a notion which is also common with 2D-video analysis (Sormani, 2016). 360VR should then allow teachers to go beyond looking at just classroom management procedures and attend to how classroom management is intertwined with the rest of teacher's local and situated classroom practices. Finally, both programmed-VR and 360VR are currently used exclusively as single-user systems. While individual work with 360VR recording of own teaching has shown to support reflective processes, improving teacher self-efficacy (Walshe and Driver, 2019), we hypothesize that shared reflection could support this process, paving the way for multiple perspectives when working with situations.

3. Designing a Digital Learning Space for Participation and Shared Reflection

The work presented in this paper is building on the parallel development of a software tool for collaboration in immersive virtual reality – CAVA360VR (Collaboratively annotate, visualise and analyse 360-degree video in Virtual Reality) - a software tool built on Unity and PhotonEngine, which allows up to 20 multiple users to remotely collaborate around 360-degree video – creating a shared space for training, problem-solving, and reflection (Davidsen and McIlvenny, 2022; Davidsen *et al.*, 2022).

Throughout October 2023 to January 2024, a design-based research project (Barab and Squire, 2004) has been run together with a Danish primary- and lower secondary school, exploring how CAVA360VR may support the supervision of newly qualified teachers. The project is part of a PhD-project, exploring how facilitated reflection using digital tools may support newly qualified teachers in navigating the complexity of entering practice. Together with practitioners from the participating school, a four-step model has been devised for implementing CAVA360VR sessions (Figure 1).

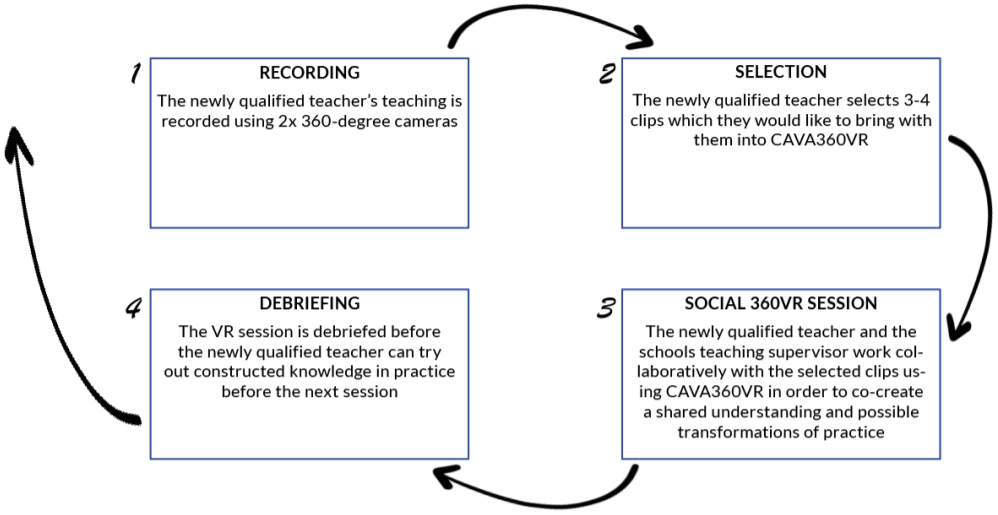

Figure 1: Four steps of using CAVA360VR for collaborative immersive classroom management development

First, the newly qualified teacher's teaching is recorded with two 360-degree cameras following students' and parents' informed consent. For each CAVA360VR session, shorter clips are selected from the recorded double-lessons (1½ hours in length). The newly qualified teacher then reviews the footage together with one of the researchers on a laptop screen, highlighting their initial noticing. Typically, 4 clips were selected, with a combined length of around 10 minutes. The clips were selected for teachers to highlight their own experiences, showcasing both good and problematic experiences.

Following the selection, clips are assigned a thematic title by the teacher, before being imported into CAVA360VR (Figure 2). The CAVA360VR session are structured by a short introduction for technical familiarity, before the newly qualified teacher and the teaching supervisor begin working with the clips in VR using two HTC Vive Cosmos HMDs. In this step, the researchers are purely observing, the VR session is entirely directed by the participants, using built-in resources in CAVA360VR: 360-degree video feeds, coloured laser pointers, an overview of the lesson, and media controls. Following the VR training, the session is debriefed, establishing an understanding of what occurred within VR, supporting the transfer of knowledge by reifying it using images from the clips, and discussing further iteration. CAVA360VR sessions and debriefings are all video recorded using screen recordings from the laptops and external cameras.

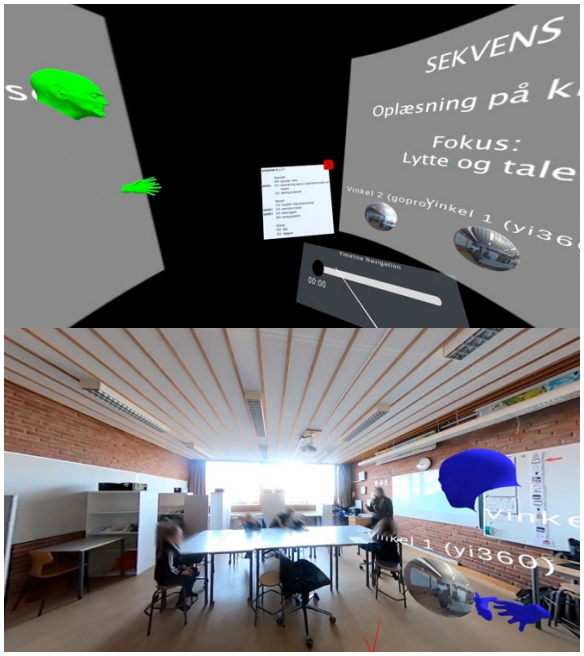

Figure 2: Title screen and resources (left), Being jointly (re)immersed into classroom practice (right).

After the session, a couple of weeks go by, where the newly qualified teachers have time to individually reflect on and try out the constructed knowledge and strategies. After this, the cycle is repeated. 2 and 3 full cycles were completed with two newly qualified teachers. The 5 cycles resulted in the teachers and supervisor co-constructing shared understandings of 18 different clips from the newly qualified teachers' teaching (Table 1).

Table 1: Overview of VR training sessions.

Session	**Number of selected clips**	**CAVA360VR Session length**	**Debriefing length**
Teacher 1, session 1	4	59 minutes	31 minutes
Teacher 2, session 1	4	44 minutes	23 minutes
Teacher 1, session 2	3	56 minutes	19 minutes
Teacher 2, session 2	4	62 minutes	20 minutes
Teacher 2, session 3	4	30 minutes	32 minutes
Average length		*~ 50 minutes*	*~ 25 minutes*

4. Results

Video recordings of all VR sessions have been inductively coded and categorised using DOTEbase (McIlvenny, Davidsen and Stein, 2024). In coding the sessions, we take a situated and interactional approach to knowledge (Jordan and Henderson, 1995), identifying different phases and sub-phases based on the visible talk and actions performed by participants in the physical and virtual space as they engage with the 18 selected clips across the 5 sessions. The VR sessions were coded through making media clips and inductively assigning tags based on the activity performed by participants, e.g. examining the hand movements of the teacher in a certain clip would be tagged as "analysing actions" (Figure 3).

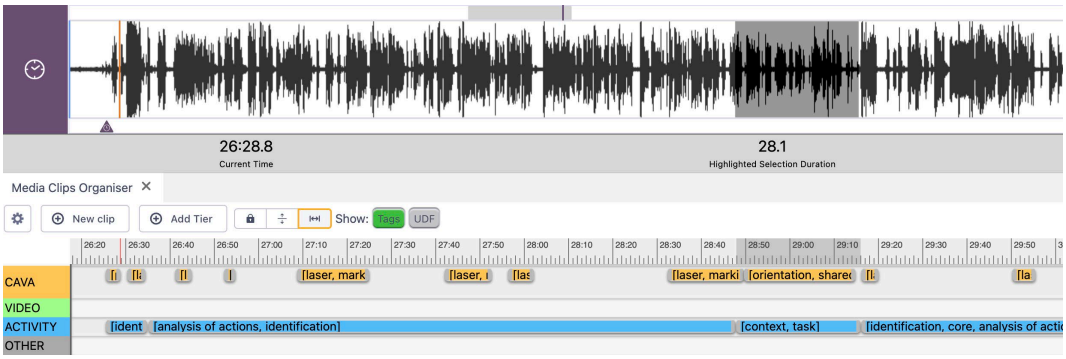

Figure 3: Excerpt of coding and tagging clips in DOTEbase

In order to move towards an empirical, data-driven model for Collaborative Immersive Classroom Management Development the tagged clips were grouped together in larger categories based on the activities performed by the newly qualified teacher and teaching supervisor. The initial grouping of the activity codes shows that working with 360-degree video clips of newly qualified teacher's own teaching is centred around moving between the three A's – Analysis, Abstraction, Actionability, and their sub-phases (Table 2).

Table 2: Coding of main- and subphases.

Main phase	**Subphase**	**Number of codes**
Analysis	(re)-identification	66
	Context	88

	Analysing actions	78
Abstraction	Other scenarios / clips	49
	Theory / general statements	38
	Team	11
	Personal experiences	9
Actionability	Alternative past actions	24
	Possible future actions	39

It is important to note that coded sub-phases are not mutually exclusive. This means that a clip can entail abstraction that is e.g., both aimed at other clips and theory, thus being coded in both sub-phases. The movement present during VR sessions consists of an overall linear motion from presenting the clip to summing up the constructed knowledge, with a non-linear movement between the three A's taking place during this overall movement (Figure 4).

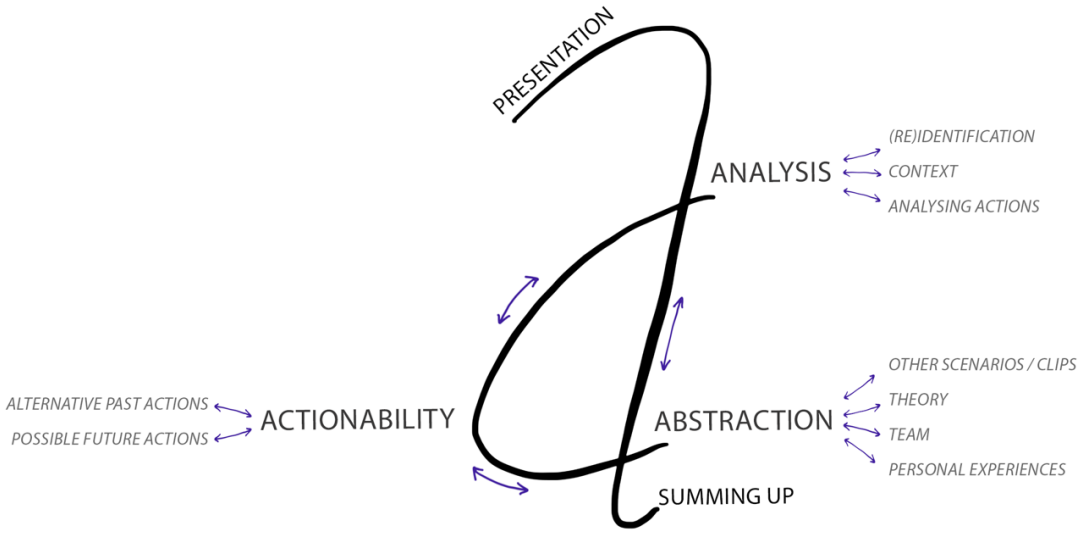

Figure 4: The three A's of Collaborative Immersive Classroom Management Development Using Multi-user Virtual Reality

The situated and interactional view of learning imposed upon the coding of the VR sessions means that while this model is a generalisation of the overall notion of classroom management competency development in social 360VR, deviations from the model exist in the empirical data, as the complex nature of situated and experiential learning processes is difficult to model. In order to show how the model unfolds, we wish to unfold the phases and expand on how the digital learning spaces supports participants in identifying and discussing classroom management strategies.

4.1 Initial Phases - Being Immersed into Recorded Classroom Practice

In the initial phases, participants present the clip and perform an initial watching of the clip. The first subphase, *presentation*, entails the newly qualified teacher presenting the clips that participants are about to watch in order to establish an initial understanding and focus. Here, the overall notion of social interaction is afforded by participants being able to communicate through the CAVA360VR software, providing a communication channel between participants' avatars. Title screens, which are embedded into the 360-degree video before each clip (Figure 2), are also a key part of this phase, providing a thematic title that helps newly qualified teachers recall the clip. As 360-degree videos are very data rich, an initial focus is needed. Initial sessions without titles revealed that clips had to be paused during initial watching in order to negotiate a shared orientation.

After the clips have been presented, they can be *watched* and *re-watched*. Here, the CAVA360VR built-in media controls such as play/pause and a timeline for scrubbing assist participants in performing such actions, with the HMD allowing participants to freely orient themselves in the 360-degree video sphere. After these two initial

subphases, a non-linear movement between Analysis / Abstraction / Actionability begins – typically starting at analysis and ending with abstraction or actionability.

4.2 Analysis - Establishing a Joint Focus and Understanding

In the analysis phase, participants identify the central theme of the clip and analyse interactions in the recorded material while providing the needed contextual knowledge in order to produce such analysis.

Identification and *re-identification* entails defining and re-defining a shared premise for watching and working with the clip. While the presentation establishes the newly qualified teacher's initial perspective on the situation, the initial watching allows the teaching supervisor to establish their own perspective. Previous studies on teacher noticing has shown that teachers with different experience levels notice different things when observing classroom situations (Wolff *et al.*, 2015). Here, the digital learning space allows the teaching supervisor to perform their own observation and noticing of the situation, leading to a re-identification of what the newly qualified teacher has initially noticed. This allows the teaching supervisor to perform their supervision with roots in the actual situation, and not just the teacher's interpretation of the situation, as would typically had been the case without the immersive video.

While the re-identification is ongoing, participants typically move into a *context* subphase, with the teaching supervisor requesting additional contextual knowledge about the clip. This both entails context about the task that students are performing but is mostly aimed at relational knowledge – "tell me about this student, what are they usually like, what do I need to know about them". This emphasises the digital learning space's ability to re-immerse participants into actual situations, and not generalised cases. It shows that professional development of teachers' classroom management competencies cannot be developed in isolation from the situational context.

Analysis of actions is aimed at micro-level analyses of the complex interactions occurring in the clip in order to co-construct an understanding of the situation. The primary affordance of this phase is being able to manipulate the 360-degree video using media controls, allowing participants to pause playback in order to freeze the classroom interaction, allowing them to perform micro-level analysis of the practice. In order to support this micro-level analysis, participants make use of their colour-coded laser trails (Figure 5), acting as a virtual marker for establishing joint-attention when pointing and marking objects/areas as relevant.

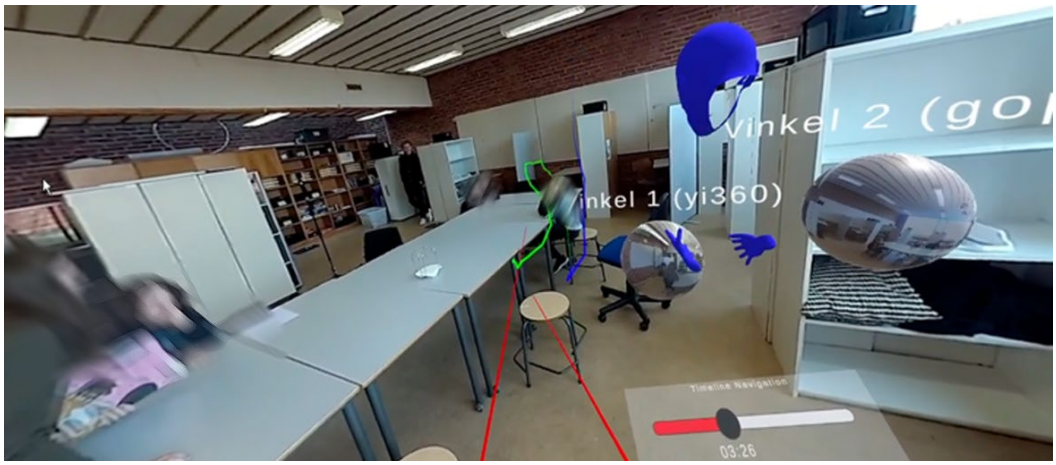

Figure 5: Pointing with colour-coded lasers (blue/green).

Identification and analysis of actions is a key part in building new understandings and reflecting upon classroom management strategies. Studies of programmed VR found that teachers struggled interacting with the virtual avatars representing the students in these spaces due to their lack of facial expressions and bodily conduct (Chen, 2022; Kugurakova *et al.*, 2023; Wang and Li, 2024). In CAVA360VR, the interactivity of being able to implement strategies on virtual students is traded for the ability to better notice what is going on in the classroom due to the immersive nature of 360-degree video, giving participants access to the students and their complex interaction in the classroom. Giving access to this complexity is then also what necessitates the use of collaborative learning strategies, with different experiences levels providing different perspectives, allowing the newly qualified teacher to further their noticing and reflection competencies. The core of the digital learning space is then the ability to jointly notice, identify and conceptualise classroom management strategies in order to discuss past and future strategies.

4.3 Abstraction – Furthering the Understanding

As participants begin co-constructing a shared understanding of the clips, they begin moving into the abstraction phase, putting their analysis into perspective by building categories. Across the sessions, 5 overall categories have been identified, to which participants compare their co-constructed understanding of the clips in order to develop and/or challenge it: (1) other scenarios / clips from their teaching or other VR sessions (2) theory, typically classroom management theory and principles (3) the team of teachers surrounding the classroom practice, e.g. "have you talked with [teacher X] about it, how do they experience [student Y]" (4) personal experiences that may impact their understanding of how to perform classroom management (5) the teaching profession as a more general notion for establishing the teacher's role when doing classroom management.

The primary actions taken during this phase is the movement between phases. The movement allows participants to go back to analysis and identify certain actions, and then move back into abstraction in order to develop and/or challenge the shared understanding of the classroom practice beyond the micro-level. Wang and Li (2024) urged researchers to develop theory driven training designs for VR training. Creating a digital learning space which affords a clear abstraction phase by allowing participants to jointly pause the classroom interaction, creating a shared reflective space within the noticing-space allows for theory to play a core role in identifying and analysing classroom management strategies, as this space is not bound by a need for action, but can be prolonged for as long as participants wish and need. Creating this 'space within a space' by pausing, effectively freezing the classroom practice around the participants, stands in contrast to current approaches, where e.g., Seufert et al. (2022) make use of pre-service teachers conducting individual VR training and then following up in groups outside of VR. Here, the use of shared reflection during the activity allows for participants to repeatedly move between noticing / reflecting / discussing, instead of the shared reflection being a follow up activity, allowing participants to actively keep engaging in establishing shared understandings of the complex scenarios.

4.4 Actionability – Transforming Practice

While abstraction is one way for participants to develop and/or challenge their co-constructed understanding, participants are also able to move into the actionability phase, transforming understandings into actionable knowledge for transforming future practices. In this phase, the colour coded laser trail takes on another role. While in the analysis phase it was used for identifying and marking actions in the recorded classroom practices, it here becomes a tool for jointly imagining actions that are not present in the video. These actions either take shape as *alternative past actions* or *possible future actions*.

Alternative past actions entail imagining alternative actions that could have been taken in the situation that participants are currently watching. This is made visible through e.g. "if I had stood over there when moving my hand up instead, then…", while using the laser trail to visualise an imaginary trail of movement from the initial position in the recorded classroom to the suggested alternative position. Future actions are aimed at imagining and discussing actions that could be taken in future situations, e.g. "next time, if I encounter such a situation I could…". Here the laser is used more loosely for imagining actions, and not necessarily tied to the actions in the recorded clip. When discussing future actions, participants also move into an *implementation* sub-phase, negotiating how to best implement the actions. Here, the laser is again used as a shared tool for establishing joint-attention and imagining actions. This sub-phase is important for adjusting the implementation of e.g., more direct body language with what the supervisor deems as best practice in a more general sense, and what the newly qualified deems as the best practice in their own classroom practice.

In programmed VR environments, real time feedback can aid training by showing a direct output of selecting e.g., a certain classroom management strategy (Chen, 2022). In CAVA360VR, direct manipulation of the classroom is not possible due to the format being tied to a video recording. Here, the real time feedback is then provided by another teaching professional, who due to their own noticing can provide both an alternative perspective on the clip, but due to the experience of the supervisor, also provide feedback on the possible future implementation of actions, drawing on both theoretical knowledge and practical experience. As shown in the context subphase, this feedback will always be tied to the specific teaching context, and therefore possibly also more actionable, as strategies are tied to specific classroom practices of the newly qualified teacher.

4.5 Summing up – Moving Back into the Classroom

Summing up the constructed knowledge into more condensed understandings is a process that occurs both inside VR at the end of each clip, as well as something that is facilitated in the debriefing sessions, where the participants are presented with a storyboard on a printed sheet, showing a screenshot from each clip and a text

box. Participants are then asked to jointly note down the central theme of each clip, allowing them to summarise and re-establish their joint understanding of the situation. The newly qualified teacher then keeps the sheet after the session, with the goal of supporting transfer and transformation of knowledge from VR to the debriefing, and from debriefing to future classroom practice through reification of the co-constructed actionable knowledge.

5. Participants' Experience of Shared Reflection in Multi-User 360VR

At the end of the debriefing participants were asked to reflect on their experience with multi-user VR. Participants highlighted the realistic and immersive nature of the format, and how the shared experience allows for identifying and applying multiple perspectives on specific situations, which may exemplify larger themes. Participants expressed that CAVA360VR allows them to dynamically shift between looking at the specific actions and their broader implications in order to qualify future actions, which aligns with the three phases of analysis, abstracting, and actionability. During the second and third debriefing, the iterative process was also highlighted, with participants detailing the transformation of their teaching practices.

In one example, during the first selection phase, one of the teachers chose a sequence from their teaching that exemplified their wish to become more direct in their use of body language when communicating with students. In the VR session, the teacher and the teaching supervisor analysed the existing use of body language, abstracted it to other scenarios, and negotiated a strategy for implementing the knowledge in practice. In the following recording and selection, the teacher noted that they had tried being more direct. In the accompanying VR session, the analysis was centred around the new actions, comparing it to the clips from the previous sessions, and negotiating minor adjustments in the use of body language. This example shows the iterative nature of facilitated reflection in CAVA360VR and how trying out conceptualisations and actions in practice can lead to further reflection and improved strategies.

6. Conclusion

In this paper, we explored how 360-video and multi-user Virtual Reality can support the development of classroom management strategies. The findings demonstrate the transformative potential of immersive technologies, especially in collaborative learning settings using multi-user 360VR, to address classroom management challenges for newly qualified teachers.

Through design-based research, a model comprising four phases (360-degree video recording, clip selection, collaborative VR training, and debriefing) set the foundation for creating a digital learning space that affords participation and shared reflection in identifying and discussing past and future classroom management strategies. Through coding the actions taken by newly qualified teachers and their teaching supervisors in 360VR sessions, we revealed three phases: Analysis, Abstraction, and Actionability, showing an iterative movement between (1) creating shared understandings of classroom management strategies, (2) developing and/or challenging the understanding of strategies by generalising through theory and/or comparing to other situations, and (3) making future strategies actionable.

This study highlights the importance of shared immersive reflective spaces in teacher development, offering both theoretical insights and practical implications. By collaboratively engaging with classroom practices through social immersive technologies, newly qualified teachers may become better prepared for engaging with the complexities of classroom practice.

With our proposed models, we have begun unfolding the potential of 360-video and multi-user Virtual Reality in teacher training. We envision that this format, and the accompanying three A's of analysis, abstraction and actionability may also be explored in other professions in order to help professionals in engaging with complex real-world practises in their transition from education to practice.

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Enhancing Higher Education in Portugal: Leveraging Generative Artificial Intelligence for Learning-Teaching Process

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Abstract: Recent advancements in Generative Artificial Intelligence (GAI) have revolutionized numerous fields, including higher education. This study focuses on the integration of GAI in Portuguese higher education institutions and explores its multifaceted implications and potential. Our research, conducted through a comprehensive survey between April and June 2023, engages with higher education faculty to understand their perceptions and utilization of GAI tools in teaching and learning processes. The potential of GAI to enhance personalized learning and interactive teaching methodologies is significant. It enables the creation of customized educational content, interactive simulations, and real-time feedback mechanisms, thus reducing the educators' workload and enhancing the learning experience. However, this integration is not without challenges. The study identifies critical ethical concerns around the use of GAI, including issues related to data privacy, intellectual property, and the potential for bias in AI-generated content. Additionally, our findings indicate a varying degree of acceptance and readiness among educators to adopt these technologies. While some express enthusiasm for the potential of GAI to transform educational practices, others remain cautious, highlighting the need for comprehensive training and support to fully leverage GAI capabilities. This paper captures the essence of the study's findings, which illustrate both the promising opportunities and the complex challenges associated with the use of Generative AI in higher education. By addressing these challenges and fostering an informed and ethical approach to GAI integration, higher education institutions can significantly enhance teaching and learning landscapes.

Keywords: Generative AI (GAI), Higher education, Personalized learning, Ethical implications, Educational outcomes

1. Introduction

Major recent breakthroughs have been reported in the field of generative artificial intelligence, which has significantly impacted the AI status quo. GAI systems are part of machine learning, deep learning, and natural language processing systems that generate content forms across texts, audio, videos, software codes, and simulations. These systems require a considerable amount of data to be fed into their systems of deep neural networks to recognize patterns in multimedia and create new materials based on the principles of probability.

As Shanahan (2022) noted, Large Language Models (LLMs) are "generative mathematical models of the statistical distribution of tokens in the vast public corpus of human-generated text, where the tokens in question include words, parts of words, or individual characters including punctuation marks. They are generative because we can sample from them, which means we can ask them questions." All these models have been trained on colossal human text, which enables them to generate natural language text using statistical and information-theoretic methods and machine learning.

These features in the evolution of LLM demonstrate how they can be interacted with by people through prompts for free text, thus predicting a new era that may be especially relevant in higher education to professors and students. Although some guidance in the writing process is possible through some of the existing tools, the introduction of this tool, which can replace the writing process creatively, represents a paradigm shift and provides new ways to improve learning and teaching. GAI, using DL and NLP techniques, can autonomously create learning materials, quizzes, and interactive simulations for each student, leading to deep involvement in the topic and understanding and personal performance in the topic of a learner without heaping more load on professors. These educators can be relieved of some duties by automating the grading, providing real-time feedback, as well as supporting administrative and pedagogical tasks. GAI has countless potentialities in education, promising a horizon full of new possibilities for the future of learning.

However, despite all the bright promises of GAI in education, there has yet to be a debate about the issues of trustworthiness, credibility, and comprehensibility of its outputs. This discussion claims that further research

should be careful, particularly in education (Crawford, Cowling, and Allen, 2023). Further, the broad adoption of GAI in higher education prompts questions and serious concerns associated with ethics, including algorithmic bias, data privacy, and the ownership of intellectual property rights. We would have to introduce GAI into education with a very responsible and ethical approach that would allow the benefits to be fully gained and the potential drawbacks to be averted.

The present paper aims to adapt GAI to higher education institutions in Portugal. The online survey period was conducted from April 1, 2023, to June 30, 2023. The collected data were subjected to descriptive and inferential analysis processing by IBM SPSS 29.0. From the identified perspectives of the teaching-learning activity, the frequency and purpose of GAI utilization by higher education instructors are identified, as is the identification of trends and future application of GAI in academia. It is also true that, for the adaptation of this idea to GAI in higher education institutions in Portugal, this research tries to base a theoretical framework to guide strategic options regarding the improvement of educational practices. This infers that GAI has the capability to significantly revolutionize methodologies to be applied in teaching-learning process but touches more on ethical considerations that all educational technologies based on AI are used in a way that is just and fair.

2. Background and Related Works

It belongs to the subclass of Maching Learning (ML) models and generates new data points within a given dataset by learning its structure and distribution. Applied to various fields such as image synthesis, natural language processing, and music composition, it has become the center of attention more often (van den Oord et al., 2016).

However, due to the wide prevalence and ever-evolving character of GAI, there remains a need for some articulation regarding its definition and the mechanisms of operation. GAI can produce text, images, video, music, and complex, sophisticated human-like content. These systems are designed to detect and mimic patterns, styles, and structures they are presented with. However, the primary concern about biases in the training processes is reliance on data quality and subjectiveness. The models might pick up human biases that are unnoticeable to them and affect the outcome. Furthermore, the training process generally exposes individuals to the harmful elements of the Internet. More so, the welfare of such individuals who might be involved in annotation and data refinement raises ethical concerns.

Since 1980, artificial intelligence began to enter education, changing the direction of the use of technology in educational practice. (Sleeman and Brown, 1982). Now, AI consists of machine learning, neural networks, and natural language processing techniques, among all other ways of simulating cognitive processes in human beings (Akgun and Greenhow, 2022). Luckin (2017) argues that AI can substantially contribute to personalizing student and teacher learning. Using other technologies has made machine learning a mainstay in AI, enabling less dependency on human intervention.

The applications are very different from each other: they range from product recommendations to disease detection. In education, meanwhile, the infusion of AI offers insights into student progress and solutions to learning disparities. There has been considerable attention paid to GAI regarding the next step in ML capabilities since the early 2010s, as it allows the development of new content based on input. There is growing interest in integrating GAI into the educational process. Despite the exponential growth of such tools, research regarding teachers' perceptions of integrating Generative AI tools, such as ChatGPT, within curricula is still at the periphery. Understanding teachers' attitudes towards such technologies is vital in the process of their incorporation into the educational system. This area thus calls for more investigation.

GAI is considered a novel, fast-evolving domain poised to impact higher education with new opportunities and challenges on multiple dimensions. Therefore, the scope of this literature review is to synthesize recent research findings and identify key themes and group papers to draw an overview of GAI's impact on higher education. In this sense, he built a search string and used it in the Scopus database: with a search period from 2022 to date, it obtained only 31 papers on "Generative Artificial Intelligence", "Higher education", and "teaching". However, the total results amount to zero when the expression "Portugal" is added to the search string. So, this section discusses the findings from the analysis of 31 papers located globally. The paper analysis identified five clusters: awareness, adoption, and usage of GAI in higher education; pedagogical implications and educational benefits; ethical challenges and academic integrity; student perspectives and engagement; faculty training and professional development.

GAI Awareness, Adoption, and Usage in Higher Education: Most research work by different researchers across the globe, for example, (Yusuf, Pervin, and Román-González, 2024; Alammari, 2024; Umme et al., 2024),

reiterates an increasing trend in awareness and intention to use GAI tools on the part of educators. Survey data show readiness and motivation on the part of educators to adopt GAI as it is likely to be a high potential area for collaborative learning, professional development, and personalized methodologies in teaching. However, the literature regarding this fact is lacking, and therefore, more empirical research studies are needed to fully exploit the effect GAI might have on teaching and learning (Bannister, Urbieta and Peñalver, 2023).

Pedagogical Implications and Educational Benefits: In their works, Koh et al. (2024), Salinas-Navarro et al. (2024), and Billingsley and Gardner (2024) demonstrate that GAI will genuinely enhance the teaching and learning experience through the adoption of new pedagogical strategies, new forms of authentic assessment, and new ways of personalizing learning. This general artificial intelligence will benefit second-language learners and bilingual students by improving language acquisition and fostering educational growth.

Ethical Challenges and Academic Integrity Ethical challenges are another recurring concern in most literature on GAI in HE. For example, (Bozkurt, 2024; Sullivan, Kelly & McLaughlan, 2023; Moya & Eaton, 2023). If academic integrity, plagiarism detection, and AI model bias are vital concerns, then transparent integration guidelines and practices in the ethical use of AI are required. To fully realize GAI, one must be careful about ethical implications and ensure compliance with copyright laws.

Student Perceptions and Engagement: Student input is one of the most profound inputs in altering the outlook for implementing GAI tools within higher education (Chiu, 2024; Yang et al., 2024; Lemke et al., 2023). Studies have noted the reinforcement of learning outcomes, student agency, autonomy, and seeking feedback behaviors. It is recommended that the student's mindset be considered and that a focus on investing in AI skills in teaching be made to develop student engagement and academic success in the environment.

Faculty Training and Professional Development There is a need to play a significant role in meeting the successful integration of GAI with faculty readiness and digital competencies through professional development (Eager and Brunton, 2023; Kohnke, Moorhouse, and Zou, 2023). Promoting professional development initiatives designed to enhance teaching effectiveness, build confidence, and ensure secure ethical AI-based practices. All integration attempts must be guided by institutional values and pedagogical considerations to harness GAI's benefits in higher education fully.

In conclusion, the literature on the impact of GAI within higher education describes a dynamic field of promise, challenges, and ongoing research activities. While GAI offers great promise to transform teaching and learning experiences by addressing ethical concerns, promoting student engagement, and supporting faculty development, responsible integration in higher education settings is essential. Further research is needed to explore the many implications of GAI entirely for future inquiries in this evolving field.

3. Methodology

This article is based on a sample of 77 individuals who are teachers and/or researchers in higher education. The information was collected online through a questionnaire with the title “Characterizing the use of generative artificial intelligence applications in higher education in Portugal”, from April 1, 2023, to June 30, 2023. With this sample we wanted to find out which IAG applications are most used in the teaching-learning process and for what purpose, how often they are used to carry out a series of tasks and the perception of control in the use of IAG. To answer these questions, the data collected was processed using IBM SPSS Statistics 29.0. The statistical analyses used was reliability analysis (Cronbach's alpha), descriptive measures (mean, standard deviation) and graphical representations (bar and boxplot), Spearman correlation coefficient, nonparametric Chi-square independence test, Kruskall-Wallis test with Dunn's test for multiple comparisons and Mann-Whitney test.

4. Results and Discussion

Of the 77 participants included in this study, 59.7% were male, while 40.3% were female. Participant’s age varied significantly, covering a wide range, from 25 to 89 years, with an average age of 51.56 years. As for educational level, the majority of participants, 83.1%, have a PhD, 14.3% a Master's degree, while only 2.6% have a bachelor's degree. Further analysis revealed the diversity of the participants' educational backgrounds. Around 16.9% of the individuals have a degree in the exact and natural sciences and 28.6% in engineering and technology. The social sciences represent a substantial proportion of the sample, with 35.1% of participants identified as belonging to this area. In addition, 10.4% of participants have a background in the humanities. The remaining participants are distributed among other unspecified areas.

Figure 1 shows the percentage of use, in the teaching-learning process, of each of the tools indicated in the questionnaire. The most used tool is ChatGPT (70% of participants) followed by QuilBot (21%), ChatPDF (14%) and BingChat (12%). It should also be noted that 16% of the participants in the study also use other GAI tools not indicated in the questionnaire.

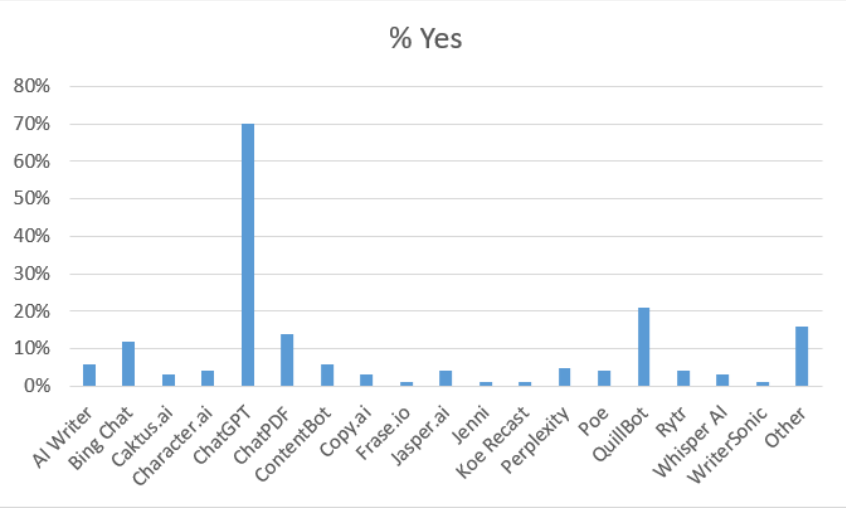

Figure 1: Bar for tasks in which GAI is used in the teaching-learning process.

Regarding the objectives for generative AI applications, Table 1 shows the percentages of use/non-use of these tools for carrying out nine tasks. The results obtained show that most participants use the GAI tools for "Idea generation" (67.5%) and "Explaining concepts" (54.5%), with 45.5% of participants use for "Brainstorming", 40.3% for "Find sources", 33.8% for "Resource generation", 37.7% for Proofreading, with lower (although higher than 15%) usage percentages for "Feedback and evaluation", "Generating presentations" and "Citing and formatting".

Table 1: Frequencies of the use/non-use of some tasks

	Explaining concepts (can simplify complex concepts)		**Resource generation (can create flash cards, review activities, analytical tools)**		**Idea generation (can simulate creative thinking and ideas as a starting point)**		**Feedback and evaluation (can provide instant feedback on work to improve quality before submission)**		**Brainstorming (create ideas or work topics to provide different suggestions or perspectives)**		**Proofreading (create activities to aid better understanding)**		**Generating presentations (can provide suggestions for improving presentations)**		**Citing and formatting (can provide correct references and advice for citing throughout the text)**		**Find sources (can be used to find sources to help with research. Similar to using Wikipedia or Google)**	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
%	45,5 %	54,5 %	66,2 %	33,8 %	32,5 %	67,5 %	83,1%	16,9%	54,5%	45,5%	62,3%	37,7%	80,5%	19,5%	84,4 %	15,6 %	59,7 %	40,3 %

Regarding the degree of agreement (5-point Likert scale from 1- Strongly disagree to 5- Strongly agree) with four statements on academic ethics and intellectual integrity, Table 2 shows some descriptive measures (mean, standard deviation, and quartiles). Cronbach's alpha reliability analysis was used to verify whether the variability of each dimension's items (answers to the questions) effectively resulted from differences in participants' opinions. In this case we obtained a value of 0.915 which is considered excellent reliability.

Table 2: Descriptive measures for questions about academic ethics and intellectual integrity

Statistics				
	Creating content without proper citation, which is unethical and plagiarized	Creating essays or projects without any personal input, which is detrimental to the learning process.	Completing tasks that are beyond their knowledge and understanding and presenting the results as their own, which is considered academic dishonesty	Asking for bibliographical references and not checking their validity and relevance, which is inappropriate.
Mean	4,10	4,09	4,22	4,31
Std. Deviation	1,187	1,248	1,154	1,042

Consulting the table allows us to conclude that the majority of participants totally agree with the statements "Creating content without proper citation is unethical and plagiarized", "Creating essays or projects without any personal input is detrimental to the learning process", "Completing tasks that are beyond their knowledge and understanding and presenting the results as their own is considered academic dishonesty" and "Asking for bibliographical references and not checking their validity and relevance is inappropriate", with the variability of responses being considered low.

Additionally, we can state that at least 75% of respondents concur with these four assertions. However, analyzing the answers to each statement further, we see that 15.6% of the participants disagree or totally disagree with the question "Creating content without proper citation is unethical and plagiarized," 13% with the question Creating essays or projects without any personal input is detrimental to the learning process," 9.1% with the question "Completing tasks that are beyond their knowledge and understanding and presenting the results as their own is considered academic dishonesty," and 7.8% with the statement "Asking for bibliographical references and not checking their validity and relevance is inappropriate.".

To assess the degree of frequency (in a 5-Likert scale from 1 – Never to 5 - Always) with which the participants use generative AI to carry out a set of tasks, a boxplot is constructed (Figure 2). The value of Cronbach's alpha (0.893), which is considered very good, shows the consistency of items.

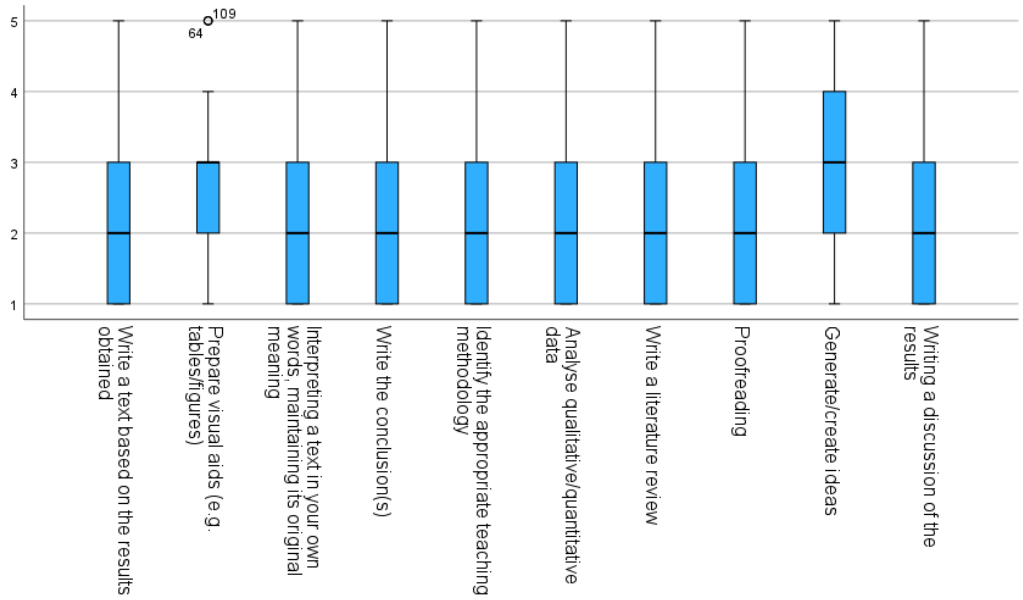

Figure 2: Boxplot for tasks in which GAI is used in the teaching-learning process.

The information resulting from Figure 2 alongside the descriptive measures obtained for these tasks (Table 3) allowed us to conclude that the most frequently used task is "Generate/create ideas," followed by "Prepare visual aids," although they are only used sometimes. All other tasks are mostly marked as "almost never". Also noteworthy in Figure 2 is the occurrence of 3 outliers (participants 64, 9 and 10), who said that they always use GAI to prepare visual aids.

Table 3: Descriptive measures for tasks in which GAI is used in the teaching-learning process.

Statistics										
	Write a text based on the results obtained	Prepare visual aids (e.g. tables / figures)	Interpreting a text in your own words, maintaining its original meaning	Write the conclusion(s)	Identify the appropriate teaching methodology	Analyze qualitative / quantitative data	Write a literature review	Proofreading	Generate / create ideas	Writing a discussion of the results
Mean	2,42	2,57	2,45	2,18	2,43	2,10	2,12	2,53	3,05	2,04
Std. Deviation	1,207	1,186	1,176	1,109	1,163	1,273	1,158	1,304	1,234	1,094

Crossing now the information about the degree to which the participants use generative AI to carry out a set of tasks with objectives for using generative AI applications we obtained Spearman's correlation coefficients (given the ordinal nature of the questions-variables). The results show that there is a strong positive correlation (when the degree of agreement in one variable increases, the other variable tends to increase as well) between the following variables:

- "Write a text based on the results obtained" versus
- *"Prepare visual aids" (rs=0.647)*
- *"Interpreting a text in your own words, maintaining its original meaning" (rs=0.649)*
- *"Write the conclusion(s)" (rs=0.674)*
- *"Analyze qualitative/quantitative data" (rs=0.666)*
- *"Writing a discussion of the results" (rs=0.688)*
- "Write the conclusion(s)" versus "Interpreting a text in your own words, maintaining its original meaning" (r_s=0.748)
- "Analyze qualitative/quantitative data" versus
- *- "Interpreting a text in your own words, maintaining its original meaning" (r_s=0.615)*
- *- "Write the conclusion(s)" (r_s=0.674)*
- "Writing a discussion of the results" versus
- *"Write the conclusion(s)" (r_s=0.693)*
- *"Interpreting a text in your own words, maintaining its original meaning" (r_s=0.677)*

After conducting an exploratory analysis, we want to verify if there are significant differences between some variables according to gender, age or teaching in University/Polytechnic higher education or researcher. To achieve this, we perform Kolmogorov-Smirnov test to determine the normality of some variables. As the hypothesis was rejected, we used non-parametric tests, specifically the Kruskal-Wallis and Wilcoxon-Mann-Whitney tests.

To assess whether there are significant differences between "Explaining concepts" as an objective to use GAI according to Professors (universities, polytechnic) or researchers (two nominal variables) we used Chi-Square test (Tables 4 and 5). The results allow us to conclude that with a significance level of 8%, there are some differences, namely, while most professors (59.2% from university professors and 62.5% from polytechnics professors) use the GAI to explain concepts, most researchers do not (25%). There were only on significant difference between gender and the objective "Brainstorming" for using the GAI (p-value=0.05); the majority of male use GAI with this objective (71.4%) and the majority of female no.

The use of the Kruskal-Wallis test revealed significant differences at the 5% level regarding the frequency of "Prepare visual aids" concerning the variable "Teaching in University/Polytechnic higher education or researcher" (p-value=0.044). A more in-depth analysis using Dunn's test for multiple comparisons concluded that what causes this difference are the answers given by university professors when compared to researchers (p-value=0.012), which is not surprising given that we are assessing the performance of these tasks only in the context of the teaching-learning process. Professors prepare visual aids more often, as would be expected.

Table 4: Contingency table

Explaining concepts (can simplify complex concepts) * Education/Researcher Crosstabulation						
			Education/Researcher			Total
			University education	Polytechnic education	Researcher	
Explaining concepts (can simplify complex concepts)	No	Count	20	6	9	35
		% within Explaining concepts (can simplify complex concepts)	57,1%	17,1%	25,7%	100,0%
		% within Education/Researcher	40,8%	37,5%	75,0%	45,5%
	Yes	Count	29	10	3	42
		% within Explaining concepts (can simplify complex concepts)	69,0%	23,8%	7,1%	100,0%
		% within Education/Researcher	59,2%	62,5%	25,0%	54,5%
Total		Count	49	16	12	77
		% within Explaining concepts (can simplify complex concepts)	63,6%	20,8%	15,6%	100,0%
		% within Education/Researcher	100,0%	100,0%	100,0%	100,0%

Table 5: Results of independence Chi-Square test.

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5,059[a]	2	,080
Likelihood Ratio	5,175	2	,075
Linear-by-Linear Association	3,118	1	,077
N of Valid Cases	77		
a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,45.			

Finally, using the Mann-Whitney test, significant differences are detected (at a significance level of 5 percent) in the degree of frequency with which the GAI tools are used to carry out certain tasks according to gender (Table 6). In particular, "Write a text based on the results obtained" (p-value = 0.003), "Prepare visual aids" (p-value = 0.0439), "Interpreting a text" (p-value = 0.031), "Write a literature review" (p-value = 0.007), "Generate/create ideas" (p-value = 0.009), and "Write a discussion of the results" (p-value = 0.019). In all cases, men use GAI more often to carry out these tasks. For example, for "Write a text based on the results obtained," 41.9% of female never do it, while only 23.9% of male never do it.

Table 6: Results of Mann-Whitney test for degree of frequency of use of GAI to carry some tasks.

Test Statistics[a]										
	Write a text based on the results obtained	Prepare visual aids (e.g. tables / figures)	Interpreting a text in your own words, maintaining its original meaning	Write the conclusion(s)	Identify the appropriate teaching methodology	Analyze qualitative / quantitative data	Write a literature review	Proofreading	Generate / create ideas	Writing a discussion of the results
Mann-Whitney U	434,500	524,000	511,500	549,000	665,500	598,500	467,000	574,000	468,500	499,000
Wilcoxon W	930,500	1020,000	1007,500	1045,000	1161,500	1094,500	963,000	1070,000	964,500	995,000
Z	-3,000	-2,023	-2,161	-1,775	-,509	-1,261	-2,681	-1,487	-2,621	-2,344
Asymp. Sig. (2-tailed)	,003	,043	,031	,076	,610	,207	,007	,137	,009	,019
a. Grouping Variable: Gender										

Finally, when it comes to the participants' perception of the use of GAI, this is identical for all five questions (in a 5-point Likert scale from 1 to 5, strongly disagree to 5 to strongly agree), as can be seen in Table 7. The median for all 5 questions is 4, which means that at least 50% of the participants agree that they have the resources, time, and opportunities to use GAI while doing their job, are confident that they can use GAI to do their job, would recommend the use of GAI to others, and agree that the use of GAI depends only on themselves. The latter, however, is the one with the lowest level of agreement; 27.3% of participants disagree or strongly disagree.

Table 7: Descriptive measures for perceptions.

Statistics						
		The use of generative AI only depends on me	I have the resources, time, and opportunities to use generative AI while doing my job	I am confident that I can use generative AI to do my job	It is beneficial to use generative AI while doing my job	I would recommend using generative AI to others
Mean		3,38	3,51	3,45	3,71	3,74
Percentiles	25	2,00	3,00	3,00	3,00	3,00
	50	4,00	4,00	4,00	4,00	4,00
	75	4,00	4,00	4,00	4,00	4,00

The questionnaire also included an open question, "What impact do, or can generative AI applications have on the teaching-learning process?" and there was a wide range of perspectives. Some people consider that generative AI can simplify time-consuming tasks in a short period of time, facilitate the generation of scenarios and content to support learning, and serve as an assistant in the work of preparing teaching activities and interacting with students to enable self-study. However, there are concerns that generative AI could block creativity, increase the risk of false conclusions or misleading learning, and even complicate the teaching-learning process. Some believe that the impact of generative AI can be both positive and negative, depending on how it is used, and emphasize the importance of incorporating AI responsibly into educational work. There is also an emphasis on the need for critical analysis and care when using generative AI as a tool to support teaching. In addition, there is mention of the need to consider ethical issues associated with the introduction of AI tools in the academic context, such as privacy, data security, and proper governance. Training and sensitization of professors on the ethical use of AI are also highlighted as important.

Overall, it seems that there is a growing awareness of both the positive and negative potential of generative AI in higher education, and there is a recognition of the need for a cautious and informed approach when integrating this technology into the educational environment.

5. Conclusions and Future Work

The study presented in this article shows the transformative potential of GAI in the panorama of higher education in Portugal. As evidenced through comprehensive surveys and statistical analyses, GAI applications are increasingly integrated into educational environments, providing substantial benefits such as personalized learning experiences and interactive teaching methodologies. Thus, based on the results obtained, these tools improve the teaching process and actively involve students, promoting a more interactive and responsive learning environment. However, the integration of this technology raises ethical concerns, such as data privacy, the integrity of academic results, and the potential for bias in AI-generated content. These issues require regulatory measures on the part of higher education institutions to take advantage of GAI's benefits and mitigate its risks.

According to the study carried out regarding the implementation of Artificial Intelligence Generating tools in the teaching-learning process, the GAI tool most used by the participants is ChatGPT. Regarding the objectives for generative AI applications, the results obtained show that most participants use the GAI tools for “Idea generation” (67.5%) and “Explaining concepts” (54.5%). The majority of participants totally agree with the questions about academic ethics and intellectual integrity. Moreover, the most frequently applied tasks in which GAI is used are "Generate/create ideas," followed by "Prepare visual aids," although they are only used sometimes. Crossing the information about the degree to which the participants use generative AI to carry out a set of tasks with objectives for using generative AI applications we found some strong positive correlations. We also concluded that are significant differences between gender and the objective “Brainstorming” for using the GAI; the majority of male use GAI with this objective (71.4%). Within the tasks where GAI is used, with

relevance, in the teaching-learning process, it was found that regarding the frequency of 'prepare visual aids', there are significant differences depending on whether the participant is a professor or a researcher – professors tend to use more. Finally, we detected significant differences in the degree of frequency with which the GAI tools are used to carry out certain tasks according to gender (men use GAI more often to carry out these tasks).

Some people consider that generative AI can simplify time-consuming tasks in a short period of time, facilitate the generation of scenarios and content to support learning, and serve as an assistant in the work of preparing teaching activities and interacting with students to enable self-study. There is also an emphasis on the need for critical analysis and care when using generative AI as a tool to support teaching. In addition, there is mention of the need to consider ethical issues associated with the introduction of AI tools in the academic context, such as privacy, data security, and proper governance. Training and sensitization of professors on the ethical use of AI are also highlighted as important.

As future work, several areas require further exploration to understand better and optimize the use of GAI in education: Longitudinal Studies to assess the long-term impacts of GAI on educational outcomes and student engagement. This will help us understand the sustained effects of integrating AI into learning environments. Expand research to include diverse educational settings and demographic groups to determine the varying impacts of GAI in different contexts. Implement targeted professional development programs to equip educators with the skills and knowledge necessary to use GAI tools effectively. This includes training in ethical considerations and technical proficiency. To summarize, although the GAI presents significant opportunities to revolutionize the education sector, carefully analyzing its challenges and potential pitfalls is essential. By addressing these concerns and focusing on sustainable development, the GAI can significantly contribute to the evolution of higher education, making learning more accessible, personalized, and efficient.

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Digital Skills' Impact on the Use of Digital Learning Tools

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Abstract: Innovations and developments in the ICT sector drive significant changes in how higher education institutions (HEIs) execute their teaching and learning processes. HEIs have always succeeded in the implementation of ICT tools for the facilitation of the process of teaching and learning. However, they have faced many challenges related to using these tools. Various tools have been introduced, not only for teaching and learning but also for socialisation. These tools include social media tools that are used to achieve different activities in response to the demands of society. Social media, however, is more utilised than digital learning tools, causing major concerns because users appear more interested in social media tools to perform academic activities than in digital learning tools. Students entering the university spaces are often comfortable using their phones but less comfortable using laptops or PCs. These, however, are the primary devices used in digital classrooms at institutions of higher learning. The basic ability to use them is crucial in succeeding in today's digitised e-learning classrooms. This study investigates the impact digital literacy could have on using digital learning tools in HEIs. The study employed quantitative research methods using a survey developed and distributed to university alums to assess their digital skills upon entering their studies and how this impacted their learning experience. The participants were recruited from two public universities and one private university in the Eastern Cape. The purpose of the study was to formulate a checklist, based on the analysis of the data collected, that will inform the digital literacy factors impacting the use of digital learning in HEIs. While the study acknowledges that different students have different learning needs, it was still possible to create a solution through the suggested checklist consisting of eight (8) interventions developed to guide universities in improving the use of digital learning tools in their institutions.

Keywords: Digital skills, Digital learning, Blended learning, Learning management system, Information and Communications Technology

1. Background

Information Communication Technology (ICT) has progressed rapidly, affecting all areas of life. The education sector is not immune to that progress with the advent of learning tools and systems that facilitate learning and teaching (Sharma, 2020). These systems are intended to improve the educational process by providing easier note-taking techniques, improved knowledge creation, accommodating all learning styles, and giving access to updated content and quick delivery of lessons (Irgashevich, 2020). All educational institutions started using some form of technology-enhanced teaching and learning for major and minor educational activities (Tatnall, 2020).

While education changes have been driven by ICT changes, social interaction and behaviour have been impacted significantly, with Social Networking Sites being the main force behind this (Osatuyi & Hiltz, 2019). Social Media (SM) has become the fastest-growing technological tool globally for communication, collaboration, and knowledge sharing (Joshi, 2019). SM is used by individuals across all income levels (Ahmad et al., 2019), and success stories include affordability, low cost, and the advantage that online communities can learn through digital connectivities (Hammerl et al., 2019).

South African institutions of higher learning were at the forefront of social media activism in 2015 and 2016 when student protest action, known as #FeesMustFall, took place nationwide. It was almost solely organised and arranged through SM (Ntuli & Teferra, 2018). Universities moved closer to digital teaching technologies after realising how easily face-to-face classes can be disrupted. These protest actions caused some institutions to close for more than eight weeks.

However, it was not until all institutions faced a further crisis during the COVID-19 pandemic, when they suddenly switched from traditional face-to-face classes to fully online classes, that digital learning spaces became a reality for all universities in South Africa. A study of this digital learning gateway suggested that the relevant digital learning skills needed by the learners to learn efficiently and effectively were lacking (Mulenga & Marban, 2020).

This paper focuses on the digital literacy skills of students in South African HEIs and the impact of the use of digital teaching tools.

2. Problem Area and Research Question

This paper is part of a larger study that identified various factors impacting the use of digital learning tools at universities. One of these factors was the digital skills level of first-year students, as South African students are often not exposed to computers before entering university.

The research question to be considered: (i) what is the impact of digital literacy on the use of digital learning tools? (ii) What interventions can be taken to improve the use of digital learning tools?

3. Literature Review

In order to fully engage with this research, a literature review was done that included Social Media benefits, barriers, and students' use of it. Then, the teaching and learning landscape in South Africa was reviewed, with a focus on traditional and digital learning. Digital learning refers to electronic means of learning, including learning management systems (LMS) and other digital learning tools such as e-books, multi-media courseware (videos, podcasts), and online classes, such as MS Teams and Zoom.

3.1 Social Media

Relying on social media for knowledge acquisition and sharing has become popular because of the capabilities that SM provides to users. These include knowledge acquisition, such as marketing skills, improving business skills, and knowledge sharing by connecting with business partners and mentors (Perreira, 2021). SM has also created the opportunity for businesses, politicians, and SM influencers to communicate effectively through real-time engagement and the sharing of documents and multimedia files (Dimitrova & Matthes, 2018; Spina, 2019). According to Brands, Graham and Broersma (2018), SM has become popular because it has benefits in various fields, including community platforms that allow incident reports to be shared within the community, which is helpful to family and friends and large organisations that use these platforms to engage with colleagues or external workers (Nyaribo, 2018).

SM, however, comes with its barriers. These include fake accounts and fake news that can cause panic and institutional risk (Baccarella, 2018; Etter et al., 2019). Privacy concerns are also raised since personal data is required for many SM platforms. This data can be used maliciously or without consent (Anderson, 2019), as people may not be aware of the associated risks (Bada et al., 2019).

Some higher education institutions incorporated SM into their policies and integrated it into their educational processes due to its effectiveness and use by students and teachers (Mirembe, 2019). Many students today use SM to engage in social matters and informal learning opportunities (Ogbomo, 2019). Considering SM's benefits and use among students, universities are looking at ways to implement SM to boost academic performance (Farinloye et al., 2020). SM only benefits students who are conscious of technology and willing to learn and collaborate with their peers by finding ways to use technology to facilitate their learning (Ma, 2018; Darvishi, 2020).

While many benefits are associated with students' use of technology (Farinloye, 2020), some lecturers are still against students using their cell phones in classes because of the perceptions that the devices cause a distraction from learning, which could cause academic failure (Kauser & Awan, 2019; Diba et al., 2019).

SM has been involved in making radical changes in many areas. The use of SM by students and the impact it can have was evident in the #FeesMustFall movement in 2015 and 2016, where the SA government found itself having to comply with the demands of students (Ntuli & Teferra, 2018; Gwaze et al., 2018). The #FeesMustFall movement revealed social injustices in HEI that resulted in a change in the support provided by the government to HEIs as well as a free/subsidised higher education for students whose households were within a specified income bracket (van den Heever & Rensburg, 2018).

3.2 Teaching and Learning Landscape

The South African teaching and learning landscape consists of public and private institutions. There are also some disparities within public schools and universities, mainly experienced in rural schools that are not well-funded and supported by the government. This paper focuses on higher education institutions in general and will not distinguish between private and public universities.

3.2.1 Traditional learning and teaching

The traditional learning and teaching approach involves a classroom setting, learning and teaching material, and a lecturer with a background in the subject (Mitchell & Sutherland, 2020). Face-to-face teaching has been fading rapidly over the last few years due to technological advancements that have brought new and improved teaching and learning methods (Mitra & Beenen, 2019).

Several drawbacks in the traditional teaching and learning method are evident in today's information age, including being misaligned with how learning takes place, influenced mainly by the ability to work as a team, innovative thinking, and critical thinking, among others (Xiao & Watson, 2019). It is also believed that the traditional teaching approach is more teacher-centred than student-centred and that students tend to forget concepts quickly as the lecturer is more engaged in the activity than the student (Al-Balushi et al., 2020; Sumanasekera et al., 2020).

The traditional teaching method does have some benefits that are often overlooked due to the popularity of digital teaching technologies. These include building solid relationships with lecturers and peers, developing social interaction and communication skills, and improving self-confidence (Machmud, 2020).

3.2.2 Digital learning

Digital learning aims to improve learning and teaching by implementing technological learning tools to improve the classroom and the distance learning experience (Pohjonen, 2019). It is seen as one of the most effective ways to deliver and facilitate teaching and learning; however, it is only applicable if implemented correctly (Nalini, 2020). Digital learning does not simply mean moving processes to an online environment and ensuring that all aspects are appropriately adapted to function effectively online.

HEIs provide a rich space to implement technological learning and teaching innovations. However, a lack of suitable strategies limited its use, with few HEIs successfully implementing mobile learning (Alrasheedi & Capretz, 2018). Despite this, the rapid changes in technology have greatly impacted learning and teaching, which in turn have had significant positive effects on the teaching and learning experience (Bayler & Oz, 2018).

A combination of face-to-face teaching and learning using digital technology is bridging the gap in the understanding of modern learning and teaching. This blended learning approach is being widely used to incorporate self-regulated learning by selecting the learning methods that are most compatible with the student's learning styles and involves some customisation and personalisation while also including face-to-face lessons (Vanslambrouck et al., 2019; Montgomery et al., 2019). Blended learning must follow a formal systematic approach to successfully handle processes, technology and face-to-face learning (Rahim et al., 2020). Digital learning in this study refers to using learning management systems (LMS), multimedia coursework (videos, podcasts), and online classes conducted through platforms such as Zoom and MS Teams.

3.2.3 The effects of #FeesMustFall and COVID-19 on South African universities

The resulting free or subsidised access to higher education from the #FeesMustFall movement meant that many South African matriculants from impoverished backgrounds had access to further studies. The benefit of removing this financial barrier highlighted the digital divide in the classroom.

The abrupt closure of institutions worldwide during the COVID-19 pandemic necessitated the transition to online learning to salvage the academic year. This sudden shift placed lecturers and students in a challenging situation, unprepared for the digital literacy skills required for online learning and teaching. After the pandemic, it was realised that the traditional face-to-face teaching and learning approach was not the only viable option for students and educators. As a result, most universities adopted a blended learning approach.

In the context of universities, this approach to learning and teaching was hindered mainly by the persistent digital divide and unequal access to technology (Mashau & Nyawo, 2021). A study at the University of KwaZulu-Natal (Lembani et al., 2020) highlighted the common barriers students from a disadvantaged background experienced upon entering university. These results corresponded with other researchers, including poor participation, limited technology, lecture preparedness, and lack of personal teaching and learning styles (Aziyona & Nhedzi, 2021). Other challenges include technological failures such as computer crashes, the loss of valuable data, and a lack of backups, which may be related to a lack of ICT skills (Lohr, 2021). In South Africa, technophobia, a term that refers to a dislike or fear of technology, is an additional negative factor associated with developing countries and rural areas (Dintoe, 2019).

3.3 Questionnaire, Sampling, and Data Collection

The literature review on the digital landscape informed the development of factors that influence the use of digital learning. The participants were Nelson Mandela University alums from the last six years, as they would have most likely used digital learning technologies. The data collection was done through an anonymous survey conducted in QuestionPro. The online survey was anonymous, and because alums completed it, there was no power relationship in play.

The paper focuses on the digital literacy factors that impact the use of digital learning technologies. These were categorised into digital readiness, ease of use, and ease of improving competency.

4. Results

The statistical report revealed that the total number of participants is 52. The level of education indicated that three participants (5.8%) had earned certificates, 25 (48.1%) had diplomas, and 15 (28.8%) had Bachelor's degrees. Nine (17.3%) participants had postgraduate degrees. The largest representation, 65%, in terms of the age of the participants was in the range of 20 – 29 years. The participants' gender was almost equally split, with 52% male and 48% female. The participants' experience with digital learning showed that 50% had less than three years of experience.

The survey showed that the participants' evaluation of their experience with using digital learning systems was mostly (58%) as a novice or frequent user.

The participants' digital learning usage was measured daily and weekly. 48% of participants indicated that they used digital learning at least three times a week, while only 10% indicated that they used digital learning daily. The participants were asked about their skills in using digital learning tools, their ease of using them, and their ability to learn to use them.

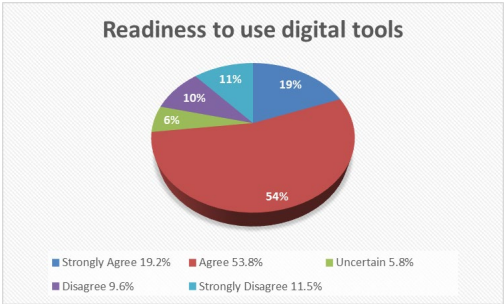

Figure 1: Readiness to use digital tools

Figure 1 indicates that 53. 8% of the participants strongly agreed that they are ready to use digital learning tools and that they find them easy to use. 51.9% agreed that developing and growing their competency in using these tools was easy. The participants were also asked about their university experience and digital readiness to use the tools in the modern digital classroom. They were asked to respond to their perceptions of their lecturers' and classmates' experiences with digital learning tools.

A comparison of the participants' experiences when they entered university reveals that they had very different experiences than in the following years. Figure 2 shows that only 26.9% of students felt ready to use digital learning tools. Furthermore, they agreed that only 34.6% of their classmates were digitally prepared.

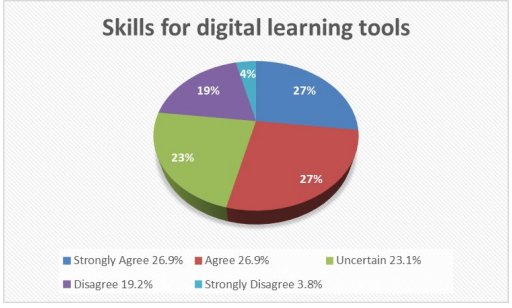

Figure 2: Digital readiness at university

These experiences starkly contrast with the 53.8% confidence the participants have in using digital learning tools. It is concerning that 30.8% agreed, and a further 23.1% strongly agreed, that their lecturers did not possess the digital skills to implement the tools required in a digital classroom.

40.4% of students feel they were given sufficient time to use the digital tools, suggesting that the university recognises the inadequacy of staff and students' skills. The university can play a crucial role in bridging this skills gap by compensating with more time. As recognised by Shadiev and Young (Shadiev, 2020), this intervention could significantly enhance the successful implementation of digital learning technologies.

The response regarding the availability of support for digital learning showed that 38.5% of students agreed there was sufficient support. This was in line with the literature review, which found that ICT support for digital learning is always available in most institutions (Ebner, 2020). In summary, the results indicated that the digital skills level of first-year students impacts their use of digital learning tools.

4.1 Findings and Suggested Interventions

4.1.1 Digital skills

Digital learning can only work well if the key users are adequately equipped. This study revealed that staff and students were unprepared for the digital classroom. Participants felt that they were not the only ones experiencing difficulties and agreed that most of their classmates were experiencing similar challenges. The less exposure to digital skills for staff and students, the higher the need to increase digital literacy and classroom readiness. Institutions need to ensure that there are proper systems to gauge each individual's digital skills level so that those lacking sufficient skills are identified early enough for customised interventions to be implemented. The intervention must be student-focused and have a component for staff to improve their digital skills requirements.

4.1.2 Digital learning tool competency development

According to He and Li (He, 2019), digital learning is better understood when one learns it informally. Students who spend more time on digital literacy skills grow their ability and competence in understanding and using digital learning tools. Since 51% of the students felt that they could easily develop their digital learning tool competence, it is important to ensure that the digital learning competency needs are evaluated and tested (Munoz, 2020). Lecturers who lack skills for teaching online can improve through training, while those who lack skills for using technology can start by looking for an improvement in that area (Perry, 2021).

4.1.3 Time and support for digital learning tools

Good digital skills enhance digital learning competency. Thus, staff and students must be provided sufficient time to improve their digital skills before interacting with digital classroom technology. These are two separate types of skills and higher education must understand them. Thus, not only should there be a focus on teaching digital literacy skills and digital classroom technology skills, but there should also be a distinction in training staff and students so that the unique skills required for both groups are recognised.

4.2 Suggested Way Forward

Table 1 has been formulated to address the interventions recommended for the impact of digital skills on the use of digital technology. The aim is not to focus only on factors that negatively impact the use of digital technology but also to ensure that factors that impact the use positively are elevated.

Table 1: Suggestions to improve use of digital learning tools

Intervention	Details
1. Digital skills evaluation program	Put in place a digital skills program for students and staff to evaluate the skills gap of each individual.
2. Self-evaluation	Students and staff should be able to perform a self-evaluation.
3. Digital skills course	Create a digital skills course to help upskill in the areas that lack sufficient skills.
4. Pedagogically sound material	Lecturers to be sent for material development course
5. Informal learning of digital literacy skills	Foster digital literacy into the curriculum of all modules and advocate for an informal learning environment.
6. Digital learning ease of use	Ensure that a simplification of user interfaces on digital learning systems.

Intervention	Details
7. Digital competency and literacy development	Ensure enough time to engage with digital learning systems.
8. Digital competency support	Ensure enough support to engage with digital learning system challenges.

Table 1 provides eight possible interventions that higher education institutions in South Africa could adopt to improve the use of digital learning tools. These suggestions include pre-evaluating lecturers' and students' digital skills so that a customised training plan can be followed to upskill in areas lacking competency. Furthermore, a suggestion is made for a self-evaluation tool to be used, which is less intimidating than sitting in a class and taking a "test." Enhancing one's digital skills assists with a greater uptake of digital learning tools.

The same type of assessment would also be valuable to determine which skills are lacking for the use of digital learning tools. A customised approach to becoming upskilled in the relevant areas can be followed. To facilitate the uptake and engagement of the required training material, digital literacy skills must be incorporated into all modules so that their value is appreciated. It is also important to make the training and upskilling programs interesting, and gamified training should be considered. The required time and support must be provided at all times to ensure that individuals involved in the training feel confident that they are supported in each step towards successfully using the tools required in a digital classroom.

5. Conclusion

The paper set out to determine the impact of digital literacy on digital learning tools. Data was collected as part of a bigger study, through literature reviews, and via a survey distributed to alums from Nelson Mandela University who completed their studies between 2018 and 2023. The participants' responses showed that the student's learning experience as first-time entering students was challenging, and only 26.9% of students indicated that they possessed the digital skills required to use digital tools when they arrived at the university. While students indicated that it would be easy to learn the digital skills required to use digital technology in classrooms, they also stated that their lecturers often did not possess the required skills. The results confirm that universities must create learning opportunities to upskill their staff in digital literacy before they can use digital teaching tools effectively. They also confirm that often, students entering university do not have the level of digital literacy expected to engage successfully in the digital classroom. Universities, therefore, have to consider how to improve this. Various suggestions were provided in this paper, such as digital skills evaluation programs followed by digital skills improvement courses.

Future studies should evaluate the interventions over a full academic year, using pilot groups of students whose progress can be monitored. Lecturers should also be evaluated and upskilled to ensure they have the digital skills to effectively use digital learning tools in the classroom. This can also be tracked over a full academic year, where the lecturer can demonstrate improved digital skills and proper use of digital learning tools.

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Enhancing Reusability Practices in Massive Online Open Courses

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Abstract: Over the past decade, the emergence of Massive Online Open Courses (MOOCs) has profoundly transformed the distance learning landscape, capturing the attention of both higher education and professional institutions. This surge of interest has not only spurred the development of innovative teaching and learning methods but has also led to a re-evaluation of content production and reuse strategies. In fact, when producing MOOCs, multiple resources and efforts are dedicated to creating a considerable amount of learning material. This is often housed within the learning environment, which serves as a sort of repository and it is accessible by learners throughout the course. However, due to a lack of management support or internal organisational structure, the use of this material sometimes remains limited to the existence of the MOOC, causing it not to be actively employed and exploited after the course has ended. Lately, issues regarding MOOCs' content management have raised critical questions about the long-term sustainability, reusability and management of the created online learning material even after the end of the online course. By using as a case study the three interlinked MOOCs on European History, Law and Governance developed in the framework of the KU Leuven programme in European Studies and the effort invested in both the planning and afterlife of the MOOC, this paper provides an overview of the formulas adopted to enhance learning content reusability. Drawing from KU Leuven's extensive experience in creating humanities-focused MOOCs, this collection of interconnected online courses represents a novel attempt at offering a series of educational courses that are designed to complement each other not only in terms of content but also in terms of content management. Also, by contributing to the discussion on MOOCs' reusability this paper intends to emphasise the importance of establishing clear guidelines to enhance educational content reuse, ultimately contributing to the long-term educational value of MOOCs.

Keywords: E-learning, Distance learning, Digital sustainability, Reusability, Massive Online Open Courses (MOOCs)

1. Introduction

Since their first appearance in 2011, Massive Open Online Courses (MOOCs) have represented a paradigm shift in the landscape of distance learning education, offering new opportunities not only for learners coming from any part of the globe but also for educators, higher education institutions and also companies interested in the development of new pedagogical business models (Zhang et al., 2016). Subsequently, and especially during the COVID-19 pandemic in 2020, the uptake of MOOCs and the number of enrolled users increased significantly, resulting in a renewed proliferation of MOOC offerings (Steinberger et al. 2023). Therefore, MOOCs have undeniably played a pivotal role in expanding learning possibilities on a broad scale by offering a wide range of distance learning options. Besides the initial enthusiasm, the hype surrounding the "MOOC revolution" has also sparked a range of differing views on broader aspects related, for instance, to the completion rates of learners and the value of MOOC certifications compared to traditional, in-person learning programs (Zhu et al., 2018, Gu et al. 2021). Moreover, in this context, while factors like enhancing the learners' engagement, adopting pedagogically successful strategies, and integrating MOOCs into higher education programs have been subjects of debate since their inception, less attention has been paid to the *life-cycle* of MOOCs or their "afterlife". What happens to MOOCs after their original use has been exploited? Debates on challenges related to the reusability and sustainability of online courses developed and adopted by higher education institutions (HEI) have in fact been somewhat overlooked (Steinberger et al. 2023).

MOOCs are generally employed by educational institutions for a multitude of purposes and scenarios. In addition to their traditional use as part of standalone platforms (such as Coursera, edX, Khan Academy, etc.), MOOCs are frequently integrated into existing curricula and educational programmes. This integration can occur in various ways, such as by adopting MOOCs as equivalent replacements for traditional courses or by incorporating MOOC content into the classroom or as supplementary material to enhance student's learning (e.g. in preparation for future classes or programs) (Steinberger et al. 2023). However, often, the content created for a MOOC becomes obsolete and remains unused and unemployed after several iterations of the course over the years (Billsberry, 2023). This can be often attributed to the inability of the learning institutions to perform consistent updates of the material or the absence of an effective and consistent MOOC content-reuse plan or even to constrained budget. However, these potential scenarios pose significant questions about the necessity for higher education institutions, aiming to integrate MOOCs into their curricula, to devise a robust sustainability plan that facilitates not only widespread course reuse but also guarantees impact (Pérez-Sanagustìn et al. 2017). A further factor that has been brought into focus in recent debates surrounding online courses is the current lack of openness

originally associated with MOOCs, whereby access to these courses is not contingent upon fees or requirements. Concerning that, a necessity has been stressed for bringing up the concept of Open Education Resources (OER) (Butcher, 2015) in relation to MOOCs and to introduce updated approaches to open access, whereby the availability and reusability of content are facilitated for both educators and learners (Ruipérez-Valiente at al. 2020)

In line with these considerations, this research aims to share and discuss the reusability methods employed within the context of the joint MOOCs development initiative, which was undertaken by three different KU Leuven faculties. In particular, the research focuses on the development of a strategy for the management and sustainability of MOOCs. Furthermore, this investigation aims to contribute to the ongoing debate surrounding the enhancement of MOOC sustainability in the higher education sector.

2. Case Study: The European Studies MOOCs

In 2021, the unit of European Studies at KU Leuven undertook a joint educational project involving the faculties of Arts, Social Sciences and Law. The primary goal of this initiative was to create three integrated Massive Open Online Courses (MOOCs), tailored to two specific learner groups:

- Prospective or current students aiming to enrol in the KU Leuven Master's programme in European Studies;
- Individuals seeking to broaden their understanding in one of the research areas covered by the online courses;

The MOOCs were developed and launched in September 2023 on the KULeuven's edX platform - KULeuvenX[1] - and intended to provide a comprehensive but still interconnected learning experience for all participants. In fact, they not only intended to highlight a variety of domains within the realm of European Studies (namely European History, Society and Culture, European Governance and European Union Law) but were also designed to be educationally interlinked while maintaining their own identity in terms of content.

From a conceptual standpoint, the online courses aimed to provide a comprehensive analysis of Europe from a historical, legal, and institutional perspective. They are structured around a series of modules, which address specific topics within the fields of European History and Culture, European Governance, and European Union law. Further attention was also given to the pedagogical methodology. Also, are conceived not only as a traditional learning environment that enables participants to expand their knowledge on the topic but also as a space for personal growth. Learners are encouraged to apply their newly acquired knowledge through a series of focused exercises, readings, video conversations, practical examples and the presentation of currently relevant case studies. This process not only encourages the immediate application of the knowledge gained but also encourages the questioning of previous habits and assumptions and the understanding of how to face new challenges. Furthermore, participants are invited to not only build their comprehension of a series of concepts (such as the role of Europe in the context of modern and contemporary history, or the legal and institutional framework of the European Union, etc.), but also to engage in active discussion with other participants through dedicated discussion forums within the learning environment.

2.1 Rationale and Educational Framework

Despite the multiple experiences of KU Leuven in producing humanities-oriented MOOCs, this can be considered the very first set of combined distance learning courses entirely produced on the basis of internal collaboration among different faculties. From an organisational and educational perspective, the MOOC implementation structure was primarily established through cooperation between the educators (mainly academic staff from the three represented faculties) and three collaborators who managed the internal communication and implemented/adapted the learning design. In addition to ensuring pedagogical alignment and harmonisation across the MOOCs, each of them was responsible for the implementation and coordination of its respective learning environment as well as for ensuring the development of a sustainability plan to be implemented after the first iteration of the MOOCs. As to ensure the flexibility of the three MOOCs both from an educational and reusability point of view, they were developed and designed with a dual purpose in mind. The intention was that they would function as three independent learning entities, each offering a distinctive learning experience that

[1] https://www.edx.org/school/kuleuvenx

could also be followed as three interlinked MOOCs. They therefore were incorporated into the KULeuvenX Professional Certificate in European Studies: History & Culture, Law and EU Governance[2].

This approach, which intended to guarantee more flexibility in terms of reusability of the material/content for each of the MOOCs, required an adapted learning design which was based on two main educational approaches. Each MOOC's learning environment was conceived to be used in a hybrid context and suitable for students with different backgrounds and needs. In fact, the content produced was not only intended for a distance learning context -as is the case for all MOOCs produced and hosted on the edX platform- but also conveyed for reuse and inclusion in blended learning academic courses. Also, their environments were designed to facilitate not only student interaction and engagement with the content but also educators' self-employment of the content.

3. Designing the Learning Environment

The initial phases in the MOOC development process are typically characterised by the definition of comprehensive educational and learning strategies, usually adopted to optimise and facilitate the learner experience (Phan, 2018). These tasks, require a significant investment of resources and are essential for facilitating the learner's engagement and participation throughout their learning path. However, the design of a MOOC learning structure that is both engaging and smooth may prove challenging, depending on the specific features of the chosen hosting platform, the number of educators involved, and the overall complexity of the project.

These challenges emerged also during the implementation of the three European Studies MOOCs and were mainly related to the use of edX as a hosting platform. In fact, like other MOOC hosting platforms, edX does not provide substantial support to educators during the content design process, offering assistance only during the course implementation phase. To face these issues and ensure a smooth but still coherent development of the course's learning environments, we decided to adopt and re-adapt for our purposes the ABC learning design approach, a model originally developed by Dianne Laurillard in 2011 (Laurillard, 2011) that spread especially during the COVID-19 pandemic when education institutions were necessitated to reinvent themselves turning their -originally- academic live courses into digital courses (Young et al, 2016).

While the ABC Design approach was originally developed with traditional academic courses in mind, we identified the potential to leverage it to develop edX MOOCs. The storyboard utilised during the ABC Design session was, in fact, modified and adapted to align with the structure of all edX MOOCs, (which is composed of modules, sections, and units). For this purpose, a collaborative Excel sheet was created, comprising a set of virtual storyboards that reflected the number of modules in the MOOCs. These storyboards were used to recreate the entire learning structure of each module through a set of learning activities derived from the ABC design methodology (practice, acquisition, inquiry, discussion).

Moreover, the collaborative storyboard was expanded to include further details related to the specific type of learning activity, the type of material to be utilized, the status of completion, and the name of the instructor responsible for creating that particular item. These learning theories, together with concrete reusability proposals, were then implemented during recurring meetings where the educators were supervised by learning designers in sketching their own modules. This allowed the educators and learning designers to thoroughly structure each element of the online course based on the type of content they wanted to offer and to think at the same time about the feasibility of reusing the same material. This provided all the partners involved in the MOOC production with the right tools for developing not only a coherent learning environment but also a reusability strategy.

[2] https://www.edx.org/certificates/professional-certificate/kuleuvenx-european-studies-history-and-culture-law-and-eu-governance

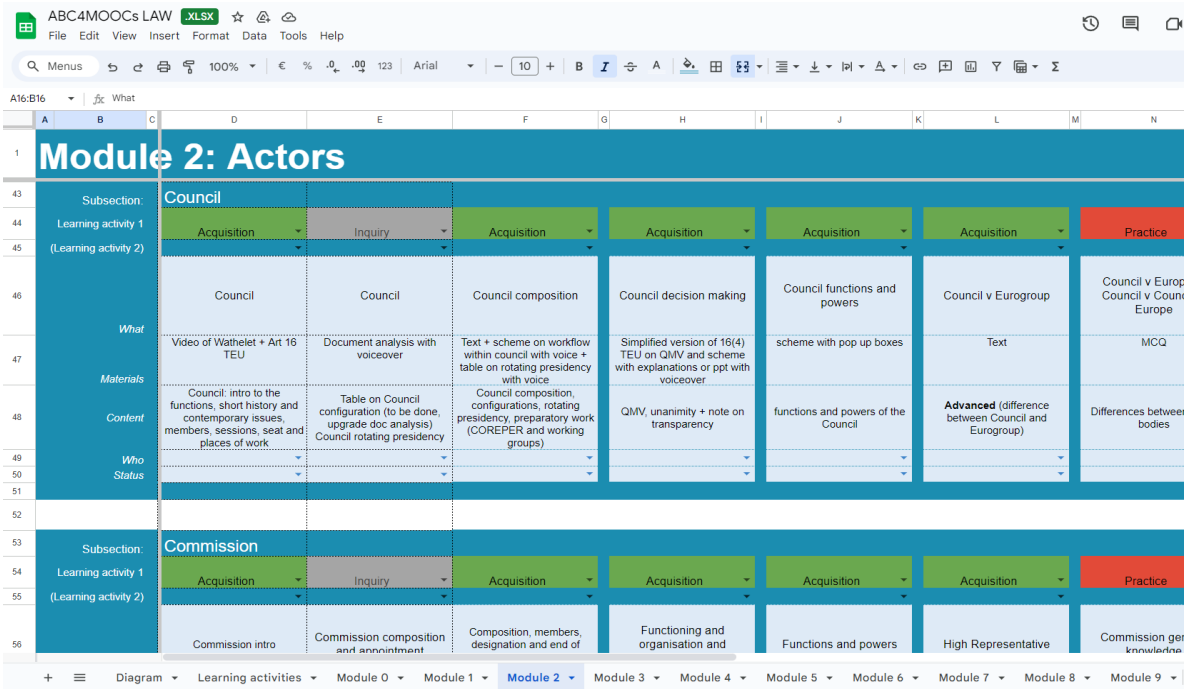

Figure 1: Example of ABC Design virtual storyboard used for the European Union Law MOOC

4. Creating a MOOC Reusability and Exploitation Strategy

The success and lifespan of MOOCs are not uniquely dependent on the quality of the content and the development of a successful educational strategy. They are also determined on effective course management, especially in the period following its initial launch. Additionally, a well-planned strategy for reusing resources in future iterations and adapting them to different educational contexts is crucial. These elements, which are most of the time addressed at a later stage (e.g. when the online course is already finalised and ongoing), represent a critical foundation of the MOOC development process and therefore should be developed in strict connection with the course design plan itself. The absence of a specific reusability plan makes the practical reuse of the course material, and therefore the long-term existence of the course itself, a challenge.

These aspects were thoroughly considered during the design process of the three European Studies MOOCs and established the basis for their development. The aim of the three MOOCs was in fact to exploit the many potentialities of a distance learning environment not only by creating an engaging, autonomous learning experience but also by leaving space for the further reuse and educational evolution of the course itself and the material/content produced. In particular, the following educational-related aspects were considered when developing the reusability/sustainability strategy for the European Studies MOOCs:

- **Flexible learning structure:** Each MOOC is composed of a series of modules that can be followed both singularly as well as part of a trajectory. This allowed not only for flexibility in learning and teaching but also facilitated the reusability and therefore sustainability of the material.
- **Modularity:** Although the sequence of modules is harmoniously structured and the following of a certain order is suggested, each module is also designed to exist independently of one another. This modular structure also allowed students to give priority to learning pathways that are relevant to them and their needs;
- **Self-paced**: Rather than an instructor-led experience, the MOOC provided a student-paced environment that prioritised individual learning;
- **Downloadable material**: To enhance accessibility and reusability, all video materials are downloadable. This allows learners to engage with the content offline and at their own pace.

4.1 Exploiting the MOOC

The implementation of three interlinked MOOCs in European Studies was carried on together with a comprehensive examination of the potential applications of these MOOCs outside the scope of the edX platform. The MOOCs were originally designed with the academic programmes of KU Leuven in mind, making it clear that the most rational approach would be to focus on repurposing these online courses within the academic

landscape. However, we were equally committed to keeping the door open for future possibilities of leveraging the MOOCs for additional purposes. In light of these considerations, we decided to formulate an exploitation strategy that incorporated the following elements:

- **Use of micro-credentials:** A novel trend observed in the academic business model, particularly in European universities, is the emergence of a micro-credential system.[3] Currently, the advent of sophisticated digital platforms and learning tools has led to the diffusion of informal learning, which is often disconnected from traditional education. While there is a clear need for a wide variety of job-oriented learning modules, the certification of knowledge and skills acquired in such a way is also crucial. For universities, there is a clear reason to facilitate the transition from partial, specific learning components to certificate degrees. Micro-credentials are expected to play an important role in facilitating this transition, as they have become an increasingly important part of the MOOC environment and are linked to more official and formal academic learning pathways (Parsons et al. 2023).
- **Integration with higher education Learning Management Systems (LMS):** This element includes the potential integration of the three MOOCs or singular MOOC modules into platforms like Blackboard or Moodle. This would not only increase scalability but also allow for their use in individual courses, thereby enhancing the learning experience and the reusability (or adaptation) of the material.
- **Inclusion into blended learning environments**: In addition to being globally accessible on the edX platform for all students interested in the subject matter, the course is also designed to be embedded into a blended learning environment within the context of dedicated courses offered at KU Leuven.
- **Allowing Creative Commons licensing:** The assignment of a Creative Commons licence to the course content serves to enhance the promotion of open knowledge sharing, while also significantly simplifying the process of reusing the content in diverse contexts, including those outside the higher education environment.

5. Conclusions

This paper presents the reusability approaches applied during the creation of three MOOCs for the European Studies programme at KU Leuven. It also discusses the challenges associated with developing sustainable online courses in the context of higher education. In particular, we conducted a detailed examination of the strategies employed in the creation of the three MOOCs in European Studies. By adopting this case study as an example we argued for the necessity of greater attention to be paid to the issue of reusability, particularly at the earlier stages of course development.

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Understanding the Effectiveness of Email Prompts to Online Asynchronous Course Participants

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Abstract: A persistent problem in asynchronous online courses is low user retention. Compared to conventional courses, participants require some form of reward or intrinsic motivation to complete these courses which do not have set deadlines or timetables. To remedy this, many online course platforms will send email reminders to participants registered in the course to prompt them to continue their participation. This study is focused on understanding the efficacy of such practices in motivating students to continue a course they would otherwise neglect or drop. This study focuses on selected courses on the online asynchronous learning platform open.uom.lk. The participants of an online asynchronous Project Management course who had enrolled but not completed the course were separated into two groups; students who enrolled but have not started the course and students who started the course but have stopped for over a month. The students of each group were divided into test and control groups, where the test group was sent prompts by email to continue the course which included a link to the course page Using user activity data from the platform the progress of students over the month prompts were sent, and the month after were analysed, and the efficacy of sending email prompts was calculated. 4.45% of the students from the test group began participating in the course again as compared to 2% of the students in the test group. 32 students (0.7%) completed the course in the weeks during and after the email prompts were sent while none of the students in the control group completed the course. This shows sending email prompts has a positive impact on increasing participation in the course.

Keywords: Online courses, User retention, Email prompts, Asynchronous

1. Introduction

Studies have found that online courses have lower retention compared to traditional in-person courses (Baker et al (2016). This is a common problem faced by all online courses but especially so for free asynchronous courses (Brown et al (2023). Although students are initially enthusiastic when signing up for courses, few continue the courses to completion (de Barba, Kennedy, & Ainley, 2016). Higher attrition rates in online courses could be due to a multitude of reasons: an isolated environment with fewer or no direct prompts from instructors or peers to engage in the course material, as well as individual characteristics of the student that could lead to difficulties in self-regulating their learning (Artino, 2007; Stone and Springer, 2019). Therefore it is vital that educators on MOOCs explore different strategies to support the student's ability to self-regulate their learning (You, 2016).

"Nudging" or prompting students to re-engage in the courses is one such strategy that is explored in contemporary literature on online education. This paper examines the use of prompts in a Project Management course available on

open.uom.lk, is an asynchronous learning platform created by the University of Moratuwa to provide free online courses. Since the launch in 2022, there have been over 270,000 registered users with consistent user activity. After the launch of its flagship course 'Trainee Full Stack Developer', a course that teaches Python programming and web development, was well-received, it was decided to release more courses in a larger variety of subjects.

In June 2023, open.uom.lk launched 'Project Management Skills' which is made up of twelve courses in project management. Since its launch, it has had 17,000 registered students enrolled in at least one of the courses. The focus of this research paper is on the foundational course, named 'Foundations in Project Management' which gives students a basic introduction to the topic of project management. Of all the courses, it has the highest registration rate and participation of the available project management courses. While sending email reminders to course participants to continue the course they have started is a common practice among online education providers, it is not a practice utilised by open.uom.lk thus far.

In a study by Brown et al (2023) they found that using emails to 'nudge' students to engage in the course and activities was effective in increasing the participation in the course. The nudges included both reminders about activities the students had to complete and their progress in the course relative to their peers. In the feedback from the students, there was both positive and negative reception to the nudges.

Some students found it to be a helpful reminder and motivating while others found it demotivating and made them feel overwhelmed by the work they would have to do. They concluded that due to the nature of the online courses students experience a greater degree of isolation and a lack of direction in their studies which can lead to feeling overwhelmed by the course work. The email nudges provided some direction in the steps they will need to tackle their work as well as motivation to continue in the course. Rodriguez et al (2022)'s study takes this a step further, examining the effect of personalized nudges- they found that nudges in general reduced attrition rates and positively impacted student performance and satisfaction. Kay and Bostock (2023) examined the impact of an institution-wide 'Early Alert System' that identified students who were at risk of dropping out, and were subsequently sent an email or text message encouraging re-engagement. The study found that students who received the prompt showed higher rates of re-engaging in the course, and also spent more time interacting with the course content. Further, these benefits were sustained for over a fortnight and resulted in the same students re-engaging and enrolling in other courses unprompted.

Brown et al (2016) suggested the cause of the low retention rate of asynchronous online courses is due to an unstructured environment that can lead to students procrastinating as there are no deadlines and no consequences for not continuing with the course. This suggests a major skill students require is both self-control and time management to thrive in a self-paced environment. A student enrolled in a course may be interested in continuing but may lack the internal motivation required to put in the time and work consistently.

In a study by Zavaleta-Bernuy et al (2022) where they sent email reminders to students in an online course to do assignments, they found there was a moderate increase in the number of students who did the homework assignment but it had no impact on the time they started the assignment.

When surveying students they found that while many students found the emails encouraging other students, who were motivated to do the assignment but were unsure how to make progress felt more stressed by the emails. Additionally, it seems to be a necessity for the emails to be personalized to the student to some degree as emails sent with reminders to start an assignment were found annoying by students who were already doing the course.

In a study of the effect of emails on students' academic performance, Ye et al (2022) found that students who received emails performed significantly better than those who did not as well engage with the course material.

The primary motivation for the study is to improve the participation and completion rates of the asynchronous online courses on the open.uom.lk platform. As is typical of free asynchronous online courses many of the courses, especially the introductory courses have a completion rate of 10% or lower. By observing the user behaviour it is evident many of the students who enroll in the course do not make it past the first few lessons, some not even completing the first lesson. This is more likely due to a lack of motivation or disinterest in the course rather than the course itself being especially difficult. As the courses are both free and have no strict deadlines there are no external motivators for students to complete the course in a timely manner. Therefore this study aims to determine if sending emails to students who are not participating in the course is an effective and minimally invasive intervention to promote course participation that could be utilised.

2. Trends in Learner Progression Through the Course

The Foundations in Project Management is the introductory course in the Project Management Programme released on the open.uom.lk platform in June 2023 . This course was chosen as the subject of the study as, of the courses in the Project Management program it has the highest enrollment and completion rate. The first course released by Open.uom.lk has been available for longer and has a much larger number of enrolled students. It was decided to focus on the Project Management course as the numbers of participants would be a more manageable number, with thousands of participants rather than tens of thousands. Additionally, as the system to send email reminders is not an automated system and requires the emails to be sent manually each time, with sending thousands of emails taking the servers several hours, it was recommended to do the study on a smaller scale.

The student registrations and behaviour of the students was tracked by the Moodle system automatically and recorded in course completion reports. A summary is shown below in Table 1. The reports were downloaded from the LMS and analyzed using Excel.

Table 1: Number students in different stages of progress in the course

Categories	Number of Students
Students enrolled but have not started the course	3205
Student who have completed the course	919
Started but not completed (Inactive for more than a month)	1749
Started but not completed (active within the last month)	379
Total enrolled	6248

The course completions over the months from July 2023, when the course was released to April 2024, before the email prompts were sent are shown in Figure 1. The average completions for each day of the week were calculated by recording the completions each day and then adding together the same weekday and dividing by how many of those days occurred in the measured period. This is shown in Figure 3.

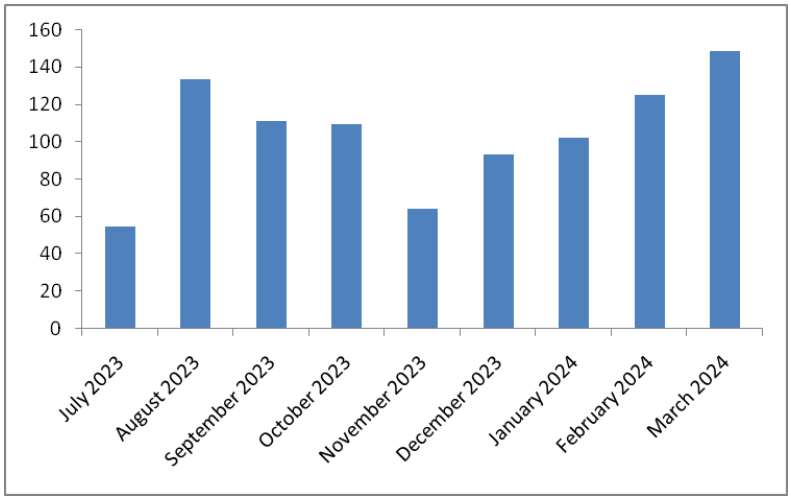

Figure 1: Course completions per month from July 2023 to March 2024

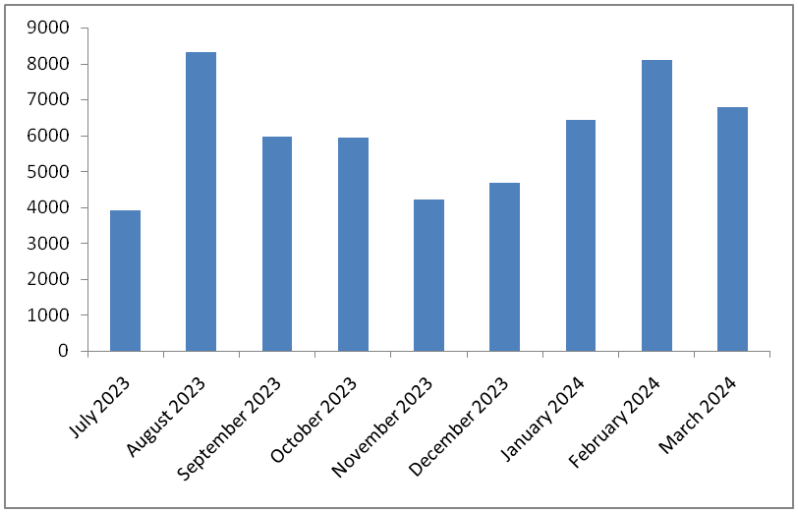

Figure 2: Lessons completed per month from July 2023 to March 2024

3. Methodology

Students who had enrolled in the Foundations in Project Management course but had yet to complete the course were identified from the activity completion reports generated by the Learning Management System (LMS) open.uom.lk is based on. The students were identified into two distinct groups; students who had started the course by completing at least one lesson, and students who had enrolled in the course but had not started it by completing at least on lesson.

The control group was randomly selected from the students from both groups of students who had been inactive for over a month. Due to the relatively small sample size of 4954 students a control group of 5% was chosen to allow the test group to be sufficiently larger to allow the change in behaviour of the students to be easier to measure. It was assumed that while the prompts would lead to some improvement in the participation and course completions the majority of the students would not return to the course.

Emails with prompts were sent to the learners who had not made active progress in the course for over a month. The emails contained text prompts to encourage the learners to continue the course, a graphic containing motivational facts about the course, and a link to the course page. Four emails were sent over 2 months to the learners. Learners were selected based on their inactivity in the course as shown in Table 1. Learners who registered for but had not yet started the course, and Learners who had started but were inactive for more than a month. Over the course of four weeks, emails were sent to the students who had been inactive for over a month. The emails included a reminder to continue the course, a graphic with a motivational saying or statistic about the likelihood of completing the course, and a link to return to doing the course.

An activity completion report which contains details about the activities completed by each student and the date and time on which they were completed was downloaded from the LMS. The activity completion report was downloaded a week after the final email was sent. If the inactivity trend continued even after the emails, they were no longer sent to that student. The report contains data on all the students and the lessons completed from the day the course was launched to the date the report was downloaded.

The results were analysed using Excel. The following criteria were extracted;

the average behaviour of a student, the overall completion rate, the activity completions per day and the course completions per day. It is also possible to determine the average time to complete the course but this is not as important to this study which focuses on primarily encouraging students to complete the course rather than doing so more quickly or within a given time period.

There were 3215 students who had enrolled but never started the course and 1749 students who had begun the course but had been inactive for over a month. A total of 4709 students were sent the email prompts while 245 who made up the control group were not. The behavior of the control group will be used to compare to the test group to see the difference in behavior and if it is influenced by the emails.

4. Results and Discussion

Table 2 summarises the results, and Table 3 gives the analysis of the students in the two categories and their comparison with the control. In the test group 210 of the 4709 students, or 4.45% were active in the course completing at least one lesson in the time after the first email was sent while in the control group there were only 5 active students out of 240 which is 2.08% . These show that the email prompting students to continue the course increased the participation of inactive and less active students. Of the 4709 students in the test group, 4499 remained inactive, either not seeing the email or deciding not to continue the course even after seeing the motivational email.

Table 2: Summary of the Sample

	Test Group	**Control Group**
Active students	210	5
Inactive students	4499	240

Total Students	**4709**	**245**
Percentage of active student	4.45%	2.08%
Total lessons completed	1801	22
Average lessons per active student	8.57	3.14
Course completed	32	0

The data was further analysed as shown in table 3 which further investigated the behavior of the two groups, students who were enrolled but had not yet started the course and students who were inactive for over a month compared to the control group to see if their previous behavior had an impact on how they reacted to the email intervention.

In the test group when comparing students who had begun the course and had since become inactive with students who had not started the course at all i.e. had not completed even one lesson, it is evident that the percentage of students who were previously inactive were more likely to continue the course they started after seeing the email prompts compared to students who had previously not started the course, the percentage of active students being 6.67 % and 3.21 % respectively. This observation is expected as students who had the initiative and interest in the course to complete a few lessons in the course are more likely to continue the course. A similar trend can be observed in the control group where 3.49% of students who were previously active became active after an extended period of inactivity compared to only 1.25% of enrolled but inactive students.

Table 3: Details of the Analysis

	Test Group		**Control Group**	
	Inactive for over a month	Enrolled students who never started the course	Inactive for over a month	Enrolled students who never started the course
Total lessons completed	1079	722	9	13
Average lessons per active student	9.63	7.36	3	6.5
Course completions	23	9	0	0
Students active	112	98	3	2
Total Students	1663	3046	86	159
% Active students	6.67	3.21	3.49	1.25
Lessons completed per student	0.65	0.24	0.11	0.08
Completion per student	0.014	0.003	-	-

As shown in Figure 3 there is a significant increase in the daily lessons completed by students who had previously stopped participating in the course. There are peaks in activity on the day the email was sent or in the days immediately after. Due to the limitations of the mass email function of the LMS it was not possible to

measure how many of the emails were opened and on which days the emails were viewed. The higher levels of activity continued even a week after the last email was sent which is promising. There is a chance that students, after seeing one or two emails got into the habit of doing the lessons and no longer needed external prompts to continue the course.

As observable in figure 3, in the days between March 25th when the students were selected for the study and the first email being sent on April 12th there was some activity where students who had previously been inactive for over a month had decided out of their own volition to continue the course. Even taking this into account as a baseline activity of this group of students it is still far less than the activity of the students after the email prompts were sent. The level of activity during this period is comparable to that of the control group.

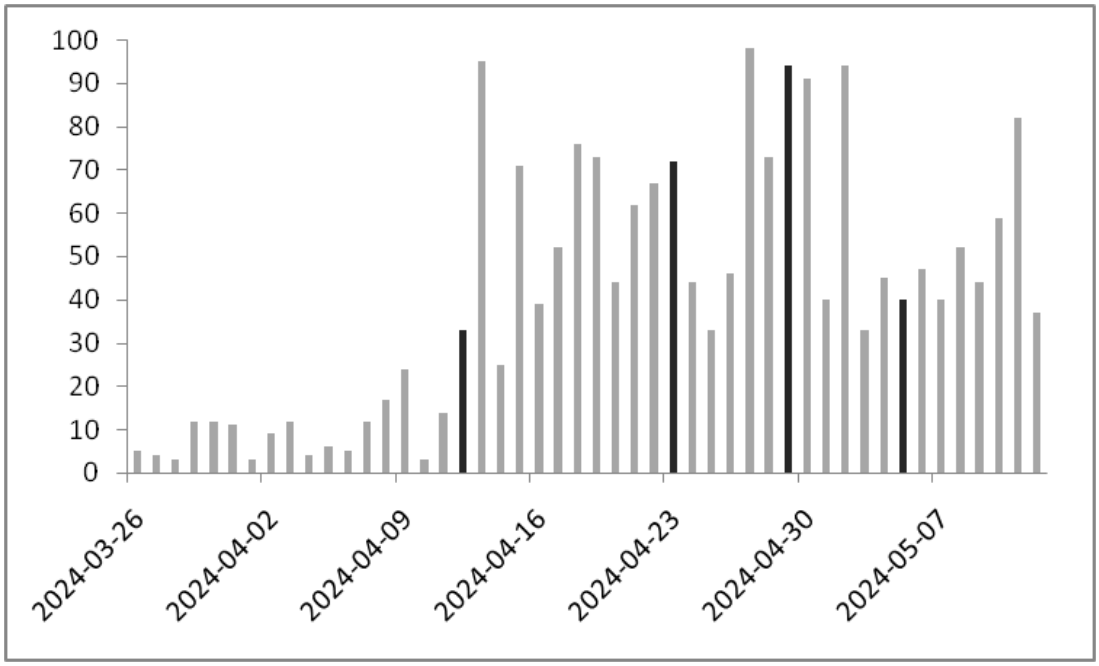

Figure 3: Lessons completed per day. The days highlighted in black are the days the email reminders were sent to students

5. Limitations

Baker et al (2016), stated that students queried and mentioned that constant emails were bothersome. It would also be valuable to know if the motivational nature of the email had an impact on the students wanting to continue the course or if it was simply the reminder and the link to return to the course that was helpful. As the course is free and asynchronous in nature with no deadlines, there is a likelihood the students simply forgot about the course until the email was sent. Identifying a frequency of emails or simply sending an email after a certain length of inactivity rather than in certain time intervals would be more useful.

As none of this essential information could be gathered based on the scope of the current study, it would also be ideal to repeat the study with a larger control as the control group used in the study was relatively small and the results may not be accurately reflective of the behaviour of the population that is not affected by the test.

6. Conclusions and Future Work

This study shows that there is a positive increase in course participation when emails are sent to motivate the students to continue the online course they started or enrolled for but did not start.

This, when compared to the control, can also be identified. While there was some activity of students in the control group it is about half of that from the test group. This shows that a relatively small remedial action such as sending periodic reminders to participants in a course does in fact have a positive outcome on increasing the participation in the course. With this it confirms that sending email reminders to students who have shown little activity in the course for an extended period of time is a good practice to implement by open.uom.lk and is proven to improve course participation and completions.

In between the date the students were selected and the first email was sent, there was some activity with a few students returning to the course after neglecting it for over a month. These could be due to the student's own inherent motivation to continue the course, and not necessarily due to the emails sent as a part of the study.

As future work a longer more in-depth study on the subject matter would be useful, identifying which types of email prompts are most effective and sending a survey to gauge if the students found the emails encouraging or bothersome.

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Human-AI Collaboration: A Student-Centered Perspective of Generative AI Use in Higher Education

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Abstract: The increasing adoption of generative AI (Gen AI) has made it even more important to investigate how education and learning is transformed. The paper investigates the evolving relationship between humans and AI in performing learning and knowledge-intensive tasks. Based on mixed data collected from business school students, the article explores the evolving relationships between human and AI in knowledge collaboration. The article sets out to address how Gen AI usage affects students' behavior, their academic work and their attitudes towards AI. It investigates how students use Gen AI in an academic context to support students' work processes. Our analysis draws on collaborative learning theories and revisits the automation-augmentation paradox in the context of management education. The aim is to address the following research questions: How does collaboration with AI affect student academic work? And how do students in higher education use Gen AI for academic work? We present insights into students' perception of benefits and drawbacks of using Gen AI, their attitude towards Gen AI, knowledge tasks in which they collaborate or delegate to Gen AI and we discuss the potential risks associated with the use of Gen AI. Students are collaborating with AI using ChatGPT for expanding knowledge on academic themes, summarizing concepts, theories, and generating ideas for research topics and methods. Time saving, enhanced productivity and user-friendliness of the tool were identified as the main benefits associated with Gen AI, whereas the risk of plagiarism, its inaccuracy in responses and the need for prior knowledge were identified as the main drawbacks. While our findings underscore the potential of Gen AI to significantly enhance student learning experiences, they also underscore the importance of exercising caution and awareness of associated risks to automate learning. This study seeks to enrich our comprehension of AI's transformative role in higher education, with a specific focus on the student-centered perspective.

Keywords: Generative AI, ChatGPT, Collaboration, Higher education

1. Introduction

The advent of generative AI has opened up opportunities for collaborative relationships to emerge between humans and machines in the performance of knowledge work and learning. AI has gained momentum in education with the development of Generative AI based on Large Language Models (LLMs).

Human-AI collaboration brings new frontiers in the development of knowledge work tasks in teams to support collaborative intelligence (Daugherty & Wilson, 2018), various areas of education including data science (Ellis & Slade, 2023; Molenaar, 2022) journalism and media education (Pavlik, 2023) and self-regulated learning (Järvelä et al., 2023). Since the adoption of AI in higher education is increasing, it is important to explore the consequences of this large-scale adoption for teaching and learning through empirical studies in different country contexts (O'Dea, 2024).

The comparison of Gen AI to calculators is interesting because both tools assist humans in managing cognitive load, but they do so in fundamentally different ways. While calculators offload numerical computation tasks, Gen AI can assist in a broader range of cognitive functions, such as generating content, solving complex problems, and enhancing creativity. Distinctive relationships between learners and machines can be formed. Gen AI can be used for cognitive offloading or as an extended mind (Lodge et al., 2023).

The rise of a new generation of Gen AI tools (AI) (such as ChatGPT by OpenAI, Copilot by Microsoft, Claude by Anthropic, and Gemini by Google) has brought new possibilities to develop (human) knowledge through prompts and interaction with AI. Among the many available chatbots, chatGPT is one of the most popular ones. ChatGPT is an artificial intelligence language model integrating a variant of GPT (Generative Pre-trained Transformer) (Banh & Strobel, 2023). Many recent studies have emphasized the oppportunities of using chatGPT (Kasneci et al., 2023) in generating text that can be difficult to differentiate from that produced by humans e.g. (Stokel-Walker, 2022).

There are at least 10 different roles of ChatGPT in teaching and learning, according to a Unesco report (Sabzalieva & Valentini, 2023). ChatGPT can act as a possibility engine, Socratic opponent, collaboration coach, guide on the side, personal tutor, co-designer, exploratorium, study buddy, motivator or dynamic assessor.

Gen AI and GPTs can be used for language processing creating chatbots or means of automating the production of repetitive or time-consuming tasks (Cotton et al., 2024). Cotton et al. (2024) have written an article about

academic integrity entitled “Chatting and cheating: Ensuring academic integrity in the era of ChatGPT” by providing prompts to ChatGPT. Chatbots offer the possibility to automate cognitive processes associated with the human mind, including problem solving, decision making, and learning. The knowledge and cognitive capabilities” of ChatGPT was tested at American universities, where the chatbot was used to pass academic law and management exams (Kelly, 2023).

Gen AI has brought the opportunity to automate activities that are associated with the human mind by giving the illusion that it can think both humanly and rationally which is one of the long-term goals of artificial intelligence (Russel and Norvig, 2010). AI encompasses a cluster of computing technologies, including intelligent agents, machine learning, natural language processing, and decision-making supported by algorithms (Tredinnick, 2017). Digital platforms increasingly incorporate AI to support communication, knowledge sharing and collaboration (Maedche et al., 2019; Roda et al., 2003). AI has started to play an increasingly important role in knowledge collaboration through facilitation of human-AI interaction in different forms, including AI-based assistants (e.g., chatbots or voice-based assistants (e.g. Siri by Apple, Alexa by Amazon), algorithmic technologies (Kellogg et al., 2020)).

As Gen AI becomes prevalent in learning, knowledge collaboration, decision making and the future of work, it becomes imperative to understand how collaboration with AI will impact student behavior, their agency and their learning. Furthermore, as AI-based interaction, e.g. human-chatbot conversations (Hill et al., 2015)), and different forms of persuasion or content personalization will proliferate, we expect AI will play an instrumental role in the future of education. It is unclear what the long-term consequences will be for management education and learning. The use of Gen AI in academia by students has so far been less explored and how business schools should adapt teaching, learning and exams to the AI age is subject to an ongoing debate (Rudolph et al., 2023). Understanding students’ use and perceptions of Gen AI is essential for understanding the rapid changes associated with the large-scale adoption of these systems (Shoufan, 2023). Moreover, while existing research has predominantly reflected the perspectives of educators, recent studies emphasize the need to consider student viewpoints when assessing the utility of technologies like ChatGPT (Malmström et al., 2023; Shoufan, 2023). This shift suggests a growing recognition of the importance of including learners' experiences and feedback in the evaluation of educational tools.

In addition to understanding how AI is changing student work and learning, the research seeks to contribute to the transformative effects of AI on knowledge collaboration and learning as it raises questions of control, trust, and expertise in the future of AI-enabled work more generally (Benbya et al., 2020). This paper aims to investigate the multifaceted role of Gen AI for learning, and in shaping new forms of collaboration, by focusing on a student perspective.

We take as a point of departure collaborative learning theories combined with an automation-augmentation paradox view adopted recently in AI in management literature (Raisch & Krakowski, 2021) . Automation implies that machines take over or are delegated the human tasks, while augmentation involves a close collaboration between humans and AI on specific tasks (Raisch & Krakowski, 2021). Taking the automation-augmentation paradox as a conceptual starting point, the question is how the competing logics of automation and augmentation will be implemented and deployed in higher education. Augmenting intelligence involves human-machine collaboration in which machines perform what they do best (e.g., computing, doing repetitive tasks) to aid humans in doing what humans do best (e.g., abstract reasoning, creating, and making discoveries) (Paul et al., 2022). Particularly, the aim is to address the following research questions:

How does collaboration with AI affect student academic work? and How do students in higher education use Gen AI for academic work?

2. Theoretical Background

2.1 The Role of Gen AI in Collaboration

Collaborative learning relies on the integration of a collaborative activity within an educational context (Dillenbourg, 1999). Collaborative learning theories emphasize the social aspect of learning and how learning and motivation can be constructed through interactions. In the age of Gen AI, the principles of social constructivism (Illeris, 2018; Mondahl et al., 2009) remain pertinent, emphasizing that learning is deeply embedded within the dynamic interplay of social interactions and individual cognitive processes (Mondahl & Razmerita, 2014).

Traditionally, knowledge collaboration has centered on the sharing, transfer, accumulation, co-creation, and transformation of knowledge through direct human interaction (Faraj et al., 2011). In the era of generative AI, however, the landscape of knowledge collaboration is evolving. It now encompasses a variety of collaborative processes that extend beyond human-to-human interaction to include engagements with AI, such as chatbots. These interactions often involve sharing knowledge, communicating, and contributing ideas through prompts that facilitate a new dimension of collaboration that may substitute human social interaction.

The introduction of AI tools in educational settings brings a new dimension to this interplay, which might enhance the traditional modes of collaboration, including collaborative learning, knowledge sharing, and problem-solving. These AI-enhanced collaborative environments not only facilitate learning processes and adapt to the evolving communicative landscapes that surround learners by making them multimodal and inclusive (Lewis, 2022), but also through hybridity by incorporating the Gen AI learning ability to scaffold human self-regulated learning e.g. (Lodge et al., 2023; Molenaar, 2022; O'Dea, 2024). Learning involves adapting to constant change and can be a challenging process (Hermansen, 2005). The integration of AI into education can create more nuanced and supportive learning experiences, thus easing the 'painful' aspects of learning by providing personalized support, context-aware insights and interactions. AI can support learning processes by providing timely answers and feedback to the students' questions similar to a "study buddy" (Sabzalieva & Valentini, 2023). The concept of trust has been acknowledged as an important element in human collaboration. More recently the concept of trustworthy human-AI collaboration has been developed. The OECD work on AI has outlined five value-based principles for responsible stewardship of trustworthy AI that aim to foster innovation and trust in AI (OECD, 2023):

- inclusive growth, sustainable development and well-being;
- human-centered values and fairness;
- transparency and explainability;
- robustness, security and safety;
- and accountability.

Trustworthy AI is defined as "fully human-centered and aims to offer high levels of human control, with the goal to lead to wider adoption and increase human performance, while supporting human self-efficacy, mastery, creativity and responsibility" (Razmerita et al., 2021).

3. Methodology

The data for this study was collected between spring 2023 (the early adoption of Gen AI) – to spring 2024 and consisted of a mixed method approach. A pre-study consisting of 16 interviews with students was conducted to understand how students use chatbots (e.g. ChatGPT) for academic work, their perception of benefits and challenges in relation to the use of Gen AI and ChatGPT. Qualitative data was also collected from business school students following an initial exploratory inductive approach. An exploratory approach focuses on generating new insights and theories rather than testing existing ones, as there is limited prior knowledge and understanding of the phenomenon. The qualitative interviews were coded for preliminary descriptive themes following an open inductive approach (Myers, 2013). This open approach is exploring new themes or patterns focusing on understanding participants' experiences and their perspectives rather than forcing data to fit into existing theories. Participant involvement allowed their perspectives to shape the direction of the study. The codes of themes covered included knowledge tasks, benefits and drawbacks, which were integrated in the design of the initial survey.

The questionnaire was conducted anonymously. Using a five-point Likert-scale question design provides the respondent with a neutral answer option which is important to increase the measurement reliability (Schutt, 2019). The survey data provides insights into Human-AI collaboration in relation to academic tasks, students' attitudes towards generative AI, including ethical considerations, the perceived benefits and challenges of adoption of chatbots in higher education as well as other AI tools they use. It also includes behavioral data (e.g. performance expectancy, facilitating conditions and behavioral intention) to measure usability and the acceptance of (Gen AI) technology in an educational context (Granić & Marangunić, 2019; Shoufan, 2023).

4. Data Analysis and Results

The final dataset used for analysis consists of 215 complete valid survey responses out of 332 collected answers. This gives us a response rate of approx. 64.8% valid answers. The demographic characteristics (N=215) are available in Table 1.

Table 1: Demographic characteristics (N=215)

Level	Frequency	Percentage
Gender		
Male	85	39.5
Female	129	60.0
Non-binary / third gender	1	0.5
Age		
Under 20	12	5.6
20-25	160	74.4
25-30	41	19.1
Above 30	2	0.9
Education		
Bachelor	159	74.0
Master	56	26.0
Frequency of GPT usage		
Very Often	17	7.9
Often	34	15.8
Sometimes	81	37.7
Hardly ever	52	24.2
Never	31	14.4

The gender distribution in the dataset is fairly even with 60% female and 39.5% male (1% non-binary). Respondents are master and bachelor students from different study programs at business schools in Northern Europe. As represented in Table 1, 74.4% of the respondents are between 20 and 25 years old. 19.1% are between 25 and 30 years, 12 respondents are under 20 years and 2 respondents are over 30 years. In relation to the frequency of use of Gen AI for academic purposes: the majority of students use chatbots only sometimes (37.7%), often (15.8%) and very often (7.9%) while some use it hardly ever (24.2%) or never (14.4%). The survey data emphasized the popularity of ChatGPT, in particular the use of the freeware version 3.5 as Gen AI tool.

An overview of the most important benefits perceived by students, presented in Figure 1, are time saving (M = 4.54 SD = 0.84), user-friendly tool (M = 4.19, SD = 0.95), enhanced productivity (M = 4.03, SD = 0.98), keeping the conversation history (M = 3.95, SD = 1.09), human-like characteristics (M = 3.61, SD = 1.02), improved learning processes (M = 3.61, SD = 1.11), and improved writing quality (M = 3.60, SD = 1.17). The least stated benefits are enhanced creativity (M = 3.36, SD = 1.20), personalization of responses (M = 3.32, SD = 1.10).

A majority of students are using ChatGPT because of time saving: “It saves me so many hours of reading and research” and “it answers anything I ask superfast.” Enhanced productivity is also important as “…it allows me to spend my time more productively and get more things done.” Students associate human-like characteristics with AI as “it feels like talking to an actual person because I can ask questions in a spoken language format, and it understands it.”

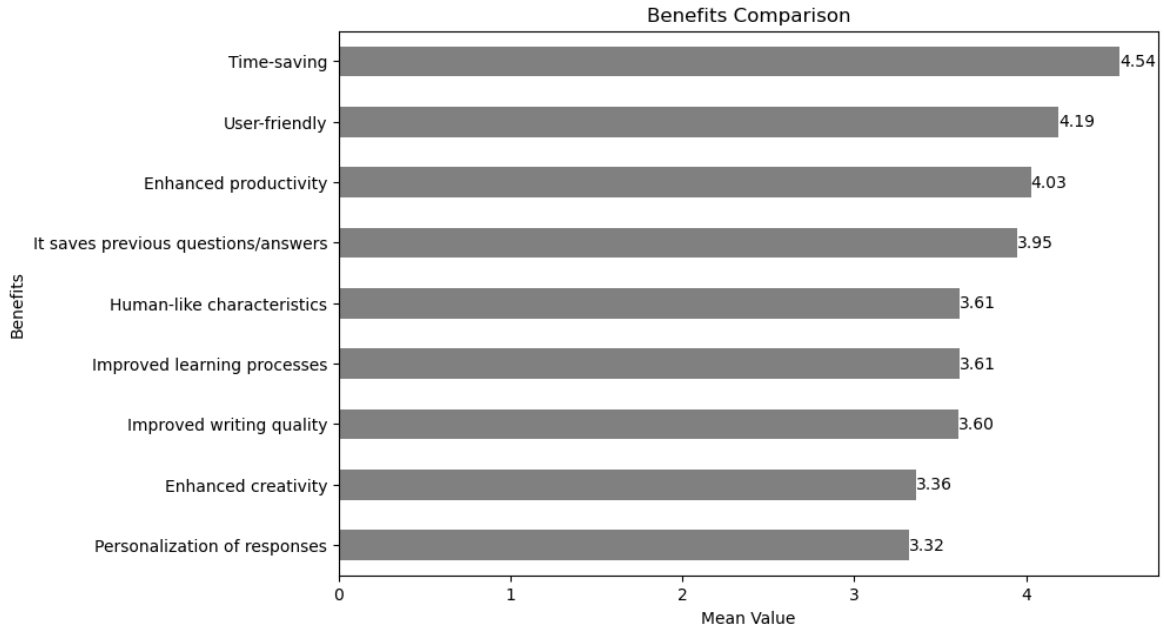

Figure 1: The mean value of participants' benefits perception of Gen AI use (n=215)

The data shows that some students perceived an improved learning process: “for me I feel like it improves my learning and thought process” while for other students it is associated with a loss of learning. For some students the use of ChatGPT leads to enhanced creativity: “it allows to be more creative in a faster way” while others perceived the opposite. “I wonder how much it takes over my own ability to think critically [..] I already feel like I am losing my creativity.”

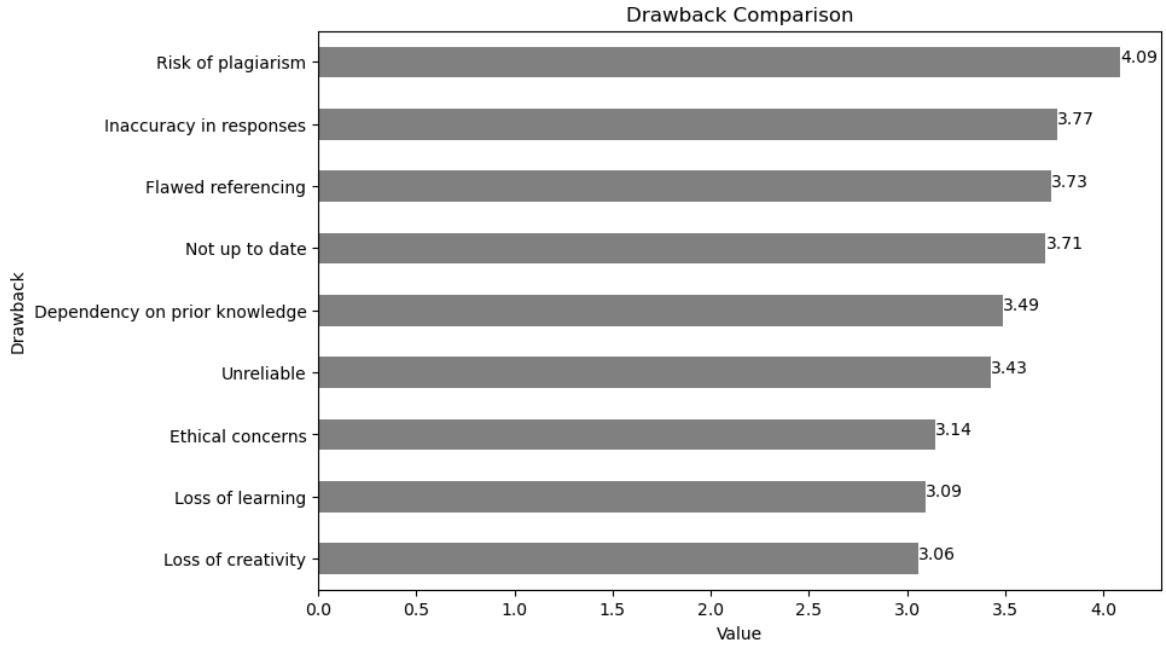

Figure 2: The mean value of participants' drawback perception of Gen AI use (n=215)

The main drawbacks in student-AI collaboration using Gen AI, as represented in Figure 2, are: the risk of plagiarism (M = 4.09 SD = 1.13), inaccuracy of responses (M = 3.77, SD = 1.01), flawed referencing (M = 3.73, SD = 1.11), not up to date in terms of knowledge (M = 3.71, SD = 1.07), dependency on prior knowledge (M = 3.49, SD = 0.99), unreliable (M = 3.43, SD = 1.06), ethical concerns (M = 3.14, SD = 1.25), loss of learning (M = 3.09, SD = 1.29) and loss of creativity (M = 3.06, SD = 1.28). Despite these drawbacks students prefer to improve their productivity and save time. By trying to save time and improve their productivity, students may automate human knowledge processes such as learning, thinking and writing, which can be detrimental for their future work skills.

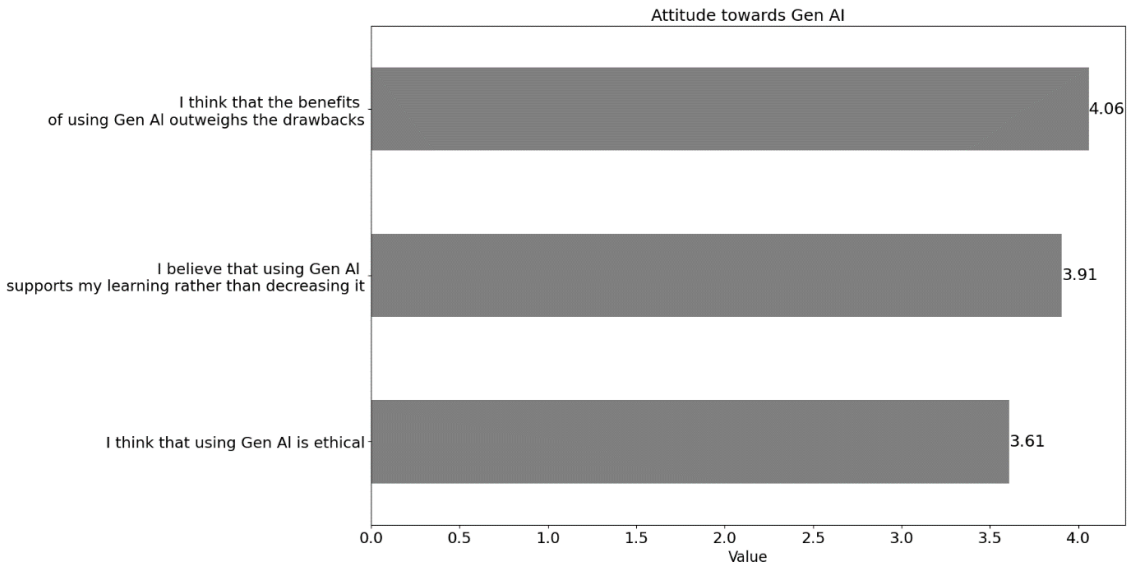

Figure 3: Attitude towards the Gen AI (n = 215)

The students' attitudes towards Gen AI, as represented in Figure 3, are: "I think that the benefits of using Gen AI outweigh the drawbacks" (M = 4.06, SD = 0.99), "I believe that using Gen AI supports my learning rather than decreasing it" (M = 3.91, SD = 1.07), "I think that using Gen AI is ethical" (M = 3.61, SD = 1.03).

An overview of the knowledge tasks involving the use of Gen AI is presented in Figure 4.

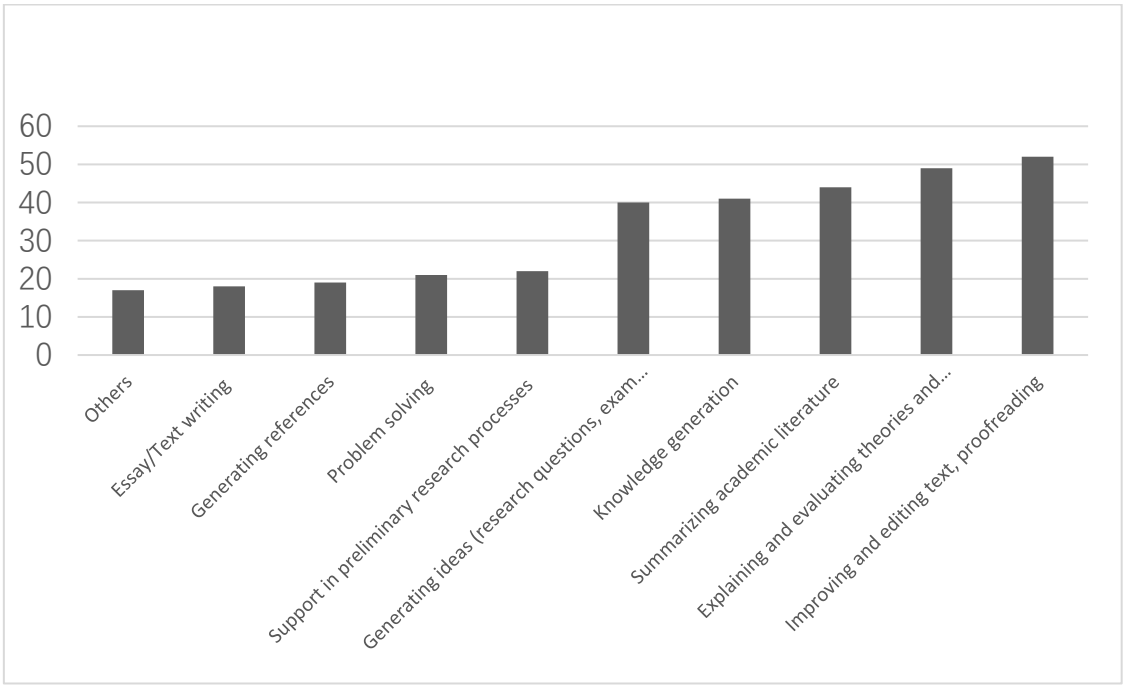

Figure 4: Knowledge intensive tasks associated with the use of Gen AI

Gen AI chatbots can play multiple roles in education. The students use them for a multitude of academic tasks, as represented in Figure 5. Improving and editing text, proofreading, followed by explaining and evaluating theories summarizing academic literature, but also knowledge generation, are the most important knowledge-intensive tasks associated with the use of chatbots.

Chatbots are also involved in creative-oriented processes: generating ideas, support in research processes problem solving, and essay and text writing but also in programing and code writing. The academic tasks were refined in the second step of data collection considering the Bloom taxonomy (Forehand, 2012) into lower-order cognitive skills versus higher-level cognitive skills and therefore it includes only a subset of 89 answers. The revised Bloom taxonomy includes (from the highest-level cognitive skills to the lowest level cognitive skills):

creating, evaluating, analyzing, applying, understanding and remembering. The students are collaborating with AI and delegating tasks to Gen AI for all categories essay/text writing, generating ideas (creating) and problem solving (applying), explaining and evaluating theories, summarizing academic literature (understanding and remembering).

The study findings emphasize that students perceive human-AI collaboration beneficial even though it may lead to different outcomes improved learning, enhanced creativity and "thought processes" or even loss of learning, loss of creativity. One student states that: "I like the fact that it can help you get started and inspire you in terms of what scholars to explore further or dive deeper into." And "It is incredible at delivering very specific answers and perspectives to my questions."

The process of knowledge collaboration can be extended and augmented through engineered prompts and personalized interaction. Generative AI brings new opportunities for creating personalized learning environments which may integrate personal assistants or a "study buddy" (Sabzalieva & Valentini, 2023). The management of plagiarism risk creates an interesting definition of Trustworthy AI from the student perspective. This suggests that although they experience the risk of plagiarism, inaccuracy in responses and perceived them to be unreliable, they still collaborate with ChatGPT for academic tasks.

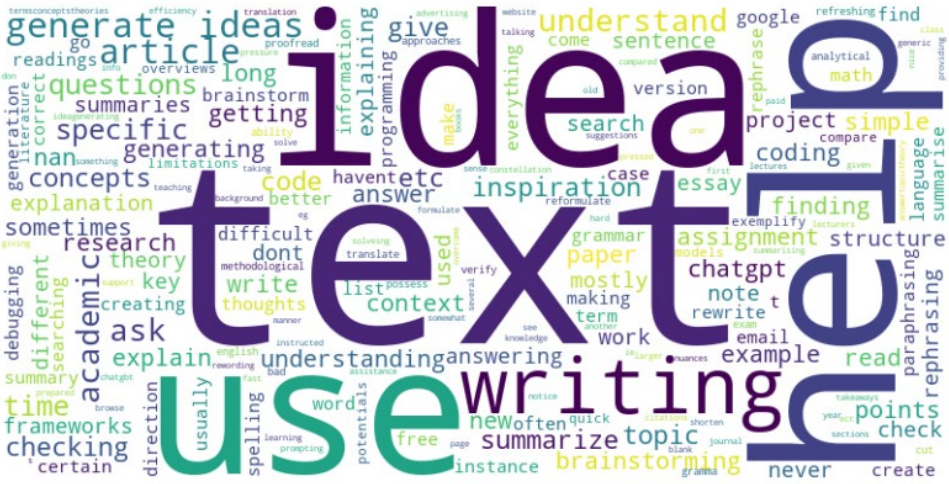

Figure 5: Gen AI in higher education word cloud

A word cloud was generated using the Python natural language toolkit (nltk) library for text analysis based on the open question text provided to "Which other tasks have you been using Gen AI in an academic context? beyond the one specified in the survey". Further we conducted sentiment analysis using the VADER package, and the results indicate that the neutral sentiment score was 0.335, indicating the overall neutral sentiment toward Gen AI.

Table 2: The top 18-word frequency based on the open question

	Word	Frequency		Word	Frequency
1	ideas	24	10	ask	7
2	texts	13	11	understand	7
3	help	12	12	questions	6
4	use	11	13	time	6
5	writing	10	14	specific	6
6	generate	10	15	concepts	5
7	text	9	16	inspiration	5
8	articles	8	17	summarize	5
9	academic	7	18	give	5

Based on Table 2, the most frequent words from the open text are ideas (n = 24), texts (n = 13), help (n = 12).

5. Discussion and Conclusions

The transformative potential of AI in education and management learning has been widely discussed, but theoretical development and empirical results have been lacking in the literature so far. This research investigates the evolving relationship between humans and AI in performing learning and knowledge-intensive tasks, using knowledge collaboration theories. Students collaborate with AI using ChatGPT for expanding knowledge on academic themes, summarizing concepts, theories, and generating ideas for research topics and methods. Time-saving, enhanced productivity and user-friendliness of the tool were identified as the main benefits associated with Gen AI (e.g. ChatGPT), whereas the risk of plagiarism, its inaccuracy in responses and the need for prior knowledge were identified as the main drawbacks.

In educational contexts, this relationship implies that learners use Gen AI not merely as a tool for finding answers, but as a platform for exploring new ways of thinking and understanding. This can transform learning experiences by potentially promoting a deeper engagement with material, facilitating personalized learning paths, and encouraging creative problem-solving.

Lodge et al. (2023) discuss these roles of AI in learning environments, emphasizing how AI can be leveraged to support both the acquisition of knowledge and the application of that knowledge in new, innovative ways. This relationship between learners and AI tools points to a future where education is not only about knowledge transmission but also about developing a symbiotic relationship with technology, which can significantly alter how we learn, teach, and apply knowledge in real-world situations.

However, the ability to enact human agency as regards setting (learning) goals, monitoring the students' progress toward it but also evaluating the Gen AI responses to adapt their (learning) strategies (Lodge et al. 2023) and prompts are essential for collaborating effectively with AI. A critical evaluation of the output of Gen AI requires self-regulation skills and learning strategy adaptations depending on the learners' needs and the learning task (e.g. individual or collaborative). Furthermore, a fully trustworthy human-Gen AI collaboration may lead to overreliance on Gen AI, decrease analytical and problem-solving skills and shortcut learning. Gen AI can be a "coach" (Mollick & Mollick, 2023), an expert system, or a study buddy (Sabzalieva & Valentini, 2023).

For the next phase of this research, we intend to use the preliminary data to explore the relationship between the automation/augmentation paradox (Raisch and Krakowski, 2021) and concepts from the student-centered learning literature e.g. (Doyle, 2023). As the set of learning tasks is subject to a combination of automation and augmentation in partnership with AI, the benefits of increased task efficiency and time-saving may come at the expense of future learning and skills. From a student-centric perspective, teaching faces new challenges of how to optimize learning opportunities in collaboration with AI, how to teach life-long learning skills, and how to obtain student buy-in for more active learning approaches. With this AI-human collaboration research, we hope to contribute to the literature on student-centered learning, and on the emerging human-AI collaboration literature.

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Exploring the Impact of Artificial Intelligence Generative Tools on Research in Higher Education Institutions: A Perspective from Portugal

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Abstract: Artificial Intelligence (AI) generative tools have emerged as transformative instruments in various domains, including research and academia. It is important to see what is positive and what is not. This study focuses on the integration of GAI in Portuguese higher education institutions and explores its multifaceted implications and potential. Our research, conducted through a comprehensive survey between April and June 2023, garnering 77 responses. To this purpose, the analysis will have several insights into the research process, namely, to assess the frequency of use and objectives of using generative AI for higher education research and to explore possible trends and future directions in the adoption and application of generative AI in this field.

Keywords: Generative AI (GAI), Higher education, Personalized learning, Ethical implications, Educational outcomes

1. Introduction

Artificial Intelligence generative (GAI) tools have emerged as transformative instruments in various domains, including research and academia. Technological evolution, and more specifically the launch of ChatGPT on November 30, 2022 (Alier, García-Peñalvo & Camba, 2024), has exponentially increased the use of GAI in higher education. But it's not just ChatGPT, there are a multitude of models competing to provide the best results, which are used through chat applications, web browsers, integrated with different applications or tools embedded in mobile devices (García-Peñalvo. JF, 2024).

Artificial intelligence in academia has been used for different purposes. In a study on Artificial intelligence in higher education until the end of 2022, Crompton and Burke (Crompton, H. & Burkused:2023), found that five usage codes were used: Assessment/Evaluation, Predicting, AI Assistant, Intelligent Tutoring System (ITS) and Managing Student Learning. In a study of the 50 most cited publications on AI in higher education in the WoS database to find researchers' focus of attention (Chu et al., 2022), it was found that AI technology has been used to analyze and provide predictions about learning effectiveness, as well such as student dropout rates, but also to aid learning by giving students appropriate learning recommendations and giving teachers useful information to help improve their teaching strategies and designs.

The potential of these tools is enormous, but many questions arise: positive and negative implications of employing AI generative tools in research within higher education institutions. While these tools offer unprecedented opportunities for innovation, efficiency, and creativity, they pose significant challenges and ethical considerations that necessitate careful examination. The emergence of GAI is having an enormous implication for science educators, and it is important that they question themselves: GAI fit into our research and teaching pedagogy (Cooper, G., 2023), knowing that in the minds of educators there is always a shadow related to potential misuse, as well as the risk of erosion of students' critical thinking skills (Hao, Y., 2024). However, alongside these promising developments, it is imperative to acknowledge the potential pitfalls and ethical dilemmas associated with the widespread adoption of AI generative tools in research. Issues such as bias in algorithms, data privacy concerns, and the displacement of human expertise raise essential questions about the ethical use of AI in academic settings. Furthermore, there is a risk of overreliance on AI generative tools, leading to the erosion of critical thinking skills and the devaluation of traditional research methods.

Although it is a recent topic, as mentioned, there are studies in the literature that show the use of GAI tools in different areas of higher education, namely language learning (Vu et al., 2024), programming teaching (Haindl & Weinberger, 2024) or just to written assignments (Črček & Patekar, 2023). Studies of GAI in higher education

have been carried out all over the world: one study (Polat et al., 2024) found that the United States and the United Kingdom have leading status in production and citation impact; Belgium, Korea, and Canada rank high in citations; The USA, Australia, and China provide most corresponding authors. What can be seen is that Gai's tools are and will change the way we learn and teach in higher education. It's time to see the problem from different perspectives and in several universities worldwide.

Through strategic implementation and ethical governance, AI generative tools can alter high-education research in Portugal, foster a dynamic research environment, empower researchers, and advance knowledge creation and dissemination in the digital age. In this context, the research question arises: "Are Portuguese researchers, in the context of higher education, using generative AI tools as 'collaborators' in their research?". To answer the question and also to find out at what stage the implementation of Artificial Intelligence tools in research in Portuguese higher education is, an online survey was carried out between April 1, 2023 and June 30, 2023, to which 77 responses were obtained. The collected data were processed through descriptive and inferential statistical procedures using the IBM SPSS 29.0 statistical software.

To this purpose, the analysis will have several insights into the research process, namely, to assess the frequency of use and objectives of using generative AI for higher education research and to explore possible trends and future directions in the adoption and application of generative AI in this field.

2. Background and Related Work

In academic, scientific, and business circles, Artificial Intelligence (AI) is acknowledged as a pivotal force driving technological change in the fourth industrial revolution (Mannuru et al., 2023). Notably, substantial strides have been made in this field, with a significant focus on Generative Artificial Intelligence (GAI). GAI, a revolutionary concept, refers to artificial intelligence tools or technologies that generate content, such as text, audio, or video, to produce new, unique, and creative content using the data on which it has been trained (Aydın & Karaarslan, 2023).

Although the concept of generative AI has been used for several years, it was only in the mid to late 2010s that it gained widespread recognition. This growth in popularity was in line with the increase and acceptance of generative models, such as Generative Adversarial Networks (GANs), in the AI research community. GANs, a class of machine learning frameworks introduced by Ian Goodfellow and his team in 2014 (Goodfellow et al., 2014), were crucial in bringing the term generative AI into the limelight. However, the term gained wider recognition, i.e. beyond the research community, around November and December 2022, which aligns with the launch of ChatGPT and other commercial tools (García-Peñalvo & Vázquez-Ingelmo, 2023).

As mentioned earlier, generative AI has the unique ability to create content from existing patterns, a feature that has had a transformative impact on fields as diverse as medicine, social sciences, biology, and particularly research. This transformative potential cannot be underestimated. The tools and applications developed are revolutionizing and enhancing productivity. Moreover, by simplifying various aspects of research, GIA can assist scientists in navigating the increasingly complex landscape of their respective fields, ultimately leading to innovative discoveries and improved research results (Chem, 2023). GAI is at the forefront of today's technological innovation, offering fresh perspectives on how machines can process data and create original and creative content. For Gangwal et al. (2024), one of the most exciting aspects of generative AI in research is its ability to ignite creativity and innovation. Studies have shown that GAI can identify intricate patterns in large data sets and, from these patterns, generate new ideas, concepts, and designs that can inspire new lines of research.

GAI, a new and rapidly evolving field, is transforming research in higher education, presenting opportunities and challenges in several dimensions. The literature review below aims to bring together the results of recent research and learn about central themes and collective undertakings to comprehensively analyze the impact of Generalized Artificial Intelligence (GAI) in the context of research carried out in higher education. In this scenario, a search sequence was built and used in the Scopus database "Generative Artificial Intelligence" AND "Higher education" AND ("research" OR "Research"), without date limitations; the result presented was 45 publications. A search was also carried out on Scopus in which Portugal was added to the search sequence, with one publication result. The second search aimed to find out whether there were any studies in Portugal.

The abstracts of the 45 articles from the search were analyzed to identify which dealt with the topic under analysis, i.e., research carried out by researchers in academic contexts using GAI. From the study carried out it turns out that only two of them present topics in the field. The first (Carabantes, 2023) explores whether chat GPT can replace a reviewer, concluding that AI models have limitations in peer review. Human reviewers are

essential due to ethical and accuracy concerns. GAI tools can help but require improvement and responsible use. The second article (Drug, T. et al., 2023) discusses the use of AI tools in higher education and tourism and hospitality research, highlighting the potential for data collection, analysis and writing in academic research; in parallel, it points out that legal complexities require transparent attribution, clear usage policies and an understanding of the implications. The study in Portugal (Gouveia et al., 2023) on Master's students analyses how they perceive and apply AI in their academic research, concluding that using AI tools in research activities is scarce or non-existent.

3. Methodology

This study is based on the responses to an online questionnaire with the title "Characterizing the use of generative artificial intelligence applications in higher education in Portugal". The information was collected from April to June 2023 and aims to find out which IAG applications are most used in research, how often they are used to support research and what they can do, as well as the strengths and weaknesses of using these applications. Were obtained 77 responses, and the data collected was processed and treated using the IBM SPSS Statistics 29.0 software. The statistical analyses used was reliability analysis (Cronbach's alpha), descriptive measures and graphical representations (for example, boxplot), Spearman correlation and Nonparametric Kruskall-Wallis and Mann-Whitney test.

4. Results and Discussion

The sample is composed by 77 individuals, with a slightly higher percentage of males (59.7%). The participants' ages ranged from 25 to 89 years, with an average age of 51.56 years. Most participants have a PhD (83.1%).

Around 16.9% of the individuals have a background in exact and natural sciences, 28.6% in engineering sciences and technology, 35.1% in social sciences, 10.4% of the participants have a background in the humanities and the remaining participants are distributed among other unspecified areas. Only 14% of individuals do not research in their area of training. Figure 1 shows the distribution of participants' publication frequencies over the last 5 years in the study.

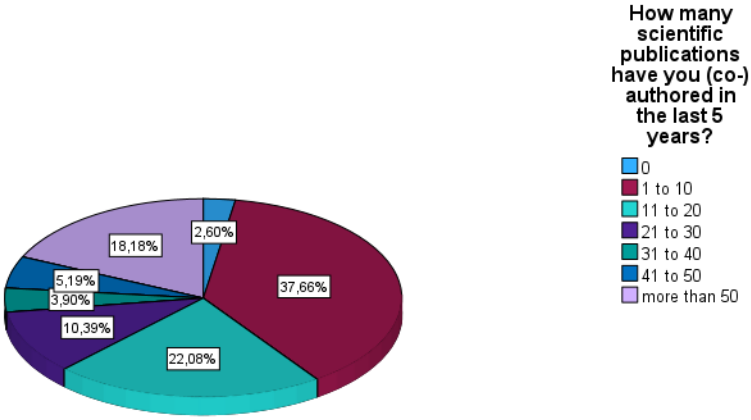


Figure 1: Pie for percentage of quantity of publications in the last 5 years

The questionnaire consists of a question about the GAI tools that are used in research by the participants involved in this study and questions about 4 dimensions, namely 1) what the use of GAI enables (in this context), 2) how often they use GAI to carry out a series of tasks and 3) the strengths and 4) weaknesses of using GAI. Cronbach's alpha reliability analysis was employed to assess whether the variance among items within each dimension (responses to the questions) genuinely stemmed from variations from the perspectives of the participants in the questionnaire.

Cronbach's alpha relies between 0 and 1 and the closer to 1, the greater the reliability. All of the four dimensions presented values which can be considered very good (alpha=0.880, alpha=0.915, alpha=0.884 and alpha=0.790, respectively).

Starting by evaluating which GAI tools were used, a bar chart was constructed showing the percentage use of each of the eighteen tools listed (Figure 2).

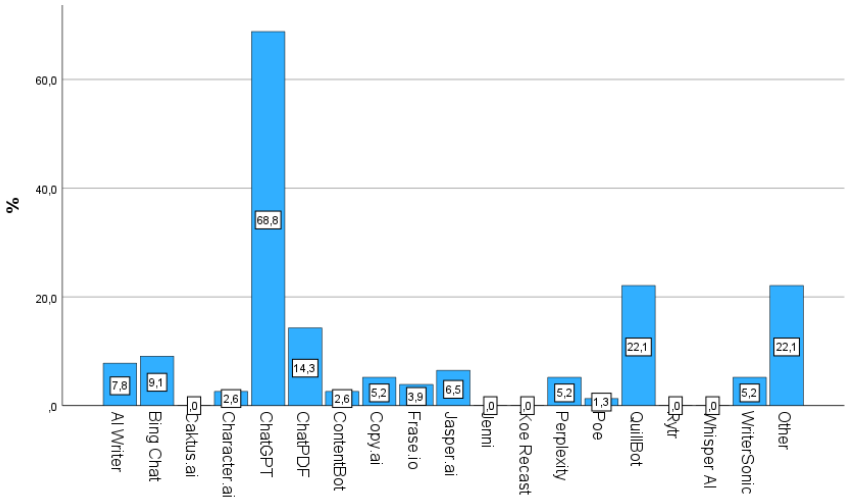


Figure 2: Frequency of use of GAI tools for research

The most used tool is ChatGPT (68.8%), followed by QuilBot (22.1%) and ChatPDF (14.3%). It should also be noted that 22.1% of participants also use tools other than those indicated in the questionnaire.

Next, we analyzed the participants' opinions on what the GAI enables for research (5 Likert scale from 1- Strongly disagree to 5- Strongly agree). Figure 3 shows that at least 75% of participants agree that GAI allows them to "Clarify issues", "Explore historical events", "Simplify scientific concepts", "Summarize articles" and "Simplify difficult vocabulary". Although the responses are more dispersed, at least 50% agree that GAI allows them to "Find important resources" and "Summarize large texts". We should also highlight the existence of some moderate outliers in some topics, namely two in "Clarify issues", "Summarize articles" and "Summarize scientific concepts", three in "Explore historical events" and one in "Summarize difficult vocabularies". The most frequent outlier (participant 15) is a woman with a master's degree and a researcher.

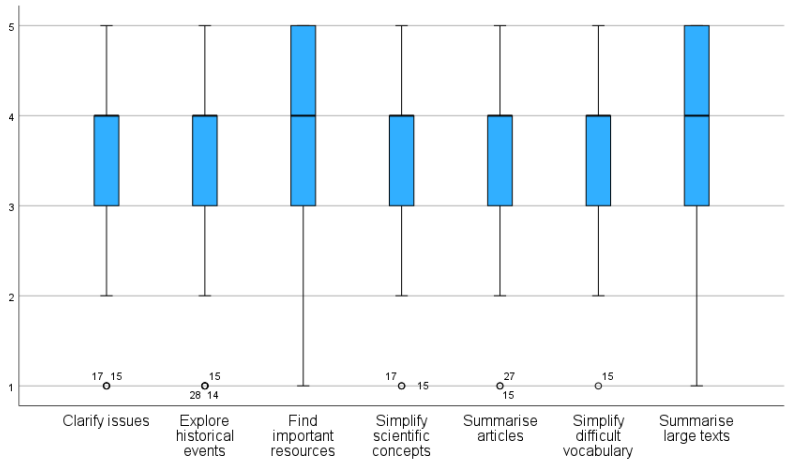


Figure 3: Boxplot for enablers in Research

To analyze the possible association between the information on the number of publications of each of the participants and what the GAI enables in the research, Spearman's rank correlation coefficient was used (given the ordinal nature of the variables in question) which led us to conclude that there is no correlation between the two questions/variables (Table 1).

Table 1: Results of Spearman correlation between enables and number of publications.

Correlations								
			Clarify issues	Explore historical events	Find important resources	Simplify scientific concepts	Summarize articles	Simplify difficult vocabulary	Summarize large texts
Spearman's rho	How many scientific publications?	Correlation	-.091	-.083	-.017	.026	-.049	-.063	.076
		Sig. (2-tailed)	**.429**	**.476**	**.882**	**.825**	**.671**	**.586**	**.511**
		N	77	77	77	77	77	77	77

To evaluate potential disparities in agreement regarding what the GAI permits based on participants' gender, the Mann-Whitney non-parametric test was conducted, with results presented in Table 2. We can conclude at a significance level of 5 per cent that there are differences in the degrees of agreement regarding "Clarify issues" (p-value=0.044), "Explore historical events" (p-value=0.034), "Simplify scientific concepts" (p-value=0.003) and "Simplify difficult vocabulary" (p-value=0.028), depending on gender.

Table 2: Results of Mann-Whitney test for enables for research, by gender.

	Clarify issues	Explore historical events	Find important resources	Simplify scientific concepts	Summarize articles	Simplify difficult vocabulary	Summarize large texts
Mann-Whitney U	529.000	517.500	594.500	447.000	547.500	509.500	573.500
Wilcoxon W	1025.000	1013.500	1090.500	943.000	1043.500	1005.500	1069.500
Z	-2.015	-2.115	-1.282	-2.921	-1.803	-2.196	-1.510
Asymp. Sig. (2-tailed)	**.044**	**.034**	.200	**.003**	.071	**.028**	.131
a. Grouping Variable: Gender							

Analyzing in more detail, through the values of the descriptive measures (mean, quartiles, standard deviation, and coefficient of variation), where these differences exist (Table 3), it was found that in any of the four situations, the male participants tended to agree more with the fact that the GAI enabled them to carry out these tasks. It should be noted, however, that the answers given by female participants show much greater variability than the answers given by male participants. The coefficients of variation associated with the female gender lies between 33% and 38%, while for the male gender is around 20%. This means that the answers given by men are much more homogeneous.

Table 3: Descriptive measures for enables for research, by gender.

Statistics						
Gender			Clarify issues	Explore historical events	Simplify scientific concepts	Simplify difficult vocabulary
Female	n	Valid	31	31	31	31
	Mean		3.45	3.26	3.32	3.19
	Std. Deviation		1.150	1.237	1.045	1.167
	C.V. (%)		33	38	35	37
	Percentiles	25	3.00	3.00	3.00	2.00
		50	4.00	3.00	3.00	3.00
		75	4.00	4.00	4.00	4.00
Male	n	Valid	46	46	46	46
	Mean		4.00	3.87	3.98	3.76
	Std. Deviation		.816	.909	.830	.874
	C.V. (%)		20	23	21	23
	Percentiles	25	3.00	3.00	4.00	3.00

Statistics						
Gender			Clarify issues	Explore historical events	Simplify scientific concepts	Simplify difficult vocabulary
		50	4.00	4.00	4.00	4.00
		75	5.00	5.00	5.00	4.00

Next, we analyzed what the participants say about how often they use the GAI to carry out certain assignments in the research (5 Likert scale from 1- Never to 5- Always) (Table 4). Evaluating all the descriptive measures presented in Table 4, but given particular attention to the median (since this is ordinal data), we see that participants sometimes use GAI to "Prepare visual aids **(b)**", "Proofreading **(h)**", and "Generate/create ideas **(i)**" and almost never use it to "Write a text based on the results **(a)**", "Interpret a text **(c)**", "Write conclusions **(d)**", "Analyze data **(f)**", "Identify the appropriate teaching methodology **(e)**", "Write a literature review **(g)**" and "Write a discussion of the results **(j)**".

Table 4: Descriptive measures for the frequency of GAI use for some tasks.

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Mean		2.34	2.51	2.60	2.13	2.39	2.10	2.36	2.64	2.95	2.10
Std. Deviation		1.177	1.231	1.280	1.140	1.237	1.263	1.234	1.347	1.234	1.165
Percentiles	**25**	1.00	1.00	1.50	1.00	1.00	1.00	1.00	1.00	2.00	1.00
	50	2.00	3.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	2.00
	75	3.00	4.00	4.00	3.00	3.00	3.00	3.00	4.00	4.00	3.00

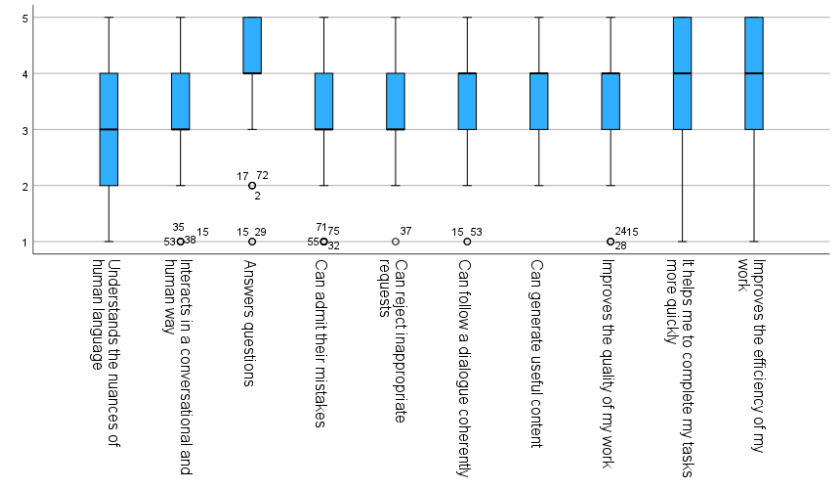
The Kruskal-Wallis test was applied to assess the possibility of differences between the degree of frequency attributed to the use of GAI to carry out these tasks, but no statistically significant differences were found; all p-values exceed 0.05.

Applying the same non-parametric test led to the conclusion that there were significant differences at 5% between level of education and "Writing a discussion of the results" and "Writing a text based on the results obtained" (p-value=0.036 and 0.031, respectively). Calculating the correlation for these two cases, we concluded with a significance level of 1% that there is a negative correlation, i.e. the higher the level of education, the less the participants use the GAI to write texts or the results of their research.

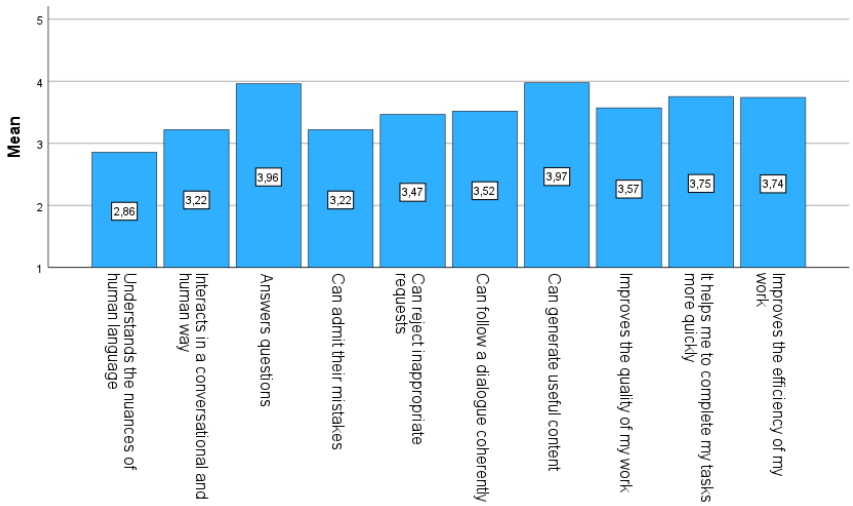
It is also interesting to note that are significant differences at 5%, resulting from the application of the Mann-Whitney test, were detected for certain objectives of using the GAI, depending on the area of research, namely with regard to the use of the GAI to "Explain concepts" between participants researching in the area of exact sciences and those in the area of humanities (p-value=0.030) and between participants in the area of engineering and those in the area of humanities (p-value=0.05). In "Idea generation" there were also differences between participants from the social sciences and humanities and finally in "Proofreading" between participants from the engineering and social sciences and between participants from the exact sciences and social sciences.

Figure 4 and Figure 5 refers to the strengths and weakness identified in the use of GAI for research, respectively. For these two questions, an ordinal scale of agreement was used (5 Likert scale from 1- Strongly disagree to 5- Strongly agree).

The strong point with the highest level of agreement was the possibility of answering to questions, where 76.6% of participants agreed or totally agreed. This was followed by agreeing or totally agreeing that GAI generates useful content (74%), helps to complete tasks more quickly (68.8%), improves work efficiency (61%), improves the quality of work (54.5%) and can follow a dialogue coherently (52%). It should also be noted that the most heterogeneous responses are found in the degree of agreement with "It helps me to complete my tasks more quickly", "Understands the nuances of human language" and "Improves work efficiency", i.e. although there are more participants who agree or totally agree, this is where there is less uniformity in the responses. There are also some outliers associated with low levels of agreement, particularly participants with numbers 15 and 17, who are female and from the exact and natural sciences.



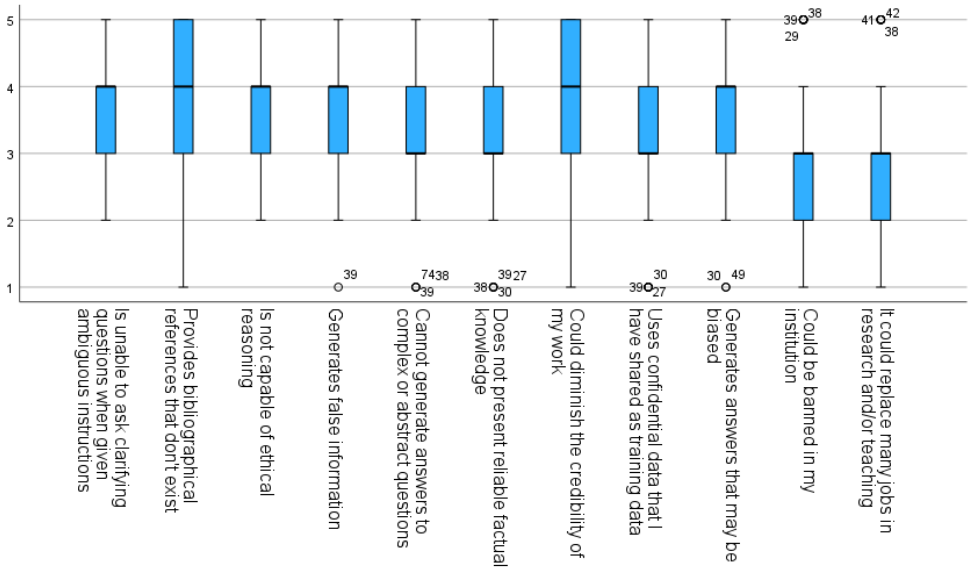
a)



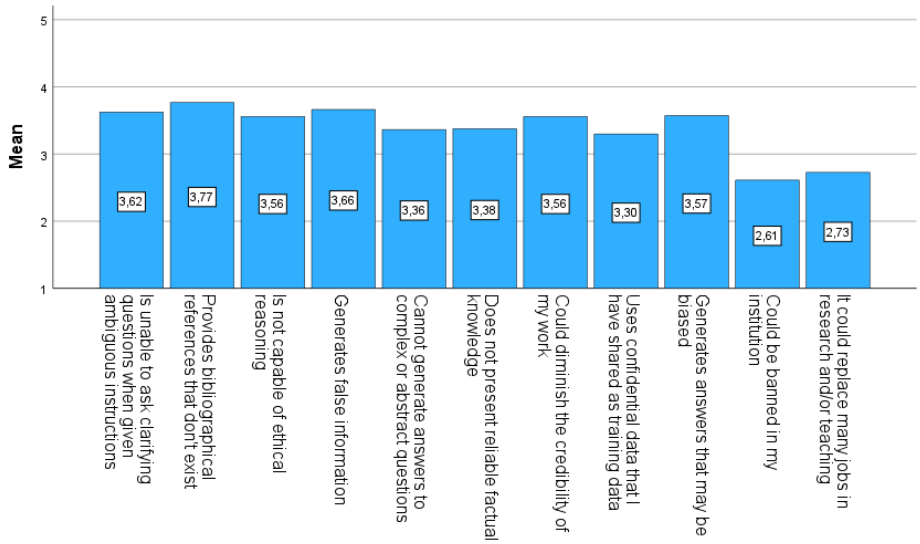
b)

Figure 4: Use of GAI a) Boxplot for strengths b) Bar for strengths.

Figure 5 shows that the most disagreed points are "Could be banned in my institution" (43% disagree or strongly disagree) and "It could replace many jobs in research and/or teaching" (42% disagree or strongly disagree). On the other hand, 61% of participants agree or totally agree that GAI "Provides bibliographical references that don't exist" and that GAI "Generates false information". The most heterogeneous responses are found in the degree of agreement with “Provides bibliographical references that don´t exist” and “Could decrease the credibility of my work”.



a)



b)

Figure 5: Use of GAI a) Boxplot for weakness b) Bar for weakness.

Also relevant as a weak point, "Could decrease the credibility of my work" where 54.6% agree or totally agree, "Is not capable of ethical reasoning" (52%) and with 50.7%, "Is unable to ask clarifying questions when given ambiguous instructions" and "Generates answers that may be biased".

The questionnaire also included an open question, "What impact does GAI have on Research?". Opinions on the use of AGI in scientific research and higher education are diverse, reflecting a multifaceted view of its potential and challenges. Many acknowledge the usefulness of AI, especially in tasks such as literature filtering, concept clarification, and idea generation. Additionally, they highlight its ability to simplify document writing and provide a broad view of the study area. However, the opinion is unanimous: AI must be employed with caution and full knowledge of its limits. A common concern is the possibility of errors in data affecting the results of AI models, emphasizing the importance of transparency in data collection and usage. In this regard, clear institutional policies are considered essential to mitigate concerns about privacy and academic fraud. In the context of scientific research, generative AI is seen as a tool with significant advantages, but its application requires regulation to ensure responsible use. It is recognized that AI is here to stay, and it is essential to formulate the right questions and continuously validate processes.

While some express uncertainty about AI, others see it as a powerful ally in research (and teaching), provided it is used responsibly. Academic integrity is valued, and institutional policies or norms are considered a valuable contribution to preventing academic fraud.

In summary, AI has the potential to have a profound and lasting impact, facilitating analysis, simplifying work, and providing access to vast amounts of information. However, it is essential to use it with caution, ensuring that it is a supportive tool and not a substitute for human critical thinking. Guidelines for the ethical use of AI in the academic context are suggested, aiming to promote fairness, security, and quality of education.

5. Conclusions and Future Work

GAI, as mentioned, can be defined as a technology based on learning models that generate human-like content, e.g., images and text, in response to complex and diverse requests, e.g., instructions and questions. Because of its potential, the technology is being integrated into research environments. However, as the literature shows, technology and its integration are evolving quickly. Still, the literature in the area needs to show more studies analyzing its integration, regarding the process, into research in the context of higher education.

According to the study carried out regarding the implementation of Artificial Intelligence Generating tools in research in Portuguese higher education, the majority of participants in the study were male, aged close to 50 and with a PhD; the dominant areas of training of these participants are Social Sciences and Technology, with the majority carrying out research in their area of training and in the last 5 years, the number of publications were between 1 and 20 publications (more than 55%).

It was found relevant the following conclusions in relation to the 4 dimensions:

- Dimension 1 (What the use of GAI enables (in this context)): most use ChatGPT as a generative AI application and at least 75% of participants agree that GAI allows them to "Clarify issues", "Explore historical events", "Simplify scientific concepts", "Summarize articles" and "Simplify difficult vocabulary"
- Dimension 2 (How often they use GAI to carry out a series of tasks): participants sometimes use GAI to "Prepare visual aids", "Proofreading", and "Generate/create ideas " and almost never use it to "Write a text based on the results", "Interpret a text", "Write conclusions", "Analyze data", “Identify the appropriate teaching methodology”, “Write a literature review” and "Write a discussion of the results".
- Dimension 3 (Strengths of using GAI): the strength with the highest level of agreement was the possibility of answering to questions, where 76.6% of participants agreed or totally agreed. This was followed by agreeing or totally agreeing that GAI generates useful content (74%), helps to complete tasks more quickly (68.8%), improves work efficiency (61%), improves the quality of work (54.5%) and can follow a dialogue coherently (52%).
- Dimension 4 (Weaknesses of using GAI): the most disagreed points are "Could be banned in my institution" (43% disagree or strongly disagree) and "It could replace many jobs in research and/or teaching" (42% disagree or strongly disagree). On the other hand, 61% of participants agree or totally agree that GAI "Provides bibliographical references that don't exist" and that GAI "Generates false information". Also relevant as a weak point, "Could decrease the credibility of my work" where 54.6% agree or totally agree, "Is not capable of ethical reasoning" (52%) and with 50.7%, "Is unable to ask clarifying questions when given ambiguous instructions" and "Generates answers that may be biased".

The survey results show that higher education researchers are already using GAI to support their research. This suggests that not using GAI tools is unrealistic and a misuse of the added value offered by these tools. The GAI tools available can be seen as digital collaborators, allowing more "routine" tasks to be conducted by the tools more productively and effectively. On the other hand, researchers have more time and space to carry out tasks that require innovation and creativity. However, in this favorable context of use, ethical issues should not be ignored, particularly data privacy and the integrity of results. To address these issues, higher education institutions must define and implement regulatory measures to maximize the benefits of the GAI and mitigate its risks.

In future work, several points will be explored to understand and optimize the use of GAI in research. (1) Expand the research to a broader range of researchers, both in terms of the number of institutions and geographical

location, and thus determine the dimension/scope of the use of the tools. (2) Evaluate the impact of the use of GAI tools.

GAI can revolutionize research by shifting the focus from 'routine' work to fostering creativity and innovation, thereby enhancing research effectiveness and efficiency. This transformative potential of GAI in research is a cause for excitement and anticipation. However, it's of utmost importance to reiterate that ethical considerations, among other factors, are not just crucial but integral to the successful and responsible use of GAI in research.

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Phrase Frame Use in EFL Learners' Argumentative Essays: A Corpus-Based Comparative Study

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Abstract: Recently, there has been a growing interest in the features and development of multi-word formulaic sequences for foreign language learners in the field of second language acquisition. While considerable amount of research has been conducted on continuous formulaic sequences both domestically and abroad, scant attention has been rendered to discontinuous phrase frames. Adopting a corpus linguistic perspective, the current study compares and analyses second language learners from different backgrounds with native speakers, focusing on the phrase frame features identified in the argumentative essays written by Chinese and German EFL learners. With a corpus-based approach, the four-word phrase frames are extracted from the English TOEFL essay texts of Chinese and German students using AntConc 4.1.4 corpus analysis software. The top 100 most frequently occurring phrase frames are manually filtered and then classified according to their structural and functional features to identify similarities and differences in terms of overall frequency, structure, and function features of phrase frames between two groups of learners and with those of native writers. The findings reveal that L2 learners significantly employ more fixed and predictable phrase frames than their native writers, with German L2 learners using more phrase frames than their Chinese L2 counterparts. In terms of functional features, German L2 learners use more stance and discourse organizing expressions than Chinese L2 learners. Awareness of the essay genre, English proficiency, and the time-limited writing environment are contributing factors to these features. Therefore, the study suggests that the accuracy and variety of phrase frame usage are more representative of L2 learners' acquisition and writing quality than their quantity of use. This study facilitates an understanding of different EFL learners' phraseological competence through the lens of their p-frame use and provides pedagogical insights accordingly into teaching and learning argumentative essays in EFL contexts.

Keywords: Phrase frames; English argumentative writing; EFL learners; Corpus-based study

1. Introduction

As an important linguistic pattern in natural English discourse, formulaic sequences (Schmitt, 2004; Wray, 2002) play an important role for EFL learners in extracting abstract linguistic structures (Ellis et al., 2015) and establishing their identities in a specific academic community (Wray, 2002). Rather than being bound by the language grammar, formulaic sequences are "a sequence, continuous or discontinuous, of words or other elements, which is … stored and retrieved whole from memory" (Wray, 2002, p.9) which encompass not only continuous multi-word sequences such as n-grams, collocation, chunks, and lexical bundles but also discontinuous sequences such as phrase frames (p-frames) (e.g., it is * that[1]). As semi-fixed phraseological sequence, p-frame retains the rather fixed framework of the continuous word combinations, as well as the relatively flexible lexical variants, thus serving as generalization of the continuous sequence (Fuster-Márquez, 2014). In second language acquisition (SLA) studies, the use of formulaic sequences is essential for accurate and fluent processing of language (Ellis, 1996; Li et al., 2020), with learners progressing from the use of memorized fixed phrases, through semi-fixed p-frames, to more open grammatical constructions (Ellis et al., 2008; O'Donnell et al., 2013). In L2 writing studies, whether learners can use p-frames appropriately to construct their epistemological position and conduct efficient dialogues in the academy, affects the accuracy, authenticity, and readability of their language. The explicit manifestation of p-frame uses in written texts, therefore, has become a pivotal criterion for assessing the writing quality and L2 English learners' phraseological competence, thus being of essential research value (Appel, 2022).

At present, a plethora of corpus-based empirical studies are flourishing in L2 studies, which increasingly deepens scholars' understanding of the formulaicity of language (Garner, 2016; Nekrasova-Beker, 2021; Ren, 2022; Tan & Römer, 2022). Due to the accessibility of spoken and written corpus, most studies focus on students' written language. For example, Garner (2016) investigates German EFL learners writing based on EF-

[1] The asterisk (*) refers to the "variants" of p-frames, which is also the items that can fill the variable slot (e.g., important, clear, and noticed in *it is * that*.

Cambridge Open Language Database which includes diverse writing tasks ranging from descriptive essays to practical emails and movie reviews. Ren (2022), however, examines the use of p-frames with an emphasis on academic writing of learners from different disciplines. An increasing number of scholars have related p-frames to register variation (Gray & Biber, 2013) and rhetorical moves (Lu et al., 2021). While extensive research has shown the important role of these non-continuous sequences in the writing practices of EFL learners, linguists are particularly interested in published research articles (RAs) or dissertations that focus on introductions (Lu et al., 2021), discussion sections (Golparvar & Barabadi, 2020), or even the relatively overlooked figure legends (Liu et al., 2023). There is devoid of p-frame research focusing on EFL learners' writing in one specific genre and in a time-limited writing context.

Echoing the call for more empirical studies of EFL learners' p-frame use in more genres and contexts, the present study attempts to investigate the argumentative essays by different cohorts of EFL learners through a corpus-based comparative approach. Specifically, the study will compare the similarities and differences of p-frame use in terms of overall presentation and functional presentation in Chinese and German EFL learners' Test of English as a Foreign Language (TOEFL) writing with those of first language (L1) English writers' argumentative essays. In addition, through a comparative analysis of p-frames used by EFL learners with references to L1 speakers, it is expected to present a comprehensive portrayal of the phraseological competence of EFL learners, thereby providing pedagogical implications for L2 writing instruction.

2. Research Design

2.1 Research Questions

The present study attempted to adopt a corpus-based method to investigate the p-frame use in the argumentative essays of two cohorts of EFL learners, namely Chinese and German EFL learners. By analysing the overall features, predictability, and variability as well as functional features of p-frame use, it is hoped to gain insights about EFL learners' phraseological competence. As a reference for the current study, argumentative essays written by their L1 English counterparts were also collected and analysed to better capture the peculiarities of learners' p-frame use. Specifically, the research aims to answer the following three questions:

1. Compared with their L1 English counterparts, what are the overall types and tokens of p-frame use of Chinese and German EFL learners in English argumentative writing;
2. Compared with their L1 English counterparts, what are the similarities and differences of p-frame variability and predictability between these two groups;
3. Compared with their L1 English counterparts, what are the similarities and differences of p-frame use across the functional categories between these two groups?

2.2 Corpora

The EFL learners' argumentative essays taken as the two observed corpora were sourced from the ETS Corpus of Non-Native Written English (hereinafter referred to as ETS Corpus), developed by the Educational Testing Service (Blanchard et al., 2014). ETS Corpus consists of 12,100 English essays each with a score level (low/medium/high) written by EFL learners of 11 different languages from independent writing tasks of TOEFL, which is an international normalized test of academic English proficiency. Test-takers are required to express their opinion about a specific issue in this argumentative writing task.

Among these 11 EFL learner groups, Chinese and German test-takers, as the representatives of the Sino-Tibetan and Indo-European language families respectively, become the focal point of this study. In terms of the reference corpus for comparison, the current study derived argumentative texts from two available ready-made corpora, namely Native English Speakers Similarly or Identically-Prompted Essays (NESSIE) and The Louvain Corpus of Native English Essays (LOCNESS) to construct the English L1 Argumentative Essay Corpus (LAEC). Through meticulously manual selection by the two researchers, a total of 916 argumentative essays (338 from LOCNESS and 578 from NESSIE) were retained after excluding essays of explanatory, narrative, and practical writing genres. Detailed information of the corpora is shown in Table 1.

Table 1: Detailed information of the learner corpora and reference corpus.

Corpus	Texts	Types	Tokens
ZHOC	560	9,375	182,909
DEUC	560	8,707	192,772
LAEC	916	19,145	404,698

2.3 Phrase Frame Identification and Analysis

The current study adopted the fully inductive approach (Fuster-Márquez, 2014; Grabowski, 2015; Gray & Biber, 2013) that begins with a frame and a variable slot through the software *AntConc 4.1.4* (Anthony, 2022). Only p-frames that are four words long and contain one internal variable slot were centered. After rounds of preliminary pilot extractions in this study, we observed that three-word p-frames were often incomplete, whereas the number of five-word p-frames was insufficient for analysis. Therefore, a rather conservative frequency threshold of 40 occurrences per million words (PMWs) was adopted. Additionally, in line with previous studies (Ren, 2022; Tan & Römer, 2022), each p-frame should occur in at least five different texts and two different topics.

The extracted p-frames were further filtered manually through concordance (KWIC) analysis. P-frames with only one variant or misspellings (e.g., by a * guide with variants tour, tourn, tours) were removed. Additionally, p-frames crossing sentence or clausal boundaries (e.g., the places that we) or four-word p-frames embedded in five-word p-frames (e.g., lot of * to in a lot of * to) were deleted. For example, the p-frame *the * of the* (e.g., *the opening of the*, and *the advent of the*), despite its high frequency and extremely diverse variants in both English L1 and L2 speakers' essays, was discarded as it did not constitute a phrase with a distinct pragmatic or discourse function. It should be noted that two researchers filtered the candidates independently and reached 95 percent inter-rater agreement. The remaining discrepancies were then discussed until complete agreement was achieved.

Then the most frequent 100 p-frames would be analyzed in terms of three aspects. First, the variability information of a p-frame was represented as the type-token ratio (TTR) generated by *AntConc 4.1.4* ranging from 0 to 1. All the p-frames were classified into three groups (Gray & Biber, 2013): (1) highly variable (0.7 < variability ≤ 1), (2) variable (0.3 < variability ≤ 0.7), and (3) fixed (variability ≤ 0.3). Second, Following Tan and Römer (2022), normalized entropy (H_{norm} henceforth) provided by *AntConc 4.1.4* was employed to determine the predictability of a p-frame. H_{norm} indicates to what extent a probability distribution is uncertain. Following Garner (2016), the present study attempts to classify the p-frame predictability into four categories: (1) highly predictable ($0 < H_{norm} \leq 0.25$), (2) predictable ($0.25 < H_{norm} \leq 0.5$), (3) less predictable ($0.5 < H_{norm} \leq 0.7$), and (4) unpredictable ($0.7 < H_{norm} \leq 1$). As for p-frames' function, the variant-based functional taxonomy by Simpson-Vlach and Ellis (2010) was adopted.

3. Results and Discussion

3.1 Types and Tokens of Phrase Frames

Through a comparative analysis of the top 100 (types = 100) most frequent four-word p-frames among the three corpora, namely ZHOC, DEUC, and LAEC, it was found that the normalized frequency of tokens (per 10, 000 words) is the highest in DEUC. Conversely, the frequency of four-word p-frames in ZHOC comes second, while their L1 English counterparts in LAEC exhibit the least usage of such p-frames. The comparison of four-word p-frames in the three corpora in terms of token frequencies is presented in Table 2 below.

Table 2: Comparison of tokens of four-word phrase frames in the three corpora

Corpus	ZHOC	DEUC	LAEC
Tokens	3,349	4,024	4,757
Normalized Freq. (per 10,000 words)	183.10	208.74	117.54

The log-likelihood ratio test was conducted to examine the variations in the tokens of four-word p-frames among the three corpora. The results revealed that there were significant differences in the usage of four-word p-frames across the three corpora. Specifically, the frequency of four-word p-frames was found to be higher in ZHOC (LL = 373.48, $p < 0.001$) and DEUC (LL = 691.37, $p < 0.001$) than in LAEC. Furthermore, DEUC

exhibited a higher frequency of four-word p-frames than ZHOC (LL = 373.48, p < 0.001). Interestingly, the difference between ZHOC and LAEC was found to be less significant compared to that between DEUC and LAEC (LL = 373.48 < 691.37), which indicates that Chinese EFL learners use fewer four-word p-frames than German EFL learners.

This result is in alignment with Paquot (2013) who found that EFL learners tend to use more recurrent continuous formulaic sequences for expression in their writing than their L1 English counterparts and that there is a tendency for the number of such combinations to decrease as bilingual proficiency increases. This overuse of formulaic sequences in learners' writing may be attributed to their inadequate acquisition which causes students to rely on a larger number of word combinations for text organization and discourse representation. In the current study, Chinese and German EFL learners were also found to employ significantly more p-frames in their TOEFL argumentative writing. Despite the TOEFL being designed for L2 English speakers aiming to enroll in universities or programs in English-speaking countries and who have already achieved a relatively advanced language proficiency, EFL learners continue to exhibit insufficient mastery. Instead, they rely on employing an increased number of p-frames to articulate their viewpoints and bolster their arguments. German EFL learners employ p-frames significantly more frequently than their Chinese counterparts, probably due to the shared Germanic language family of English and German, which results in a high degree of similarity in formulaic sequences and fewer challenges during acquisition. In contrast, Chinese belongs to the Sino-Tibetan language family, posing relatively more challenges in acquiring formulaic sequences.

3.2 Variability and Predictability of Phrase Frames

Through intercorporal comparison, the distribution of the p-frames across three variability levels were presented, which demonstrated the extent of language formulaicity in the argumentative writing. As shown in Fig. 1, the numbers of distinct p-frames suggested no significant difference between the p-frame variability of Chinese and German EFL learners (Fig. 1 c-1), while there were significant preferences when EFL learners were compared with their L1 counterparts (Fig. 1 a-1, b-1). Among the most frequently used 100 p-frames, Chinese learners used significantly more fixed p-frame types than L1 counterparts (LL = 7.82, p < 0.005). German EFL learners exhibited significantly more reliance on fixed p-frames (LL = 12.84, p < 0.001) and less reliance on highly variable ones (LL = 10.89, p < 0.005). In terms of the normalized tokens in the three corpora, both Chinese and German EFL learners relied statistically more on fixed p-frames and less on variable sequences and highly variable sequences (Fig. 1 a-2, b-2). However, despite German writers having a higher number of total normalized tokens, Chinese EFL learners employed significantly more highly variable p-frames (Fig. 1 c-2, LL = 72.45, p < 0.001).

The above findings informed by Fig. 1 have provided further evidence that EFL learners tend to utilize more p-frames in their writing practice, with a particular reliance on fixed p-frames. Additionally, this finding has supported the notion that learners prioritize the use of formulaic language when composing written discourse. Students stick with familiar and safe sequences "which the learners feel confident in using" (Schmitt, 2004, p.13), which also leads to a limited lexical diversity in EFL learners' writing. However, it is also important to note that it is not that their L1 English counterparts do not use highly fixed p-frames; in fact, *on the * hand* (TTR = 0.04) occurs very frequently in their writing. And it is not that learners are completely incapable of using highly variable p-frames; for instance, the p-frame *in the * of* ranks as the 5th most frequently used in German EFL learners' writing (TTR = 0.65) and the 21st most frequent in Chinese EFL learners' essay writing (TTR = 0.84).

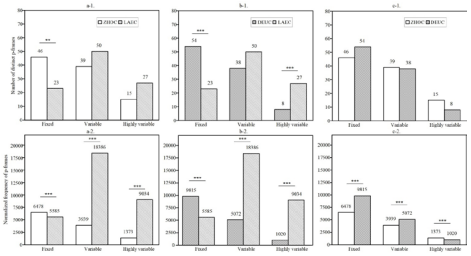

Figure 1: Variability of the four-word p-frames in the argumentative essays by Chinese and German EFL learners compared with their L1 English counterparts. ** p < 0.01, *** p < 0.001

Regarding the distribution of p-frames across four predictability levels, no significant differences were revealed between ZHOC and DEUC in terms of the p-frame types, while German EFL learners used significantly more less predictable and unpredictable p-frames in terms of the normalized tokens than Chinese EFL learners as

shown in Fig. 2. When shifting to comparison between learners and their L1 English counterparts, a larger number of predictable p-frames were used in the ZHOC and DEUC essays than were in LAEC essays, showing significantly higher normalized frequency. However, another finding of interest is that both groups of EFL learners use significantly more less predictable p-frames than their L1 English counterparts, which seems to contradict previous findings. One approach that may be helpful is to see unpredictable and less predictable p-frames as a broad category, and then this category of hard-to-predict p-frames can be found with significantly lower normalized frequency in both Chinese EFL learners (LL = 1924.88, $p < 0.001$) and German EFL learners (LL = 150.57, $p < 0.001$).

Based on a close examination of the p-frame lists, the reason for learners' more use of less predictable p-frames may be attributed to the presence of ungrammatical or unintentional misspellings in both Chinese and German EFL learners' essays. In essence, the predictability value of p-frames may have been to some extent overestimated due to the inclusion of misspelled variants, resulting in an inflated observed frequency. As such, the actual number of hard-to-predict p-frames may be lower than what was reported in this study. But even so, the differences in the use of p-frames between EFL learners and their L1 English counterparts in writing argumentative essays have been found, which signifies a deficiency of EFL learners' acquisition and highlights the potential for further development.

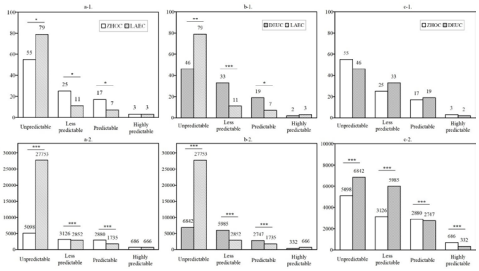

Figure 2: Predictability of the four-word p-frames in the argumentative essays by Chinese and German EFL learners compared with their L1 English counterparts. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.3 Functional Features of the Phrase Frames

On the whole, three groups of writers displayed similar distribution patterns as can be seen from Fig. 4 a-1, b-1, c-1. Of the top 100 most frequent p-frames in all three corpora, referential p-frames remain the largest of the three major functional groupings, demonstrating the focus of the genre to deliver informational content. This result was in line with previous studies on p-frames in academic writing (Golparvar & Barabadi, 2020; Liu & Chen, 2022), where referential p-frames (i.e. *in the * of* in example 1) were also found to be the predominant type. Stance p-frames (i.e. *people are * to* in example 2) rank as the second largest category in all three corpora; ZHOC and DEUC contain a higher proportion of 35 percent and 38 percent respectively, whereas LAEC contains 28 percent. P-frames that perform the discourse organizational function (i.e. *on the * side* in example 3) are the least utilized, with their percentage being around 10 percent.

- Example 1. ... are now eager to research *in the field of* renewable energy and seek to invent ... (from ZHOC)
- Example 2. ... of these weight-loss techniques, young *people are likely to* give them up sooner or later ... (from LAEC)
- Example 3. This is the way older people like to follow but younger people *on the other side* have not got in mind. (from DEUC)

Interestingly, when examining the overall function distribution as illustrated above, there appears to be some convergence and divergence between findings in the current study and in some previous studies (Fuster-Márquez, 2014; Lu et al., 2018; Ren, 2022; Tan & Römer, 2022). Previous studies all conclude that referential, namely research-oriented p-frames are the most used which is consistent with the present finding (Fuster-Márquez, 2014; Tan & Römer, 2022). However, they also report that stance p-frames or participant-oriented sequences are the smallest ones in their corpora (Lu et al., 2018). Similarly, Ren (2022) argues that there exists an overuse of stance p-frames in their L1 English counterparts. These results are quite different from the findings of this study. One of its most probable explanations is the corpus genre, as previous scholars all investigate academic writing, whereas this present study examines argumentative essays. Both genres focus on the delivery of information, so their referential p-frames outnumber the other functional categories, but

the argumentative essays focus additionally on conveying the writer's point of view. There are prompts of the learner corpora used in this study which explicitly state "Do you agree or disagree ...". So, the writer's primary task and aim in writing is to express his or her position clearly. In this sense, it is reasonable that stance p-frames are not the least frequent in the present study.

With respect to the underuse or overuse issue through log-likelihood ratio tests, new results can be yielded as for the normalized frequency of p-frames from each primary function (Fig. 4 a-2, b-2, c-2). It can be found from Fig. 4 c-2, within the two learner groups, significant difference is revealed with the fact that Chinese EFL learners underused referential (LL = 21.07, $p < 0.001$), stance (LL = 343.62, $p < 0.001$) and discourse organizing frames (LL = 214, $p < 0.001$) compared to German EFL learners, which can be attributed to German EFL learners' over-reliance on such recurrent sequences to a large extent (Schmitt, 2004). In comparison with LAEC, both Chinese and German EFL learners employed significantly more stance p-frames and fewer referential p-frames. German students also employed significantly fewer discourse organizing frames (LL = 285.36, $p < 0.001$). Their excessive use of stance p-frames can be explained by the argumentative genre of the selected essays in the corpora. Furthermore, these argumentative essays were collected from the TOEFL writing test, a time-constrained examination with outcomes that can exert a direct and substantial influence on test-takers. Consequently, participants are justifiably under pressure to demonstrate their ability to compose well-crafted argumentative essays with distinct argumentative characteristics. It is through the use of stance expressions that "writers stamp themselves on their claims and propositions, and express the attitude they hold toward the content" (Wu & Paltridge, 2021, p. 2) as well as make their personal response to the given prompt. However, whilst students' awareness is helpful, their English proficiency is probably limited, so it remains challenging to demonstrate their familiarity with the discussed topics, which results in the underuse of referential p-frames.

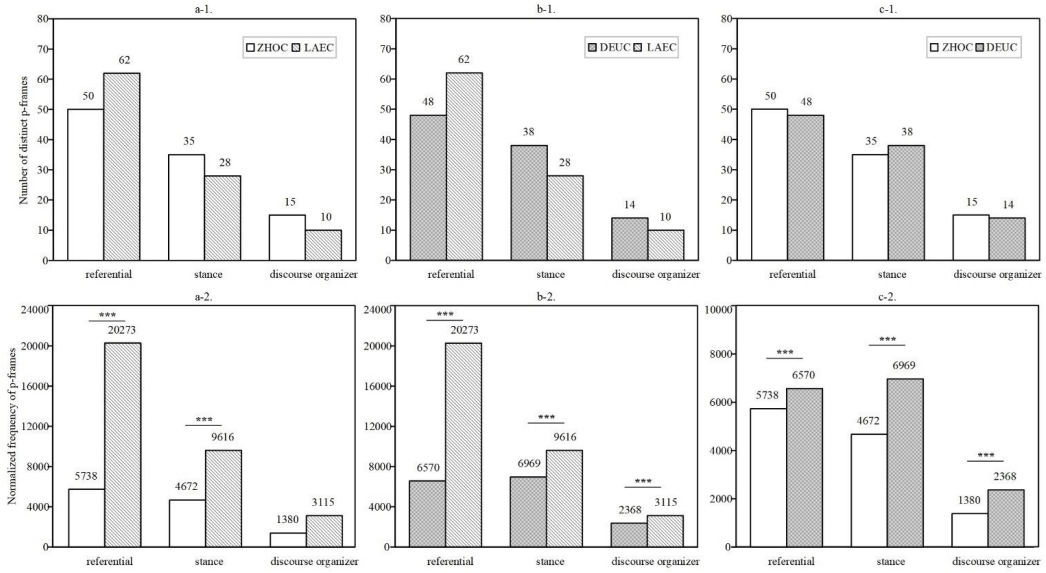

Figure 3: Functions of the four-word p-frames in the argumentative essays by Chinese and German EFL learners compared with their L1 English counterparts. *** $p < 0.001$

German EFL learners' tendency to overuse could be attributed to the crosslinguistic influence of the German language when compared to Chinese EFL learners. Within the context of the current study, the anticipatory-*it* structure serves as an illustrative example. In German, the word "es" can function similarly to the anticipatory-*it* in English, representing subordinate clauses (e.g., "It is good to do something." and "Es ist gut, etwas zu tun."). However, Chinese lacks an equivalent counterpart for the anticipatory-*it* structure, which can pose a significant challenge for Chinese EFL learners. As evident from the p-frame lists, the p-frame "*it is * to*" occurs with a normalized frequency of 794.53 occurrences PMWs in DEUC, which is higher than the 415.42 occurrences PMWs in ZHOC. Likewise, the p-frame "*it is * that*" was used 220.89 instances PMWs in DEUC, which is higher than the 200.67 instances PMWs in ZHOC. The frequency disparities suggest a possible crosslinguistic influence from EFL learners' native language to their foreign language learning (Güngör & Uysal, 2020). However, the p-frame "*it is * to*" continues to be the most frequently used in Chinese EFL learners' writing, which can be attributed to students' awareness of the differences and deliberate practice based on explicit instruction (Chen & Hu, 2020).

Furthermore, Huang (2015) pointed out that more does not mean better, and "quality speaks louder than quantity in benchmarking phraseological proficiency" (p. 21). Although EFL learners are inclined to use a limited number of formulaic word combinations more frequently and even though senior students tend to use them with higher lexical complexity in their essay writing, they have not used them significantly more accurately than junior ones. As is the case in the present study, EFL learners use significantly more p-frames than their L1 English counterparts, but there are also many ungrammatical or misspelling sequences. Meanwhile, there still remains a gap between the p-frame structural and functional realization of learners and that of their L1 English counterparts. Therefore, the quality and diversity of the p-frame used in students' writing are much more important than simple quantity. Only quantitative gains cannot guarantee the progress of L2 proficiency. As illustrated by Ellis (1996), language learning is the learning of sequences and learners "must acquire word sequences in phrases" (p.92). The goal of effective instruction is to not only raise learners' awareness of using formulaic sequences but also to instruct them to use them in a grammatically correct and functionally appropriate manner.

4. Conclusion

This current study, by comparing the p-frames used by Chinese and German L2 learners with those used by their L1 English counterparts, has produced three major findings that bear important implications. Both Chinese and German EFL learners used significantly more fixed and predictable p-frames than their L1 English counterparts. Chinese EFL learners reported significantly fewer tokens of p-frames than German learners, which were significantly more variable, but also significantly more predictable. As for the functional features of p-frame use, although Chinese students had significantly fewer p-frames for each functional category than German, they all used significantly more stance p-frames and fewer referential p-frames than their L1 English counterparts. Finally, it is suggested that EFL learners should understand the characteristics of p-frames and learn to use them accurately rather than blindly piling up more and more of them. This study highlights the importance of corpus-based, data-driven phrase learning in writing instruction. Emphasizing frequent and variable p-frames raises students' awareness and promotes conscious learning. Corpus technology, including various corpora and concordance tools, aids in teaching appropriate word and phrase use. This self-motivated exploratory learning helps learners grasp the structure and function of p-frames effectively.

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The Digital Revolution in Education: The Role of AI from the Perspective of Future Teachers

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Abstract: We are currently witnessing rapid technological advancement and modernisation of society, with digital technology, particularly artificial intelligence (AI), increasingly asserting its dominance. This study focuses on understanding the attitudes and expectations of future teachers towards AI, which has an impact on all areas of society, especially on the education and preparation of future teachers. Through a questionnaire survey, the study seeks to gain a more detailed insight into how future educators perceive AI and their attitudes towards it. The questionnaire, which was specifically designed for this research, focuses on different aspects of perceptions of AI in education. Respondents from both primary and secondary school teacher education programmes expressed their views on the use of AI in the pedagogical process, its impact on teacher-student interaction and indicated possible implications for the future of education. The main objectives of the research were to determine the views of prospective teachers on the use of AI in teaching, to identify positive, negative or neutral attitudes towards the integration of AI into the educational process, to identify the future role of AI in education, to determine how prospective teachers envision the use of AI in the pedagogical environment in the long term, to identify areas where teaching with AI could be most effectively integrated, and to identify areas where AI could be most appropriately used to improve educational outcomes and processes. The data presented through this paper is part of the "Perceptions of AI by current and future teachers" project. The results of this study could provide valuable information for educational institutions, policy makers of educational strategies and frameworks, and AI developers to better understand the needs and expectations of future teachers in the context of the increasing digitalisation of education. Our intention is to fill the knowledge gap on the perception of AI in educational contexts and thus provide important information for the future development of pedagogical strategies and technologies in education.

Keywords: Video games, Academic performance, Projective testing, High school, Addiction

1. Introduction

Traditionally conceived education is currently facing many challenges, and not only in the Czech Republic. Pressure is currently exerted on current and future teachers from several directions, forcing them to constantly adapt teaching methods, forms, activities and educational content to the current times. The catalyst for these changes is ever-accelerating technological developments led by artificial intelligence (AI). According to a study conducted by the European Commission (2018), AI is one of the main drivers behind the transformation of the education system, both in the teaching process and in the creation of new pedagogical methods and tools. It can be assumed that the integration of AI into education at all levels will be gradual. One of the hurdles that teachers in many countries face in coping with this new technology is their heavy workload as expressed by the student (pupil)-teacher ratio. However, digital technologies (including AI) can be an effective solution to some of the current problems in education (excessive teacher workloads, increased personalisation of learning and working with gifted pupils and pupils with special needs or from disadvantaged backgrounds, etc.). Related to this is the need to scientifically validate different solutions for the use of AI in education across different target groups. From the perspective of learners, AI tools have a demonstrable positive impact on skills development in the form of improved written expression and step-by-step problem solving according to some authors. There were also positive impacts in learning fixation, with students using ChatGPT to create quizzes on different subjects. Chatbots enable access to educational content according to their learning preferences and subsequently improve learning outcomes and promote the integration of old and new knowledge. Beyond the direct interaction of AI with the student, pedagogical research also talks about the effect of AI on the teacher's work. Here, saving time in a teacher's routine tasks (planning, assessment, question generation, etc.) and in the extension and improvement of the quality of teaching seems to be a significant benefit. The promising scientific results and findings will therefore have to be transferred to pedagogical practice. We believe that one of the potential barriers may be the fears, prejudices or negative attitudes of current and future teachers towards the use of AI in teaching practice, which may stem from a very narrow awareness of this technology and its potential

benefits for the educational process. We therefore think it is essential to map positive and negative opinions, attitudes and concerns to understand how current and future teachers perceive the advent of AI.

Therefore, we focus on this issue in one of the parts of our research and present partial research findings on the relationship of future teachers to AI in the text of the paper. We must bear in mind that this generation of future teachers is in most cases still not systematically prepared for the use of AI in education, but it cannot be ruled out that they will avoid this technology in their future work. A questionnaire was used to determine the opinions, attitudes and potential concerns of trainee teachers towards the use of AI in education. This survey will allow us to answer the following research questions:

RQ1: How are trainee teachers familiar with applications and tools of artificial intelligence and their possible use in future teaching work?

RQ2: What is the attitude of future teachers towards the use of AI tools in teaching?

RQ3: How do future teachers perceive the use of AI tools in their future work?

RQ4: What are the perceived potential risks of using AI for trainee teachers in relation to their future professional work?

2. Methods

We chose a quantitative strategy for our research and used a questionnaire as a research tool to analyse the issue of AI in education through the eyes of future teachers. Our research looked at several factors, such as views on the use of AI in the teaching process; AI as an 'enhancer' of learning outcomes; possible challenges for the future and, conversely, the risks associated with it. The questionnaire entitled 'Artificial Intelligence and Future Teachers' contained a total of 22 questions and was specifically designed for the purpose of this research. The nature of the questions included a combination of closed-ended multiple-choice, open-ended and scaled questions. The first seven questions were used to obtain information about the respondents, i.e., their gender, the focus of the study programme, its forms, type of school and year, study approbation and parent college. The following questions offered them an opportunity to express their own views and attitudes towards AI in the context of teaching such as student motivation, improved learning outcomes, change in language and communication skills, and critical assessment of generative tools. Respondents also commented on the use of AI in their future professional work as teachers, reflecting on possible future use, but also related limitations. The questionnaire itself was distributed by email using Google Forms, a platform chosen for its user-friendliness, ease of distribution and the possibility of efficient data collection. The main target group of the questionnaire survey was students of teacher-oriented study programmes, specifically Pedagogy for Lower and Upper Primary School and Pedagogy for Secondary School, Social and Special Education. The selection of these groups was motivated by the desire to understand and analyse how the current young generation, who will be working in the department in a few years, views AI from the other side. The data was collected in April 2024. We managed to collect responses from 222 respondents.

3. Results

The survey asked several key questions regarding familiarity with AI applications and tools, attitudes towards their use in teaching and potential risks associated with their implementation. The results of the study can be used to discuss the modernisation of the educational process, to innovate/revise the courses of the given study programmes and to adapt to new technological trends in the field of pedagogy. In the research part we focused on the overall view of the students as well as on subgroups, which were divided according to the following criteria.

Table 1: Distribution of the research sample by gender, field of study and type of study

Gender		
Female	167	75%
Male	54	24%
Do not want to answer	1	1%
Field of study		
Teaching for lower primary school	45	20%
Teaching for upper primary school	59	27%

Teaching for secondary school	78	35%
Social pedagogy	17	8%
Special education	22	10%
Type of study		
Full-time	160	72%
Part-time	62	28%

If you have already encountered AI tools, what specific tools have you come across?

The results of the questionnaire show that out of 222 respondents, 35 have never had experience with AI tools. Among those who had experience, tools such as ChatGPT and OpenAI predominate (167 respondents). Others mention applications like Geminy, Deepl and other tools for generating text, images and music. This data suggests that experience with AI tools is quite widespread among trainee teachers, with ChatGPT tools being used most frequently. If we look at the distribution by the type of study, it shows that out of the 35 respondents who have no experience of using AI, 10 are from part-time studies and 25 are from full-time studies. Although in absolute numbers the number of respondents who have never had experience with AI was lower in part-time study than in full-time study, if we look at the percentages of the total, the result is very similar in both forms (16.1% in part-time and 15.6% in full-time). Similar results are obtained for respondents who have some experience, and it turns out that the use of AI is not related to the type of study.

Different results are obtained if we divide the respondents according to their study programmes (social pedagogy, special education, lower primary school, upper primary school and secondary school). Our data analysis shows that there are differences in the experience of using AI between different groups of students according to the type of study. The highest percentage of students with no experience with AI is recorded in special education and lower primary school, at 19% of the total. On the contrary, upper primary and secondary school students show lower percentages (6% and 4% respectively). This data may indicate differences in the integration of modern technologies in the educational process between different disciplines.

The gender breakdown also shows that there is some correlation among our respondents. As many as 91% of men have some experience with AI tools, while the figure for women is lower at around 82%.

How many teachers have introduced you to AI applications and tools and how can they be used in future teaching work?

Respondents chose from 1 (all) to 5 (none). The data obtained from our quantitative research showed that the mean response was 3.59, indicating that most respondents stated a medium level of familiarity with these technologies, with a standard deviation of 1.42 indicating a dispersion of values around the mean. The median response of 4 then suggests that half of the respondents were rarely or not at all familiar with AI from their teachers, indicating a certain lack of awareness in the teaching environment regarding technological trends dealing with AI. If we look at gender, women answered on average 3.57, men 3.69. The dispersion for women was higher. Both groups are around a medium level of familiarity. The differences between part-time and full-time students are not significant either. Similar results are obtained if we divide the respondents into part-time and full-time students (part-time 3.44 and standard deviation = 1.70; full-time 3.65 and standard deviation = 1.29). However, a certain difference can be traced if we look at the student's individual study programmes (lower and upper primary school, secondary school, special education and social pedagogy). The results show that the mean score is low, indicating that students generally feel a lack of familiarity with these topics. The group of social pedagogy students received the best rating (closest to 1) with an average rating of 3.06, indicating that familiarity with AI applications was most prevalent in this group. Conversely, the worst rating (closest to 5) was obtained by the group of trainee teachers for upper primary school level with an average rating of 4.01, indicating that these students perceive their familiarity with AI applications as least sufficient, see Figure 1.

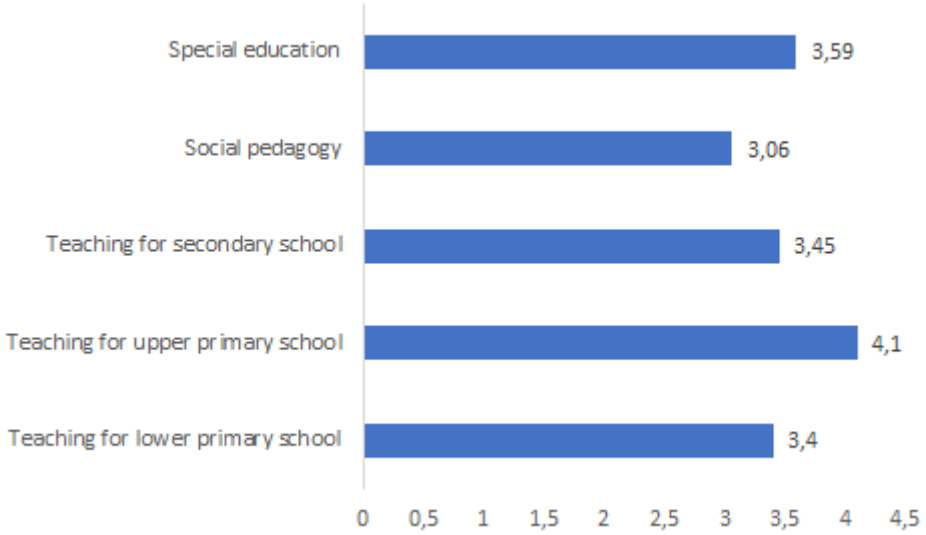

Figure 1: Average number of teachers who introduced students to AI applications and tools and their potential use in educational work. Divided according to the field of study. (1 – all; 5 – none)

What is your attitude towards the use of AI tools in education?

For this question, students again chose from 1 (positive) to 5 (negative). The graph shows the frequency of responses.

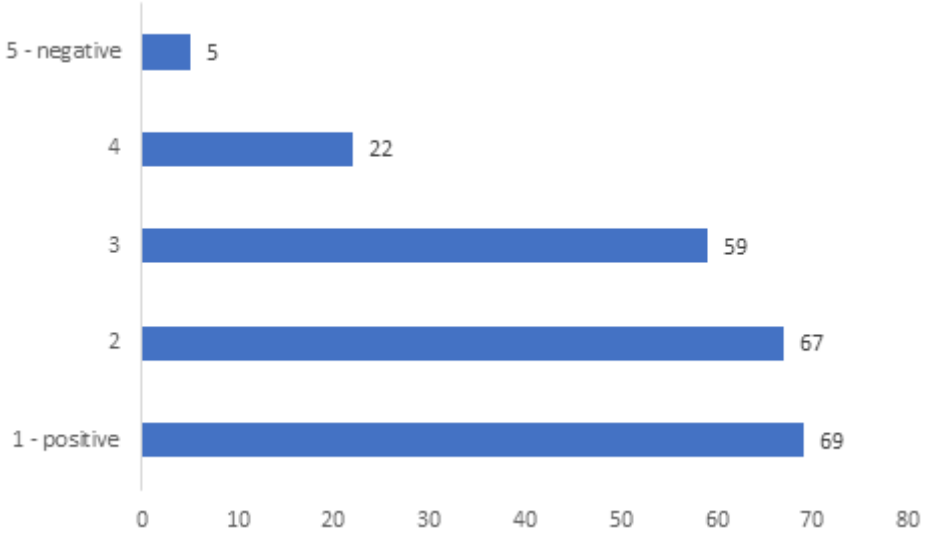

Figure 2: Distribution of students' attitudes towards the use of AI in teaching

The average attitude of respondents towards this issue was 2.22, indicating a rather positive attitude towards the use of AI in teaching. The standard deviation of 1.07 shows some variability in the responses, yet together with the median value of 2, it confirms that the majority of respondents have a rather positive attitude towards this issue. This suggests that trainee teachers are interested and open-minded about the use of AI tools in teaching, although there is some diversity in their views.

The gender breakdown of the respondents yielded the following findings on their attitudes towards the use of AI tools in teaching. For male respondents the average response was 1.83, indicating an even more positive attitude towards this issue than the overall average. A standard deviation of 0.96 indicates less variability in responses among men, which may indicate greater agreement in their views. The median value of 2 suggests that, here too, most men have a rather positive attitude towards the use of AI in teaching.

On the other hand female respondents had a higher average response, specifically 2.34, indicating a slightly higher level of scepticism or reserve compared to males. The standard deviation of 1.07 indicates a greater variability in women's responses, suggesting that opinions among women may be more diverse. The median value of 2 indicates that most women still have a rather positive attitude towards this issue, although slightly lower than men. From these results, it can be concluded that men generally show more positive attitudes towards the use of AI tools in education than women, although both groups show similar trends in the direction of their attitudes.

It can be observed that, similarly to the previous question, it does not matter much whether our respondents are from part-time or full-time studies. This similarity is interesting. Part-time students have on average a higher age, which would suggest a lower interest in new technologies. On the other hand students studying part-time might have different attitudes because of the greater involvement of technology and distance learning. However, the fact that their attitudinal responses were not significantly different from those of full-time students suggests that the use of technology in teaching may be perceived similarly regardless of the particular form of study, and this would certainly be worthy of more detailed research.

Table 2: Attitude towards the use of AI in teaching by type of study (1 – positive, 5 – negative)

	Type of study	N	Mean	Median	SD
Attitudes towards the use of AI tools in education	Full-time	159	2.23	2	1.04
	Part-time	62	2.18	2	1.14

Interesting findings are the results of the distribution of students according to their future focus into lower primary school teachers, upper primary school teachers, secondary school teachers, social pedagogy teachers and special education teachers. Despite the different expectations in attitudes towards the use of AI tools in education by focus, the results proved to be very similar. The average attitude of students across the range of focuses was around 2.2, indicating a rather positive attitude towards the use of AI in teaching. A standard deviation of around 1.1 indicates some variability in responses, suggesting that despite similar means there may be differences in attitudes between groups. The most positive attitudes in this respect were from prospective upper primary school teachers, who had a mean value of 2.02 and a lower dispersion in responses (0.86). This result may indicate that these students have a more positive attitude towards the use of AI in teaching than students with a focus in other areas. On the other hand students with a focus on special education had the worst results in this respect, with the highest mean value (2.55) and median response (3), indicating a slightly more negative attitude towards the use of AI in teaching. This group may have special needs or concerns about the use of technology in special education. These results suggest that despite the expected differences in attitudes by focus, students generally have similar attitudes towards the use of AI tools in education.

Table 3: Attitude towards the use of AI in teaching by type of study (1 – positive, 5 – negative)

	Study	N	Mean	Median	SD
Attitudes towards the use of AI tools in education	Lower primary school	45	2.27	2	1.176
	Upper primary school	59	2.02	2	0.861
	Secondary school	78	2.24	2	1.119
	Social pedagogy	17	2.24	2	1.147
	Special education	22	2.55	3	1.057

Would you use AI tools in your future professional work as a teacher?

The average response to the question "Would you use AI tools in your future work?" was 1.98, indicating that students showed a rather positive attitude towards using AI tools in their future teaching work. A standard deviation of 1.15 indicates some variability in responses, suggesting that some students may be more sceptical than others. The median response of 2 indicates that the majority of respondents have a rather positive attitude

towards this issue. A comparison with responses to the question "What is your attitude towards the use of AI tools in education?" shows that students have generally similar attitudinal responses to the use of AI in teaching, but slightly prefer the possibility of using these technologies in their future work than in teaching in general. These results show that trainee teachers have a positive attitude towards the use of AI tools both in education in general and in their future teaching work. This indicates students' openness and readiness to use modern technology to support teaching and learning. If we compare both results with the first question "How many teachers have introduced you to AI applications and tools and their potential use in future teaching work?", the average answer to this question indicates that most students are not fully familiar with AI applications and tools and their potential use in future teaching work. A comparison with the previous two questions suggests that although students have a rather positive attitude towards the use of AI tools in teaching and in their future work, most of them were not sufficiently familiar with these technologies. This may impact their ability to use these tools effectively in future teaching work.

We also observed that for men, the average response to the question "Would you use AI tools in your future professional work as a teacher?" was lower than the overall average, specifically 1.67. This suggests that male respondents showed an even more positive attitude towards the use of AI in their future teaching work. The dispersion of responses for men was 0.99, indicating less variability in their attitudes. The median response for males was 1, indicating that the majority of male respondents clearly expressed their willingness to use AI in future work. On the other hand the average answer for women was higher, specifically 2.08. This suggests that female respondents were less inclined to use AI in their future teaching work than males. The dispersion of responses for women was 1.19, indicating greater variability in attitudes among women. The median response for women was 2, indicating that the majority of female respondents shared a moderately positive attitude towards the use of AI in future work. If we look at whether students study full-time or part-time, again both groups show almost identical results.

Table 4: Use of AI tools in future teaching work by type of study (1 – definitely yes, 5 – definitely no)

	Type of study	N	Mean	Median	SD
Use of AI tools in future work	Full-time	159	1.99	2	1.13
	Part-time	62	1.95	1	1.22

Quite visible differences can again be seen if we look at the respondents according to their future focus. Prospective upper primary school teachers had the most positive result with an average of 1.66 and a deviation of 0.99. Furthermore, a median of 1 indicates a positive perception of the use of AI in their future work. The lowest results in the notional rankings were from students focusing on special education. Their mean was 2.55 with a deviation of 1.30 and a median of 2.50.

Table 5: Use of AI tools in future teaching work according to the focus of study (1 – definitely yes, 5 – definitely no)

	Study	N	Mean	Median	SD
Use of AI tools in future work	Lower primary school	45	2.02	2	1.215
	Upper primary school	59	1.66	1	0.993
	Secondary school	78	2.05	2	1.115
	Social pedagogy	17	1.94	1	1.249
	Special education	22	2.55	2.5	1.299

What do you perceive as possible risks of using AI in your future career as a teacher?

Students were given several options to choose from. The results of the quantitative research conducted at the University of Ostrava indicate that out of 222 respondents, 125 perceived the substitution of human interaction as a possible risk of using AI in teaching work, while 60 respondents expressed concerns about technical difficulties. Furthermore, 110 respondents cited the unpreparedness of educators to integrate these technologies as a potential problem, and the majority of respondents, specifically 172, see the possibility of cheating as a risk. Only 3 respondents do not consider any of these risks to be significant.

Let's look at the interpretation of the results of your quantitative research:

- Replacement of human interaction (125 responses)
- *This result suggests that the majority of respondents perceive the possibility that AI may replace human interaction in the teaching process, which could lead to less personal contact between teacher and pupils.*
- Technical difficulties (60 responses)
- *About a quarter of the students surveyed see technical difficulties as a possible risk. This may include technology issues such as equipment failure, internet connectivity issues or the difficulty of using technological tools.*
- Unpreparedness of teachers (110 responses)
- *The majority of respondents perceived that educators may be unprepared for the integration of AI into the classroom. More preparation and training for teachers and curriculum adjustments in teacher-centred programmes are needed to enable them to use modern technology effectively in teaching.*
- Cheating (172 responses)
- *This result shows that many respondents consider the possibility of cheating to be a risk associated with the use of AI in educational settings.*
- No concerns (3 responses):
- *Only a small number of respondents see no potential risks associated with the use of AI in their future professional work.*

Students also had the opportunity to write their own opinion on possible concerns. This option was used by 19 respondents. In this part, three main areas were repeated. As an example, we always present a few answers from the students themselves

- Problems with critical thinking
- *"It is possible that students' critical thinking will decline and that they will rely more on AI."*
- *"Lack of critical thinking when AI does it for you."*
- *"A confluence of true and false information that we will not be able to critically distinguish."*
- Work with errors
- *"Use of unverified, erroneous information; loss of ability to search on the internet."*
- *"Incomplete or incorrect answers."*
- Cyberbullying
- *"Bullying using pupils' faces. Spreading false information about teachers that may jeopardise their credibility or job position."*
- *"Deep fakes, cyberbullying."*

This part of the study highlights the importance of taking the concerns and preparation of educators into account when implementing AI in the learning environment.

4. Discussion

In our research we investigated key aspects related to familiarity with AI applications and tools, attitudes towards their use in teaching and potential risks associated with their implementation among the target group of future teachers. The research findings reveal important factors and potential consequences associated with the integration of AI tools into the education process, especially in the preparation of future teachers. The results of the study provide a basis for discussion on the modernisation and innovation of study programmes and their adaptation to new technological trends. The discussion focuses on three main areas: students' awareness of and experience with AI, their attitudes towards the use of AI in teaching and the potential risks associated with the implementation of these technologies.

Awareness and experience with AI tools

The results show that the majority of trainee teachers already have experience with AI tools, with ChatGPT and OpenAI being the most frequently cited applications. This trend is evident across different study programmes and types of study, indicating a relatively high level of technological awareness among prospective teachers. However, there is still a minority of students who have no experience with AI, suggesting the need for a greater focus on integrating these technologies into the curriculum.

Attitudes towards the use of AI in education

The results show that student teachers have a generally positive attitude towards the use of AI tools in teaching. This positive approach to AI in teaching indicates the willingness of trainee teachers to embrace and use modern technology to support the learning process. At the same time our respondents show a higher willingness to use AI in their future teaching work, with average responses again indicating a more positive attitude. This positive attitude is key to the successful integration of AI into the classroom, as it reflects students' openness and willingness to experiment with new technologies.

Risks associated with the implementation of AI

Identified risks associated with the use of AI in education include the replacement of human interaction, technical difficulties, unpreparedness of educators and the potential for cheating. The most significant risk, according to respondents, is the possibility of cheating, cited by 172 respondents. These concerns need to be taken seriously and addressed through targeted and thorough teacher training. Furthermore, effective integration of AI tools into teaching, which may minimise risks, is necessary.

Based on these findings it is clear that integrating AI into the education process requires a comprehensive approach. This can be achieved, for example, through:

- *An increase of awareness and training:* Providing more training seminars and courses on the use of AI in education to increase the competences of educators. Providing practical workshops and training for teachers.
- *Innovation of study programmes:* Revising and modernising study programmes to integrate AI technologies and tools into the curriculum in order to equip students with practical skills and knowledge. Incorporating specific AI-focused courses into study programmes.
- *An individual approach:* Adapting education programmes and training to the specific needs of each group of students, taking into account differences in attitudes towards AI.
- *Support of critical thinking:* Focusing on the development of critical thinking and information handling skills so that students are able to use AI effectively while recognising potential risks and errors.
- *Ethical aspects and safety:* It is imperative to develop clear rules and ethical guidelines for the use of AI in the education of future teachers to ensure safe and ethical use of these technologies.

5. Conclusion

The results of our research provide insight into the current state of awareness, experiences and attitudes of trainee teachers towards AI tools. We analysed the responses of 222 respondents studying in various teacher training programmes and identified several trends that can contribute to the modernisation of the education process. Although there are differences between respondents depending on their field of study and gender, they generally have a positive attitude towards the integration of AI in the classroom. The results suggest that there is a need for more awareness and training of educators in AI, as trainee teachers are willing to use AI in their future professional work. Although the majority of students expressed a positive attitude towards the use of AI in their future teaching work, a significant number of respondents pointed out the risks associated with the implementation of these technologies. The main concerns included the possibility of replacing human interaction, technical problems, a lack of teacher training and the risk of cheating.

In conclusion, students are willing and ready to embrace modern technologies, including AI, as part of their teaching work. However, our research has also highlighted the need for more familiarity and hands-on experience with AI. The key to successful implementation is ensuring that all stakeholders are sufficiently informed and prepared for the challenges that these technologies bring. This will ensure that future teachers are prepared to use AI effectively in their work, which could significantly contribute to the modernisation and improvement of the educational process.

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Student Learning Performance Evaluation: Mitigating the Challenges of Generative AI Chatbot Misuse in Student Assessments

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Abstract: Since the launch of ChatGPT, a growing number of generative artificial intelligence (AI) chatbots have entered the market. Although chatbots have the potential to help students learn, misusing them to complete assessments raises questions about the authenticity of the work and puts students at risk of academic misconduct. Given the crucial role of assessments in evaluating students' learning performance, uncertainties about the authenticity of the work call into question the extent to which students have achieved the intended learning outcomes. This study conducted a thematic analysis to provide an overview of the challenges that chatbot misuse may pose to student learning performance evaluation, followed by the various mitigation strategies to overcome these challenges. This study searched the Education Resources Information Centre (ERIC) database for peer-reviewed articles published in scholarly journals after 30 November 2022 (the launch date of ChatGPT, as this study focuses on generative AI rather than other types of AI) and until 30 April 2024. The thematic analysis of 17 articles identified five major themes (and respective sub-themes) in the discussions of these articles, i.e., reasons students use chatbots for assessments, challenges that chatbots may pose to student learning performance evaluation, mitigation strategies, detection strategies, and counter-detection strategies. As chatbots become more prevalent and powerful, the study's findings provide education stakeholders with insightful information on the implications of students misusing chatbots for assessments and how this affects their learning performance evaluation.

Keywords: Assessments, Education, Education policy, Generative AI, Learning erformance, Performance evaluation

1. Introduction

Generative artificial intelligence (AI) chatbots' (e.g., Google's Gemini, Microsoft's Copilot, and OpenAI's ChatGPT) ability to easily generate content for a wide range of topics at the command of a prompt has made such chatbots a popular tool among students to help with their assessments (Ansari et al., 2023; Ayanwale and Ndlovu, 2024; Tang and Chaw, 2023). Students can benefit from leveraging chatbots for tasks such as paraphrasing text, generating ideas, searching for information, etc. (Farrokhnia et al., 2024; Nugroho et al., 2024). Chatbots can quickly complete these tasks, despite concerns about the accuracy and originality of their outputs (Altun et al., 2024; Khalil and Er, 2023).

However, some students may misuse chatbots to complete their assessments (Crompton and Burke, 2024; Kooli, 2023), e.g., by copying and submitting chatbot output as their original work. Because assessments typically measure students' levels of achievement in the intended learning outcomes (Gao et al., 2020; Gerritsen-van Leeuwenkamp et al., 2019), misusing chatbots to complete assessments not only undermines students' ability to learn essential skills but also distorts assessment grades or marks, misrepresenting the students' true learning performance (Kooli, 2023).

Although academic literature has discussed the impacts of chatbots on student assessment, these discussions often occur in silos. Therefore, this study intends to perform a thematic analysis to synthesise the discussions, identify themes, and explore the relationships between these themes. Specifically, this study aims to provide a deeper and expanded answer to two research questions: (1) What are the challenges chatbots may pose to student learning performance evaluation if students misuse chatbots to complete their assessments, and (2) What are the measures to mitigate these challenges?

The study's findings contribute to the overall understanding of the implications of misusing chatbots for assessments and provide stakeholders in the education system, such as educators, students, policymakers, and administrators, with an overview of the challenges that misusing chatbots for assessments may pose to student learning performance evaluation, as well as mitigation strategies to address these challenges.

The remainder of this paper provides a background to the research, explains the research design and method, presents the study's findings, and concludes with a discussion of the study's findings and future research directions.

2. Research Background

Student assessments are an essential part of the teaching and learning process. Depending on the purpose and objective of the assessment, educators typically use a variety of assessment methods, including reports, presentations, projects, exams, case studies, tests, and so on, to evaluate student learning performance to determine quality of work, progress, and areas for improvement (Flores et al., 2015; Neto et al., 2023). Broadly, assessment methods can be categorised into two types: formative and summative. Formative assessments provide information about students' progress towards the intended learning outcomes, whereas summative assessments measure student achievement of the intended learning outcomes (Lau, 2016).

Accurate evaluation of student learning performance provides meaningful feedback for continuous improvement in teaching and learning, policymaking, and governance (Al-Thani et al., 2014; Chaudhry et al., 2023). Educators and education institutions use the results of assessments to evaluate the effectiveness and quality of teaching and learning. They then implement necessary changes, such as modifying teaching and learning policies, strategies, activities, and assessments, to improve future student performance in achieving the learning outcomes (Biggs, 2014; O'Neill and Padden; 2022).

To accurately reflect the student's learning performance, it is essential that the assessment is the student's own work and that the student has put in their best effort to complete it. However, the emergence of chatbots, which can generate answers to nearly any question despite concerns about their accuracy, exposes educators and education institutions to the possibility of students misusing these chatbots and submitting the generated answers as their own (Dwivedi et al., 2023). This misuse of chatbots for assessments not only raises concerns about academic dishonesty, but also challenges the fundamental purpose and objective of student assessment, potentially misleading educators and education institutions about students' true learning performance (Kooli, 2023).

3. Research Design and Method

3.1 Thematic Analysis

Thematic analysis is a qualitative data analysis method that aims to identify and interpret repetitive patterns (themes) in the data, and the relationships between those themes, that are underlying certain aspects of a phenomenon (Boyatzis, 1998; Braun and Clarke, 2006). This study followed the reflexive thematic analysis approach as outlined in Braun and Clarke's (2006) six-phase guide: (1) familiarising with data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining themes, and (6) producing the report.

3.2 Database and Article Screening Process

This study searched for articles that expressly addressed the challenges that generative AI may pose to student assessment in an educational setting. To find these articles, this study searched the Education Resources Information Centre (ERIC) database via ProQuest. This study did not limit the search to any specific educational disciplines, levels, or assessment methods, as the intention was to find articles discussing assessments in the broader context of chatbots. The search utilised a specific search string (see Figure 1 for the search string) and restricted the results to peer-reviewed, scholarly journals. This study conducted the search on 01 May 2024, and as the focus was on generative AI, limited the search to articles published after 30 November 2022 (ChatGPT's initial launch date). The search returned 120 articles.

o screen articles that were eligible for the thematic analysis, this study first examined the titles and abstracts of individual articles, and 92 articles were rejected based on several specific criteria (see Figure 1 for the criteria). This study then read the full text of the remaining 28 articles. This process removed another 12 articles. In addition, the analysis identified three more articles via citations in some of the articles. This study reviewed these additional articles but eliminated two of them. In total, this study deemed 17 articles eligible and included them in the thematic analysis. Figure 1 depicts the flow diagram of the screening process.

Figure 1: Flow diagram of the screening process (adapted from the PRISMA 2020 statement (Page et al., 2021))

3.3 Data Analysis

The dataset consisted of the articles identified through the screening process. Each article is deemed a data item in thematic analysis. After reading the individual articles to have a broad understanding of what they discussed, this study began extracting data that described certain aspects that were relevant to the research questions. The data extracts were typically a partial or complete sentence or paragraph. This study then coded the individual data extracts. It is possible to code a data extract one or more times to different codes. To maintain coding consistency, the coder was the same person who diligently applied the codes.

This study generated the codes following an inductive (data-driven) approach to look for thematic similarities across the data items (Braun and Clarke, 2006; Braun and Clarke, 2021). The inductive approach works without referring to an a priori framework but to look for themes that reflect the data. This study generated a preliminary list of 34 codes during data analysis.

A subsequent review of the codes indicated that some of them shared similar characteristics with an underlying theme. As a result, this study followed an iterative approach of merging these similar codes, reducing the number of codes to 19, and then categorising the 19 codes into five main themes. Each main theme consisted of several sub-themes, respectively. To validate the codes (which are also considered sub-themes), this study reviewed them again, both at the level of the coded data extracts and the dataset. It appeared that these codes reflected coherently the underlying patterns in the data.

4. Study Findings

This study identified five main themes in the data, i.e., reasons for using chatbots for assessments, challenges that chatbots may bring to student learning performance evaluation, mitigation strategies, detection strategies, and counter-detection strategies. There appears to be a relationship between the themes. Figure 2 depicts the thematic map, which includes the final five main themes and their sub-themes (denoted by bulleted points). There are 19 sub-themes.

Figure 2: Thematic map (bulleted points denote sub-themes)

4.1 Reasons for Using Chatbots for Assessments

Some discussions in the articles indicated four main reasons why students leveraged chatbots for help with their assessments: (1) cognitive offloading (e.g., Alexander et al., 2023; Bai et al., 2024; Perkins, 2023); (2) academic pressure and stress (e.g., Crawford et al., 2023; Perkins et al., 2024; Yeadon et al., 2023); perceived benefits versus risks (e.g., Adilov et al., 2024; Nikolic et al., 2023); and minimum resources required (e.g., Bai et al., 2024; Lancaster, 2023; Yeadon et al., 2023).

4.2 Challenges That Chatbots may Pose to Student Learning Performance Evaluation

Most of the discussions in the articles focused on academic integrity violations (e.g., Lancaster, 2023; Nikolic et al., 2023; Perkins et al., 2024). Some specific examples include misinformation (Alexander et al., 2023; Chaudhry et al., 2023); questionable references (Bai et al., 2024; Niloy et al., 2024); plagiarism (Elkhatat, 2023; Ibrahim, 2023); biases (Alexander et al., 2023; Mao et al., 2024); cheating (Adilov et al., 2024; Chaudhry et al., 2023); misuse (Crawford et al., 2023; Mao et al., 2024); academic misconduct (Lancaster, 2023; Perkins, 2023); originality (Elkhatat, 2023); and authentication (Crawford et al., 2023).

A large percentage of discussions highlighted the possibility that chatbots, if misused, could hinder students from learning higher-order thinking skills such as critical thinking, creativity, analytic thinking, problem solving, and knowledge application (e.g., Bai et al., 2024; Blanke, 2024; Chaudhry et al., 2023; Mao et al., 2024; Niloy et al., 2024). Several discussions underlined that students could use chatbots as a shortcut tool (Blanke, 2024), outsourcing cognitive skills to chatbots (Chaudhry et al., 2023) and thus failing to satisfy learning outcomes (Lancaster, 2023). Some discussions, on the other hand, emphasised that if students did not gain essential skills from their learning (Chaudhry et al., 2023) or did not achieve the learning objectives (Alexander et al., 2023), or if the reputation of education institutions was in doubt (Crawford et al., 2023), the perceived value of education could decline.

Some discussions focused on compromised assessment reliability and validity when it was uncertain whether the assessments truly reflected student learning performance or achievement (e.g., Chaudhry et al., 2023; Gorichanaz, 2023; Ibrahim, 2023). A few discussions also raised concerns that students could gain an unfair

advantage by misusing chatbots to complete their assessments, even if unintentionally, and perform better than their peers who did not (e.g., Chaudhry et al., 2023; Perkins et al., 2024; Yeadon et al., 2023).

Other discussions stated that uncertainty about the authenticity of students' work (Blanke, 2024) could have potential adverse effects on trust relationships between students and lecturers, as well as between humans and technology (e.g., Bai et al., 2024; Mao et al., 2024; Gorichanaz, 2023) and could lead to accusations of academic misconduct (e.g., Gorichanaz, 2023; Perkins, 2023; Lancaster, 2023).

4.3 Mitigation Strategies

Many of the discussions in the articles suggested designing assessments to make it more difficult for students to misuse chatbots. Some specific examples include oral or physical assessment (Blanke, 2024; Gorichanaz, 2023; Yeadon et al., 2023); authentic assessment (Gorichanaz, 2023; Kortemeyer, 2023; Nikolic et al., 2023); skill-based assessment (Nikolic et al., 2023); critique of chatbot responses (Blanke, 2024; Kortemeyer, 2023; Perkins et al., 2024); interview-based assessment (Nikolic et al., 2023); specific requirements (e.g., discipline, framework, pre-approved topics) (Lancaster, 2023; Perkins et al., 2024); and podcasts (Crawford et al., 2023). Some discussions also called for incorporating AI as part of the assessment (e.g., Lancaster, 2023; Perkins et al., 2024) and developing assessment policies (including rubrics) (Alexander et al., 2023).

Some discussions emphasised the importance of institutional academic integrity policies (e.g., Alexander et al., 2023; Chaudhry et al., 2023; Lancaster, 2023), honour codes (e.g., Elkhatat, 2023), and the development of student moral characters (e.g., Crawford et al., 2023). Other discussions also highlighted the need for use policies or guidelines that promote the ethical, safe, and transparent use of AI (e.g., Gorichanaz, 2023; Mao et al., 2024; Perkins et al., 2024).

Concerning academic integrity and use policies, many of the discussions in the articles also stressed the need for educators and students to receive training and education on the ethical use of chatbots and their limitations (e.g., Gorichanaz, 2023; Lancaster, 2023; Mao et al., 2024), academic integrity policies (e.g., Chaudhry et al., 2023), and detection of AI-generated text (e.g., Alexander et al., 2023; Perkins et al., 2024).

Furthermore, some discussions pointed out the importance of designing learning to incorporate AI to teach students the AI skills they would need in the future (e.g., Bai et al., 2024; Kortemeyer, 2023; Nikolic et al., 2023). Such new skills could include prompt engineering (Alexander et al., 2023; Crawford et al., 2023), AI literacy (Mao et al., 2024), ethics (Nikolic et al., 2023), and greater emphasis on analysis and critical thinking (Blanke, 2024).

Other discussions touched on the need to engage stakeholders to better understand their perspectives on the use of AI. These stakeholders should include educators, students, education institutions, AI developers, etc. (e.g., Bai et al., 2024; Chaudhry et al., 2023; Lancaster, 2023).

4.4 Detection Strategies

Most of the discussions in the articles outlined the use of software to detect misuse of chatbots but raised concerns regarding its reliability and accuracy (e.g., Adilov et al., 2024; Ibrahim, 2023; Perkins et al., 2024). While software tools could detect AI-generated text, detecting AI-generated ideas proved more difficult (Gorichanaz, 2023). Some discussions focused on using human judgement to detect misuse (e.g., Chaudhry et al., 2023; Lancaster, 2023; Mao et al., 2024) and training educators to recognise AI-generated text by identifying specific features, such as questionable references or complex language (Perkins et al., 2024), spelling mistakes, or sentence construction (Alexander et al., 2023).

4.5 Counter-Detection Strategies

Some discussions in the articles noted how some students attempted to evade detection of their chatbot misuse by employing various strategies (e.g., Gorichanaz, 2023; Nikolic et al., 2023), such as prompt engineering or writing short sentences in bullet style (Perkins et al., 2024).

5. Discussion and Conclusions

The study's findings indicate that because chatbots are user-friendly and cost-effective, students are inclined to use them to reduce their cognitive load (Alexander et al., 2023; Bai et al., 2024; Perkins et al., 2024). Consequently, students who are experiencing academic pressure and stress may be more inclined to misuse chatbots (Crawford et al., 2023; Perkins et al., 2024; Yeadon et al., 2023). These findings are consistent with Alshurafat et al.'s (2024) findings that factors such as pressure and technology accessibility may lead to chatbot misuse. Besides, students who misuse chatbots may be willing to prioritise perceived benefits over the risks of

academic misconduct (Adilov et al., 2024; Nikolic et al., 2023). Given that students may use chatbots for cognitive offloading, education institutions could set clear use policies about how the students could do so ethically. For instance, education institutions could allow the use of chatbots for legitimate cognitive offloading tasks such as editing support (Nikolic et al., 2023), grammar checking, and idea generation (Crawford et al., 2023).

The study's findings reveal that educators frequently use software to detect AI-generated text to prevent chatbot misuse for assessments, despite such software's limited reliability and accuracy (Adilov et al., 2024; Alexander et al., 2023; Ibrahim, 2023). In addition to using software, educators also rely on human judgement for detection (Chaudhry et al., 2023; Lancaster, 2023; Mao et al., 2024). This practice is consistent with suggestions to train educators to more accurately identify AI-generated text (Alexander et al., 2023; Perkins et al., 2024). It appears that chatbots and detection software are competing to outdo one another. As chatbots improve their capabilities, this may become a recurring scenario in which they play catch-up with one another (Nikolic et al., 2023). Students who misuse chatbots, on the other hand, will adopt strategies like prompt engineering to evade detection (Gorichanaz, 2023; Nikolic et al., 2023; Perkins et al., 2024).

The study's findings highlight the challenges that chatbots may pose to student learning performance evaluation if students misuse chatbots to complete their assessments. It appears that students who misuse chatbots face the possibility of academic integrity violations (Lancaster, 2023; Nikolic et al., 2023; Perkins et al., 2024), and the misuse will also compromise the reliability and validity of assessments in measuring students' true learning performance (Chaudhry et al., 2023; Gorichanaz, 2023; Ibrahim, 2023). This casts further doubts on these students' learning performance in terms of achieving the learning objectives, meeting the learning outcomes, and whether they have indeed grasped essential higher-order thinking skills in their studies (Blanke, 2024; Chaudhry et al., 2023; Lancaster, 2023). As a result, the value of education and education institutions' reputation may be questioned (Alexander et al., 2023; Chaudhry et al., 2023; Crawford et al., 2023). Students who misuse chatbots may also gain an unfair advantage over their peers, if the misuse is undetected, which creates an unfair situation for student learning performance evaluation (Chaudhry et al., 2023; Perkins et al., 2024; Yeadon et al., 2023). Additionally, doubts or accusations that arise about the authenticity of the assessments would in turn affect the trust between students and lecturers, which is detrimental to student engagement (Mao et al., 2024).

The study's findings identify several mitigation strategies for overcoming the challenges arising from students misusing chatbots for assessments. Education institutions should establish clear academic integrity policies, including plagiarism and cheating, and use policies that clearly define acceptable and unacceptable use of chatbots (Gorichanaz, 2023; Lancaster, 2023; Perkins et al., 2024). Furthermore, it is critical to effectively communicate these policies to educators and students (Perkins, 2023) through training and education (Alexander et al., 2023; Gorichanaz, 2023; Mao et al., 2024). It is also vital to engage key stakeholders in the education system to better understand their perspectives while formulating policies (Alexander et al., 2023; Bai et al., 2024; Chaudhry et al., 2023). This study's findings also indicate that, given the capabilities of chatbots, there is a need to redesign assessments into skill-based or authentic formats to improve their reliability and validity for measuring student learning (Blanke, 2024; Gorichanaz, 2023; Yeadon et al., 2023). On top of that, there is also a need to redesign learning to increase emphasis on higher-order thinking skills to better equip students with essential AI competences for the future (Chaudhry et al., 2023; Kortemeyer, 2023; Nikolic et al., 2023). This finding supports Guo and Lee's (2023) and Tlili et al.'s (2023) assertions that, with proper learning design, chatbots can assist students in developing thinking skills.

In conclusion, the thematic analysis synthesises and categorises the discussions in the articles into five major themes, each with respective sub-themes, and identifies the relationships between these themes. Students find reasons and benefits for adopting chatbots to assist them with their assessments, and they may employ counter-detection measures to prevent detection in the case of chatbot misuse. However, the integrity of the education system is challenged when chatbot misuse undermines the reliability and validity of assessments for performance measurement, resulting in the perception that the assessments may not accurately reflect students' true learning performance (Kooli, 2023). The education system must address these challenges with effective mitigation strategies rather than depend on detection strategies that fail to address the underlying challenges (Khalil and Er, 2023). The study's findings will help educational stakeholders better understand key discussions on the use of chatbots in student assessment, specifically the challenges that chatbot misuse may pose to student learning performance evaluation, and the various mitigation strategies to address these challenges.

Future research may consider two directions. First, broaden the scope of the thematic analysis by including articles from a wider range of databases to corroborate the themes identified in this study or uncover new

themes. Secondly, use the themes identified in this study as a framework to apply other research methods, such as questionnaire surveys or experiments, to triangulate the findings.

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Online Teaching and Learning Post-Covid: An Analysis of LMS Usage and Student Outcomes Following the Pandemic

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Abstract: In 2020, the global higher education sector plunged into online teaching and learning within a very short timeframe with the onset of the Covid-19 pandemic. The Sri Lankan state higher education system was no exception. While the initial readiness of both students and teachers for this switch varied or, in many cases, was low, online instruction was the predominant form of teaching and learning for most of the subsequent two years. The Sri Lankan university sector resumed face-to-face teaching for undergraduates in mid-2022 but aspects of online teaching and learning remain, providing a valuable opportunity to take stock of the experiences gathered during the pandemic. This study aims to use data on undergraduate courses offered both during and after the pandemic period at the Faculty of Business in the University of Moratuwa in order to identify online teaching practices that persisted beyond the COVID-19 period and relate student interactions with these activities with academic outcomes. The dataset spans 473 students in five cohorts across six undergraduate courses and includes Moodle (the LMS used by the university) logs, data on academic outcomes, and features of the online course pages. The student level data for the selected courses are augmented with interviews with the corresponding lecturers to gain further insights into why certain learning activities were considered successful and others not. By doing so, the paper aims to identify effective learning tools and best practices that arose during the unplanned transition to online teaching from both lecturer and student perspectives. The results show that there is a continuity in the tools between the online mode during the pandemic and the post-pandemic return to face-to-face teaching with tools such as quizzes, assignment submissions, and videos/lecture recordings used noticeably more than in the pre-Covid period. The use of interactive tools increase the student engagement with the course Moodle pages, which in turn are positively associated with learning outcomes. The paper thus highlights some positive consequences of the pandemic period on education in terms of enhancing the adoption of digital tools for learning among both staff and students.

Keywords: e-Learning interactions, Online course design, Covid-19, Undergraduate education

1. Introduction

The Covid-19 pandemic in 2020 led to large-scale disruptions to schools and universities globally, as face-to- face instructions were suspended to prevent spread of the virus (Sophie Lu et al. 2021). This resulted in a very rapid shift to online learning as a response to minimising the impact of these disruptions. While online learning and massive open online courses (MOOCs) were not a novelty at this time, the transition of courses primarily intended to be delivered face-to-face into an online delivery mode within a short period of time was not without challenges. Key among these was the difficulty of replicating physical classroom learning using distance learning infrastructure in contexts where institutions, teachers and students had limited exposure to online teaching and learning (Turnbull et al. 2021; Chiu et al. 2021; Adedoyin and Soykan, 2020).

In Sri Lanka, the first nation-wide Covid-19 lockdown was declared in March 2020. However, it is estimated that within three months, almost all universities had switched to online modes of learning (Hayashi et al. 2020). This is particularly commendable given that both teachers and students faced considerable barriers to accessing suitable devices and internet connectivity and, for the most part, lacked exposure to online instruction (World Bank, 2020). The transition to online learning in the state university sector (where undergraduate degrees are offered tuition-free) was facilitated by several measures taken at the time. Notably, the provision of free access to university web servers by internet service providers which allowed date-free access to video-conferencing tools via these servers. Accordingly, teaching in state universities took place online for the better part of two years, only resuming physical teaching towards mid-2022.

Maintaining student engagement and ensuring the achievement of student learning outcomes is not easy in an online environment, as evinced by the literature on MOOCs (Pilli and Admiraal, 2017; Moreno-Marcos et al. 2018; Deng et al, 2019; Israel, 2019). The online teaching and learning that occurred in the university system during the pandemic was different in key aspects such as the qualifications being offered and the courses being offered within defined time intervals (semesters), which means that the student motivation and independence over learning was different to that seen in MOOCs (Brooker et al, 2018; Tsang et al. 2021). However, given that

these courses were not originally meant for online delivery and were often delivered to simply replicate physical classrooms (Brancaccio-Taras et al, 2021; Pagoto et al, 2021), the questions of student engagement and learning remain valid, further compounded by the issues of infrastructure constraints on the side of the students. Even after the pandemic, online teaching and learning are still being used by state universities in Sri Lanka in the face of subsequent disruptions to on-site teaching such as the economic crisis and resulting fuel shortages in the second half of 2022 and during trade union actions carried out by academic and non-academic staff in the university system.

Four years down the road, we are now well-placed to look back on the online learning experience and draw lessons from this period. This paper, therefore, aims to use data on courses offered at a state university in Sri Lanka obtained from the learning management system (LMS), to identify changes in teaching practices that arose due to the onset of the pandemic and have since persisted. The paper has the specific objectives of identifying changes to course design and delivery because of the switch to online teaching and learning, identifying the online activities that increased student interactions and engagement, and finally, studying the relationship between student academic outcomes and interactions with the different types of activities. In doing so, the study links together improvements from the use of online learning tools as perceived by lecturers and manifested in changes to the design of the LMS course pages and the impact of these changes on student learning outcomes.

The literature on online learning highlights student characteristics, course design and course interactions as being the main categories that influence learning outcomes (Moreno-Marcos et al. 2018). While student characteristics are exogenous factors that the instructor should consider, the design of the course is within their control. Comparisons of face-to-face teaching with online settings suggest that the provision of interactive content, continued educator feedback with provision of formative feedback, and structured online discussions are key to fostering learning in online settings (Castro and Tumibay, 2019). Specific examples arising during the pandemic period of effective tools for online delivery include the use of quizzes and questionnaires to reinforce take-home messages (Rossi et al. 2021), provision of opportunities to interact with the instructor as well as other students through, for example, group work (Tsang et al, 2021), and the provision of recorded lectures to facilitate learning at a time that works best for the student (Hollister et al, 2022). Moreover, whereas the instructor may not achieve the same level of interaction with students in an online environment, the availability of massive amounts of data generated within the LMS can be used to increase what is known about the learner (Nguyen, 2015).

This paper adds to the growing body of knowledge that studies the effectiveness of online teaching and learning triggered by the pandemic, focusing on the Sri Lankan experience. Specifically, the study provides some insights on what worked and continues to work in terms of optimising the use of educational technology in higher education in a developing country context where the use of educational technology was limited prior to the pandemic. At the time of writing, Sri Lankan universities are facing disruptions to on-site learning as a result of trade union action but the impact of this is minimised due to the availability and experience with online teaching and learning. Taking stock of the lessons learnt during Covid-19 are therefore useful in a context where switches back to online learning, even sporadically, may continue to occur. More generally, the paper provides some reassuring findings on the adoption and evolution of online learning in a developing country setting.

2. Data and Methods

This paper aims to study changes to teaching practices and student interactions that arose during the period of online teaching and learning that was triggered by the Covid-19 pandemic. It does so in two parts. The first considers changes to course design that arose during this period and persisted thereafter to obtain insights on the activities and course design perceived by lecturers to be effective for use even after the switch to on-site teaching. Then, student interactions with the course page are used to study the levels of engagement generated by different types of activities and relate these interactions to student learning outcomes to identify the most effective activities from the student perspective.

2.1 Selected Courses

To achieve these objectives, this paper uses data from six different courses offered to undergraduate students at the Faculty of Business of the University of Moratuwa. We use information on course page design for each of the selected courses from before, during and after the onset of the pandemic. Note that the learning management system, Moodle, was already in use from well before the pandemic, though used to varying degrees by different lecturers. We select subjects that were taught by the same lecturer in all three periods to

ensure comparability over time. The subjects used for this analysis are Principles of Programming (Semester 2), Probability and Statistics II (Semester 3), Introduction to Econometrics (Semester 4), Data Structure and Algorithms (Semester 5), Business Application Development (Semester 6) and Financial Econometrics (Semester 7).

2.2 Changes in Course Design

For each subject, we study changes to course design from before to after the Covid-19 pandemic by computing counts of the different types of activities employed by the lecturer in each of the three periods considered. We break the activities down into quizzes, assignments and online submissions, content-related files that have audio or video elements and content-related files that do not, and other activities. The other activities category includes Moodle tools such as forum posts, glossaries, H5P interactive lessons, virtual programming labs, etc.). Given that these counts will not capture the nuances of course design, which is a much more qualitative concept, we obtain additional insights directly from the lecturers whose courses are included. It should be noted our measures of course design are limited to what is observable on the Moodle course pages – activities conducted in real-time during lectures or Zoom sessions are excluded from this analysis.

2.3 Student Interactions and Outcomes

The student perspective is incorporated into the analysis by considering the level of student interaction generated by different types of activities and the relationship with student learning outcomes. This analysis focuses only on courses offered during and after the pandemic: this provides a sample of 12 courses (2 offerings each of the selected 6 subjects) and 473 students, some of whom are covered in multiple subjects.

Learning outcomes are measured by the continuous assessment (CA) marks (based on assessments carried out during the semester) that make up 40-60% of the final grade for a course. CA marks usually capture a wider array of learning outcomes (e.g. use of software, writing skills, and practical applications) than the written examination held at the end of the Semester. Students' interactions with the course pages are measured using Moodle activity reports and course logs, which allow us to construct total clicks by type of activity, time spent on quizzes and number of submissions completed.

2.4 Analysis

The identification of changes in course design and levels of student interaction generated on the course page are based on a descriptive analysis.

For the study of how student interactions affect student outcomes, we use correlation analysis and multiple linear regression which are carried out on the entire dataset of 1055 student-course LMS interactions and learning outcomes. While the correlation matrix provides a bivariate analysis, the regression allows for a more nuanced analysis. For instance, together with the identified course interaction variables, we are also able to control for subject and cohort specific differences given that we are comparing subjects that may vary in levels of difficulty and cohorts which were exposed to varying amounts of online instruction. Specifically, we estimate the following regression model:

$$y_{ist} = \beta X_{ist} + \gamma Z_{st} + \alpha_s + \theta_t + u_{ist} \qquad (1)$$

where y_{ist} are the CA marks obtained by student i on subject s offered to cohort t, X_{ist} is the vector of course page interactions for the same, Z_{st} are the characteristics of the course page, and α_s and θ_t refer to the subject and cohort fixed effects, respectively.

3. Results

3.1 Changes in Course Design - Lecturer Perspectives

Figure 1 visualises the changes in course design observed across the selected courses using the number of different types of activities and learning materials used before, during and after the pandemic. The categories analysed are quizzes and assignment submissions (both formative and summative), other activities (including discussion forums, H5P interactive lessons, virtual programming labs, questionnaires, etc.), learning materials with an audio/video element (e.g. video recordings and voice-embedded PowerPoints) and learning materials without the audio/video element (e.g. lecture notes and slides). It should be noted that of the six subjects considered, there were two that were offered for the first time during the Covid-19 period.

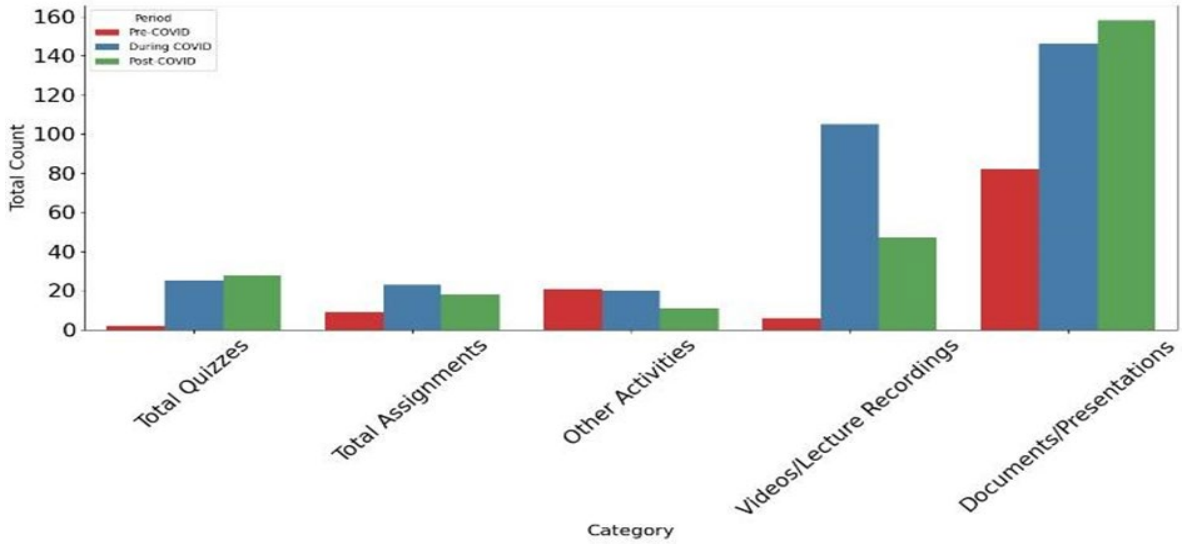

Figure 1: Features of selected course pages before, during and after the Covid-19 pandemic

Figure 1 clearly shows the increased usage of most tools during the Covid-19 period as compared to pre-Covid. When comparing the during and after Covid-19 periods, we see a mixed pattern though in most cases, the activities were still used more than in the pre-Covid-19 period, highlighting the increased adoption of Moodle tools following the pandemic period. There is a much greater use of quizzes, with a continued increase even from the during-Covid to post-Covid period, though the biggest increase is from pre- to during-Covid. There is a similar increase in the number of assignments from pre- to post-online learning. This is intuitive given that assessments had to be conducted online rather than through pen-and-paper tests or physical submissions.

The most dramatic change is seen in the provision of videos and lecture recordings, highlighting the transition to asynchronous learning during the pandemic period with a sharp decline following the return to face-to-face lectures. The number of non-video/audio learning materials provided also continues to rise during the duration of the period studied. The only type of activity to show a decline from before to after the pandemic is the "other category" - the decline from pre- to during Covid is driven by the removal of virtual programming labs in Principles of Programming while the decline from during to post-Covid is driven by the removal of H5P interactive lessons from Introduction to Econometrics.

3.1.1 Reasons for the changes

Discussions with the lecturers in charge revealed that the use of Moodle quizzes is perceived by the lecturers as a more efficient way of assessing certain outcomes, given the automatic grading options, while also ensuring that students remained on track with the content over the course of the semester. Once the lecturers gained familiarity with the wide array of question types and the possibility of randomising questions and enabling sequential navigation, concerns about cheating were also minimized. Accordingly, Moodle quizzes have become the main format of in-class tests during the Semester even after returning to on-site delivery. However, when it came to the submission of tutorials, this kind of randomization was less feasible, resulting in a return to hard copy submissions to at least ensure students wrote out their own solutions.

The steep increase in lecture recordings during the pandemic was driven by issues of internet connectivity faced by many students. Given the difficulties faced in remaining connected to video-conference sessions for prolonged periods, lecturers were encouraged by the institution to make recordings available so as not to penalise students facing this issue. However, following the return to on-site lectures, lecturers could decide whether to provide previous recordings and if so, which recordings to make available. Most of the recordings provided post-Covid period were of lectures carried out for the previous cohort - recordings of tutorials or Q&A sessions from previous cohorts were not posted, resulting in the post-Covid decline.

The only category to show a decline from the pre- to post-Covid period was "other" activities. Discussion with lecturers revealed an interesting reason for this. While H5P lessons provide an interactive way of presenting learning material given the combinations of audio, video and quiz content, it was revealed that students had a preference for voice-embedded PPT or video recordings as these could be downloaded to their devices and viewed without an active internet connection whereas the H5P lessons required continuous internet

connectivity. Given that many students were not using these lessons, they were subsequently discontinued, with selected lessons being provided as additional learning material. The discontinuation of the virtual programming labs was explained by the availability of questions of the type "Coderunner" in Moodle quizzes, which provided the same level of functionality.

3.2 Interactions with Different Types of Activities

Next, we use the LMS logs and activity reports for the selected courses during and after Covid to measure the level of interactivity generated by different types of Moodle activities. Specifically, we consider clicks in total and per unit for the broad categories of course page, static learning materials (including lecture notes and slides, recordings and voice embedded PowerPoint files), assessments (quizzes and assignment submissions, both formative and summative), and other (which includes items such as forums, questionnaires, interactive lessons, etc.). We also compute the time spent on untimed quizzes (where students decide the time they spend), the percentage of the permitted duration used for timed quizzes, and the share of submissions made early/on time or late. The mean values of these measures are provided in Table 1.

Table 1: Interactions across activity types

	During Covid	After Covid
Total clicks		
1.1 Total clicks (average per student per course)	450 (std dev 242)	453 (std dev 236)
1.2 Clicks on learning materials (% of total)	18.65	24.30
1.3 Clicks on assessments (quizzes, submissions) (% of total)	34.93	25.80
1.4 Clicks on other activities (% of total)	6.78	7.75
1.5 Clicks on course page (% of total)	39.64	42.15
Clicks per unit		
2.1 Average clicks per item of learning material	2	3
2.2 Average clicks per assessment	16	17
2.3 Average clicks per "other" activity	10	22
Time spent on quizzes		
3.1 Time spent on quizzes with no time limit (minutes per subject)	1121 (std dev 6208)	1068 (std dev 281)
3.3 Time spent on timed quizzes (% of allowed duration)	87%	88%
Assignment submission		
4.1 % assignments/submissions submitted on time	80%	64%
4.2 % assignments/submissions submitted late	7%	21%

The time spent on quizzes further highlights the role assessments play in increasing student interactions during online learning. The average time spent on untimed quizzes (which are formative rather than summative assessments) is more than 19 hours per course per semester during Covid and 18 hours post-Covid, though the standard deviations are large suggesting considerable variation. In the case of untimed quizzes, it is possible that students open the quiz and keep it open on their browser while engaging in other activities, which means that the computed time is a noisy measure of the time actually spent completing the quiz. Timed quizzes do not have this issue and on average, students use close to 90% of the assigned time when completing quizzes with a time limit (which are mostly, but not exclusively summative). Assignments are also mostly submitted within the deadline by most students (80% during Covid and 64% after). The late or non-submissions can be explained by submissions here include both summative and formative assessments.

3.3 Relationship Between Course Interactions, Course Design and Learning Outcomes

While the previous results link student interactions with the course page with the design of the course page, the more important connection is that between student learning outcomes and course design, which facilitates interaction. As such, in this section, we relate continuous assessment marks with the course design and student interaction measures, starting with the correlation matrix provided in Figure 2.

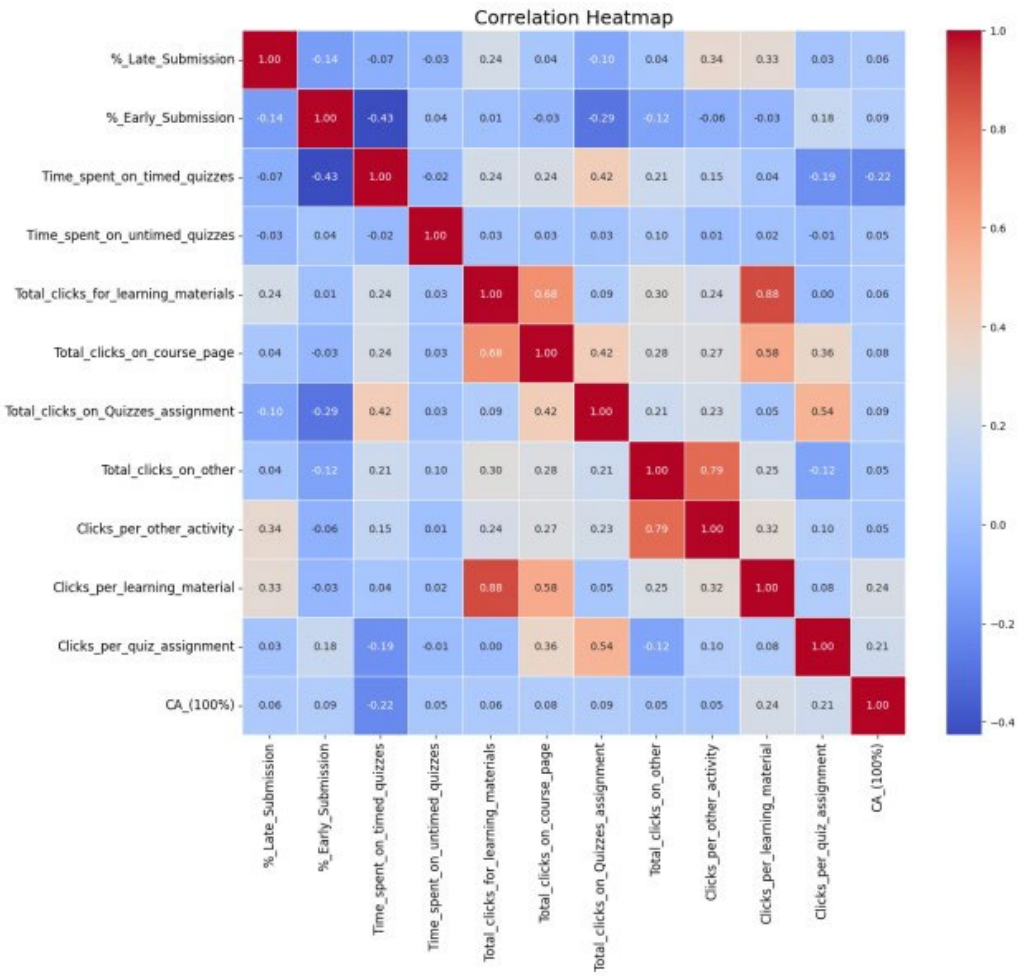

Figure 2: Correlation heatmap of interaction with course page metrics

The correlation matrix (Figure 2) provides some interesting insights. Among the student interaction variables considered, most are positively correlated with CA marks, though the correlations are not strong. So, for example, the total number of clicks or the percentage of assignment submissions or clicks per assessment or learning material are positively associated with CA marks. The only exception is the percentage of allowed time used for timed quizzes, which is negatively correlated with marks - students who spend more of the allowed quiz time tend to get lower marks. These students spending more of the assigned time are also less likely to submit their assignments on time (correlation of -0.43), potentially due to poor time management.

These bivariate correlations hide variations in subject difficulty, differences in student cohorts and course design. Accordingly, the final set of results are based on the estimation of Equation (1) using a multiple linear regression model. The results are presented in Table 2.

Table 2: Estimated effects of course design and course page interactions on CA marks

Covariate	**Coefficient**	**p-value**
Course design		
Number of quizzes	1.7990	0.000
Number of submissions	9.6300	0.000
Number of other activities	4.5632	0.000
Number of content related files (videos/lecture recordings)	-0.4232	0.000
Number of content related files (lecture notes/slides)	-1.0113	0.000
Interactions with course page		

Covariate	**Coefficient**	**p-value**
% assignments submitted late	0.1582	0.000
% assignments submitted early/on time	0.2671	0.000
% allowed duration used in timed quizzes	0.0803	0.004
Time spent on untimed quizzes	2.582e-05	0.220
Total clicks on learning materials	-0.0182	0.477
Total clicks of assessments	0.0024	0.852
Total clicks on other activities	0.0330	0.049
Total clicks on course page	0.0073	0.231
Clicks per learning material	0.6407	0.532
Clicks per assessment	0.1863	0.047
Clicks per other activity	-0.0197	0.655
Fixed effects (reference categories: Cohort 2022 and Subject: Probability and Statistics II)		
Cohort 2017	-33.4191	0.000
Cohort 2018	-34.0604	0.000
Cohort 2019	-24.5115	0.000
Cohort 2020	-7.9419	0.002
Subject: Business Application Development	33.2756	0.000
Subject: Data structures and algorithms	28.2435	0.000
Subject: Financial econometrics	13.2363	0.085
Subject: Introduction to econometrics	-25.1790	0.000
Subject: Principles of Programming	47.5210	0.000

Note: The table reports the coefficient and p-values from estimating Equation (1) using data on 1055 student-subject observations. The regression model has a R-square value of 0.415.

Table 2 shows the associations of different interaction measures and aspects of course design with learning outcomes. Starting with the course design variables, the number of quizzes, assignments and other activities are positively and significantly associated with CA marks. On the other hand, the number of content related files are negatively associated with marks, suggesting that it is the activities that generate more student engagement that have a stronger bearing on the continuous assessment marks, after controlling for differences in average marks between subjects and cohorts (which themselves are also statistically significant).

There are again many course interaction variables significantly correlated with marks. For instance, submission of a larger share of assignments on time or even late has a positive impact on marks relative to non-submission. Specifically, increasing the share of assignments submitted on time by 1 percentage point is associated with a 0.27 increase in the CA mark compared to non-submission. Interestingly, the multiple regression results in a reversal of the negative correlation seen between % of permitted time spent on timed quizzes and CA marks because of controlling for differences in mean marks across courses and cohorts. We now see a significant and positive relationship between the two variables. Among the variables measured by clicks, the only variables that appear statistically significant are the clicks on other activities (including forum discussions, questionnaires, H5P interactive content, etc.) and the number of clicks per assessment. Taken together these results suggest that students who engage more with the interactive components of the course are obtaining higher marks in the continuous assessments.

4. Discussion and Conclusion

This paper makes use of data on courses offered to undergraduates before, during and after the Covid-19 pandemic period to identify changes to the teaching practices, as reflected on the Moodle course pages, over this period and relate the Moodle activities used since the online learning period to student interactions with the LMS and their final learning outcomes. The study finds that there are substantial changes in the use of

Moodle activities during the online learning period with many of the changes persisting even after the return to onsite delivery. For instance, tools such as quizzes and assignments, video recorded lectures were used more frequently after the online learning period. When considering the interactions generated by the different types of activities, quizzes and submissions generated a large portion of clicks on the LMS, followed by learning material, though the per item number of clicks is higher for interactive content than for learning materials. The story is completed by linking student interactions with learning outcomes and the results from the bivariate and multivariate analysis suggests that course design and student interactions are indeed significantly linked to marks, where courses with more interactive content or students engaging more with interactive content are positively associated with better performance in the continuous assessment.By and large, this exercise suggests that the Moodle course pages were used for a wider range of functionalities during and after the pandemic than before Covid when the pages were used primarily to share lecture slides or tutorials. Moreover, the continuous increase in learning materials and activities used on Moodle suggests ongoing efforts to provide a broader range of learning resources to enhance students' learning. This confirms the technological disruption aspect of the Covid-19 pandemic on education with both staff and students compelled to adopt digital technology for learning (Adedoyin and Soykan, 2020). Given the continued use of online learning tools sporadically or in a blended learning mode, these results provide some heartening evidence of positive changes arising from a challenging time.

The analysis in this paper is subject to several limitations, starting with the relatively small sample of courses under study. It would be instructive to expand to a broad range of subjects for more generalizable conclusions. This will be carried out in future work. We are also constrained in terms of data available for some of our selected measures. For instance, our analysis of student interactions and course design are limited to those taking place through the LMS - activities that were carried out in the lecture hall or during Zoom meetings as well as interactions taking place via email or social media are not observed. Similarly, measures such as clicks and time spent on quizzes may not capture the true level of interaction the course page generates. However, to the extent that these measures are easily monitored through the LMS, they have the advantage of being useful for early warning systems or flagging of students who may be falling behind. As such, we believe that it is not wrong to conclude a heightened use of digital technology in education, which can be beneficial for both students and teachers, as a positive consequence of the Covid-19 pandemic period of online teaching and learning.

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Teaching Online in a Developing Country Context

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Abstract: This study explored lecturer perceptions of their use of a Learning Management System (LMS) at a rural university in the Eastern Cape Province of South Africa. The study took place just prior to the COVID-19 lockdown and provides a brief insight into the thoughts of lecturers at this time. A sample of 141 lecturers from six faculties at the rural university completed an online questionnaire. A factor analysis (using principal component analysis and varimax rotation) of 46 items on lecturers' perceptions of the LMS yielded six factors: their perceptions of usefulness, performance expectancy, self-efficacy, technical support, effort, and institutional support using the LMS. The reliability of factors was confirmed, while group differences were determined with independent sample t-tests and ANOVAs. The results indicate that although lecturers found the LMS to be beneficial, they were reluctant to use it when teaching face-to-face. There was a large discrepancy between the perceived usefulness and their actual use of the LMS. They perceived the LMS to be very useful but found technical- and institutional support to be low, which in turn strongly influenced their low self-efficacy (confidence) to use it. It emerged that increased training and support for lecturers would address both work performance and the confidence of lecturers using the platform. It was also evident that each academic department requires a dedicated teaching and learning consultant and that a centralized teaching and learning division may not be the answer. The one academic department with their own dedicated consultant was the best prepared for the demands of online teaching when the need arose.

Keywords: LMS; Higher education, Lecturers' perceptions, UTAUT, Online teaching and learning, Learning management systems

1. Introduction and Background

The outbreak of Severe Acute Respiratory Syndrome Coronavirus 2 (Sars-CoV-2) exposed the lack of readiness of higher education institutions (HEIs) to teach online globally (Bender, 2020). During the outbreak, higher HEIs were forced to move quickly from face-to-face to online teaching (Snoussi, 2019). Despite being exposed to learning management systems (LMSs), many South African lecturers were mainly accustomed to face-to-face teaching at the time and were not ready for the online mode.

Intergenerational differences between student and lecturer approaches to online teaching complicate the effective implementation of online teaching. While many researchers (Bullen & Morgan, 2011; Nicolini & Cirilli , 2019) identify current students in higher education as Digital Natives and Millennials, most lecturers are from an older generation of Digital Immigrants (Smith et al., 2020). Although students prefer technology incorporated into their teaching and learning, they are very different from previous generations, often display low concentration skills, and cannot sit still for long periods in the classroom (Bullen & Morgan, 2011; Nicolini & Cirilli , 2019). To meet the needs of digital natives, lecturers may still need to incorporate technology into their teaching (Kivunja, 2014). To this end, many HEIs have now made better use of their LMSs (Snoussi, 2019). This study is timely as previous studies have primarily focused on students - neglecting lecturers' points of view on this topic (Cantabella et al., 2018).

2. Literature

To better equip students for the 21st century, HEIs dramatically increased technology use to meet these demands (O'Flaherty & Phillips, 2015). Govender and Mhkize (2015) have reported a more blended approach since 2005. It is already well-known that students can benefit from the integration of information and Communications Technology (ICTs), but the best evidence of the effect of online teaching was seen when schools and HEIs were forced to move to online teaching during the COVID-19 pandemic (Bender, 2020; Sahu, 2020). Numerous studies have documented how the pandemic forced HEIs to switch from face-to-face to online instruction in many countries (Weeden & Cornwell, 2020). HEIs in South Africa also implemented online teaching to overcome this issue, and LMSs were an essential part of this initiative. Alenezi (2018) notes that a LMS is valuable when institutions engage in online teaching. Unfortunately, lecturers only use some LMS features and many tend only to use it for administration and the uploading of content (Washington, 2019).

According to Zanjani et al. (2016), mindset, training, and capacity building are the cornerstones of successful online teaching and learning implementation and are required for the LMS to be effective at HEI. Coleman and Mtshazi (2017) and Jokiaho, May, Specht, and Stoyanov (2018) identify internal (personal) and external

(environmental) elements that affect lecturers' impressions of using an LMS. Fear, worry, a lack of interest in technology, and a sense of incompetence are internal causes. Lack of time to prepare for lectures using technology, organizational issues (such as poor technical support or insufficient training), technological issues (such as restricted access to valuable, relevant, and appropriate hardware and software), and social issues (such as how much peers or institutions encourage or discourage the user from using technology) are examples of external factors.

Several variables affect LMS use by lecturers (Ivankova, Moss, 2018; Jokiaho et al., 2018; Kiryagana et al., 2017; McConnell, 2018; Shelton, 2017; Ugwoke et al., 2019). Some authors mention a need for more institutional support, training, and motivation to use the LMS for pedagogical purposes (Walker et al., 2016; Wingo et al., 2017; Washington, 2019). Webstock and Fisher (2016) and Govender and Govender (2014) indicate that LMSs are underutilized due to poor digital skills and the lack of incentives for innovation and training. De Paepe, Zhu, and Depryck (2019) and Isabirye et al. (2017) found that a lack of training and poor ICT capabilities lead to inefficient use of an LMS by teaching staff.

3. Theoretical Framework

The unified theory of acceptance and use of technology (UTAUT) was the theoretical underpinning for this study (Venkatesh & Davis, 2000; Venkatesh et al., 2003). Although UTAUT 2 is an upgraded version of the UTAUT model, UTAUT was used for this study because the objective was to understand the factors influencing the lecturer's use of the LMS in an organizational context rather than to evaluate consumer acceptance of new technology (which is where UTAUT2 would be used). The UTAUT model, as used in this study, is presented in Figure 1.

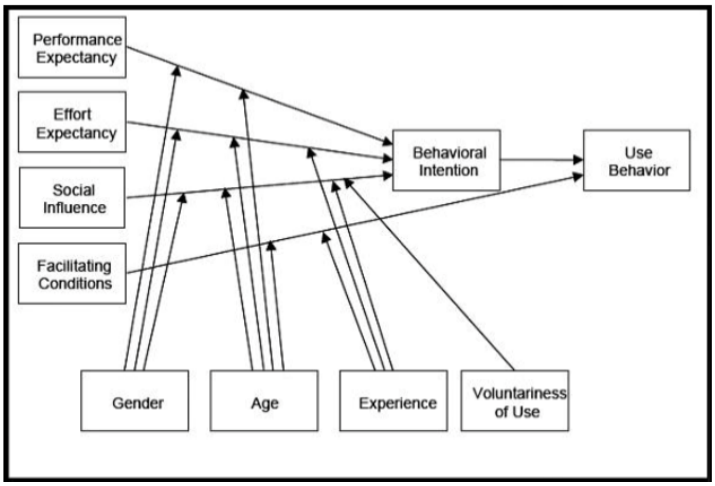

Figure 1: Unified theory of acceptance and use of technology (UTAUT)

Performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitation conditions (FC) are the four components that make up the UTAUT and have an impact on the behavioral intention and use of online instruction. Performance expectancy is "the degree to which an individual believes that using the system will help him or her to improve job performance" (Venkatesh et al., 2003, p. 447). Effort expectancy (EE) refers to "the degree of ease associated with the use of the system" (Venkatesh et al., 2003, p.450). Social influence (SI) is "the degree to which a person perceives that important others believe that he or she should use the new system" (Venkatesh et al., 2003, p.451). Facilitating conditions (FC) are defined as the "degree to which an individual believes that organizational and technical infrastructure exists to support the use of the system" (Venkatesh et al., 2000, p. 453).

4. Methodology

After reviewing similar studies that measured lecturer perceptions, it was decided that the quantitative approach was the most appropriate (Compare Zaki & Zawaidy, 2014; Alenezi, 2018; Cigdem et al., 2015; Gamdi & Samarji, 2016; Wasserman & Migdal, 2019). The research site, a rural university in South Africa's Eastern Cape Province, included 353 lecturers from six academic departments (including Health Sciences, Social Sciences, Humanities, Education etc.). The online questionnaire was completed by 39.9% of the invited lecturers, generating a sample (Etikan, 2016) of 141 participants.

The e-questionnaire consisted of two parts, namely a biographical section and a second section with 46 items covering lecturer perceptions of LMS use. Two pre-existing (previously validated) surveys by Alshorman and Bawaneh (2018) and Xu and Mahenthiran (2016) were adapted. The 46 items were subjected to an exploratory factor analysis using Principal Component Analysis (PCA) with Varimax Rotation. The factorability of items was determined using Bartlett's test of sphericity and the Kaiser-Meyer-Olkin criteria of sample adequacy. The Scree Plot suggested a six-factor solution for the analysis. Cronbach's alpha was used to determine the reliability of the factors as a statistical index for internal consistency. Gender group differences were determined using independent sample t-tests, and faculty group differences were determined with a one-way analysis of variance (ANOVA).

5. Results

The study included 141 teachers, aged 24 to 73, from six different academic departments. 116 participants (82.3%) indicated that they used the LMS. It must be noted that this was done just before the pandemic and subsequent lockdown in 2020 and that post-pandemic surveys could have different results. Lecturers at that time indicated that they had been using the LMS on average for 4.21±2.83 years, spending only 28.07 ± 21.39 percent of their teaching time on it. Most of them (83.7%) uploaded materials or course content on the LMS, followed by announcements (69.5%). Less than half of the participants in this survey claimed that they used other LMS features. The LMS is only used by 35% of participants to give homework, compared to 30.5% for tests and quizzes, 23.4% for discussion boards, and 17.7% for group projects. Only 2% of the participants used more sophisticated LMS capabilities, including blogs, journals, and other features.

Before factor analysis through principal component analysis and varimax rotation could commence, the suitability of the data from the 46 items was assessed. Bartlett's test of sphericity (p =.000) obtained statistical significance. At the same time, the Kaiser-Meyer-Olkin value for sample adequacy (.885) exceeded the advised value of .6. These two values substantiated the correlation matrix's factorability. The study did not include items with a factor loading of less than .4. The factor analysis yielded six factors with an Eigenvalue of more than 1, explaining 59.53% of the variance, presented in Table 1.

Table 1: The six results with their eigenvalues, variance, means and standard deviations, and reliability

Factor Name	Eigen value	% of Variance	Cumulative %	Mean	Std. Dev	Reliability
Factor 1: Usefulness	16.12	17.48	17.48	3.99	.664	.937
Factor 2: Performance expectation	3.48	15.00	32.48	3.55	.723	.932
Factor 3: Self-efficacy	2.74	9.75	42.24	3.60	.693	.848
Factor 4: Technical support	1.82	7.96	50.21	3.18	.758	.771
Factor 5: Effort	1.63	4.91	55.12	3.47	.804	.441
Factor 6: Institutional support	1.57	4.41	59.53	2.65	.832	.442

All factors had a high reliability score (Cronbach's alpha > .7) except for factors 5 and 6. These two factors had low reliability scores (Cronbach's alpha < .7). Factors with too few items usually render low reliability. The low reliability of Factors 5 and 6 is attributed to only two items contributing to the factors. Alternatively, the mean inter-item correlation (r = .286 and r = .287) for the two factors, respectively, was high enough (between .2 to .4) to regard the factor as reliable (Briggs & Check, 1986).

The first factor was "Perceived Usefulness" and included items such as, "Using the LMS would improve my performance," and "Using the LMS would enhance my effectiveness." It is consistent with the definition of perceived usefulness (PU) (Davis, 1989) - improving a lecturer's performance by utilizing the system. This factor obtained the highest mean score (3.99; sd =.664), and the findings revealed that 83.7 percent (n = 118) of respondents strongly believed in the LMSs value as a teaching tool.

Factor 2 was "Perceived Performance Expectation" and included items like, "I find that using the LMS increases the involvement of my students in the classroom," and "I use the LMS because it helps to clarify the content of my course." According to Visvanath et al. (2003, p 447), perceived performance expectations are "the degree to which an individual believes that using the system will help him or her to attain gains in job performance," which implies that using the LMS will help them achieve their specific performance goals in the modules they teach. The factor mean was 3.55 (standard deviation = .723), with 58.5 percent (n = 85) of lecturers having a high perception that the LMS would assist them in achieving their performance goals in the modules they teach.

As the lecturer's impression of their ability to use an LMS for the particular courses they teach, factor three was labeled 'Perceived Self-efficacy.' Coleman and Mtshazi (2017) describe perceived self-efficacy as the user's computer expertise, knowledge, and abilities, which may significantly impact whether or not they are willing to utilize a LMS. The factor included items like, "I have the necessary skills to implement the LMS as the e-learning platform," and "I am confident to use the LMS as my e-learning platform." Factor 3 had the second highest mean (3.60; standard deviation = .693), with 61.7 percent (n = 87) of the lecturers showing high self-efficacy (high confidence) in using the LMS.

Factor 4 was "Perceived Technical Support." This factor represents how lecturers believe they can get technical help when using the LMS. Items include "I received adequate training on using the LMS " and "When I am stuck, technical support is available." This is consistent with Facilitating Conditions (FC), which outline the conditions necessary for using the LMS, such as technical assistance and instructor training. The median score for factor 4 was 3.18 (standard deviation:.758). According to the data, only 48.9% of respondents (n = 69) felt they could access enough technical help. In fact, most instructors believe that technical assistance needs to be improved.

Factor 5 was Perceived Effort and consisted of items such as "It takes too much of my time to use the LMS " and "My workload is already too high to spend additional time on e-learning." The term "Perceived Effort" was given because it measures how much an instructor thinks they would have to work to make the LMS a useful e-learning platform. This is consistent with effort expectation (EE) which Viswanath *et al*. (2003) defined as "the degree of ease associated with using the system." The factor produced a mean score of 3.47 (with a 0.804 standard deviation). The findings revealed that 59.6 percent (n = 84) believed using the LMS in their teaching program would require too much work.

The "Perceived Institutional Support", factor 6, measures a lecturer's perception of how much assistance they believe they receive from their university to utilize the LMS successfully. This is consistent with what Viswanath et al. (2000) define as Facilitating Conditions (FC), which is the "degree to which an individual believes that organizational and technical infrastructure exists to support the use of the system" and what Kleinveldt et al. (2016) and Webstock and Fisher (2016) refer to as Social Influence (SI), which describes how other people, such as Institution or management, can motivate or hinder the use of the LMS by the lecturers. The factor included two items: "My university's e-learning policy provides clear and proper strategies for the use of e-learning." and "My institution provides incentives for integrating e-learning into programs." With just 21.3 percent (n = 30) of lecturers claiming good institutional support for LMS use, this factor had the lowest mean of 2.65 (standard deviation =.832), indicating the lowest score by lecturers in this study. This is concerning and shows that most lecturers (78.8%) require institutional support for the LMS.

While no gender group differences were observed (p-value > .05), some faculty group differences were observed. Statistically significant differences between faculties were found for perceived usefulness and perceived technical support. A statistically significant difference (p = .013) was found between lecturers' perceptions in the Faculty of Health Sciences and Social Sciences and Humanities. Lecturers in the Faculty of Health Sciences perceived the LMS to be much more helpful (mean = 4.30; standard deviation = .560) than lecturers in the Faculty of Social Sciences and Humanities (mean = 3.69; Standard deviation = .792).

The perception of technical support by lecturers was the other statistically significant difference across faculties (p =.000). It appears that lecturers in the Faculty of Health Sciences had a significantly higher opinion of the technical support the university offered (mean = 3.75; standard deviation =.673) than lecturers in the Faculty of Social Sciences and Humanities (mean = 2.85; standard deviation =.867) and the Faculty of Education (mean = 2.81; standard deviation =.520).

6. Conclusions

According to O'Flaherty & Phillips (2015), there is a tremendous demand for HEIs worldwide to adapt to an increasingly technology-oriented world. This pressure is enhanced by the current cohort of students who grew up with technology and prefer technology in the classroom. Older lecturers and digital natives are very different in how they perceive and utilize technology today (Smith et al., 2020). Since this study aimed to comprehend the factors influencing the use of an LMS in an organizational setting at a rural university, UTAUT was utilized to define and understand technology adoption in an organizational context. In this study, only some lecturers at the rural university actively engaged students in LMS features and activities. However, while lecturers did not participate much in online teaching before the pandemic, they thought it was beneficial and a substantial part of the future of education.

The research site had been using the LMS before the pandemic, but lecturers primarily used face-to-face instruction at the time. In fact, very little time was spent engaging with course materials and teaching via the LMS. The length of time that lecturers spent using it had little bearing on how much of their class time they spent using the LMS. The time needed to prepare lecturers was a significant deterring factor for lecturers not using the LMS for teaching activities. The various functionalities of the LMS were also used inconsistently at that time. It was evident that the platform was primarily used for uploading content and announcements. However, the assessment tools for assignments, tests, and quizzes were often utilized. Blogs and journals were features that the lecturers seldom ever used. Similar patterns have been reported previously (Eldridge, 2014; Kitoo, 2020).

A six-component solution for the sub-structure of the questionnaire emerged from the factor analysis using PCA on the questionnaire items. These factors were usefulness, performance expectation, self-efficacy, technical assistance, effort, and institutional support. These elements were evaluated for their dependability and the lecturer's perceptions of them as obstacles to, or justifications for using an LMS. The lecturers strongly agreed that the LMS was helpful but also concurred that there is a significant discrepancy between this perception and the actual use of the LMS. This concurs with the findings of a Kenyan study (Maina & Nzuki, 2015) which found the same patterns.

Usefulness is a vital component of the UTAUT model that affects performance expectations and is based on how much an instructor believes the LMS is useful. Lecturers at this rural university had a lower perception of the effectiveness of the LMS in achieving their teaching goals. Effort expectancy was perceived as being low by the lecturers; however, according to Moonsamy and Govender (2018), 80% of lecturers from another South African institution had a high performance expectancy, while their effort expectancy was relatively low. This is very similar to this study at the rural university. Low effort expectancy can result from a lack of training and assistance in LMS use. Since their evaluations of technical and institutional support were much lower than their perceptions of the LMSs usefulness, most lecturers felt they needed more technical and institutional help from the university. The strong correlation between the six variables implies that poorer views of technological and institutional support are linked to lower perceptions of utility, performance expectations, and effort. Thus, this strengthens the case that lack of assistance may be a factor in lecturers' decreased use of the LMS.

Many studies confirm that a lack of training, institutional support, and technical support have a negative effect on the effectiveness of the use of an LMS by lecturers (Al-Meajel & Sharadgah, 2018; De Paepe et al., 2019; Jokiaho et al., 2018; Maina & Nzuki, 2015; Okiaho et al., 2018). It was determined that ongoing technical assistance and appropriate training would help lecturers gain greater confidence using the LMS and make them aware of the advantages of utilizing the LMS.

There were no variations in this study between the gender groups regarding how university instructors felt about the LMS. However, the study did find discrepancies amongst departmental groups. The LMS was seen as far more beneficial by lecturers in the Faculty of Health Sciences than by lecturers in the other faculties. This can be ascribed to the Faculty of Health employing an e-learning specialist to help lecturers become more proficient on the platform. LMS use among lecturers increased as a result. Even though the Teaching and Learning Centre trained the other faculties, lecturers needed to engage.

A recommendation that stems from our findings is that institutional and technical assistance is essential to promote instructor use of LMSs, essential. This was seen during the lockdown, where continuous support and training were given to the lecturers at this rural university, and the confidence of the lecturers grew in using the LMS for online teaching. Each faculty also needs a dedicated support staff member who constantly supports and trains the lecturers of the specific faculty. The technical staff should also be more visible. An e-

learning policy also needs to be constructed, and e-learning should be included in the IPA process to incentivize the lecturers to use the LMS.

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ChatGPT in Higher Education: A Comprehensive Study of the Literature. Friend or Foe?

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Abstract: This paper presents a qualitative, high-quality State-of-the-Art (SotA) extended literature review on integrating ChatGPT, an advanced and contemporary natural language processing model, a sophisticated AI-powered chatbot that OpenAI developed in higher education. Snyder (2019, p.1) emphasised that "a literature review as a research method is more relevant than ever". According to Barry et al (2022, p. 663), "the fundamental purpose of SotA literature review is to create a 3-part argument about the state of knowledge for a specific phenomenon: *This is where we are now. This is how we got here. This is where we could go next*". This 3-part argument will underpin this study. With the rapid advancement of artificial intelligence (AI) and its potential to transform various sectors, including education, integrating AI-powered tools like ChatGPT to enhance teaching and learning has become a topic of significant interest. This study explores the diverse applications of ChatGPT in higher education, including pedagogical practices, student engagement, intelligent tutoring systems, personalised learning, language learning support, academic research, feedback, grading, and administrative support. Additionally, it identifies the challenges and ethical concerns this technology poses, focusing on bias, privacy, data security, reliability, accountability, accuracy and the balance between human interaction and artificial intelligence. Analysing the literature on ChatGPT's role in higher education presents future directions for implementing it in higher education settings, ushering in an era of exciting possibilities. The research concludes that higher education institutions should provide clear and transparent guidelines for their staff and students on using ChatGPT responsibly for academic purposes to mitigate any ethical concerns.

Keywords: ChatGPT, Higher education, Artificial intelligence, Teaching and learning, Integrating, SotA literature review

1. This is Where we are now

The University of Southern Queensland (UniSQ) (2024a, para. 1) defined Artificial Intelligence (or AI) as "the science and engineering of making intelligent machines. It recognised that machines can learn techniques and processes to solve problems and perform tasks that we associate with human minds and intelligence". Artificial intelligence (AI) has recently substantially transformed various industries, including healthcare, finance, and education. AI has immense potential to transform teaching and learning processes, making education more personalised, adaptive, and accessible. One of the leading AI models in natural language processing (NLP) is ChatGPT. ChatGPT is an AI chatbot developed by OpenAI and launched on November 30, 2022. It has accumulated over a million users in several days (Ropek 2022). ChatGPT is a state-of-the-art language model capable of generating human-like text based on its input (Alawida et al, 2023). Its versatility and ability to understand and respond to natural language have ignited interest in its application across different domains, including the higher education sector. According to Alawida et al (2023, p. 1), "it is based on the GPT (Generative Pre-Trained Transformer) language model technology, and it is capable of understanding and interpreting user requests and generating appropriate responses in natural language, allowing it to complete a wide range of text-based tasks such as answering questions and generating responses". Sundar and Mok (2023) argued that "Chatbots like ChatGPT are powered by large amounts of data and computing techniques to make predictions to string words together in a meaningful way. They tap into a vast amount of vocabulary and information and understand words in context. This helps them mimic speech patterns while dispatching an encyclopedic knowledge" (para. 8). Ropek (2022) wrote the following regarding ChatGPT: "…trained by powerful machine learning, the program promises to disrupt entire industries and change the way people interact with machines permanently" (para. 2). Different versions are available, namely GPT 3.5 (free and paid) and GPT 4 (paid only). ChatGPT-4o was launched on March 14, 2023. It is OpenAI's newest flagship model and is more robust and faster than ChatGPT-4 in quantitative questions (math and physics) and creative writing. This model can generate content or understand commands in voice, text, or images.

The use of ChatGPT also caused debate and disagreement, provoking intense debates about the technology's benefits and potential dangers (Ropek 2022). Its adaptability and capability to understand and respond to natural language have triggered interest in its application in higher education. On the contrary, it also presents challenges and concerns related to bias, privacy, and dependence on technology. This paper thoroughly investigates the applications of ChatGPT in higher education, discusses the associated challenges, limitations, and ethical considerations, and proposes future directions for implementing ChatGPT in higher education

settings. It also synthesises a broad range of literature to offer a new perspective on using ChatGPT in Higher Education.

2. This is how we got Here

ChatGPT can be applied and integrated into various academic and non-academic activities, such as teaching, research, tutoring, personalised learning, language learning support, assessment, and administration (Rahman et al, 2023; UniSQ 2024a). Lazarides (2024 p.1) advised that educators should use it in their teaching to teach learners the "skills they need to work with them in a smart way".

2.1 Pedagogical Practices and Student Engagement

Piaget's learning theory highlights the importance of active engagement and knowledge construction by learners (Leva 2014). Hasanein (2023, p. 2601) echoed that "according to the constructivist perspective, education is an active process involving the construction of knowledge influenced by factors such as students' needs, the learning materials at their disposal, the tools they use, and the overall learning environment". In Basilio's (2023, p. 2) opinion, "…ChatGPT can provide opportunities for students to engage in authentic and interactive learning experiences, promoting active learning and knowledge co-construction". In the older and traditional teaching methods, the students were passive learners, while the constructivist learning theory underpins the importance of autonomous and active learning (Hasanein 2023). The Technological Pedagogical Content Knowledge (TPACK) framework by Mishra and Koehler (2006) illustrates how teachers can effectively integrate technology into their pedagogical practices by integrating ChatGPT (Basilio 2023). Deci and Ryan's (2012) Self-Determination Theory "focuses on intrinsic motivation and the satisfaction of basic psychological needs, namely autonomy, competence, and relatedness" (Basilio 2023, p. 2). When integrating ChatGPT in teaching, educators "…need to consider how the technology can support students' sense of autonomy and competence and foster meaningful interactions and relationships with peers and teachers" (Basilio 2023, p. 2; Lazarides, 2024. Researchers mentioned that ChatGPT has the capability to "foster creativity, critical thinking, and problem-solving skills among students" (Huang & Li, cited in Basilio 2021, p. 4; Parker & Chao 2007). The University of Southern Queensland (2024b; 2024c) encourages staff and students to integrate AI tools in learning and teaching and advocates integrating these tools into current assessment practice to enhance efficiency and insights into student learning; and modify any learning outcomes that can be easily achieved by AI. They further promoted reimagining assessment design, leveraging these tools' capabilities to create more engaging and effective assessments. The University of Southern Queensland (2024b) provided clear and transparent guidelines for their staff and students on how to be responsible and ethical when using these tools in teaching and research. ChatGPT should be utilised in activities encouraging students to analyse, evaluate, and synthesise information (Parker & Chao 2007).

2.2 Intelligent Tutoring Systems

Vujinović et al (2024 p. 3) defined intelligent tutoring systems (ITS) as "computer-based instructional systems that mimic human tutors and provide personalized instruction at scale. ITSs rely on artificial intelligence to personalize and automate teaching". ITS provides adaptive and interactive support to diverse groups of students and promotes learners' motivation and emotional development (Lazarides 2024). It offers real-time assistance, answers questions, provides explanations, conducts formative assessments, and offers immediate feedback on assignments and assessments by simulating human tutoring interactions (Kohnke et al, 2023). Intelligent tutoring systems powered by ChatGPT adapt to students' progress, identify areas of difficulty, and scaffold learning experiences to support mastery learning. Vujinović et al (2024 p. 1) indicated that using ChatGPT "as an annotator is an effective alternative to human experts", and it is cost- and time-efficient when developing a large dataset of suitable pedagogical actions.

2.3 Personalised Learning

One of the primary benefits of integrating ChatGPT in higher education is its potential to support and facilitate personalised learning experiences for students (Basilio 2023). The United Nations Educational, Scientific and Cultural Organization (UNESCO) acknowledged the role of ChatGPT in "promoting equitable access to quality education, fostering personalized learning, and supporting lifelong learning opportunities" (Elfert 2019, p. 537). ChatGPT analyses students' responses, learning preferences, and performance data to generate customised learning materials, exercises, and explanations tailored to individual needs. This personalised approach helps address students' diverse learning styles and pace, ultimately improving their engagement and academic outcomes.

2.4 Language Learning Support

ChatGPT supports language learning and communication skills development for students studying a second language. Kohnke et al (2023, p.1) summarised its capabilities to "communicate with users intelligently, continuously learn from prior interactions, improve over time, and act as tireless language-learning assistants". It engages students in conversational practice and language proofreading, corrects grammatical errors, provides real-time vocabulary explanations, and facilitates an authentic, interactive language-learning environment (Kohnke et al, 2023; Hasanein 2023). Additionally, ChatGPT generates language exercises, language translation, dialogue generation, text completion, text summaries, prompts, and simulations to facilitate language acquisition and fluency, enhance structural support, reduce anxiety, increase student engagement and access to large knowledgebases (Alawida et al, 2023; Basilio 2023; Hasanein 2023). It lessens shyness among learners and "reduce the perceived transactional distance between learners and teachers" (Kohnke et al, 2023, p. 2). Integrating ChatGPT into language learning platforms provides students with immersive and interactive language learning experiences.

2.5 Academic Research

ChatGPT is a versatile tool that can significantly enhance various stages of the research process. It helps educators and students generate and construct initial ideas, refine research questions, and explore potential topics (Rahman et al, 2023). It supports drafting, editing, and improving academic papers' clarity, coherence, and style during the writing phase. ChatGPT is suitable for collecting information employing historical or non-historical documents (Rahman et al, 2023). Its adaptability and broad range of capabilities make it an invaluable resource throughout the research journey, from initial conceptualisation to final publication.

2.6 Grading and Feedback

Educators often spend significant time grading assignments, providing feedback, and assessing student work. Automated grading and feedback systems powered by ChatGPT save instructors time, standardise assessment practices, and provide timely and immediate feedback to students (Kohnke et al, 2023). Pinto et al (2023) applied ChatGPT to grade and correct open-ended questions. They found it could identify "semantic details in responses that other metrics could not observe…and that subject matter experts tended to agree with the corrections and feedback given (Pinto et al, 2023, p. 293). ChatGPT automates the grading process by analysing student submissions, identifying key concepts, and evaluating the quality of responses based on predefined criteria. ChatGPT generates personalised feedback for students, highlighting strengths and areas for improvement.

2.7 Administrative Tasks

Beyond teaching and learning, ChatGPT has enormous potential to "support the work of academics and higher education professionals. But many are still unsure how to put this into practice" (Dianati & Laudari 2023, para. 1). They listed 25 administrative duties, such as student email correspondence, creating reading lists, send reminders and notifications and write a letter of recommendation. ChatGPT-powered chatbots handle inquiries from students, faculty, and staff for tasks and inquiries that are unrelated to their academic coursework or learning objectives: admissions, enrolment, course registration, scheduling, campus resources, financial aid, and other administrative processes (Hasanein 2023). These chatbots provide information, answer frequently asked questions, and assist users in navigating complex systems. ChatGPT assists students in advising and guiding course selection, degree requirements, career pathways, student services, and academic support services. It can also answer questions about academic policies, deadlines, and student resources (Dianati & Laudari 2023). By automating routine administrative tasks, ChatGPT offers prompt and helpful responses to such administrative inquiries, simplifying students' access to information and resources outside the realm of academia, streamlining operations, save time, reducing workload, and improving user experience (Hasanein 2023).

3. This is Where we Could go Next

Using and implementing ChatGPT responsibly in higher education involves several challenges and ethical considerations. Currently, plagiarism detection programs do not easily identify the use of ChatGPT in preparing assignments or writing academic articles, which may raise ethical concerns. Copyright and intellectual property rights still apply to ChatGPT-generated content, and insufficient referencing may result in copyright violations (Hasanein 2023). Educational institutions and educators should establish ethical guidelines to ensure the responsible use of ChatGPT in higher education. Eacersall (2024) stated that the use of Gen AI may breach academic and research integrity requirements and outlined the principles of E.T.H.I.C.A.L AI use with the following acronym:

- E - Examine existing policy/guidelines (international/national/local)
- T - Think about the social impacts (bias, paywall, wellbeing, jobs)
- H - Have knowledge of the technology (quality, bias, copyright)
- I - Indicate use (transparency, authorship, copyright)
- C - Check and revise outputs (quality, authorship, copyright)
- A - Access secure and protected versions (copyright, IP, privacy)
- L - Look at user agreements (authorship, copyright, IP, privacy) (Eacersall 2024, p. 3).

3.1 Bias and Fairness

ChatGPT presents biased language-generated data related to gender, race, ethnicity, and socio-economic status, leading to unfair or discriminatory outcomes (Huang et al, 2021). Language models collect data from various sources, including the Internet, that can create and generate incorrect, cruel, and biased answers (Kaushik et al, 2024). Alawida et al (2023, p. 15) emphasised "that text generated with ChatGPT is based on patterns and stored data, thus may struggle to account for and understand cultural and societal contexts".

3.2 Privacy and Data Security

Integrating ChatGPT in educational settings raises concerns about privacy and data security (Basilio 2023; Mishra & Koehler 2006). A primary concern is the potential to generate sensitive or personal information without the individual's consent, such as medical records, financial information, or personal details (Alawida et al, 2023). Ethical considerations regarding data privacy, bias, and algorithmic transparency exist. The less transparent the programs' algorithmic are, the less responsible they are (Kaushik et al, 2024). Kaushik et al (2024, p. 437) signalled that although "AI plays an increasingly vital role in identifying, preventing, and mitigating cyber risks … privacy-related ethical issues become more important". Hackers may use ChatGPT content to create custom-made and personalised junk messages, phishing, scams, malicious activities, and images that hide dodgy code (Kaushik et al, 2024; Alawida et al, 2023). Privacy infringements may occur with comprehensive data collection and surveillance powers built into security systems (Kaushik et al, 2024). They further mention the global concern that AI systems in one country have impacted systems in other countries and can be detected as security bridges.

3.3 Educator Versus ChatGPT

Lazarides (2024, p. 1) advocated that technology and the use of ChatGPT in education "is not a cure-all and will not reinvent teaching". Overreliance on ChatGPT often leads to dependence on technology, influences students' ability to think critically and solve problems in a negative way (Hasanein 2023); and causes the potential loss of the social and emotional aspects of learning when the human involvement in teaching declines (Freina & Ott 2015). While it provides valuable support and assistance when generating human-like text, ChatGPT cannot replace human interactions and personalised teacher-student relationships (Alawida et al, 2023; Basilio, 2023). Balancing technology for efficiency and meaningful human interaction in education is essential. Educators should use ChatGPT to complement and advance their teaching practices rather than replace human interaction (Kaushik et al, 2024; Martin & Thompson, 2022). Vujinović et al (2024, p. 3) stated that this automated "approach involves making decisions using a predefined set of rules manually defined by experts". ChatGPT development is time-consuming and expensive, and it has several noteworthy weaknesses. They further replied that "it relies on a specific set of attribute values (triggers), limiting its ability to generalize. These systems cannot automatically adapt through interactions with individual students, thus making them a poor methodological choice when the end goal is to provide a genuinely personalized student experience (Vujinović et al, 2024, p. 3). ChatGPT needs to progress to create a whole scientific article similar to a good and experienced researcher (Rahman et al, 2023).

3.4 Reliability, Accountability, and Accuracy

The unclear and indefinite nature of ChatGPT often poses challenges regarding accountability. It is essential to increase transparency in these systems by explaining model behaviour, disclosing limitations and uncertainties, and enabling users to verify ChatGPT-generated outputs. Ropek (2022) found in his review of the chatbot for Gizmodo that it makes mistakes, covers its gaps in knowledge by making things up, and has a human-like capacity for making its way around gaps in its database. Kohnke et al (2023, p.1) echoed that "they are not so "intelligent" and cannot answer questions that they were not programmed to answer". Various concerns are related to the quality and accuracy of responses generated by ChatGPT (Basilio 2023; Deng & Smith 2020). Singh (2023) suggested that "students need to be taught how to engage with them rather than vilifying them" (p. 203).

Educators ought to create teaching and learning environments that allow these technologies to be used responsibly, especially in how we assess (Singh 2023). Green (2022) feared it might undermine what universities do and called it “apocalyptic," meaning the world's destruction. When ChatGPT delivers false or misleading information, Lacy (2024, para. 8) wrote that they “hallucinate, and that “chatbots hallucinate anywhere from 3% to 7% of the time”. These challenging characteristics of ChatGPT impacted the academy's integrity, and the advancements in ChatGPT have re-ignited discussions about the value of Higher Education and its role in delivering and facilitating knowledge (Singh 2023). Rahman et al (2023) noted that researchers might experience challenges regarding literature synthesis, citations, problem statements, and data analysis; ChatGPT provides hypothetical problem statements and research gaps, generates made-up citations and fake references, and does not have the capacity to conduct statistical analysis. Lacy (2024) emphasised that while ChatGPT is still a work in progress, the European Union only approved the Artificial Intelligence Act in March 2024 (which seeks to foster the development of trustworthy AI) with clear requirements and obligations for specific uses.

4. Discussion

ChatGPT' is a transformative and complex tool that can be integrated as a flexible resource with various benefits across multiple industries. In higher education, its adaptability allows for personalised learning experiences, fostering student engagement and facilitating a shift toward more interactive and authentic pedagogical experiences. Educators can effectively incorporate technology to enhance learning outcomes by utilising frameworks such as Piaget's learning theory and the TPACK model. ChatGPT serves as an intelligent tutoring system, offering tailored support and real-time feedback, which can improve both academic performance and engagement.

However, the use of ChatGPT is not without significant challenges and concerns. Ethical considerations regarding bias, privacy, and data security must be rigorously addressed. The potential for biased outputs underlines the need for critical engagement with this tool in educational contexts. Concerns about academic integrity and the implications of over-reliance on ChatGPT require higher educational institutions to establish clear ethical guidelines, such as the principles of E.T.H.I.C.A.L AI use, to underpin and steer the complexities of AI integration in academia. It further reveals a dichotomy between balancing ChatGPT’s capabilities and maintaining essential human interaction in education. While ChatGPT offers various supportive functions, it cannot replicate or replace the unique relationships between educators and students. This highlights the importance of a balanced approach that values both technological advancements and human interaction in pedagogical practices.

5. The Future of ChatGPT in Higher Education

ChatGPT's role in higher education is promising and will expand as it develops and improves. Future directions should focus on developing comprehensive ethical frameworks that address the critical issues of bias, reliability, academic integrity and data security. Higher education institutions must continuously redesign pedagogy that embraces ChatGPT's unique capabilities while preserving education's core values. Traditional and constructivist educational methods should not be abandoned; educators should strive to foster a holistic and authentic educational environment, promoting active learning and knowledge co-construction.

6. Conclusion

In conclusion, ChatGPT presents a transformative opportunity for higher education, enhancing pedagogical practices, enriching student engagement, and streamlining administrative processes. The integration of ChatGPT into academic settings must be considered with caution, ensuring that ethical standards and human connections remain fundamental to the educational experience. As educators pilot the advancements in technology, it is crucial to balance the benefits of ChatGPT while addressing the ethical, social, and pedagogical challenges it brings. The future of ChatGPT in higher education holds promise, but its successful integration depends on the educators’ ability to critically and continuously assess and adapt to the evolving educational landscape.

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The Content and Form of School Reading as a Factor Influencing Text Comprehension in Society 4.0

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Abstract: The content and form of School reading lists significantly impact pupils' understanding of various types of texts, including artistic, non-artistic, and electronic. To this end, a research study explores whether recommended School reading lists at secondary technical schools in the Moravian-Silesian and Zlín regions of the Czech Republic are available electronically on school websites. Additionally, the study aims to determine whether they include everyday life texts that reflect the current characteristics of Society 4.0, influenced by digitisation, automation, and electronicisation. The study examined factors influencing readers' comprehension of printed and electronic digital texts through a questionnaire-based survey of 439 pupils from four Czech secondary technical schools and two vocational schools. It also explored how the content and form of secondary school reading impact the comprehension of various types of traditional and non-traditional texts. The research findings indicated that Czech secondary school students tend to engage with texts from everyday life on social networks and electronic texts in their free time. However, they frequently struggle to understand journalistic texts such as reviews and do not frequently engage with everyday life texts in their schoolwork. These results provide valuable insights into the concept of traditional and non-traditional readers, along with current typologies of texting. Moreover, they highlight factors influencing functional literacy and reading comprehension, viewed through the lens of secondary school students in Society 4.0. It is worth noting that international research by PISA (2018, 2021) has drawn attention to the average to below-average reading and digital literacy levels among Czechs, particularly 15-year-old boys.

Keywords: Text typology, Analysis of lists of reading, Text comprehension, Students of secondary and vocational schools, Digital/reading Society 4.0

1. Introduction

The current 4.0 society in the 21st century is closely linked with the fourth industrial revolution (4.0), which involves digitisation, automation, and robotisation. These changes also impact education as new technologies and techniques are being developed. The evolving social needs in the 21st century are reflected in the Czech school curriculum reforms and updates to the Framework Education Plans (FEP) for primary and secondary schools. The demand for lifelong education across all age groups, focusing on functional literacy and problem-solving skills, increases. In the Czech education system, there is a growing emphasis on encouraging interest in reading various types of texts and a new concept for the school leaving examination in secondary schools. Based on the Ministry of Education, Youth and Sport's recommendations, students are given a school-specific list of recommended readings for the Maturita exam (CERMAT, 2020).

2. Society 4.0 and Readership

The effects of digitisation processes on the education system have been brought to the forefront not just by the COVID-19 pandemic (2019-2020) but also by global-scale manifestations of energy and political crises. These crises have accelerated changes in texting, such as the use of spoken communication expressions in written text, the loosening of language and expression norms, and the acceptance of Anglicisms into everyday speech. There is a growing demand for higher communication and digital competencies in work communication. The curricula of primary and secondary education are revising the framework programs to achieve a higher level of functional literacy among educated communities of pupils. Formal/informal lifelong learning is also transforming and developing new technologies. "Language competencies represent the cultural capital of each person and influence their educational opportunities, employment opportunities, and social status" (Janus-Sitarz and Nowak, 2014, p. 9).

Enhancing language awareness in educational practice was underscored by Štěpáník (2019, p. 13), who asserts that "the only person who is truly communicatively competent is the one who can choose the language means that best suits the communication situation and the fulfilment of his communication intention— who has an informed language awareness." Linguistic and reading awareness development is intricately linked with the need to grow communication and cultural capital in the digital information age.

3. Typology of Texts and Teaching Text

Various scientifically oriented typologies can perceive the problem of the text in multiple ways: linguistically, stylistically, sociologically, psychologically, pedagogically, historically, geographically, etc. According to Höflerová (2011, p. 6), a text can be defined from a semiotic perspective as "a structure that is composed of signs and is intended for communication between people. A sign is an entity that relates with varying degrees of similarity, relationship, vividness, and relevance to the phenomena of reality, both concrete (persons, objects, parts of nature...) and abstract (thoughts, voluntary activity, events, states …)."

In everyday communication situations and educational practice, we encounter different types of communication situations in which various forms of formal and informal communication acts and expressions in written and spoken communication form and style dominate. The communication situation contains communication factors, objective and subjective stylistic factors, including all communicators and code (Prošek, 2013) in Beneš-Schneidrová, Uličný (2013, p. 143). From the stylistic point of view, texts can be viewed according to their targeted functions and functional styles. Through the lens of SERR (2002, p. 122), it can be understood as a broad concept encompassing the stylistic layers of language characteristic of different contexts". Modern stylistics follows the development of changes concerning communication norms. "Every contemporary stylistics must address the relationship between style and communication and the theory of communication" (Čechová, 2016, p. 10). In the typology of texts, the functions of communication, functional styles, and stylistic aspects (e.g. stylistic agents) are emphasised. The functions of texts (e.g. informative, educational, aesthetic, critical, etc.) are essential in helping to understand the content and form of communication based on various communication situations. The research on functional styles is carried out by Hoffmannová (1997). Čechová, Krčmová and Minářová (2008, p. 98) classify functional styles into six categories: 1. simply communicative, 2. journalistic, 3. professional, 4. administrative, 5. artistic, 6. rhetorical.

Educational texts come in both printed and electronic forms. According to Höflerová (2011, p. 27), educational text is a professional communication tool derived in function and style from a professional text. Printed and electronic, or hybrid, texts are part of everyday life, fulfilling many different functions in social life, resulting in corresponding differences in form and content. Different media are used for different purposes, and these differences in medium, purpose, and function lead to corresponding differences in the context of messages and their organisation and presentation. Therefore, texts can be classified into different genres. Reading various types of texts helps us understand specific communication situations and use appropriate language (SERR 2002, p. 95).

The artistic text primarily serves an aesthetic function, which we encounter in literary forms such as poetry, prose, and drama. Vařejková (1998, p. 13) argues that "a work of art is the subject of work in literary education. Therefore, it is a dominant component in the teaching process, determining the goal of the activity, its content, and methodological procedures." The communication situation and cooperation play an essential role in the communication acts of the artistic text, reflecting the perspectives of the author and recipient.

In the 21st century, the approach to teaching literature has shifted from a purely factual orientation to actively engaging with artistic texts and developing reading skills for everyday life, including non-artistic texts.

4. School Reading as a Factor in the Development of Reading Literacy and Readership

The demand for functionally literate individuals is increasing due to the abundance of information, not only in cyberspace. According to Štěpáník (2019, p. 6), "In connection with the information explosion and today's constant life in cyberspace, understanding various types of communication becomes a means of self-preservation for a person." Trávníček (2008, p. 34) defines reading as "planned and targeted development of reading, especially with the help of schools, libraries, and other educational institutions; development, which is frequently accompanied by institutionally organised campaigns and support actions." schools need to support the education of readers and encourage an active interest in reading. Lederbuchová (2004, p. 21) describes reading interest as "a form of spontaneous affection, which is not always conscious. The need for reading also changes, and the child's attitude towards reading develops." Trávníček (2008) categorised readers into four groups based on the number of books read per year and reading frequency: 1. non-reader (0 books read per year), 2. sporadic reader (1-6 books read per year), 3. regular reader (7-12 books read per year), and 4. frequent reader (13 or more books read per year).

The latest annual report (2022/23, p. 121) from ČŠI indicates insufficient use of teaching methods that promote active student engagement, independence, critical thinking, and shared responsibility for learning outcomes in

secondary schools. It also points out that Czech students are not adequately learning various reading techniques involving digital skills, and there is a lack of active engagement with different types of texts and strategies for reading texts from different perspectives or challenging the opinions presented in the text (VZ ČŠI, 2023, p. 97).

The current concept of school Maturita reading in the Czech Republic

The school reading list can be described as a canonical document. In 2007, Markiewicz defined "canon" as "a rule, norm, and also a pattern or set of such rules, norms, or patterns" (p. 63). The author also identified five critical functions of the literary canon: formative, artistic, competence, identification, and integration.

The Ministry of Education, Youth and Sports of the Czech Republic has changed the curriculum model for the Maturita examination in the Czech language and literature (ČJL) since 2022. The common part of the examination now only consists of a didactic test prepared by the CERMAT company. In previous years (2011 – 2020), the common part of the examination included a written essay, an oral exam, and a didactic test. The Maturita Catalogue was a critical document for the exam concept during that period. The written secondary school thesis and the oral examination are now the only profile parts of the secondary Maturita examination from the Czech language, and the responsibility for their content and organisation lies with the school head teacher, without the mandatory acceptance of the previously binding curriculum catalogue. However, the Ministry of Education, Youth and Sports of the Czech Republic recommends that secondary schools work with the school reading lists. Currently (2024), most secondary schools still accept the information contained in the so-called Catalogue of Examination Requirements of the Common Part of the Maturita examination (CERMAT, 2019/2020) and the recommended rules for compiling school reading lists and student reading lists.

In the Czech Republic, every secondary school that administers the Maturita examination (2024) informs students at the beginning of their studies about the school's approach to reading, including the school's reading guidelines and the requirements for compiling mandatory reading lists for students. The mandatory secondary school reading mainly consists of literary works. An emerging trend in secondary school education is the emphasis on improving students' reading skills for non-literary texts. However, the lists of non-literary texts for secondary school reading are not part of the official Czech language and literature Maturita examination curriculum. Each secondary school that administers the Maturita exam is responsible for determining the recommended reading list, both literary and non-literary. Králíková (2020, p. 5) states, "the school environment tends to focus on specific authors rather than specific works."

Critical curricular rules for creating a school reading list (valid until 2019/2020, according to the Catalogue)**:**

- The minimum total number of literary works offered is 60. The upper limit is not set.
- A comprehensive work, not a part of it, is considered a literary work.
- The edition is specified for a literary work from world literature.
- The student submits a list of 20 literary works compiled based on the criteria for selecting graduation assignments for the oral exam to the head teacher" (Catalogue, 2019/2020).

Critical curricular rules for creating a school reading list (valid until 2019/2020, according to the Catalogue)**:**

- Prose, poetry, and drama must be represented in the list by at least two literary works.
- The list can contain a maximum of two works by one author" (Catalogue, 2019/2020)."

Our research plan and selection of research tools for content analysis of reading lists at selected secondary technical schools in the Czech Republic are based on a mixed research design (Vicherková, Paličková, and Davidová, 2020).

5. Research Methodology 1

In the first phase of the research, we dealt with the problem of the school reading list as a factor affecting the understanding of the content of artistic texts in printed and electronic form. The research goal was to analyse the content of four secondary school reading lists (focused on education) completed with the Maturita examination.

5.1 Content Analysis of School Reading Lists (Artistic Literature)

5.1.1 Objectives of content analysis and research questions

The research objective is to analyse the content of the school reading lists of secondary technical schools completed with the Maturita examination.

Partial objectives:

- To determine how much contemporary Czech literature of the 21st century (published since 2000) is represented in selected school reading lists.
- To determine how many works of contemporary world literature of the 21st century (published since 2000) are represented in selected school reading lists.
- To determine how many works of world and Czech literature up to the end of the 18th century are represented in selected school reading lists.
- To determine how many works of world and Czech literature from up to the end of the 19th century are represented in selected school reading lists.
- To determine whether there is a difference in the number of books in individual selected school reading lists.
- To determine how many printed publications are represented in selected school reading lists.
- To determine how many electronic publications are represented in selected school reading lists.

Research questions related to sub-objectives 1-5:

- Are works of world and Czech literature up to the end of the 18th century represented in the selected school reading lists in a minimum number of 2 literary works (according to the requirements set out in the Catalogue of Examination Requirements for the Common Part of the Maturita examination (CERMAT, 2019/2020)?
- Are works of world and Czech literature up to the end of the 19th century represented in the selected school reading lists in a minimum of 3 literary works (according to the requirements set out in the Catalogue (CERMAT, 2019/2020)?
- Are works of world literature of the 20th and 21st centuries represented in the selected school reading lists in a minimum of 4 literary works (according to the requirements set by the Catalogue (CERMAT, 2019/2020)?
- Are works of Czech literature of the 20th and 21st centuries represented in the selected school reading lists in a minimum of 5 literary works (according to the requirements set out in the Catalogue (CERMAT, 2019/2020)?

Research questions related to sub-objective 5:

- Do the selected school reading lists contain a higher number of works than the specified minimum number according to the Catalogue, 2019/2020 (60 works)?
- How many works match in the selected school reading lists?
- Do the selected school reading lists contain fewer works than the specified minimum number according to the Catalogue, 2019/2020 (60 works)?

Research questions related to sub-objectives 6 and 7:

- Are printed texts represented in selected school reading lists?
- Are electronic texts represented in selected school reading lists?

5.1.2 Research sample

School reading lists of four secondary vocational schools with a pedagogical focus in the Moravian-Silesian and Zlín regions in the Czech Republic (Ostrava, Havířov – Suchá, Vizovice, Kroměříž)

5.1.3 Variables

Variable 1 - works of world and Czech literature up to the end of the 18th century

Variable 2 - works of world and Czech literature up to the end of the 19th century

Variable 3 - works of world literature of the 20th and 21st centuries

Variable 4 - works of Czech literature of the 20th and 21st centuries

Variable 5 – minimum number of cannons (60 cannons)

Variable 6 – printed publications

Variable 7 – electronic publications

We researched using content analysis of the school reading lists from four secondary vocational schools in the Moravian-Silesian and Zlín regions.

The school reading lists from the four examined schools included the following variables:

- P2: Works of world and Czech literature up to the end of the 19th century (minimum of 3 literary works)
- P3: Works of world literature of the 20th and 21st centuries (minimum of 4 literary works)
- P4: Works of Czech literature of the 20th and 21st centuries (minimum of 5 literary works)
- P5: Minimum of 60 offered works
- P6: Printed works

Item P1 (works of world and Czech literature up to the end of the 18th century in a minimum number of 2 literary works), which was included in the school reading lists of the three examined schools, resulted in the most differences in the number of publications. The school reading lists varied in comprehensiveness among the examined schools; the lowest number of texts recommended for school reading was 61, and the most extensive list contained 110 items. Variable P7 indicates that there are no works in electronic form (e.g. in the form of a link) in any of the examined school reading lists. Additionally, the school reading lists do not contain texts reflecting the characteristics of everyday life in the current 4.0 society and texts of a non-artistic nature.

Table 1: Number of occurrences of variables (Column 1 means - contains, column 2 means - does not contain)

List →	S1		S2		S3		S4	
Item↓	1 (contains)	2 (doesn't contain)	1 (contains)	2 (doesn't contain)	1 (contains)	2 (doesn't contain)	1 (contains)	2 (doesn't contain)
P1	X		X			X	X	
P2	X		X		X		X	
P3	X		X		X		X	
P4	X		X		X		X	
P5	X		X		X		X	
P6	X		X		X		X	
P7		X		X		X		X

6. Research Methodology 2

In our quantitative questionnaire research, we concentrated on four secondary vocational schools and two higher vocational schools in two Moravian regions of the Czech Republic. The research took place from November 2023 to February 2024, and we collected data from 439 respondents. The semi-structured questionnaire included 24 semi-open items categorised as A to E.

A. Non-artistic text and reader interest (5 items)
B. Artistic text and reader interest (5 items)
C. Reading strategies (4 items)
D. Comprehension and reflection of the read information (5 items)
E. School reading (6 items)

Research objectives

The research aimed to determine what factors influence the reader's understanding of printed, electronic, and digital texts. The research problem was decomposed into the following research questions:

- Is there a connection between the search for professional non-fiction texts for personal reading interest and the interest in the formal organisation of the text (the structure of the text)? A1/A5
- Is there a connection between regular reading of printed books and the perception of hybrid texting as an innovative strategy? E1/E3

Results

The research objectives and questions led to the formulation of two hypotheses. In the next chapter, these hypotheses are presented along with the verification results.

Descriptive research data

Descriptive data more closely characterises the factors influencing the reader's comprehension of the individuals of the research group in terms of content, form, and type of texts. Research into the expression of preference for the type of non-artistic text showed that the greater half of 240 respondents (54.67%) prefer to read scientific professional texts, and 199 respondents (45.33%) read historical documents with preference. 208 respondents (47.38%) commented on the point of view of readers' popularity of the form of non-artistic texts, respectively, that they like to read scientific articles. Furthermore, 115 respondents (26.20%) answered that they consider textbooks their favourite reading, and 116 respondents (26.42%) prefer popular science books.

Relational research results

Two hypotheses were tested Using Pearson's Chi-square for the contingency table. The following two tables present the source data and corresponding statistical results.

In the questionnaire, the students answered questions A1 (whether they search for professional non-artistic texts based on personal interest) and A5 (whether they are interested in the structure of the text/graphics and references when reading a non-artistic text).

Table 2: Detected and expected frequencies to H1

Pearson´s chi-square = 14,467513	degree of freedom = 1	significance *p*= 0,0001426	
Q A1	**Q A5 - yes**	**Q A5 - no**	**Line totals**
yes	138 (118,24)	73 (92,76)	211
no	108 (127,76)	120 (100,24)	228
Column totals	246	193	439

Hypothesis 1 stating that students who search for professional non-fiction texts based on their interest are more frequently interested in the formal organisation of the text (text structure) when reading a non-fiction text than students who do not search for professional non-fiction texts based on their interest, **was confirmed** (Table 2). There is a statistically significant relationship between the answers to both questions (searching for professional non-fiction texts based on personal interest and interest in text structure when reading non-fiction texts).

In the questionnaire, the students answered questions E1 (attitude towards electronic books, e-books) and E3 (opinion about hybrid texts).

Table 3: Detected and expected frequencies to H2

Pearson´s chi-square = 0,052519	degree of freedom = 1	significance *p*= 0,818736	
Q E1	**Q E3 - I find them innovative**	**Q E3 - I find them less understandable**	**Line totals**
I read them regularly, and I prefer them to printed texts	83 (82,00)	37 (38,00)	120
I like printed texts	217 (218,00)	102 (101,00)	319
Column totals	300	139	439

Hypothesis 2, suggesting that students who prefer reading electronic texts would consider hybrid texts more innovative than students who prefer printed books, **was not confirmed** (Table 3). There is no statistically significant relationship between the attitudes towards electronic books (e-books) and opinions towards hybrid texts.

A survey conducted with 439 Czech secondary school students found that factors influencing the understanding of texts in Society 4.0 include comprehensible and well-structured content and format of school reading, reading experience, and the need for daily reading of non-artistic texts in electronic or printed form. In Czech secondary schools completed with the Maturita examination, more than 240 (54.67%) respondents read scientific professional articles in printed or electronic text form, and 199 (45.33%) preferred reading historical documents

in printed or electronic text form. In Czech secondary schools completed with the Maturita examination, more than 240 (54.67%) respondents read scientific professional articles in printed/electronic text form, and 199 (45.33%) preferred reading historical documents in printed/electronic text form. According to the thematic preference of reading, 101 respondents (23.01%) prefer reading science fiction and fantasy literature, and 50 respondents (11.39%) prefer reading artistic texts. Secondary school students are most interested in reading texts of an everyday nature with a focus on current events, as stated by 156 (35.54%) respondents. The majority, 333 respondents (75%), prefer a printed book to a printed magazine (preferred by 31 respondents, 7.06%) or to a printed newspaper (31, 7.06%). Less than one-third of respondents (120, 27.33%) prefer reading electronic texts to reading printed texts, and 319 respondents (72.67%) prefer reading printed texts. More than two-thirds of respondents (300, 68.4%) consider hybrid texts innovative, while only 139 respondents (31.66%) think they are too complex. Pupils read non-artistic texts more often while studying, as stated by 283 respondents (64.46%), and only 156 respondents (35.54%) answered that they mostly read non-artistic texts in their free time. Of the non-artistic texts, secondary school pupils most frequently read professional texts as part of their education, as stated by 89 respondents (20.28%). Respondents (207, 47.15%) also mentioned simply informative texts as frequently read non-artistic texts, while administrative texts were read the least frequently (according to 143 respondents, 32.57%). More than half of respondents (240, 54.67%) consider school reading important for developing intellect; 197 respondents (44.87%) consider school reading as a waste of time. More than half of 242 (55.13%) respondents consider school reading an essential activity.

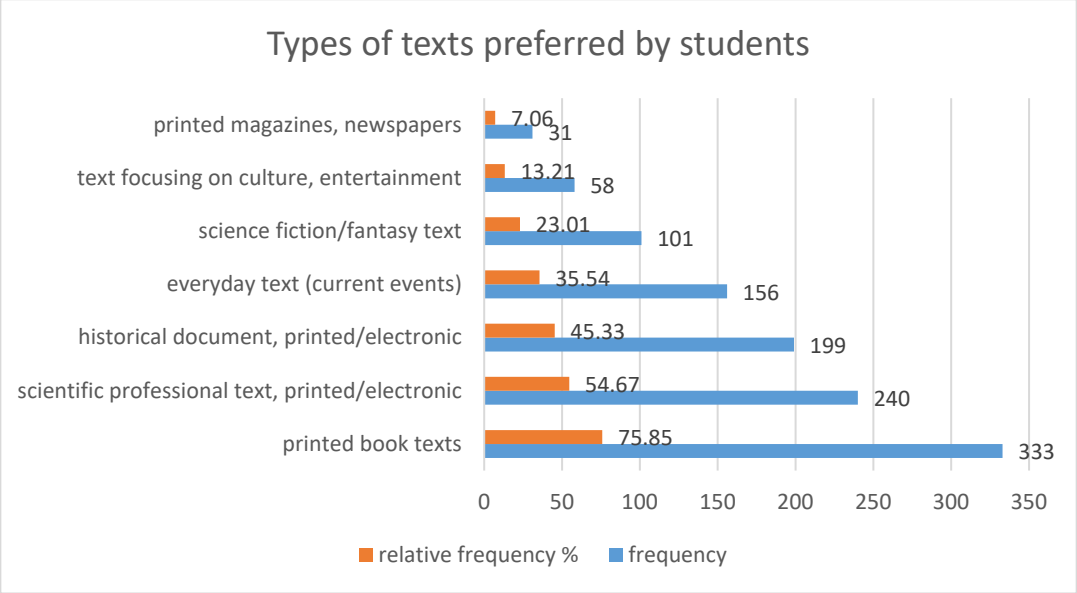

Figure 1: Types of texts preferred by students

7. Discussion and Conclusion

The initial phase of the research involved using content analysis to examine the "School reading list" document, which included artistic and non-artistic texts from four vocational secondary schools in the Czech Republic. The results indicate that while schools list literary works in printed format, they provide e-links to literary and non-literary publications on their websites. The analysis reveals that the number of recommended literary works for secondary school art reading ranges from 61 to 110, focusing on contemporary Czech literature. Notably, the school reading lists do not include texts that reflect the characteristics of life in the current 4.0 society.

The results from the second phase of quantitatively oriented questionnaire research indicated that text content (what the text tells about) and text form (how the text is organised, what parts the text consists of, and what form it is written in) influence reader comprehension. Factors influencing reading comprehension include lists of school reading and criteria for compiling school reading, such as comprehensibility, clarity, logic, quality, and quantity of information. This also encompasses publishing information on recommended school/daily reading by the school institution, electronic/digital links to resources, and a repository of electronic and hybrid texts (artistic and non-artistic). An important aspect is the placement of information on recommended/leisure reading of artistic/non-artistic texts in an electronic/digital environment, for example, on the websites of secondary schools, as well as understandable, clear digital access to information for pupils/their parents, teachers/school staff, the educational public, and the general public. The research results indicated that hybrid texts are

innovative in Society 4.0 and that school reading is discussed in Czech secondary education. The research data present the relationship of pedagogically oriented Czech high school students to various types of texts, the popularity of reading artistic/non-artistic texts, the understanding of read information in terms of content and form of texting, and the importance of reading different types of texts in printed and electronic formats.

The quantitative research results confirmed Hypothesis 1, indicating a statistically significant relationship between students' attitudes towards electronic books and their reading interest in the formal organisation of the text. However, the research did not confirm Hypothesis 2, which suggested a statistically significant relationship between students' attitudes towards e-books and their attitudes towards hybrid texts. An interesting finding is that the majority (88.15%) of respondents consider it necessary to read texts daily to develop knowledge.

The role of informal learning in adult education was examined in a recent study by Sulkunen, Nissinen, and Malin (2021). This research sought to analyse the impact of informal education compared to formal and informal learning on adult literacy in Denmark, Finland, Norway, and Sweden among individuals aged 35-65. The study utilized a subset of respondents from the Nordic countries sourced from the PIAAC dataset from 2011-2012 and employed regression analysis to examine the influences above. The study's findings indicate that non-work-related reading significantly influences educational ambition and the potential for literacy development among adults with lower levels of education or those who are unemployed. Research conducted by Akimova in 2019 delved into the issue of understanding Internet texts. The study's primary objective was to investigate the impact of user experience with Internet texts on the process of interpreting them. This was achieved through a semantic and receptive experiment and methods such as semantic and pragmatic interpretation, content analysis, and subjective scaling on a sample of 716 respondents. The research results revealed that over half of the users underestimate the complexity of Internet texts. Furthermore, it was found that experience with Internet texts enhances the accuracy of understanding by 15%, and users evaluate it more consistently, even as their awareness of their attitude towards it grows. It was also evident that experienced users correctly interpreted only a quarter of the texts, while random users interpreted only a sixth. Additionally, Brožová and Brož (2006), Hník (2016), and Horáková (2021) researched Maturita examination reading in the Czech context. Curkovič and Krpanec (2023) explored the relationship between the amount of school reading experience and attitudes towards reading. Lastly, Tegmark, Alatalo, Vinterek, and Winberg (2022) focused on students' motivation to read at school in terms of reading strategies (pp. 986 – 1004).

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Video-Feedback on Assignments: A Case Study From Norway

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Abstract: The background for the study was a desire to strengthen the students' learning outcomes, and to support their development, preferably to become reflective practitioners. Knowing that the students prefer feedback on assignments and the opportunity to improve based on this feedback, summative feedback may not provide enough feedback in order to know what and how to improve. Also, some students, both younger students and students returning to school, are insecure and uncertain about studying in higher education and need psychological safety to be able to unlock their potential. The aim of the study is to investigate how they perceive personalized video feedback to contribute towards their development and their enhanced learning outcomes. By using video feedback, the students would be spoken to by name and get feedback on their assignment, including both what was adequately presented and why, and points for improvement and clues for improvement. The methods of inquiry have been survey, individual interviews and group interviews. We have treated this study as a case study. The results from the study have been very positive. The students claim that they perceive the feedback to be personal and they understand what and how to improve, in addition to how to prepare for the exam. Although some students still prefer written feedback, the majority of the respondents and informants are positive towards the video feedback, and some would even like to have this in other courses as well. They understand what and how to improve, and they perceive it as personalized and reassuring. The conclusion is that video feedback in general has had a positive impact on the students. The perception of personalization contributes to boosting confidence and supporting learning outcomes.

Keywords: Video feedback, Feedback, Assessment, Personalized feedback, Learning outcome, Reflection

1. Introduction

Supporting students' development and learning outcomes is of great importance. Not only does it help the students, but it may also support them finishing their education on time. One of the major contributors to students' enhanced learning is feedback (Haave et al., 2016, Hole, 2014).

There are two major types of assessment, summative and formative assessment, in which summative is in general a numerical score with limited or no additional or written feedback, while formative assessment provides students with feedback on their performance (Glazer, 2014). However, the score may provide the students with a sense of how they are doing, and they can also compare their score with others. Nonetheless, this score will not provide students with any clues on how to improve, what they have excelled in or where they have not met the expectations. Feedback can be offered in many different ways, for example, through conversations with either teacher or peers, or through written feedback from teachers or peers (Engh and Gran, 2021).

In this paper, we present a case study with students from The Inland Norway University of Applied Sciences, Rena, Norway and Østfold University College, Fredrikstad, Norway. The video feedback follows a structure that includes starting with addressing the students by name (if it is a group, then all the group members' names will be mentioned), a short version of what the assignment was about, how well they have done, what they need to approve, advice on what to practice more on regarding their future exam, and lastly if they have passed their assignment. The study was done over a period of two years, and in this paper we are comparing the students' answers to see if they have changed from one year to the next. The video feedback lasted from four to seven minutes each.

We set out to investigate if the students' perception of video feedback had changed. The previous investigations showed that the students appreciate this type of feedback (Vold et al., 2023b, Vold et al., 2023a). They find it personal and useful, and they claimed to learn from the feedback. The students also claimed that they would also like to have video feedback in other courses. Would the second cohort of students have the same attitude towards video feedback? Would they be just as enthusiastic about it as their predecessors? Additionally, would the students who had video feedback in two courses following each other still be as positive toward the second round of video feedback?

We will first present the theory that has informed our study, and then explain our method of inquiry. Lastly, we will then present and discuss the results of our investigation before we conclude.

2. Theoretical Foundations

Hattie and Timperley (2007) define feedback as "information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" (p. 81). One type of feedback is feedback provided via video from a teacher to a student. Borup et al. (2015) claim that video feedback provides personal and personalized feedback. As the number of students has increased, there is a risk that feedback becomes less personalized, since the need to provide a lot of feedback leads to standardization. According to Borup et al. (2015), video feedback enables a maintained information richness.

Although feedback should be provided as quickly as possible after the assignment (Daft and Lengel, 1986) to have an impact, video feedback, although time consuming (Borup et al., 2015), makes it possible to provide positive and encouraging feedback via video. Enabling psychological safety when starting higher education (Edmondson et al., 2016, Edmondson, 2019) may provide the students with the affective support they need to gain confidence in the study situation (Palloff and Pratt, 2007).

According to Borup et al. (2015), students find that written feedback is easier to access, as they tend to use their mobile phones for study purposes. Moreover, the students in Borup et al.'s investigations (2015) claim that written feedback is more efficient, as they can skim the text, as opposed to a video in which they have to listen to- and watch the video. However, they find the video feedback more elaborate, supportive and understandable, as they can interpret more listening to the tone of the voice in the video. There is also a higher word count in the video, hence, more opportunities for praise, support and relationship building.

Blair et al. (2013) have done investigations as to what type of feedback students want. They base their study on the seven principles provided by Nicol and Macfarlane-Dick (2006), in which good feedback:

1. Helps clarify what a good performance is
2. Facilitates the development of self-assessment (reflection) in learning
3. Delivers high-quality information to students about their learning
4. Encourages teacher and peer dialogue around learning
5. Encourages positive motivational beliefs and self-esteem
6. Provides opportunities to close the gap between current and desired performance
7. Provides information to teachers that can be used to help shape teaching

Blair et al. (2013) also point towards a possible discrepancy between teachers' perception of importance of feedback, and the students' perceptions. The teachers may deliver feedback they think the students need in order to pass a test. According to Blair et al. (2013), some students do not have the ability to use the feedback provided.

They also claim that there may be more miscommunication in written feedback, as it may be written in a very academic style using academic language, which requires insight into this academic language from the students.

Due to the large number of students, there are also fewer opportunities for staff-student dialogues. These dialogues may have supported student engagement with feedback (Blair et al., 2013).

Hattie and Timperley (2007) conducted an overview of studies looking at the effects of formative feedback, and found that the most effective feedback provides information about the task in question and how to improve it. Praise, rewards and punishment did not contribute to any effectiveness. Their suggestion is that effective feedback should be asking: "Where am I going (goals)?", "How am I going (progress)" and "Where to next (improve progress)" (p. 86). In this way, it should be possible to "reduce the discrepancy between current and desired understanding" (Hattie and Timperley, 2007). They provide a model for feedback to enhance learning that ends up in four levels: Task level, Process level, Self-regulation level and Self level. The Task level is about how well tasks are understood and performed, whereas the Process level is about what process is needed to understand and perform regarding tasks (assignments). The Self-regulation level is about self-monitoring, directing and regulating actions, while the last level, the Self-level, is about personal evaluations and their effect on the learner. The Self-regulation level is about how to provide feedback that makes the students seek and accommodate information that will support the learning outcome. Hattie and Timperley (2007) have suggestions as to how the feedback on the task should be provided. For example, they claim that "feedback aimed to move students from task to processing, and then from processing to regulation to regulation, is most effective" (p. 91).

Drawing on both what Hattie and Timperley (2007) and the theorists above claim, the Self-level has less of an effect on the learning outcomes as praise, with Self-regulation being something that we want to achieve.

Balancing the task level and the process level is also important. Consequently, based on the theoretical foundation above, and how we have designed our video feedback, we propose the following model:

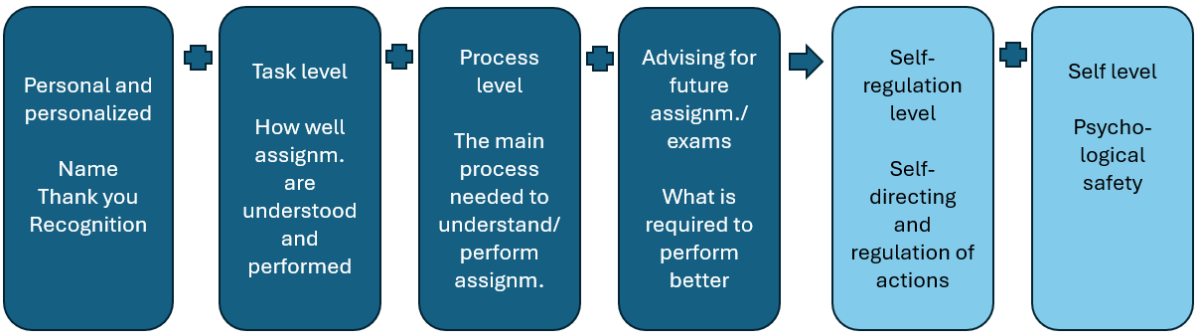

Figure 1: New figure on levels of video feedback

This figure (Figure 1) shows how the video feedback is provided based on the theoretical foundations of this paper. In the personal approach, we direct the feedback to the students by name, thank them for their assignment and recognize their assignment by addressing what they have written about. We then move to the Task level, in which we provide them with information on how well the assignment is understood, and how well they have performed. The next level is the Process level: how they need to understand and perform regarding improving their assignment. After that, there is the level of providing advice for how to solve an assignment, and work on their process towards their new assignment and/or exam. We hope this will lead to self-regulation regarding taking actions to improve their assignment, as well as support their "self" by providing any needed psychological safety.

Our aim for this research is to unveil whether this model still applies to the students who receive video feedback in the second semester, and whether this applies to the new students being exposed to video feedback.

3. Method of Inquiry

We have chosen a qualitative approach designed as a case study (Yin, 2003) to help improve our understanding of the students' perceptions, perspectives and reasoning for receiving written feedback and video feedback.

We have chosen to use a strategic selection of our full-time and part-time students on a bachelor and master level to investigate a wide array of specific experiences and perceptions of the experience of receiving written and video feedback on their assignments. We have chosen these students because they were typical, relevant and appropriate regarding our problem statement and the phenomenon to be studied (Clark et al., 2021).

Our study can be called a case study, as we have used several data sources in the investigations, and instead of generalizing, we will look at the differences and any potential for improvement. Case studies can be undertaken by utilizing several methods for collecting a detailed and rich data (Yin, 2018).

We used a combination of individual and group interviews, and distributed surveys to a selection of the students using the digital tool "Questback," which enables collecting and effective analyzing data. This methodological approach was chosen to provide us with a better understanding and nuances of the students' experiences and preferences, while at the same time allowing us to analyze the individual perceptions.

To help enhance our understanding of how students experienced receiving video feedback on their assignments, we have chosen to rely on Gadamer's understanding of conversation and language, who claims that to interpret underlies all perceptions of reality (Gadamer, 1975). It will be of vital importance to understand the students' perceptions, as well as our own. As lecturers, we have our own experiences and knowledge in the field of research. We are attentive to how our own experiences and background may influence the work on- and interpretations of the interviews, and an understanding of responses from the surveys. It may have its advantages, but at the same time our experiences and previous background may lead us towards interpretations that are subjective, since our own preconceptions may determine these interpretations.

The preconceptions we bring will determine what is possible to understand, and what is less possible to understand (Gadamer et al., 2012). According to Gadamer, understanding is never without its preconceptions (Gadamer et al., 2012), with these preconceptions guiding us in our interpretations and creation of meaning. Prejudice and preconceptions are our basis of experiences and preconditions that influence our interpretations.

According to Gadamer et al. (2012), the perceptions and attitudes within the sphere of understanding are explained by the expectations one brings into a situation. When the expectations do not suit the purpose, they need to be modified and corrected to become coherent with what we wish to obtain an understanding about. When one is clear about your preconceptions and previous knowledge, this will help enable an understanding of the opinion of others. Subjective convictions and opinions could hamper one's understanding if one is not aware of this. Gadamer (2012) pointed out the importance of being open towards other people's differences. Gadamer (2012) also claims that prejudices may be positive or negative, and that they do not necessarily hamper, but may be a precondition to help understand the future. Without a prior understanding, the understanding of a phenomenon will be difficult to understand. According to Grønmo (2004) and Gadamer et al. (2012), the pre-understanding will represent a possibility for a common acquired knowledge. By knowing the field of research, it will be possible to develop relevant knowledge and increase validity and reliability (Lindboe and Skrefsrud, 2016). At the same time, the researcher needs to be aware of not becoming too close to the research field, and thus hamper the analytical process.

Our study includes feedback to approximately 250 students. The students were located at two different universities, with two different courses at The Inland Norway University of Applied Sciences and Østfold University College. The students were encouraged to volunteer for the interviews, and we only conducted six individual interviews. The group interviews were conducted with four groups: two with 10 persons, one with 12 persons and two with approximately 40 students. The survey was sent to 167 students, with approximately 26 replies. Although the number of respondents compared to the number of students in total is low, we still get an indication of how they have perceived the video feedback.

4. Results and Discussion

As we have suggested in Figure 1, upon investigating how they perceived the video feedback, we found that most of the students claim that video feedback provides them with the feedback they need to understand how to improve on their assignments, and how to improve for their exams. Statements like: "In the video, the lecturer explained how well I had done on the assignment, but also provided me with input as to how I could improve the assignment" (informant X), and "the feedback provided in the video gave me concrete tips as to how I should have gone about solving the assignment" (informant Y), thereby supporting the two levels, the "Task level" and the "Process level" (Hattie and Timperley, 2007).

Our approach of opening by addressing the students by name, thanking them for their assignment and recognizing their assignment was our way of recognizing without praising, which according to Hattie and Timperley (2007) does not contribute to learning outcomes. According to the informants, they found that this made the information "personal" and was "directly addressed to them". Some of the informants also claimed that "when the teacher opened the way she did, it gave me a boost of confidence and made me less 'afraid' of the rest of the feedback" (informant XX). This supports what we have aimed for in our model (Figure 1). It indicates that they have been provided with some psychological safety (Edmondson et al., 2016, Edmondson, 2019).

Most of the informants are also clear about how the initial address of seeing the face of the lecturer and hearing the tone of voice provides them not only with a sense of psychological safety, as we appear clear about wanting them to improve and providing them with support (Edmondson et al., 2016, Edmondson, 2019, Palloff and Pratt, 2013), but they also trust what we convey about their assignment. They also claim that they understand what is being said, something that is in coherence with what Borup et al. (2015) explain about media richness. They can both see us and hear us, which according to them not only reassure them about our good intentions, but also allow for a better understanding of what they could do to improve their assignments. The latter may also be due to that video feedback in general contains more words, hence providing a more extensive explanation of the task and process, as pointed out by Borup et al. (2015).

Only a few students claimed that written feedback was perceived as "better" than video feedback. One of these students stated that: "I can go back to the written feedback, and check out that I have remembered all for my new assignment" (informant Z). This coheres with what Borup et al. (2015) found. According to Borup

et al. (2015), the students could skim the written feedback and download it onto their mobile devices. Although none of our students claim that it is easier to access the written feedback on their phones, as opposed to the video feedback, they do claim that they like to skim the feedback, and to be able to do so several times.

With our fourth level about providing tips for task and process management towards exams, the students claim to both understand and appreciate this input from the lecturers. For this reason, Blair et al.'s (2013) findings on how the students may misconceive, or are unable to utilize the advice, may not be the case in our case study. In fact, after the introduction of the video feedback, the average grade went from C to B (which means an improvement). Although some of the students that we interviewed after their exam claim that they utilized the advice provided in the video feedback, AND the average grade went up, we still need to investigate further to establish more solid evidence of these coincidental happenings.

The students in the second semester also claim to enjoy video feedback for the same reasons. However, upon asking them which semester they would prioritize to receive video feedback, they unanimously claim that it is most important in the first semester. Statements like, "If I had to choose, it is more important to have video feedback in the first semester, as it is then that we need to build our confidence. Coming straight from a work situation, I was very unsure about how to become 'academic enough' to pass my exams" (informant Yy), and "I was so insecure and almost afraid to receive the first feedback, but the tone of voice, the reassuring comments and the way the advice on improvements were provided made me feel more relaxed, and inspired me to continue my work on my assignment although we were not to hand it in again. In this [second] semester, I feel more confident, so for this semester I could just as well have gotten written feedback" (informant Zz). Again, this implies that starting out with video feedback and being provided according to Figure 1, and based on the theory on good feedback (Nicol and Macfarlane-Dick, 2006, Borup et al., 2015, Hattie and Timperley, 2007), this supports Self-regulation and a Self level, including psychological safety (Edmondson et al., 2016, Edmondson, 2019, Palloff and Pratt, 2013).

Summing up, the video feedback seems to follow up on Nicole and Macfarlane-Dick's (2006) explanation about good feedback, as it seems to "help clarify what good performance is", "facilitate reflection in learning", provide "high-quality information" on their learning, "encourages positive motivational beliefs and self-esteem", and provides possibilities and support by "closing the gap between current and desired performance".

What we have had less of an emphasis on are number 4 about "encouraging teacher and peer dialogue around learning" and number 7, which is about "providing information to teachers that can be used to help shape teaching".

5. Conclusion

Our conclusion is that video feedback based on the model displayed in Figure 1 has been successful, as according to our informants it has provided them with meaningful information about their task (assignment) and process. The first level about addressing them by name, thanking them for their assignment and recognizing what they have written their assignment about made the information personal, and helped put them at ease. Many of the informants also claim it provided them with a psychological safety that encouraged them in their further studies. The advice on the forthcoming assignment and/or exams, in addition to the information about their task (assignment) and process, provided some of the informants with Self-regulation, in which they claim to have gone through their assignments again to look at how they could improve, as well as preparing for the forthcoming assignment and/or exam. The average grade in one of the courses where video feedback was used for the entire course improved (from C to B), but this needs to be more extensively verified.

Although written feedback was emphasized as easy to skim and to return to when working on assignments and exams, it seems that video feedback is the preferred form of feedback by the students.

5.1 Further Research

In this paper, we have focused on the students' perspectives, as our investigations have been among the students. It would be interesting to also investigate the lecturers' perspectives. The theory we have used to inform this study also provides some information on the teacher perspectives, but it would be interesting to do a separate inquiry among the lecturers that have been a part of this investigation.

Also, to do a more in-depth investigation on any coherence between the increased average grade and video feedback would be of interest.

There is also a rapid development in tools that may aid regarding the time spent doing the video feedback. We do not yet know the full extent of what Artificial Intelligence (AI) can do for us, nor the digital tools available that can record and replay, and even text video messages. We will keep a close eye on the developments, and suggest testing different tools in the very near future.

In the following study year, we have decided to only provide video feedback in the first semester and written in the second semester, and repeat our qualitative investigations among the new students. The aim of this study will be first to establish if starting out with video feedback will provide the students with the necessary self-regulation and psychological safety needed to study in higher education.

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Post COVID-19: Students' Expectations of HyFlex Learning Opportunities

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Abstract: Posterior to COVID-19, many universities have returned to ordinary classroom education. Recognizing the impact of the isolation in the form of psychological strain, one of the takes were to return to on campus education to secure follow up and the personal contact with lecturers and fellow students. However, in some studies, the COVID-19 paved the way for combinations of ways of studying that many students had been waiting for. Hence, returning to an on-campus solution is not an option. Each year after the COVID-19 we have done investigations into "if" and "why" the students prefer a HyFlex solution and many of the same answers keeps being repeated: home situation, work situation and travel costs. The last investigations have also included "sustainability" as a reason for not attending classes physically. Through our mixed methods approach to collecting data, we will present and discuss our findings and the trend in the longitudinal study.

Keywords: Hyflex learning, Online learning, Flipped classroom, Lifelong learning

1. Introduction

Prior to the COVID-19 pandemic, most of the courses were offered either online or on campus. The Inland Norway University of Applied Sciences, Rena, Norway, serve several thousand students online from all over the country in a number of different studies.

Although we had Skype, Zoom and Teams, these tools were mostly for meetings, except for the dedicated conference tools used for the online education. From one day to the other, this all changed, and all education was conducted mostly using Zoom. The pandemic put us through a test, but we believe that we managed, and it was a true upgrade for some of the scholars. The COVID-19 pandemic also isolated students and students' mental health became an issue (Visser and Law-van Wyk, 2021, Dodd et al., 2021, Kohls et al., 2021, Defeyter et al., 2021). Hence, many universities urged students to come to campus when the pandemic ended. The exception was for the students that signed up for online education only.

However, there were also a number of people that now, due to going online during the pandemic, were able to sign up for and follow courses and study programs that were not available as online studies. These students had difficulties attending classes due to a number of different reasons. Some of the reasons were being located in various parts of the country with difficulties of travelling to a campus, children or parents that needs to be taken care of on a daily basis (which unables going away for several days at a time), and not wanting to produce a huge carbon footprint by travelling.

For a while, due to a risk of an escalating pandemic, we offered a HyFlex version of several courses on several study programs. This was a very welcomed solution for a lot of the students.

In the study program of Knowledge Management, all the courses were offered in a HyFlex mode. There are three two-day seminars per semester. Many students have chosen to attend one or two physical seminars, some choose to attend only one, some attend all three, and others have chosen to attend online only.

Every year since the pandemic, we have investigated by interviewing the students as well as doing a survey, to unveil their perceptions of this HyFlex way of providing education (Vold and Kiønig, 2023).

This paper presents the longitudinal and new findings and trends of the students' feedback on how they perceive the HyFlex learning opportunities.

2. Theoretical Foundations

In 2023 we developed this model for HyFlex learning based on the theory informing our study:

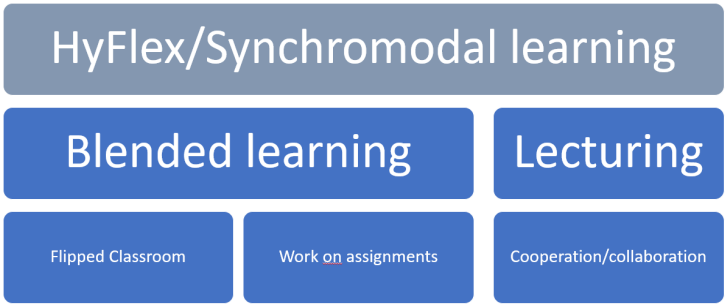

Figure 1: Overview of HyFlex learning as an overarching learning method, with the different learning adaptions within this context (Vold &Kiønig, 2023)

This was based on the different definitions of HyFlex learning, Blended learning, Lecturing, Flipped Classroom, Work on assignments and Cooperation/collaboration and how this was executed in the study program of Knowledge Management at the Inland Norway University of Applied Sciences, Rena, Norway. As HyFlex is about doing a course online synchronous to having students in a physical classroom (Howell, 2022), and Blended learning is defined as not doing distance learning and face-to-face learning simultaneously (Cronje, 2020) it is placed alongside Lecturing as a synchronous classroom event.

New insights on HyFlex learning are provided by Eija et al. (2024) and although in a different study program (health science education). According to their investigations, hybrid learning can improve students' motivation for studying as well as improving their self-direction. It may also support the students self-management skills and increase their "responsibility for their learning" (Eija et al., 2024).

Another interesting finding from these investigations was about the "educator's competencies as a part of successful hybrid teaching". The data showed that the pedagogical competencies of the educators mattered regarding having a learning outcome. The effort the educator invested in planning and variety of teaching methods had an impact on the students' experiences from the hyflex learning.

However, in the classroom it seemed easier to have good discussions in which students online had problems taking part in, sometimes due to the teacher "forgetting about the online students" (Eija et al., 2024).

Technology is also pointed out as important for facilitating good hyflex learning. Problems with audio equipment and camera, internet disconnection and functionality regarding applications are listed as hampering the learning (Eija et al., 2024).

Interaction is highlighted as important for learning. The respondents in this study pointed out that the lack of interaction between the different student groups (online versus face-to-face) made the online group miss out on the community feeling.

However, the hybrid education supported the students' interaction and learning skills developed. Also, their motivation to learn increased as well as their sense of responsibility, self-direction and self-management skills developed (Eija et al., 2024).

They also found that hybrid education supported the students' well-being as the possibility of taking part online may save them money (in travel costs), save time (time that could be spent with family and/or at work) and this fit with work and family contributed to their total well-being. Also some of the students claimed that the distance learning eased the social pressure of being face-to-face with other students (Eija et al., 2024).

Wong et al. (2023) have looked into research and practices regarding HyFlex learning. This research does to a certain extent support the research of Eija et al. The students learning experiences and outcomes are supported, as well as their engagement in learning. However, the same struggles appear here, too, about the limited interaction between online students and teachers. Also, it is difficult for the teachers to provide attention to both the students online and the students in the classroom, and the teachers experience a high workload when preparing (Wong et al., 2023).

Other challenges have been technical problems, difficulties in adjusting teaching and learning approach, and a feeling amongst the online students of being ignored (Wong et al., 2023).

Amiruddin et al. (2024) provided a somewhat nuanced look on technological skills and students self-regulation abilities. Here they found that students that possessed good technological skills also had better self-regulation

abilities. They were more effective in managing their time, setting goals, monitoring their own process and adjusting their learning strategies (Amiruddin et al., 2024). Also, they were able to access and organize learning materials, seek collaboration with others and more independently look for other sources. This self-regulation supports the overall learning success and engagement. They claim that students with less or poorer technical skills will choose to attend physically (face-to-face).

The students that are positive towards blended learning and positive towards the possibilities of interaction online tend to do most of their education online. (Amiruddin et al., 2024).

3. Method of Inquiry

For this study, we have done a mixed methods research (Creswell, 2022). The data are collected from evaluations as well as interviews. This mix of quantitative and qualitative research methods provides a comprehensive picture of the students' perspectives towards HyFlex learning.

The study is conducted of a period of three years. Hence, this paper also contains the results of the data for the study year of autumn 2023 and spring 2024.

The survey consists of the same questions as the two previous surveys, and the semi-structured interview guide used for the previous interviews, has also been used for the last interviews. Hence, we have sought to develop a longitudinal study so that we should be able to compare the results from each year.

Unfortunately, there is a very low number of students having replied to the survey for the last year (23/24), hence, most of the data are from interviews.

4. Results and Discussion

Here we will present the longitudinal data with emphasis on the new data from the last year (autumn 23_ spring 24).

The results from the data collection showed that the sound often is a problem regarding being online. If the teachers are not good at repeating questions in the physical classroom to the students online, they may miss out on what is going on. This is supported by statements like: "One of the teachers remembered most of the time to repeat questions from the face-to-face class. When it was forgotten, it was hard to pay attention as we only heard what the teacher said…." (Informant X). This refers to both the teachers' competence and ability to plan and prepare (Eija et al., 2024, Wong et al., 2023). Also, it may refer to the technological shortcomings regarding audio and video equipment (Wong et al., 2023, Eija et al., 2024).

They are only on average "ok" with following online and they find the material available in Canvas (our LMS) relatively supportive regarding being able to take part online. This, too, may refer to problems with access as well as teachers' ability to organize the Learning Management System (Eija et al., 2024, Wong et al., 2023).

They claim to enjoy breakout rooms online. However, it is only a small percentage that take part in these breakout rooms. Some of the informants claim that they like breakout rooms but it is not always easy to take part in them due to work-issues. Either they are at a work-place where they have little or no possibilities of occupying a separate room, hence, they have to sit with other colleagues and they are afraid to disturb them. Some of the informants that are working from home, may claim that they do not want to disturb other students as they have children at home making noise.

The students find it easy to address the teacher during class. Statements like: "I just unmuted myself and addressed the teacher and shortly after, I could say my comment." (informant Z), and "I raised my hand, but the teacher had in beforehand alerted us that it was impossible to see the "raised hand" symbol, so I just unmuted and asked my question and got good feedback on that." (Informant W). This at least show that the teacher wants to facilitate for the inclusion of the online students (Eija et al., 2024).

The students online claim they would like to see the other students that are present physically when online. Again, this is a technical issue. The tools that we so rapidly adopted during the COVID-19 pandemic are basically the same as the ones available today (Eija et al., 2024, Cronje, 2020, Amiruddin et al., 2024). As the research progresses and there seems to be a continuous need for the HyFlex learning, the tools should be developed as it is now almost viewed as a technological shortcoming (Eija et al., 2024).

5. Conclusion

We find that there is a steady or slightly growing number of students that choose HyFlex learning as they sometimes choose to be face-to-face (physically) at a campus, and sometimes on a home office or in a workplace. The reasons for not attending face-to-face always are the same as previously; economy, sustainability, not being able to have time off from work, home situation that does not allow travelling, etc.

When they are online, they would like to a much larger extent than now be a part of the class. This includes seeing the other students (not only the ones online), interacting more with teacher and other students and being able to hear (and take part in) the conversations in the classroom. Although some constraints are with the students being in an office with few opportunities of fully engaging or being afraid of disturbing other students from their home office, the technological equipment does not support the full-scale equal attendance – yet.

The theory points out that the teachers need to plan and be positive towards utilizing the technology for the purpose of HyFlex learning. The students seem to appreciate the efforts by the teachers, but again the shortcomings of the technological tools and applications are strenuous also for the teachers.

5.1 Further Research

As research on HyFlex learning progresses, we hope to be able to do more extensive research together with other scholars. As our university is more interested in getting the students to attend face-to-face classes at the campuses, it is limited funds for doing research on HyFlex learning. Hence, the willingness to invest in appropriate technological tools seem low. In spite of this, we, the teachers that are into HyFlex learning believe that this is only the start of how education will be in the future.

Hence, the next step for us will be to look in the literature for other supporting factors that will enable better HyFlex learning. Also, we will look at incorporating AI as a tool for learning, as well as mixed reality (MR) tools.

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Generative AI in Higher Education: Educators' Perspectives on Academic Learning and Integrity

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Abstract: Generative Artificial Intelligence (Gen AI), exemplified by models such as ChatGPT, has rapidly advanced, becoming a significant force in various sectors, including higher education. ChatGPT, a leading application of Gen AI, utilizes large language models (LLMs) to generate human-like text, providing capabilities that range from answering complex questions to facilitating software development. As these tools become increasingly integrated into academic environments, their impact on teaching and learning processes has become more under focus. However, there are not many studies focusing on the impact of such systems on students' performance and the use of such systems. This study therefore examines the impact of GPT tools on higher education, aiming to address the following research questions: How does the use of GPTs influence the teaching and learning process in higher education? What are the perceived impacts of GPTs on educational practices from university educators' perspective? The research employs a qualitative methodology, incorporating semi-structured interviews with educators from Swedish universities who have integrated GPT into their curricula. Data were transcribed and analysed using OpenAI's Whisper to extract key themes and insights. Data analysis was done through thematic analysis and categorizing the data using codes. The study uncovers a dual impact of GPT on education, while it offers substantial opportunities for enhancing productivity and personalized learning, it also raises significant concerns about academic integrity, over-reliance on AI, and the potential influences on students' soft skills. These findings contribute to the discourse on digital learning by highlighting the need for instructional and constructive integration of AI technologies such as GenAI, in educational settings. In addition, the rise and integration of GPT technology is irreversible, and we must adapt to it rather than return to old ways. Embracing AI's potential while addressing its challenges is essential for progress and innovation in this new era. The study emphasizes the importance of developing clear policies and guidelines to ensure that the benefits of GPT are realized without compromising the integrity of the educational process. As such, this research provides valuable insights for educators, policymakers, and scholars interested in the ethical and effective implementation of AI in higher education.

Keywords: Generative AI, ChatGPT, Higher education, Academic integrity, Digital learning

1. Introduction

Artificial Intelligence (AI) has rapidly permeated various societal and educational domains (Alam, 2021), including higher education, and becoming more prominent in various aspects of life (Tlili et al., 2023). Generative Artificial Intelligence (GAI) systems, powered by Large Language Models (LLMs), offer new opportunities for engaging with educational content by generating human-like text that facilitates novel learning experiences (Kasneci et al., 2023; Thorne, 2024). Among the notable advancements are Generative Pre-trained Transformers (GPTs), such as ChatGPT, which have brought transformative changes to educational environments (Hrastinski, 2020) and academic integrity (Sullivan, Kelly, & McLaughlan, 2023). These technologies provide extensive and relevant information and enriching educational practices, when used responsibly (Dempere et al., 2023). These technologies enable innovative methods of teaching, learning, and interaction (Kasneci et al., 2023; Tlili et al., 2023), while enhancing the risks such as dishonesty and potential over-reliance on AI (Sullivan, Kelly, & McLaughlan, 2023). Universities need to explore and adopt new technologies, which fundamentally change long-standing educational methods, although concerns about the changes are understandable and schools failing to embrace these opportunities will find the technologies disruptive (Lucas, 2016).

Recent advancements in Natural Language Processing (NLP) have urged the development of sophisticated LLMs and GAI systems, such as GPTs, which have notably influenced on Knowledge Management (KM) and learning processes across various fields (Aghaee, 2024). Digital tools like ChatGPT, Midjourney, Copilot, and Gemini revolutionized learning and teaching by reshaping conventional educational methods (Kurtz et al., 2024; Bahrini et al., 2023). Despite promises of increased accuracy, efficiency, and productivity, GAI tools come with significant challenges (Trust, Whalen & Mouza, 2023). The risk of misinformation and hallucinations highlights the need for cautious implementation and critical use of such AI-based tools. LLMs, while advanced, face difficulties in managing input uncertainty and comprehensive problem-solving which can lead to inaccuracies (Thorne, 2024). Additionally, the algorithm-based mechanism behind AI-generated responses complicates the validation and

reliability of the information, raising concerns about trustworthiness and inherent biases (Bahrini et al., 2023; Dempere et al., 2023).

Kasneci et al. (2023) highlight both students' and teachers' perspectives on the use of ChatGPT in higher education, noting the lack of empirical studies on effective learning strategies with chatbots. The strategic and structured adoption of AI in education has been slower compared to other fields, as many educational institutions initially viewed it with apprehension, rather than a digital tool to be strategically used to support students' self-learning. Instead, some institutions attempted to avoid or abandon its use. While there are many scientific studies on the topic, little focus has been placed on educators' perspectives regarding students' performance and academic integrity. Recent research has focused on automated student assessment, personalized feedback, and generating teaching materials, but there remain significant knowledge gaps and uncertainties in successfully integrating LLMs into educational processes. Teachers play a key role in shaping curricula and assessment methods, making their insights critical to understanding AI's impact on education. Furthermore, the adoption of such technologies is fraught with challenges related to academic integrity and potential misuse, necessitating a careful approach to implementation of such tools in courses (Dempere et al., 2023; Sullivan, Kelly, & McLaughlan, 2023)

This study aims to explore the impact of GPT on students' performance and academic integrity in higher education, as well as its influence on the design of educational programs – necessitating adjustments to curricula, grading methods, and assessment formats in response to GAI. By incorporating educators' perspectives, the study seeks to understand how these tools affect both positive and negative on the learning process and outcomes. The goal is to identify factors that contribute to either improved or diminished academic performance. While prior research shows students use tools like ChatGPT to enhance learning (Kasneci et al., 2023; Dempere et al., 2023), little is known about their impact from educators' perspectives. By centring on educators' viewpoints, we can gain a deeper understanding of how these tools shape the educational environment (Hrastinski, 2020), impact students' performances, and examine how to more strategically integrate these tools into higher education to facilitate optimal usage. In order to fill in this gap, the following research questions were developed: How does the use of GPTs influence the teaching and learning process in higher education? What are the perceived impacts of GPTs on educational practices from university educators' perspective?

The goal is to understand the opportunities and challenges posed by GPT and provide insights that could guide the responsible integration of such technologies into educational practices. The study focuses on teachers' perspectives, with the terms "educator" and "instructor" used interchangeably with "teacher".

2. Digital Technology and Generative Artificial Intelligence in Education

The role of digital technology in education has been transformative, reshaping traditional learning environments and introducing new possibilities and challenges for teaching and learning (Escueta et al., 2017; Raja & Nagasubramani, 2018). The integration of digital technology in education has led to increased accessibility, personalised learning, and enhanced student engagement (Deng & Lin, 2023). However, it also presents challenges, such as the need for educators to adapt to new tools and methodologies (Hrastinski, 2023). Artificial Intelligence (AI) refers to a computer's ability to perform tasks typically associated with human intelligence, such as reasoning, learning, and adapting, although current systems are still limited in their flexibility across broad domains (Deng & Lin, 2023).

Generative AI (GAI) involves systems, like GPT, that generate new content based on learned patterns from large datasets, such as text, images, or code. While it enhances productivity and creativity, it also raises concerns about over-reliance on automated systems (Kasneci et al., 2023). A significant advancement in GAI is enabling machines to understand and generate human-like text based on large datasets, like Generative Pre-Trained Transformer (GPT), which is a type of LLM designed to generate human-like text by predicting and producing language based on vast datasets. It has significantly impacted fields like education and software development (Kasneci et al., 2023). However, concerns about the ethical aspects and the potential for academic dishonesty remain prominent (Sullivan, Kelly, & McLaughlan, 2023; Jin et al., 2024).

ChatGPT, a specific implementation of GPT, enables interactive, human-like dialogues, offering instant responses and feedback. It has found applications in various sectors, including education, where it helps with tasks like writing and instant learning support, though concerns about academic integrity and the overuse of AI-generated content persist (Dempere et al., 2023; Deng & Lin, 2023). GPT models have become increasingly prevalent in higher education, with applications ranging from assisting with essay writing and summarizing texts, to providing

immediate feedback on assignments. The evolving demands of the labour market have made autonomous lifelong learning essential for individuals to remain competitive and adaptable. Lifelong learning approach involves education throughout a person's life, encompassing both formal learning and informal learning (through self-directed study, experiences, and training), which means “learning lasts for life” (Hargreaves, 2004). Lifelong learning is increasingly supported by autonomous, flexible learning formats, such as Generative AI (e.g., GPTs), which allow individuals to engage with personalized, AI-driven educational content at their own pace and according to their specific needs (Rawas, 2024).

While these tools can enhance learning by offering tailored support and developing independent study habits, they also raise concerns about students' reliance on AI and the potential attrition of critical thinking skills (Dempere et al., 2023). The dual nature of GPT's impact—both as a facilitator of learning and as a potential source of academic misconduct—necessitates a careful examination of its role in education. Ratheeswari (2018) writes that teachers must have the knowledge and skills to use new digital tools and resources to help students achieve high academic standards. Furthermore, Conole (2012) states that the use of technologies for academic purposes requires specific skills, which affects the way Learning opportunities are designed and supported, which must provide appropriate support to benefit the potential of technologies. In addition, as discussed by Bergdahl, Nouri, and Fors, (2020), GAI and GPTs enable students to acquire targeted knowledge, while the quality of the information acquisition and its use depends and varies based on students' digital skills.

3. Methodology

This study adopts a qualitative research approach, utilizing semi-structured interviews with university teachers to gain in-depth insights into their experiences and perceptions of digital technologies’ impact on higher education. The choice of a qualitative methodology was motivated by the need to explore the nuanced views (Creswell, 2013) of educators, who play a key role in shaping the learning environment. The research was conducted with teachers responsible for various courses in informatics at three Swedish universities. Teachers are central figures in bridging students and education, providing valuable insights into how both the curriculum and students are affected by digital technologies like GPTs, as well as the opportunities and challenges presented in higher education.

Participants were selected using purposive sampling to include educators from various disciplines within informatics. This selection was based on the assumption that course coordinators in informatics would likely have direct experience with GPT tools, either through their own use or through their students' use of these technologies. In-depth-interviews were conducted with five educators, either in person or via video conferencing, using a semi-structured interview guide (developed based on Creswell, 2013). These interviews were recorded with the participants' consent and later transcribed using OpenAI's Whisper tool for analysis. Informed consent was obtained from participants before starting the data collection. The participation was voluntarily, and respondents were given the option to withdraw from the study at any time during the data collection process or skip any questions they were uncomfortable answering. Furthermore, no sensitive or personal data was collected.

Data analysis followed Creswell's iterative, upward spiral model (Creswell, 2013), where the researcher learns through the process. The first step involved organizing the interview data into separate documents to manage the large volume of information. Transcriptions were carefully reviewed alongside the audio recordings to correct any errors, and initial reflections were noted. Thematic analysis was then employed to identify patterns and themes within the collected data. The data was coded, and recurring sub-themes were categorized under broader main themes, as shown in Table 1. This process involved coding the data, grouping the codes into themes, and interpreting these themes within the context of the research questions. The analysis focused on identifying the perceived changes, opportunities, challenges, and effects of GPT on student’ performance in higher education, as observed by the instructors.

4. Results and Analysis

Table 1 summarizes the key themes and subthemes from the thematic analysis in this study, providing a clear overview of the main findings related to digital technology and GAI and its impact on higher education. All respondents were lecturers in information systems or systems sciences disciplines, with experience in both on-campus and distance teaching, and used GPTs quite extensively in their teaching, since its emergence.

Table 1: Key themes and subthemes on digital technology and GAI, and their impact on higher education

Themes	Subthemes	Description
Changes in Education	Digitalization of Education	The introduction of digital and generative AI tools has transformed teaching methods, student learning, and information access.
	Tailored/ personalized learning	Digital and AI technologies enable personalized learning, tailoring education to individual needs, styles, and pace.
	Autonomous Lifelong Learning	Flexible learning formats utilizing GAI, such as GPTs, require responsible technology use to support autonomous lifelong learning.
	Change of Examination Formats	Course assessment methods should ensure that students' acquired knowledge and performance are original and not directly influenced by the use of GPTs.
Opportunities	Global Knowledge Accessibility	Digital technology with GAI tools, facilitate autonomous access to the global wealth of knowledge and resources.
	Productivity	Opportunities to create texts, summaries, relevant topics and information in the requested context.
	Flexibility and Adaptability	Learning aids to create tasks, exercises, explanations, and provide feedback, allowing a focus on core concepts.
Risks & Challenges	Digital Divide and Unequal Access	Creating new challenges in ensuring equal educational opportunities for all. Negative impact on equality between students with different access to digital tools, basic digital literacy, and digital skills,
	Lack of Social Interaction	Less social interactions affecting students' social development and soft skills, such as collaboration and group learning.
	Teachers' and Students' Adaptability	Adapting to new digital tools and teaching methods, requiring increased training and support to ensure effective teaching in a changing learning environment.
Students' Performance	Measuring Educational Outcomes	More sophisticated to measure student performance and evaluating results and outcome.
	Student-content interaction and knowledge trustworthiness	GAIs enhance interactive learning and student independence. Increasing concerns over unreliable knowledge sources.
	Influence on Social Skills	Digital transformation in education and its cognitive and social effects, with some tools boosting abilities while others hinder interpersonal grow.

4.1 Changes in Education

Digitalization of Education: The introduction of digital tools and GAI tools in education has transformed teaching methods and the student learning experience and information channels. This change with the use of GAI includes campus and distance learning as well as hybrid classes, and the educational plans to use GPT as part of the curriculums. All respondents agreed that the integration of GPT in education is irreversible, and higher education institutions must adapt, as expressed by Respondent 1: "the genie is out of the bottle" and Respondent 4: "it's a one-way street". Respondent 1 emphasized that universities must quickly embrace these changes, referring to the profound impact of GPT when they first encountered it, describing it as the most challenging event in their 22 years of teaching experience. Respondent 5 mentioned that the consensus is clear: "GPT is here to stay". All respondents acknowledged and affirmed that returning to pre-GPT methods is not an option. Respondent 3 emphasized that while GPT's integration is essential, universities are still in a transitional phase. They noted the ongoing development of guidelines for GPT usage, including workshops for educators on how to integrate the tool effectively. GPT has revolutionized teaching and learning, making it a critical tool for both campus-based and distance education.

Tailored/personalized learning: Digital and AI-based Technologies enable more personalized learning, where Respondent 1 and 2 mentioned that education can be tailored to each student's needs, learning style, and pace, improving student outcomes and engagement. Its adaptability is seen as another key changes, allowing students to customize their learning experiences and receive personalized educational support. Respondent 1 noted, "I'll give a concrete example: programming. This is one of the use cases where generative AI might have the most significant impact. Quite a few experts and evaluators believe this too". Another mentioned, "With the help of ChatGPT, for example, you can tailor your own learning experience. If you're a student who understands better

with metaphors, you can just ask for metaphors". Three respondents believed that GAI technologies provide customized learning experiences rather than a one-size-fits-all approach, which would lead to a dramatic change in educational settings.

Autonomous Lifelong Learning: Changing labour market demands have made lifelong learning a necessity, meaning both formal and informal education continues throughout life, supported by autonomous and flexible learning formats, through digitalisation such as GPTs. As mentioned by two respondents, the accessibility and flexibility of GAI help continuously acquire new skills and knowledge as part of lifelong learning, enabling them to adapt to the rapid technological and industry shifts shaping modern work environments. One respondent stressed the importance of educating students on the "responsible use of GPT", to facilitate their autonomous lifelong learning. With changing labour markets, lifelong learning through flexible formats, including GPTs, make students accountable for their learning, their learning methods, and the channels they use to learn about a new subject.

Change of Examination Formats: The results highlight the need to update assessment formats to account for GPT's influence. Oral exams, in-person written tests in controlled environments—referred to as "controlled examinations" or "exams in a controlled environment"— are seen as effective alternatives for assessments. Three respondents emphasized the importance of conducting digital exams in secure environments, such as using Safe Exam Browser (which restricts access to external resources) or invigilated digital or on-paper exams without aids, to prevent the use of any digital tools such as GPTs and ensure equal and fair assessments. Respondent 1 experimented with innovative exam formats even before GPT's arrival, such as film-based submissions and pre-released questions. Respondent 2 has introduced oral defences to verify the authenticity of students' written work. Both respondents noted a shift toward in-class exams, as written assignments have become less reliable due to GPT's influence. Respondent 3 also suggested "traffic light" system to categorize exams based on the likelihood of GPT interference, with red representing high risk (e.g., take-home exams) and green indicating low risk (e.g., in-class exams).

4.2 Opportunities

All respondents expressed that GPT tools offer new opportunities for both teaching and learning, although their opinions differ on which opportunities are most relevant.

Global Knowledge Accessibility: All respondents reflected that digital technology has opened doors for students to access a global range of knowledge and resources. They mentioned that students can autonomously access knowledge in various fields and broadening their horizons, using GAI tools. A major advantage highlighted by two respondents was the 24/7 accessibility of GPTs. One mentioned about the expectation of similar tools, which will become increasingly available and powerful, facilitating global knowledge access in an autonomous way. Two respondents mentioned that GPT is viewed as a valuable productivity tool, enhancing efficiency in various domains, particularly in text and task development, by creating activities, exercises, and providing feedback, which saves time for focusing on core concepts in the learning process. Its potential to improve language skills, grammar, and fluency, especially in English, is also noted. Additionally, one respondent mentioned that GPT is valuable for explaining new concepts, demonstrating their applications, and providing examples, exercises, and feedback.

Productivity: Technological advances offer new opportunities to create texts, summaries, relevant topics, and information in the desired context. Respondent 4 noted that GPT can serve as a time-saving tool by providing a "starting point" for selecting themes or directions, thereby enhancing productivity. Respondent 2 specifically reflected on practical subjects like programming, highlighting tools such as GitHub Copilot and ChatGPT for their significant impact. They emphasized the importance of teaching students how to use these tools: "We need to teach them how to use GitHub Copilot and ChatGPT. Both offer significant opportunities for learning and productivity." GitHub Copilot is already widely adopted in programming courses: "Currently, we primarily use GitHub Copilot. It is extensively used every semester in all courses with programming elements". GPTs can clarify code, helping students learn a new programming language effectively.

Flexibility and Adaptability: By using GPTs, students and teachers benefit from enhanced flexibility in both teaching and learning. Digital technologies have proven to be excellent learning aids for students, as digital tools are now "more or less part of learning" and educational systems. GPT is viewed as a valuable flexible tool with considerable potential to enhance learning flexibility and productivity, when used appropriately. Respondent 5 mentioned that GPT can serve as a good teacher or mentor by confirming a student's knowledge or explaining new concepts. Another noted that GPT can explain concepts and programming codes. Respondent 3 specifically

emphasized that GPT should be seen as a tool for student learning, similar to Grammarly or other digital aids, rather than a substitute for any current components in higher education.

4.3 Risks and Challenges

Digital Divide and Unequal Access: Rapid digitalization by development of GAIs can impact negatively on equalities between students with different access to cutting edge digital tools, the basic digital literacy, and digital skills, creating new challenges in ensuring equal educational opportunities for all. Respondent 5 reflected that differences in access to premium versions of tools could lead to significant disparities among students. Respondent 1 reflected on some students might have a significant advantage if they use more advanced versions, which could create an "A- and B-group," mentioning, "I'm possibly a bit worried that it can generate a certain laziness" and this may affect segregation of students based on their digital access, skills, and literacy. Two respondents noted the issue of trust, as one mentioned, "the big problem is trust... how do we know that they haven't just generated everything?".

Lack of Social Interaction: The result suggests that increased use of GAI tools could impact students' social interactions, potentially affecting their development of cognitive and soft skills, such as collaboration and group learning. A respondent observed and mentioned that different students are using digital tools differently implies varied levels of motivation, which may indirectly affect social learning experiences. Respondents argued that GPT's influence on students' learning abilities, motivation, and social interaction. One mentioned that these depend on the user than the tool itself: "Students who were extremely interested in learning and truly wanted to understand their studies now have a new tool to help with that.".

Teachers' and Students' Adaptability: Teachers face the challenge of quickly adapting to new digital tools and teaching methods, requiring increased training and support to ensure effective teaching in a changing learning environment (to reduce or fill in the gap for the digital divide). The need for teachers to adapt quickly is emphasized, saying, "It takes knowledge to create knowledge", implying that effective use of GPT requires a deep understanding of how to leverage it properly. Respondent 2 pointed out the necessity for better understanding of digital technologies such as GPT tools among students, stating, "They must actually understand what a transformer is... What does it do?" This highlights a gap in both student and teacher knowledge and forces to learn using new technologies in an appropriate way.

4.4 Students' Performance

Measuring Educational Outcomes: New technology enables assessment of students' performance and tracking progress to provide quicker feedback. Respondents expressed challenges of evaluation and measuring educational outcomes and difficulties in assessing GPT's impact on students' performance, as it is still quite new. Concerns were raised about potential effects on creativity and originality, comparing it to children growing up with smartphones: "What will happen to students' creativity? What will happen to their originality? [...] We don't know what will happen with these things. [...] What happens if you give five-year-olds smartphones? We're about to find out." Results suggest learning should be assessed formatively rather than relying solely on summative assessments. However, there was no clear reflection on grading trends, and one respondent noted, "It's hard to judge if grades have changed since the examination formats have changed". Most respondents believed grades have remained stable, particularly when exams are conducted in controlled environments without access to any resources. One also remarked, "You can talk about learning, but how do you measure learning?"

Student-content interaction and knowledge trustworthiness: Digital tools, particularly gamified platforms and conversational AI can enhance students' motivation and promote independent learning. However, concerns have arisen about the reliability of knowledge on these GAI sources, as it may not always be scientifically validated. While GPT can clarify concepts, over-reliance may lead to mistakes. Respondents noted that students often use AI-generated content without verifying its accuracy, leading to errors. Respondent 2 reflected on "students just read something quickly and use it, thinking they're learning without checking if it's accurate, creating a risk." Respondent 3 noted: "students can complete assignments without learning because ChatGPT does it for them." Respondent 4 mentioned that students may rely on AI-generated code without understanding it: "I see things in the code that are completely illogical. Why is it written like that? Well, I don't know, Copilot inserted it." Other respondents expressed similar concerns about students submitting incorrect content without proper comprehension.

Influence on Social Skills: The digital transformation in education affects students' cognitive and social skills, with some technologies enhancing while others hindering interpersonal skills. Respondent 1 noted that GPT may

reduce creativity if it outsources the creative process, as "requesting a creative response from GPT does not guarantee true creativity". The long-term impact on critical thinking remains unclear, as Respondent 2 stated, "GPTs might impact critical thinking in the long run, but it's possible that it might not". One respondent suggested that creativity may still flourish, as users must engage creatively with GPT tools. Ultimately, the impact on skills like critical thinking depends on how students use GPT, potentially widening gaps between more and less creative individuals.

5. Discussion

The integration of GPT into higher education offers both opportunities and challenges, as shown by this and earlier studies. The findings here emphasized that schools must adopt new technologies like GPT to avoid falling behind, continuing the trend of slow adaptation (Lucas, 2016; Kasneci et al., 2023; Alam, 2021). Based on the result of this study, educators agree that GPT's role in education is inevitable, reflecting broader trends in AI integration (Tlili et al., 2023; Kasneci et al., 2023). Respondents in this study emphasized the need to rethink how education is delivered and assessed to prevent AI misuse, especially with exams, where oral or in-person assessments might help maintain academic integrity (Sullivan, Kelly, & McLaughlan, 2023; Dempere et al., 2023).

GPT tools like ChatGPT, Copilot, and Gemini, revolutionized teaching by enabling personalized learning. These tools allow tailored support for students, confirming previous claims that AI can revolutionize teaching by promoting accessibility and engagement (Kasneci et al., 2023; Bahrini et al., 2023) and providing feedback. The study results confirm that GPT's 24/7 availability and adaptability underscore its role in promoting flexibility and personalized learning, in line with Escueta et al. (2017) and Raja & Nagasubramani (2018), who stated that increased accessibility and engagement were facilitated by digital technologies. However, concerns about students over-relying on AI, bypassing learning, and unequal access to premium tools were raised. This reflects broader issues of digital inequality and risks of misinformation from AI (Trust, Whalen & Mouza, 2023; Thorne, 2024).

This study result highlighted the need to update examination formats, such as shifting toward oral exams and in-person assessments, to reduce the risks of AI misuse, academic dishonesty, and over-reliance on AI, as well as to address concerns about academic integrity (Sullivan, Kelly, & McLaughlan, 2023). Although grades in controlled environments remain stable, measuring learning progress and grading assignments outside such settings has become more complex. The findings emphasize the importance of adapting teaching methods and developing educators' skills to teach students using and integrating GPTs responsibly (Ratheeswari, 2018; Hrastinski, 2023). However, the study found no direct evidence of GPT's impact on assessments and grading.

While AI offers valuable educational opportunities, its potential to undermine academic honesty cannot be ignored and should be carefully considered by educational institutions (Dempere et al., 2023; Thorne, 2024). Some respondents expressed concerns about AI's impact on students' soft skills (Aghaee, 2024; Sullivan, Kelly, & McLaughlan, 2023), while others believed this depends on individual motivation, digital skills, and the use of digital tools (aligns with Dempere et al., 2023; Bergdahl, Nouri, & Fors, 2020). All respondents mentioned that these tools assist in developing tasks, exercises, feedback and learning opportunities, allowing more time to concentrate on core concepts and knowledge-centred instruction and learning.

The study emphasizes the need for educators to quickly adapt to digital tools like GPT, a process still in its early stages. Teachers must build skills to effectively integrate these technologies (Ratheeswari, 2018; Hrastinski, 2023), echoing broader challenges in adopting new digital tools (Hrastinski, 2020). The results show that universities are still developing guidelines for responsible GPT use, highlighting the ongoing knowledge gap among educators (Conole, 2012). However, the ongoing development of guidelines for GPT usage, including workshops for educators and students on how to integrate the tool effectively, is suggested.

6. Concluding Remarks

This study contributes to the growing body of literature on GAI in education by providing empirical insights into how the use of GPTs influence the teaching and learning process in higher education and what are the perceived impacts of GPTs on educational practices from university educators' perspective. By focusing on educators' perspectives, the study highlights the complexities of integrating GAI tools into educational settings, emphasizing the need for a balanced approach that maximizes benefits while addressing potential challenges. Overall, the study reveals that while GPTs offer numerous opportunities for enhancing education, it also presents significant challenges and risks that must be managed through thoughtful implementation, clear guidelines, and

ongoing investigation to teach students using digital technologies responsibly and the importance of academic learning and integrity.

Respondents reflect on a shift towards controlled examinations or exams in a controlled environment and more formative assessment and new strategies, to be less vulnerable to GAI-generated responses. However, the long-term impact of GPT on students' performance in higher education remains uncertain, with instructors divided on whether the benefits outweigh the risks. Respondents view GPT as a transformative and flexible tool that enables personalized and efficient lifelong learning (in line with Rawas, 2024), while there are concerns about its potential to undermine academic standards and the integrity of educational institutions.

To harness the potential of GPT while addressing its challenges, it is recommended that educational institutions develop clear guidelines, workshops, and learning opportunities for both educators and students on the proper use of such digital technologies in academia. Additionally, there should be a focus on teaching students critical thinking skills and the ethical use of any digital technology to help them navigate in learning environments autonomously and effectively. Therefore, it is crucial to educate students about the benefits and risks instead of banning digital outright.

Future research should explore the long-term effects of GPT on students' learning outcomes and performances, and the sustainability of GAI-driven educational practices. Further studies could also investigate the effectiveness of different assessment strategies in the context of AI tools, helping to identify best practices for evaluating student performance in an era of advanced educational and digital technologies.

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Towards Responsible Use: Student Perspectives on ChatGPT in Higher Education

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Abstract: The advent of generative artificial intelligence (AI) tools, particularly Large Language Models (LLMs) like ChatGPT, presents a dichotomy of opportunities and challenges within the educational sector. These tools offer the promise of personalized learning support, accessible at any time, thereby enhancing educational engagement and resource availability. However, they also introduce significant concerns, notably the risk of plagiarism, complicating their integration into academic settings. Despite the widespread adoption of ChatGPT by students, there remains a gap in understanding their experiences with these tools and the need for frameworks to guide responsible use. To address this knowledge gap, this study investigates the utilisation of ChatGPT for academic tasks and students' perceptions of its benefits and drawbacks in a university context. The findings reveal that half of the students used ChatGPT either regularly or occasionally for academic tasks. However, only slightly more than one-third of the participants expressed confidence in maintaining the authenticity and originality of their outputs when using ChatGPT. In terms of utility, respondents' perceptions varied, with 25.0% considering it moderately useful, 39.3% very useful, and 10.7% extremely useful for their assignments. Notably, 42.8% observed a significant enhancement in the quality of their work with ChatGPT, compared to assignments completed independently. Despite these advantages, 71.4% of students encountered errors or inaccuracies in ChatGPT's outputs, underscoring the tool's limitations. A significant majority (89.7%) advocate for the establishment of specific guidelines or training to foster effective and responsible usage of ChatGPT in academic contexts. The Chi-square test indicated a significant difference in ChatGPT usage between White and BAME students (p=0.031). These findings underscore the broad utilisation of ChatGPT in student learning and general satisfaction with its application. Nonetheless, students acknowledge the tool's potential for errors and inaccuracies. In light of these challenges, there is a pronounced demand for clear guidelines and proper training to navigate the responsible use of ChatGPT in educational settings. This study illuminates the imperative for educators and institutions to develop strategies that not only leverage the benefits of generative AI tools but also mitigate their risks and promote meaningful learning outcomes.

Keywords: Generative AI tools, ChatGPT, Responsible use, Student perceptions, Academic assignments

1. Introduction

The advent of artificial intelligence (AI) has profoundly impacted various domains, including education. Among the most notable advancements in AI is the development of large language models (LLMs), particularly ChatGPT, designed to understand and generate human-like text based on vast amounts of data. Developed by OpenAI, ChatGPT is a sophisticated AI model that utilises deep learning techniques to engage in meaningful dialogues, answer questions, and provide explanations across a wide range of topics. The deployment of ChatGPT in educational settings represents a significant shift in how students and educators interact with information and learning resources.

The integration of ChatGPT into educational practices has been the subject of many studies, highlighting various benefits, challenges, and future research directions. Sevnarayan (2024) explores the dynamics of ChatGPT usage from the perspectives of students and lecturers in an open distance e-learning university. The findings suggest that ChatGPT is particularly beneficial in supporting distance learners by offering timely assistance and fostering a sense of connection with the learning material. However, the research also points out the need for adequate training and support to maximise the benefits of ChatGPT. Sandu et al. (2024) present a case study on the impact of ChatGPT in educational practices within Australian higher education. Their research indicates that ChatGPT enhances student engagement and learning outcomes by providing interactive and immediate support. The study also highlights the importance of integrating AI literacy into the curriculum to help students and educators effectively utilize ChatGPT.

Firat (2023) investigates the perceptions of students and scholars towards ChatGPT in universities. The study finds that while there is a general positive attitude towards the use of ChatGPT, concerns about data privacy and the ethical implications of AI in education persist. Firat (2023) suggests that addressing these concerns through transparent policies and ethical guidelines is essential for the widespread acceptance of ChatGPT in academic settings. Almogren et al. (2024) examine the factors influencing the acceptance of ChatGPT in higher education through a comprehensive theoretical framework. Their study identifies key factors such as perceived ease of use, perceived usefulness, and social influence as significant predictors of ChatGPT adoption. The research underscores the importance of user-centred design and ongoing evaluation to ensure the

effective implementation of ChatGPT in educational settings. Hasanein and Sobaih (2023) explore the drivers and consequences of ChatGPT use in higher education from the perspectives of key stakeholders. They identify factors such as perceived usefulness, ease of use, and the quality of feedback as critical determinants of ChatGPT adoption. The study also notes the potential of ChatGPT to reduce the workload for educators by automating routine tasks, thereby allowing them to focus on more complex teaching responsibilities. Rasul et al. (2023) highlight how ChatGPT can facilitate personalised learning by adapting to individual student needs and providing tailored feedback. However, they also caution against over-reliance on AI, noting potential issues such as inaccuracies in generated content and the need for continuous monitoring by educators to ensure the quality and reliability of information. According to Das and Madhusudan (2024), higher education students perceive ChatGPT as a valuable tool for enhancing their academic experience. Their study reveals that students appreciate the accessibility and immediate feedback provided by ChatGPT, which supports self-directed learning and helps clarify complex concepts.

In the context of higher education, the responsible use of AI tools, such as ChatGPT, is vital for upholding academic integrity and fostering equitable learning outcomes. Responsible use entails not only adherence to principles of academic integrity (Yang, 2023) but also an awareness of the potential biases and limitations inherent in AI systems (Díaz-Rodríguez et al., 2023). Scholars have expressed concerns about the potential for AI systems to reinforce existing biases and inequalities within education (Ferrer et al., 2021). Language models like ChatGPT are trained on vast amounts of internet data, which may reflect and perpetuate societal biases, including those related to race and culture (Ray, 2023). Furthermore, the concept of "responsible use" must be scrutinised within the context of power dynamics present in educational institutions. The introduction of AI technologies in education is not a neutral process; rather, it carries the risk of reinforcing existing power structures and norms (Mohamed et al., 2020).

Constructivism Learning Theory is a learning theory positing that learners construct their own understanding and knowledge through experiences and reflecting on those experiences (Fosnot, 2005). Jean Piaget and Lev Vygotsky are two prominent figures associated with this theory. Piaget's theory emphasises the processes of assimilation and accommodation, where learners integrate new information into existing frameworks or adjust their frameworks to include new information (Piaget, 1954). Vygotsky, on the other hand, highlights the social context of learning, arguing that knowledge is constructed through interaction with others and the environment (Vygotsky, 1978). Constructivism asserts that learning is an active, contextualised process of constructing knowledge rather than passively receiving information. This approach emphasises the importance of the learner's active involvement in the learning process and the significance of real-world contexts. In a constructivist classroom, students are encouraged to use active techniques such as experiments, real-world problem-solving, and discussions to create a more profound understanding and meaning (Fosnot, 2005).

Using ChatGPT in educational settings can be effectively explained through the lens of Constructivism Learning Theory. ChatGPT serves as a dynamic tool that facilitates the construction of knowledge by allowing students to interactively engage with information. This aligns with Piaget's idea of active learning, where students assimilate and accommodate new knowledge through interaction with AI, thereby refining and expanding their cognitive structures (Piaget, 1954). ChatGPT's interactive nature supports Vygotsky's concept of social constructivism. Although AI is not a human peer, it can simulate conversational interactions that promote deeper understanding. Students can engage in dialogue with ChatGPT, ask questions, and receive immediate feedback, mimicking the collaborative learning processes described by Vygotsky (Vygotsky, 1978). This interaction encourages students to articulate their thoughts, confront misconceptions, and build new understanding through guided discovery (Hasanein and Sobaih, 2023).

Despite the expanding body of research on the use of ChatGPT in education, several knowledge gaps remain. The user experience and acceptance of ChatGPT among diverse student populations, including those with varying learning styles and needs, require further study. Understanding how demographic factors, such as gender and ethnicity, influence the acceptance and effectiveness of ChatGPT can help in designing more inclusive and accessible AI-based learning solutions (Almogren et al., 2024). This research, utilising a questionnaire survey, aims to understand the experiences and opinions of students at a university regarding their use of ChatGPT. The study particularly focuses on potential differences in opinions between genders, ethnicities concerning demographic factors.

2. Methodology

This study employed a quantitative research design, utilising a structured questionnaire to gather data from university students regarding their experiences and opinions on using ChatGPT. The questionnaire comprised

three main sections: demographic information, usage patterns, and perceptions and opinions. It was administered online using Microsoft Forms. This research seeks to explore the different experiences and acceptance of ChatGPT among various student groups. The study was conducted at one British University. Aiming to capture a diverse cross-section of the student population, the survey targeted both domestic (home) and international students. Efforts were made to include participants from various ethnic backgrounds, with the sample comprising students who identified as White as well as those from Black, Asian, and Minority Ethnic (BAME) groups. This diverse participant pool allows for a more nuanced understanding of how different student groups perceive and engage with ChatGPT in their academic pursuits. Upon completion of data collection, the responses were downloaded and prepared for analysis using Python. The primary analytical method employed was the Chi-square test, which determined if there were significant differences in opinions between genders, ethnicities (White vs BAME) regarding their experiences with ChatGPT. The survey was approved by the Ethics Committee of the School of Archaeology, Geography and Environmental Science, University of Reading.

3. Results

The questionnaire reveals that half (50%) of the surveyed students used ChatGPT either occasionally or regularly for academic tasks (Figure 1.a). None of the students indicated using ChatGPT frequently or very frequently. Notably, 20% of surveyed students reported never using ChatGPT for academic assignments. The *p*-value of the Chi-square test (0.822) is significantly higher than 0.05, indicating no statistically significant difference in the frequency of ChatGPT use for academic assignments between different genders. Conversely, the *p*-value (0.031), which is less than 0.05, indicates a statistically significant difference in the frequency of ChatGPT usage for academic assignments between different ethnic groups (White vs BAME students). Among White students, 57.14% never used ChatGPT for academic assignment, and 28.57% used ChatGPT occasionally or regularly (Table 1). In contrast, 8.70% never used ChatGPT for academic assignments, and 56.52% of BAME students used ChatGPT occasionally or regularly.

Table 1: Contingency table of the frequency of ChatGPT usage for academic assignments among White and Black, Asian and Minority Ethnic (BAME) students

	Frequency of ChatGPT usage for academic assignments					
Ethnicity	Never	Rarely	Occasionally	Regularly	Frequently	Very frequently
White	57.14	14.29	28.57	0.00	0.00	0.00
BAME	8.70	34.78	30.43	26.09	0.00	0.00

Approximately 35.8% of the participants expressed confidence or substantial confidence in maintaining the authenticity and originality of their outputs when using ChatGPT (Figure 1.b). A quarter of the students, 25%, are not very confident, and notably, 7.1% of students do not feel confident at all. The Chi-square test yielded a *p*-value of 0.281, indicating no statistically significant difference in students' confidence in the authenticity and originality of their work when using ChatGPT between different genders. The p-value (0.467), greater than 0.05, suggests no statistically significant difference in confidence levels regarding the authenticity and originality of work when using ChatGPT between White and BAME students.

The largest segment, 39.3%, rated ChatGPT as "Very useful," indicating a strong positive reception (Figure 1.c). Additionally, 25.0% found it "Moderately useful," and 10.7% considered it "Extremely useful," suggesting that a majority of students view ChatGPT as a valuable tool in their academic work. Conversely, 17.9% of students rated it as "Slightly useful," and 7.1% found it "Not useful at all", indicating that a minority of students either do not see significant benefits or may encounter issues with its application. The Chi-square test yielded a *p*-value of 0.606, indicating no statistically significant difference in students' opinions on the overall usefulness of ChatGPT in assisting with assignments between different genders. The *p*-value (0.722), greater than 0.05, suggests no statistically significant difference in the perceived usefulness of ChatGPT for assignments between White and BAME students.

Notably, 42.8% of surveyed students agree or strongly agree that using ChatGPT significantly enhanced the quality of their work, compared to assignments completed independently (Figure 1.d). Meanwhile, 17.9% of students disagree with the statement, and 3.6% strongly disagree. This distribution highlights that while a substantial portion of students acknowledge improvements in the quality of their assignments with ChatGPT, many are either indifferent or sceptical about the tool's effectiveness. The Chi-square test yielded a *p*-value of 0.731, indicating no statistically significant difference in students' opinions on the quality of their work when

using ChatGPT compared to completing assignments without it between different genders. The *p*-value (0.078), greater than 0.05, indicates no statistically significant difference in perceptions of quality differences when using ChatGPT for assignments between White and BAME students. A significant majority, 71.4%, reported experiencing errors or inaccuracies, while 28.6% did not encounter such issues (Figure 1.e). The Chi-square test *p*-value of 0.806 is much higher than the typical significance level of 0.05, indicating no statistically significant difference in opinions between genders regarding encountering errors or inaccuracies in ChatGPT. Based on the Chi-square test (*p*=1), there is no significant difference in students' opinions on encountering errors or inaccuracies in ChatGPT across different ethnicities.

A substantial majority of students, 48.3%, agree with the establishment of specific guidelines or training to foster effective and responsible usage of ChatGPT in academic contexts, while an additional 41.4% strongly agree, indicating a clear consensus on the importance of such guidelines or training (Figure 1.f). A smaller proportion, 10.3%, remains neutral, neither agreeing nor disagreeing. Notably, there are no respondents who disagree or strongly disagree with the need for guidelines or training. The Chi-square test *p*-value of 0.279 is higher than the typical significance level of 0.05, indicating no statistically significant difference in opinions between genders regarding the need for specific guidelines or training on how to effectively use ChatGPT in an academic setting. Given the *p*-value of 0.156, there is no statistically significant difference in opinions on the need for specific guidelines or training for ChatGPT between White and BAME students.

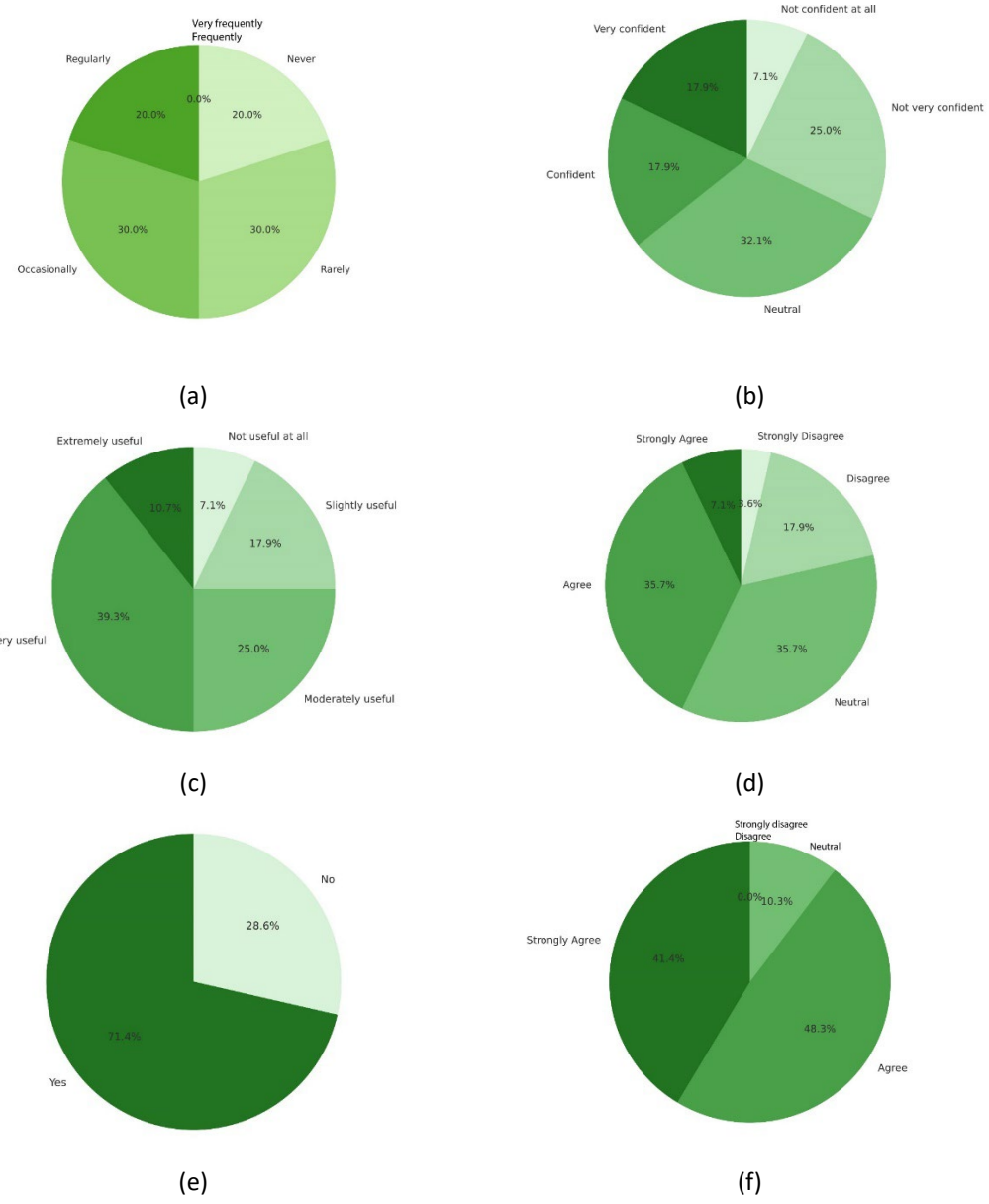

Figure 1: Frequency of Students' Usage and Opinions of ChatGPT

(a) Frequency of student use of ChatGPT for academic assignments; (b) Frequency of students' confidence in the authenticity and originality of their work when using ChatGPT; (c) Frequency of students' opinions on the overall usefulness of ChatGPT in assisting with their assignments; (d) Frequency of students' perceptions of significant differences in the quality of their work when using ChatGPT compared to completing assignments without ChatGPT; (e) Frequency of students' reports of encountering errors or inaccuracies in ChatGPT during its use; (f) Frequency of students' opinions on the need for specific guidelines or training on effectively using ChatGPT in an academic setting

4. Discussion

4.1 Interpretation of Results Using Constructivism Learning Theory

Constructivism, as posited by Jean Piaget and Lev Vygotsky, suggests that learners actively construct their understanding and knowledge through experiences and reflections (Fosnot, 2005). This theoretical framework can elucidate how students engage with and benefit from ChatGPT in their academic endeavours.

The data indicates that half of the surveyed students used ChatGPT either regularly or occasionally for academic tasks (Figure 1.a). This pattern of usage aligns with the constructivist emphasis on active engagement and self-directed learning. Students appear to use ChatGPT as a supplementary tool, integrating it into their learning processes as needed. Approximately 35.8% of participants expressed confidence in maintaining the authenticity and originality of their outputs when using ChatGPT, while a quarter were not very confident (Figure 1.b). Vygotsky's social constructivism emphasizes the role of interaction in learning (Vygotsky, 1978). The varying levels of confidence among students could be interpreted as reflecting their differing experiences and the extent to which they have effectively interacted with ChatGPT to internalise its capabilities and limitations. The need for better management of AI-generated content highlights the importance of providing students with the skills to critically evaluate and reflect on the information generated by AI, an essential aspect of constructivist learning. The majority of students rated ChatGPT as "Very useful" or "Moderately useful," with 39.3% and 25.0% respectively (Figure 1.c). This positive reception aligns with constructivist principles that value tools and resources supporting active learning and problem-solving. ChatGPT's ability to provide immediate feedback and tailored responses can facilitate the construction of knowledge by allowing students to engage in iterative learning processes, and receive feedback, which supports Piaget's concept of active learning (Piaget, 1954). A significant portion of students (42.8%) reported that ChatGPT enhanced the quality of their work, although some were sceptical or indifferent (Figure 1.d). This finding can be understood through Vygotsky's notion of the Zone of Proximal Development (ZPD), which suggests that students can achieve higher levels of understanding with appropriate support (Vygotsky, 1978). ChatGPT can act as a scaffold within the ZPD, helping students to accomplish tasks they might not be able to complete independently (Figure 2) (Cicconi, 2014). However, the reported concerns about errors and inaccuracies (71.4% experiencing issues, Figure 1.e) suggest that while ChatGPT can enhance learning, it also requires critical engagement and reflection, core aspects of constructivist learning. Students must learn to identify and correct errors, fostering deeper understanding and critical thinking skills. The overwhelming consensus among students for the need for specific guidelines or training (89.7% agreeing or strongly agreeing, Figure 1.f) underscores the importance of structured support in the effective use of AI tools. From a constructivist perspective, this need reflects the importance of scaffolding—providing learners with the necessary support to use new tools effectively (Fosnot, 2005). Guidelines and training can help students integrate ChatGPT into their learning processes more effectively, enhancing their ability to construct knowledge and apply it in meaningful ways.

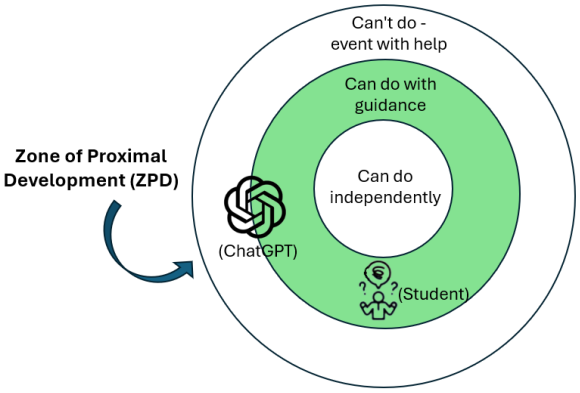

Figure 2: ChatGPT can support students' leaning in the Zone of Proximal Development (ZPD) (after (Dorrell, 2022))

4.2 No Significant Difference in ChatGPT Usage Between Genders

The Chi-square analysis of the survey data revealed no significant differences in opinions on using ChatGPT between genders. This finding is particularly interesting in the context of existing research on gender differences in the adoption and use of technology in educational settings. Previous studies have often suggested that gender can influence technology acceptance and usage patterns, with some reporting that males are generally more inclined towards technology adoption compared to females (Venkatesh and Morris, 2000). However, the current study challenges this notion by showing a convergence in attitudes towards ChatGPT among male and female students. The lack of significant gender differences might be attributed to several factors. Firstly, the ubiquitous nature of digital technologies and their integration into academic and social activities have likely diminished traditional gender gaps in technology use. As digital natives, today's students — regardless of gender — are generally comfortable with technology, including advanced AI tools like ChatGPT (Bouzar et al., 2024). This comfort level may contribute to the uniformity in their perceptions and usage patterns. Secondly, the specific context of ChatGPT as an educational tool might also play a role. ChatGPT's utility in assisting with academic assignments, providing feedback, and offering personalised learning support appeals equally to both male and female students. Studies have shown that when the perceived usefulness of a technology is high and directly related to academic performance, gender differences in technology adoption tend to diminish (Teo, 2008). The practical benefits of using ChatGPT for improving academic outcomes could, therefore, transcend gender-based preferences and attitudes.

4.3 Significant Differences in ChatGPT Usage Between Ethnic Groups

The Chi-square test revealed a statistically significant difference in the frequency of ChatGPT use between White and BAME students, with a *p*-value of 0.031. This significant disparity highlights the divergent patterns of technology adoption and utilization among different ethnic groups. Several factors may contribute to this disparity. One possible explanation is that BAME students may view ChatGPT as a means to level the playing field in academic settings where they might feel disadvantaged. As noted by Roscoe et al. (2022), ChatGPT can provide personalised assistance and explanations that some students may not feel comfortable seeking from instructors or peers due to cultural barriers or fear of stigmatization (Yang, 2021). In addition, cultural attitudes towards education and technology use might also play a role. BAME students might perceive generative AI tools like ChatGPT as valuable resources to support their academic endeavours, especially in contexts where they might lack other forms of academic support. The inclination towards using such tools can be seen as a strategy to bridge gaps in academic preparedness and performance (Selwyn, 2009). Furthermore, the higher usage of ChatGPT among BAME students could also reflect a broader trend of minority students actively seeking out supplementary educational resources. Research indicates that minority students often engage in proactive learning behaviours, utilising various online tools and platforms to enhance their learning experiences (Larson et al., 2018). This proactive approach might stem from a desire to overcome systemic educational barriers and achieve academic success.

4.4 Implications of the Results

The implications of these findings are multifaceted, affecting students, educators, and policymakers. For students, the results suggest that while ChatGPT is a valuable educational tool, its benefits depend on proper

usage and understanding. The mixed confidence in the tool's authenticity and originality indicates a need for critical engagement with AI-generated content. Educational institutions need to carefully integrate AI literacy into their curricula, ensuring students are equipped to discern and verify information produced by ChatGPT (Firat, 2023). For educators, the findings highlight ChatGPT's potential to facilitate personalised learning. However, reported inaccuracies and errors necessitate a balanced approach where ChatGPT is used as a supplementary tool rather than a replacement for traditional teaching methods. Training educators to effectively incorporate ChatGPT into their pedagogical practices is crucial for maximising its benefits (Sandu et al., 2024). Policymakers should consider these insights when developing regulations and guidelines for AI use in education. The high demand for specific guidelines and training underscores the need for comprehensive policies that address the ethical, practical, and pedagogical aspects of AI integration in education. These policies should focus on the ethical use of AI to ensure equitable access and usage (Hasanein and Sobaih, 2023).

The disparity between White and BAME students in ChatGPT usage raises concerns about potential over-reliance on AI tools among BAME students. As cautioned by Xie and Wang (2024), excessive dependence on AI for academic tasks could potentially hinder the development of critical thinking skills and original thought processes. Educators need to be aware of this trend to ensure that all students, regardless of ethnicity, develop the necessary skills for academic and professional success.

The findings of this study underscore the varying experiences and acceptance levels of ChatGPT among various student groups, with notable difference between White and BAME students (Table 1). The concept of responsible use, as previously explained, must therefore be contextualised within these disparate outcomes. The results suggest that while ChatGPT is a valuable tool for many students, its design and application may inadvertently align with white-centric norms, thereby placing additional responsibility on Black students and other students of colour to adapt to these norms. This dynamic raises concerns about the equity of AI-driven educational tools. If such technologies continue to operate within frameworks without fully accounting for the diverse cultural contexts of all students, they may risk perpetuating systemic biases and reinforcing existing inequalities in education (Ferrer et al., 2021). The responsibilisation of marginalised groups to conform to dominant norms represents a significant ethical challenge in the deployment of AI technologies. In light of these considerations, the responsible use of ChatGPT should be re-envisioned as a practice that actively resists these biases by fostering inclusivity and ensuring that the technology is adaptable to the needs of all students, regardless of their racial or ethnic background (Zheng, 2024). This reconceptualisation of responsible use not only addresses the ethical deployment of AI tools but also contributes to a broader effort to decolonise educational technologies and create more equitable learning environments (Mohamed et al., 2020).

4.5 Limitations and Future Outlook

As with most studies, this research is not without limitations. The primary limitation is the sample size and demographic diversity of the survey participants, which may limit the generalisability of the findings. Future research should aim to include a more diverse sample, for example, from multiple countries, to enhance the validity of the results (Das and Madhusudan, 2024). Moreover, the current study focuses primarily on students' perspectives, whereas the views of educators and administrators are equally important for a holistic understanding of ChatGPT's impact in higher education (Sevnarayan, 2024). An additional limitation is the exclusive focus on ChatGPT as the generative AI tool used in teaching and learning contexts. While ChatGPT represents only one facet of the rapidly evolving landscape of generative AI technologies, other tools, such as Perplexity and Copilot, offer distinct features and functionalities that could potentially enhance their educational value. Future research should expand beyond ChatGPT to include a comparative analysis of various generative AI tools in educational contexts.

5. Conclusion

The integration of generative AI tools, particularly ChatGPT, in teaching and learning has gained substantial attention due to its potential to transform educational practices. These findings underscore the broad utilisation of ChatGPT in student learning and a general satisfaction with its application. Nonetheless, students acknowledge the tool's potential for errors and inaccuracies. In light of these challenges, there is a pronounced demand for clear guidelines and proper training to navigate the responsible use of ChatGPT in educational settings. This study illuminates the imperative for educators and institutions to develop strategies that not only leverage the benefits of generative AI tools but also mitigate their risks to uphold academic integrity and promote meaningful learning outcomes.

Acknowledgements

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Goal-Setting, Active Practice, Self-Monitoring: A Web-Based System to Improve Programming Proficiency

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Abstract: Mastering programming fundamentals poses a significant challenge for students, especially in demanding higher education environments. This pilot study investigates the effectiveness of a web-based system, SoftwareSkills, designed to enhance programming proficiency among second-year bachelor students. SoftwareSkills leverages, active practice, and self-monitoring to support programming practice. Thirty-six students (n=36) participated in a quasi-experimental design, divided into independent exploration and instructional session groups. User interaction data, exercise performance, and behavioural patterns were analysed. The study revealed four distinct learning strategies: reviewing skill masteries, dedicating sufficient time to each question, striving for mastery, and adapting spaced practice. However, some students exhibited rapid responses and minimal practice, suggesting a need for deeper learning strategies. These findings highlight the suitability of self-regulated learning and deliberate practice in programming education. Future work will involve first and second-year programming students and integrate AI-driven personalised learning features to optimise the learning experience. This research contributes insights into effective practices and the potential of technology-aided learning to support student success in programming education.

Keywords: Deliberate practice, Higher education, Programming fundamentals, Self-Regulated learning, Web-Based systems

1. Introduction

Many students who study computing-based courses, particularly software development, encounter problems understanding programming fundamentals (Matthews et al., 2009; Nandigam and Bathula, 2013; Patil et al., 2022). These challenges stem from the multifaceted nature of programming, encompassing core concepts like conditional statements, loops, functions, and variables. Beyond these basics, programming requires strong problem-solving skills and extends to debugging, testing, maintenance, and documentation. Moreover, additional factors such as syntax, code quality, best practices, and software engineering principles further contribute to the overall complexity (Medeiros et al., 2019). Furthermore, the higher education environment can exacerbate these difficulties. Juggling multiple modules each semester forces students to divide their focus, potentially limiting the time available for in-depth learning and skill development. Additionally, individual learning paces necessitate varying levels of time, resources, and support which can challenge lecturers to accommodate effectively (Medeiros et al., 2019).

A strong foundation in these core concepts transcends the need for merely passing exams; it equips individuals with essential building blocks for success in various fields. Programming proficiency empowers individuals to automate tasks, analyse data, and design innovative solutions across diverse industries. In today's increasingly technological world, the ability to think logically, solve problems algorithmically, and translate those solutions into code remains a valuable asset, regardless of career path.

Educators and researchers have explored various technology-aided learning strategies to address these challenges and improve learners' understanding of programming fundamentals. These include Intelligent Tutoring Systems (ITSs), Open Learner Models (OLMs), and Self-Regulated Learning (SRL) frameworks that personalise the learning experience and offer targeted support. This paper presents the findings of a pilot study that explored how learners interacted with a web-based system, SoftwareSkills, which leverages active practice, self-monitoring, and personalised feedback to support programming practice and guide preparation for class tests. The study particularly investigated beneficial strategies learners employed while using the system.

2. Literature Review

2.1 Technology-Aided Learning Strategies for Programming

Educators and researchers have explored various strategies and tools to address the challenges faced by students in programming. One approach focuses on tackling specific learning difficulties through techniques

like visualisation tools and problem-solving methodologies, which make programming concepts more intuitive, particularly for those struggling with syntax (Patil et al., 2022). Intelligent Tutoring Systems (ITSs) offer another avenue for personalised learning, addressing the limitations of one-size-fits-all teaching methods by adapting to individual needs and offering targeted challenges and feedback (Orhun, 1989; Butz et al., 2004).

Open Learner Models (OLMs) empower learners to become self-directed by externalising learner data into comprehensible formats (Thomson and Mitrovic, 2010; Bull, 2020). These visual representations of knowledge mastery and performance promote reflection and metacognition, enabling students to critically analyse their strengths and weaknesses and develop more effective learning strategies (Thomson and Mitrovic, 2010; Suleman et al., 2016; Bull, 2020).

2.2 Self-Regulated Learning (SRL)

SRL empowers learners to take control over their educational journey, a crucial skill in programming (Vieira et al., 2018; Ceron et al., 2021) as success in programming hinges on breaking down complex problems, adhering to deadlines, and critically evaluating code. Web-based platforms that personalise the learning experience and offer targeted support can significantly enhance SRL, especially for students who find traditional methods challenging (Niemi et al., 2003). These platforms can foster self-regulation by allowing students to track their progress, identify areas needing improvement, and adjust their study strategies accordingly (Azevedo et al., 2010). This reinforces the positive correlation between self-assessment and better learning outcomes observed in programming education (Azevedo et al., 2010).

2.3 Panadero's Model of SRL

This research adopts Panadero's model (Panadero, 2017) as a foundation for understanding SRL in programming education. Panadero's model integrates elements from various established SRL models, providing a comprehensive framework that encompasses cognitive, metacognitive, motivational, and emotional aspects of learning across three key phases:

- Forethought Phase: Learners define goals for their programming tasks, engage in strategic planning, and assess their motivation and self-efficacy, which are crucial for initiating and sustaining engagement in learning (Pintrich, 1995).
- Performance Phase: Learners implement their planned strategies, actively monitoring their progress through self-monitoring and self-control, enabling real-time adjustments to their learning approach (Weinstein et al., 2011).
- Self-Reflection Phase: Learners evaluate their performance and the effectiveness of used strategies, reflecting on their learning outcomes compared to initial goals and identifying areas for improvement (Bozpolat, 2016).

2.4 Ericsson's Contribution to SRL

Ericsson's (Ericsson et al., 1993; Nandagopal and Ericsson, 2012; Ericsson and Harwell, 2019) work on deliberate practice has significantly influenced our understanding of how learners develop and apply strategies to achieve expert performance. His contributions emphasise the strategic regulation of learning activities, focusing on three key aspects highly relevant to SRL:

- Strategy Presence: Effective learning involves a repertoire of strategies. Ericsson's model highlights the importance of developing comprehensive study plans, actively monitoring learning processes, and regulating learning environments to enhance self-efficacy (Bransen and Govaerts, 2020). Nandagopal and Ericsson's (2012) study found that successful learners actively utilise a wider range of strategies.
- Strategy Frequency: Regular implementation of these strategies is essential. Frequent use of time management and problem-solving techniques fosters engagement and skill refinement through deliberate practice (Nandagopal and Ericsson, 2012).
- Strategy Consistency: Consistent application of SRL strategies across different contexts is crucial for long-term learning goals. Consistent practice fosters robust metacognitive awareness, enabling learners to make informed decisions about their learning processes (Nandagopal and Ericsson, 2012).

2.5 Learner Strategies in Web-Based Learning

Learner strategies are crucial, offering insights into how students develop approaches for mastering programming skills. For example, learners who actively engage with interactive elements like coding exercises, quizzes, and simulations tend to develop better problem-solving skills and a deeper understanding of

programming concepts (Chi, 2009). Furthermore, learners who consistently practice coding tasks and receive immediate feedback are more likely to correct errors and refine their understanding of complex concepts (Ericsson et al., 1993).

Dedicated web-based systems designed specifically for programming practice offer several benefits to learners. These systems complement traditional learning methods by providing opportunities for deliberate practice, a key component of skill acquisition (Ericsson et al., 1993). Learner interaction with these systems can also foster the development of self-regulation skills, such as self-monitoring and self-assessment (Azevedo et al., 2010). Finally, by analysing learner interaction patterns, educators can gain valuable insights to inform teaching practices and personalise the learning experience for future students.

2.6 Research Questions

The central research questions:

- What specific learner strategies are observed during interaction with the system?
- Can learner interactions with the system be categorised into strategies for mastering programming skills?

3. Methodology

We developed SoftwareSkills, a web-based system which allows users to view their skill masteries for various skills (e.g. functions, variables, loops, and conditional statements) belonging to a higher level skill area (e.g. procedural programming), set focus on specific skills they wish to improve and practise those skills by undergoing a series of exercises (5 questions per practice). The system was available to 36 (n=36) 2nd-year bachelor students enrolled in a software engineering module, capturing their interactions with the system and practice-related performance.

This study employed a quasi-experimental design. The class was divided into two groups, each assigned a specific topic (either code smells or user stories) using SoftwareSkills. Independent exploration commenced on November 15th. Due to observed low engagement, an additional dedicated class session was held on November 29th to provide further instruction and support, enhancing the utilisation of the tool. The course structure included graded weekly quizzes, worth 1% each. On December 6th, the understanding of both groups regarding their respective topics was evaluated through an exam.

4. Findings

The analysis of learner data revealed four distinct strategies that may influence learning outcomes. These strategies were categorised with each phase presented in Panadero's model, see Table 1. Each strategy aligns with key components of the SRL cycle: for instance, viewing skills before, during, or after a session incorporates task analysis, self-monitoring, and self-evaluation. Spending at least 10 seconds per question reflects task analysis, self-control, and self-judgement. Achieving 100% mastery at least once involves goal setting, self-motivation, and self-satisfaction. Lastly, participating in more than five sessions demonstrates strategic planning, self-discipline, and reflective self-evaluation. These alignments suggest a structured approach to self-regulated learning, promoting enhanced academic performance through deliberate practice and reflection. However, a significant limitation of this study is the small sample size (n=36), which limits the generalisability of these findings. Future studies should aim to include a larger and more diverse participant group to validate the results across different contexts.

Table 1: Alignment of Identified Learning Strategies with Phases of Panadero's SRL Model.

Strategy	Forethought Phase	Performance Phase	Self-Reflection Phase
Viewing skills before, during, or after a practice session.	Task Analysis, Goal Setting	Self-Monitoring, Self-Control	Self-Evaluation, Reflection, Self-Judgement
Dedicating enough time to each question.	Task Analysis, Strategic Planning	Self-Control, Self-Monitoring	Self-Evaluation, Self-Judgement
Practising until mastery was achieved (100% on a skill).	Goal Setting, Strategic Planning	Self-Motivation, Persistence	Self-Evaluation, Self-Satisfaction, Self-Judgement

Strategy	Forethought Phase	Performance Phase	Self-Reflection Phase
Using spaced repetition to practice.	Strategic Planning, Goal Setting	Self-Discipline, Self-Monitoring	Self-Evaluation, Reflection, Self-Judgement

4.1 Learner Interaction and Practice Patterns

Examining how learners interacted with the system from the beginning of the study and beyond its conclusion (see Figure 1) revealed insights into their exercise practice and reflection on skill development. This analysis suggests some students independently adopted spaced practice, even though neither the system nor the lecturer prompted them to use it. In Figure 1, we observed that 25% (n=9) revisited their skills approximately 250 hours (~10 days) into the study, 11.1% (n=4) revisited their skills around 100 hours (~4 days) in, and 19.4% (n=7) returned at least once more after the dedicated session.

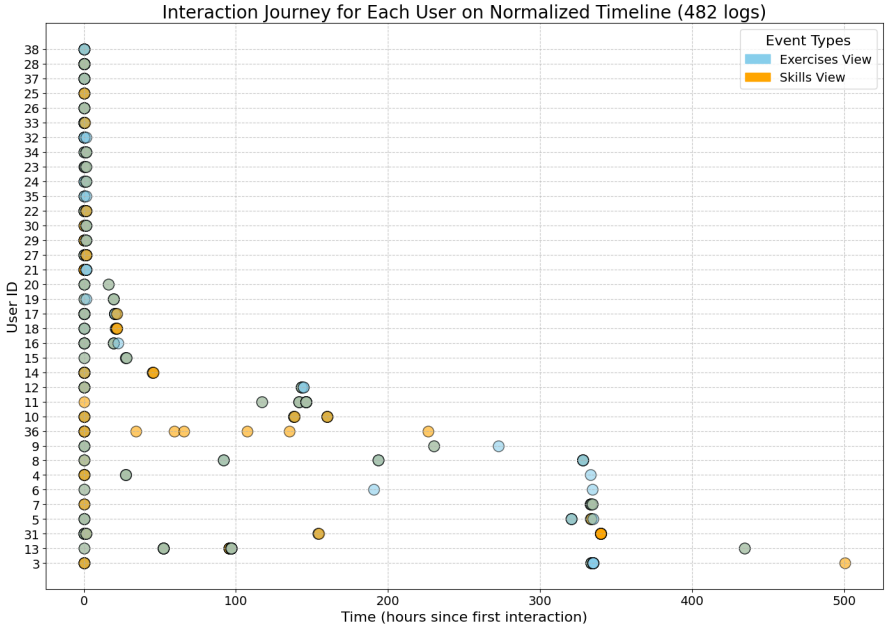

Figure 1: Illustrates varying patterns of spaced repetition, as exemplified by Users 8 and 13, and that certain learners revisited practising specific skills even after the dedicated session

Initial interactions with the system revealed that most learners (88%, n=32) started by exploring the "skill mastery" page, suggesting a focus on understanding their skill gaps or what might be available to them. However, some students (e.g. User IDs 28, 14, and 38) were found alternating between practice sessions and reviewing their skill mastery, before attempting to interact with an exercise. This insight suggests that the learner might have been initially confused about the mechanics.

4.2 Interaction Patterns

We identified four distinct patterns of learner interactions with the system, illustrating varying approaches to viewing skill mastery before and after practice sessions, ordered by popularity (see Figure 2):

- Reviewing skill masteries upon completing a practice session: This was the most common interaction, where learners reviewed their skill mastery after finishing their practice, allowing them to assess their performance immediately.
- Reviewing skill masteries during a sequence of practice sessions: In this pattern, learners took breaks between practice sessions to reflect on their progress, perhaps to determine if further practice is necessary.
- Reviewing skill masteries before initiating a practice session: Some learners preferred to review their skill levels before starting a new practice session, perhaps to guide their focus or set goals.
- Not reviewing skill masteries at any point: The least common pattern involved learners who did not engage in reviewing before, during, or after practice sessions, potentially missing out on valuable insights into their learning progress.

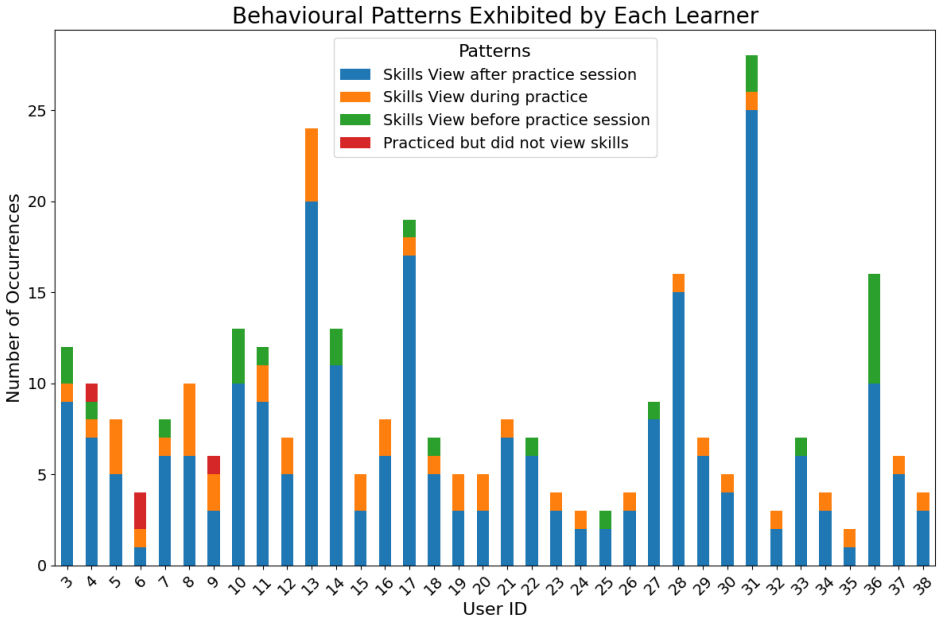

Figure 2: Different interactive patterns identified in each learner

4.3 Mastery Levels

Mastery levels, defined as achieving 100% on either skill (code smell or user stories), varied among learners. As shown in Figure 3, 67% of learners (n=24) achieved mastery at least once, 8% of learners (n=3) reached 50% mastery from a single practice session, and 25% of learners (n=9) did not participate in a single practice session. Of the 24 learners who achieved mastery at least once, 42% (n=10) concluded their practice had reached mastery, whereas 50% (n=5) achieved mastery more than once.

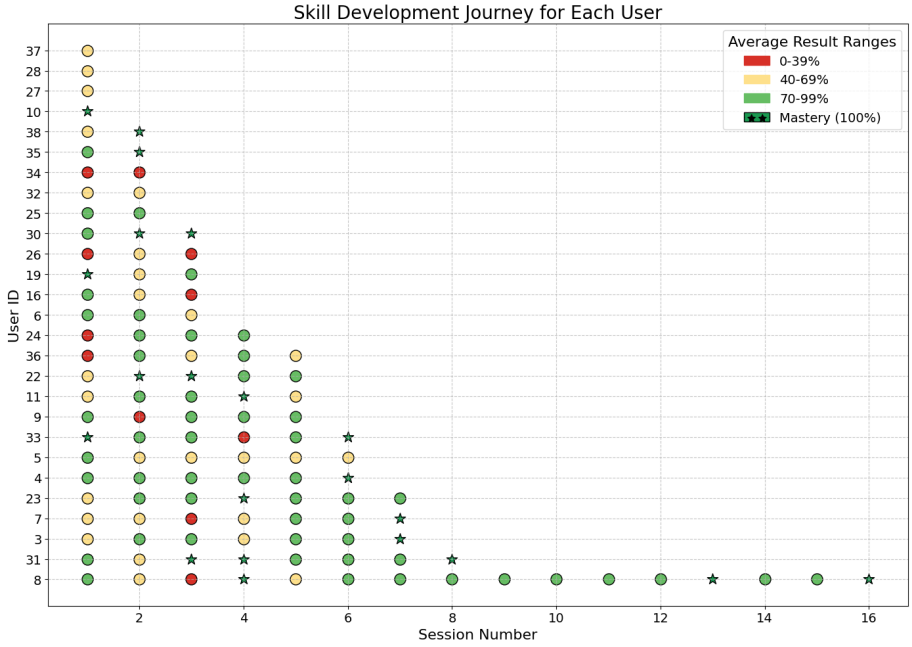

Figure 3: Mastery progression for each user who interacted with the system, a star represents mastery (achieving 100%)

4.4 Response Time Analysis

A deeper analysis of learners' mastery, specifically focusing on the duration spent on each question, revealed a tendency for quick responses (see Figure 4). A significant portion of the questions were answered within 10 seconds. This rapid response rate raises concerns about superficial engagement with the material, potentially

hindering deep learning and comprehensive understanding. Addressing this issue is crucial, as quick responses can undermine the benefits of practice by promoting guessing over genuine problem-solving.

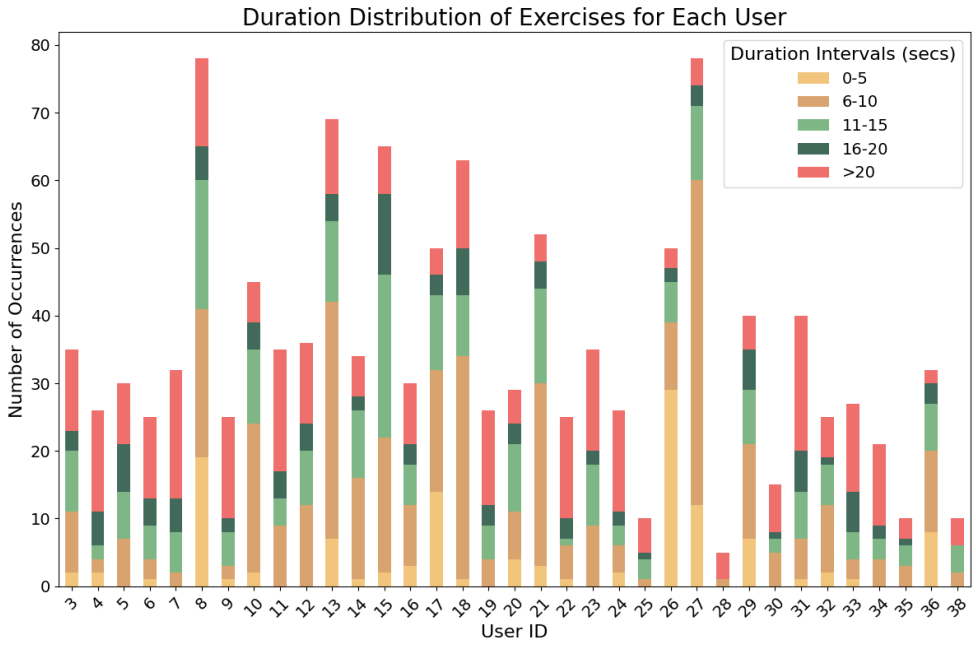

Figure 4: The time taken for each learner to submit their answer to each question encountered

4.5 Session and Attempt Data

Figure 5 provides detailed information on the number of sessions, the number of attempts, and the accuracy of those attempts, including potential guesses (indicated by a response time of less than 10 seconds on the first encounter with a question). The data shows that students who made more attempts did not necessarily guess more often.

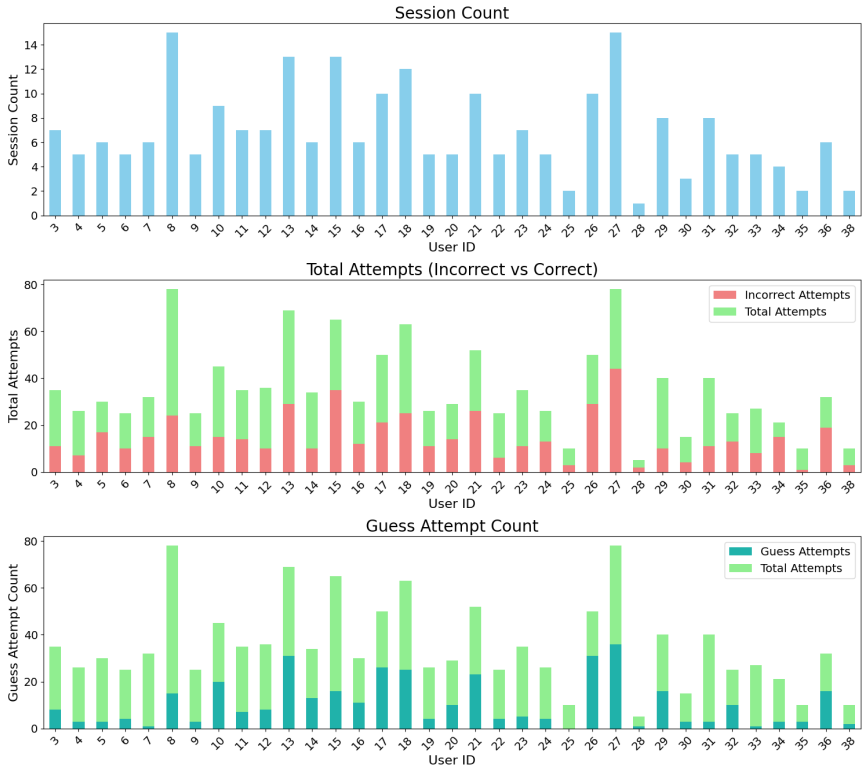

Figure 5: The data includes the number of sessions, the ratio of incorrect attempts to total attempts, and the ratio of correct guesses to total attempts for each learner

4.6 Positive vs. Negative Strategies Ratio

Finally, having explored the different strategies in more detail (e.g., reflecting on skill masteries and taking the time to reach mastery), categorised as positive or negative. The positive-to-negative ratio was estimated at 0.714 vs 0.286 (see Figure 6) using the criteria as defined in Table 2, suggesting that most learners exhibited strategies conducive to learning.

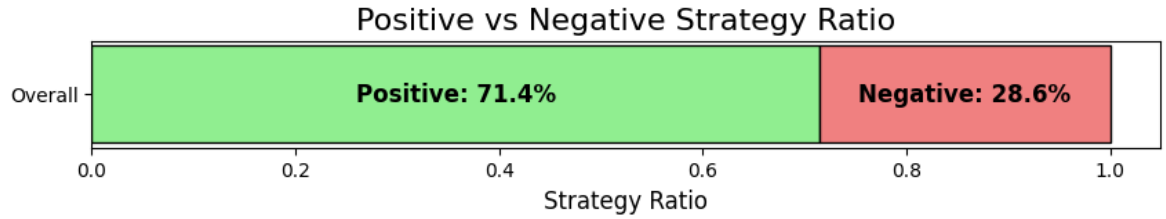

Figure 6: Calculated positive vs negative ratio for learning strategies

Table 2: Criteria for measuring the ratio between positive and negative strategies.

Positive Strategy	**Negative Strategy**
Viewing skills before, during or after a practice session.	Practising without viewing skill masteries.
Spending at least 10 seconds per question (dependent on the exercise).	Guessing attempts (spending less than 10 seconds on a question).
Achieving 100% mastery at least once.	Never achieving 100% skill mastery.
Participating in more than 5 sessions (ideally spaced days apart from each other).	Participating in less than 5 sessions or closely spaced sessions.

5. Conclusion

This pilot study identified four strategies that may influence learning outcomes in programming education: reviewing skill masteries, dedicating sufficient time to each question, striving for mastery, and adapting spaced practice. These strategies align with the principles of SRL and deliberate practice, highlighting the importance of metacognitive strategies and thoughtful engagement with learning materials. The identification of these strategies provides valuable insights into how learners approach skill mastery in web-based learning environments. Notably, the most common pattern involved reviewing skill mastery after practice sessions, suggesting that immediate self-assessment can deepen learners' understanding of their strengths and weaknesses. However, a subset of learners did not review their skills at any stage, indicating an inability to identify areas needing improvement and adapt their learning strategies. Integrating features that prompt reflection and self-assessment could enhance the learning experience and outcomes within SoftwareSkills.

Moreover, the study revealed that a significant proportion of learners achieved mastery at least once, demonstrating the potential effectiveness of the web-based system in supporting skill acquisition. Some students independently adopted spaced practice without prompts, suggesting that reminding students about spaced practice techniques could further increase their use. However, the study also highlighted a tendency among some learners to respond quickly to questions, often within 10 seconds. This rapid response rate raises concerns about superficial engagement with the material, potentially hindering deep learning and understanding. Addressing this issue is crucial, quick responses can undermine the benefits of practice by promoting guessing over genuine problem-solving. Future iterations of SoftwareSkills could incorporate features that prompt learners to spend more time on each question, such as detailed feedback mechanisms.

In conclusion, while the small sample size and limited duration of the study are notable limitations, the findings provide valuable insights into learner strategies in web-based learning environments. Future research should focus on addressing these limitations by including larger and more diverse participant groups and extending the study period. Additionally, incorporating qualitative data collection methods, such as interviews or focus groups, would provide a richer, more nuanced understanding of learner behaviours and preferences.

6. Limitations

This pilot study provides valuable insight, but some limitations should be considered when interpreting the findings. The study involved a relatively small sample size of 36 second-year bachelor students. This small sample size may not fully represent the diverse range of learners in computing-based courses. Future studies with larger and more diverse populations are necessary to generalise the findings more broadly. The study was conducted over a limited period of time, which may not have allowed enough time to observe long-term learning strategies (e.g. spaced practice) and mastery. Longer-term studies could provide a more comprehensive understanding of how strategies evolve and their impact on learning outcomes.

Despite offering a dedicated class session to enhance tool utilisation, some learners exhibited low engagement with the system. This variation in engagement levels might have influenced the results, potentially underestimating the effectiveness of SoftwareSkills for those who did not fully utilise it. While the analysis primarily focused on quantitative metrics such as time spent on questions and frequency of practice, it did not capture the qualitative aspects of learner experiences and the underlying reasons for certain strategies. Incorporating qualitative research methods, such as interviews, focus groups, or open-ended surveys, would provide a richer, more nuanced understanding of how students perceive and interact with the learning tool.

7. Future Work

We plan to conduct a follow-up study with first and second-year programming students, integrating the system into their curriculum. This follow-up study will address the sample size limitation by including a larger and more diverse cohort of students to validate the results and enhance the generalisability of the findings. The system will become available to students as they cover specific topics in class, with first-year students unlocking access to specific exercises only after they have been covered in lectures, while second-year students will have access to the entire system, having covered the fundamentals in the previous year. This study will span the entire educational year to address the limitation regarding the duration, providing a more comprehensive understanding of how learning strategies evolve over time.

The targeted skills will range from programming basics such as loops to more advanced concepts like classes. Second-year students will take a pre-test before utilising the system to establish a baseline understanding and identify any existing knowledge gaps or misconceptions. This pre-test allows us to tailor the learning experience to each student's individual needs. Following the pre-test, students will be encouraged to use the system to develop their skills towards mastery. Upon achieving mastery in all skill areas, as determined by the system's benchmarks, students will complete a post-test designed to challenge them with complex questions.

The data collected in the follow-up study will include user-system interactions such as viewing skills, focusing on specific skills, engaging in deliberate practice, and accessing resources available within the system. Additionally, the data will record each response, result (correct/incorrect), and duration for each question. This data will be analysed for strategies and their impact on knowledge development. To balance quantitative with qualitative data, all learners will receive a feedback questionnaire at the end of the study to gauge the system's usability, applicability, relevance, and user experience. Incorporating qualitative methods such as these will provide a richer, more nuanced understanding of student behaviours and preferences, potentially enriching the findings with insights that quantitative data alone cannot provide.

To further enhance the learning experience and address the identified need for personalised learning approaches, we plan to develop the following features:

- Progress Trackers: Implement trackers that display days of practice in a calendar format and highlight ongoing streaks. This visual representation can help students maintain consistent practice and monitor their progress over time.
- Interactive Skill Map: Display an interactive map of all skills to highlight the overall development of knowledge. This map can help students visualise their progress and understand the interconnectedness of different programming concepts.
- Prompts and Notifications: Regularly prompt learners with reminders to practice, encouraging more thoughtful engagement with exercises and adoption of more positive strategies like spaced practice.

The varied levels of engagement and mastery observed highlight the need for personalised learning approaches. To address this, we are considering the integration of Artificial Intelligence (AI) through the following features:

- Learning Path Guidance: This feature will recommend the next steps based on each student's learning progress, ensuring they focus on areas requiring improvement and navigate through the material effectively.
- AI Mentor: An AI mentor will provide students with in-depth personalised feedback on their data, performance, strengths, and weaknesses. This feedback will guide students in optimising their learning strategies and addressing specific challenges.

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Supporting Educators to Co-Design Interdisciplinary Projects Integrating Educational Robotics and Arts

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Abstract: The growing call to foster interdisciplinary learning has found educators struggling to co-design learning across disciplinary boundaries. Aiming to contribute to the area of interdisciplinary learning design, we explored how to support educators in co-designing interdisciplinary projects integrating Educational Robotics (ER) and Arts, hereafter called Artful ER projects. Our research included developing the "FERTILE" Learning Design methodology as a conceptual tool scaffolding the integration of discipline-oriented viewpoints while educators co-design. Acknowledging that one of the challenges in interdisciplinary collaboration derives from educators' different intentions for students' learning outcomes, the "FERTILE" methodology introduces Computational Thinking (CT) skills as an Artful ER project's primary learning outcome. In this line, the "FERTILE" methodology adapts the Creative Computational problem-solving model, which has been reported to cultivate CT skills through its staged process. Furthermore, we developed the "FERTILE" Community Platform as an online environment providing two-fold support to educators as designers of interdisciplinary learning. The "FERTILE" Community Platform incorporates community functionalities that address collaboration practicalities while educators co-design. Additionally, it integrates authoring functionalities scaffolding educators in designing Artful ER projects based on the "FERTILE" Learning Design methodology. This paper explores how the authoring functionalities of the "FERTILE" Community Platform support educators in designing interdisciplinary learning. We report on a pilot study conducted with Greek and Spanish educators. In this study, we applied a mixed-method research design with a quantitative strand adopting indicators from the Usability Metric for User Experience (UMUX) model and a qualitative strand providing insights into participants' perceptions. The findings indicate that scaffolding disciplinary elaboration (e.g., robot technical requirements and art forms) and systematising interdisciplinary context (e.g., through project categories) may trigger educators' mutual understanding. The participants endorsed authoring functionalities that adopted high contextualisation levels for learning design representation to communicate their design ideas across disciplinary boundaries. Also, the participants valued CT skills as the primary outcome of interdisciplinary learning, indicating that CT skills' cultivation may be the broker among disciplines and trigger educators to overcome disciplinary barriers. Finally, we discuss the findings and implications for refining the "FERTILE" Community Platform as an online environment for educators co-designing Artful ER projects.

Keywords: Interdisciplinary learning design, Community platform, Educational robotics, Arts education, Computational thinking

1. Introduction

There is a growing call to foster interdisciplinary learning by challenging students to construct knowledge based on a synthesis of perspectives derived from multiple disciplines (Stentoft, 2017; Wu, Peng and Hu, 2021). Meanwhile, Learning Design (LD) research highlights the role of educators as learning designers (Asensio-Pérez et al., 2017), advocating a shift from focusing on subject-specific content to devising compelling learning experiences (Mor, Craft and Maina, 2015). In the case of interdisciplinary learning, such a role entails a synergetic combination of discipline-oriented viewpoints to solve a common problem or develop a common artefact. However, educational research suggests that educators struggle to communicate across disciplinary boundaries and achieve interdisciplinary collaboration (Warr and West, 2020; McCance and Blanchard, 2024).

Aiming to contribute to the area of interdisciplinary learning design, we focused on the educators' perspective and the challenges they face while co-designing with educators of other disciplines. To facilitate interdisciplinary learning design, in the context of the "FERTILE: Artful Educational Robotics to promote Computational Thinking in a Blended Learning Context" project, we developed the "FERTILE" Design Methodology, an LD methodology guiding educators to design projects that integrate Arts and Educational Robotics (ER), hereafter called Artful ER

projects. Acknowledging that one of the challenges in interdisciplinary collaboration derives from educators' different intentions for students' learning outcomes, which are anchored in disciplines and subject areas (Stentoft, 2017), the "FERTILE" Design Methodology introduces Computational Thinking (CT) skills (Wing, 2006) as the interdisciplinary learning's primary outcome. It leverages computer programming as a natural habitat for CT skills development (Yeni et al., 2023) and employs the popularity of ER as a motivational and engaging programming practice (Wang, Shen and Chao, 2022; Tzagkaraki, Papadakis and Kalogiannakis, 2021). Also, it exploits the dynamic of Arts as a discipline that has been reported to foster creativity and promote the cultivation of CT skills in recent years (Yeni et al., 2023). Notably, the "FERTILE" Design Methodology acknowledged the marginal role that Art has played in Art-based ER activities (Almpani and Alimisis, 2021) and that ER activities have promoted learning in subjects such as History, Arts and Literature (Tzagkaraki, Papadakis and Kalogiannakis, 2021) suggesting an integrative approach to ER and Arts.

Furthermore, exploiting LD digital tools as authoring tools supporting the design process (Asensio-Pérez et al., 2017; Zalavra and Papanikolaou, 2018) and as community platforms facilitating designers' collaboration (Hernández-Leo et al., 2018; Zalavra and Papanikolaou, 2019), we developed the "FERTILE" Community Platform. The "FERTILE" Community Platform incorporates an authoring tool supporting the design process by synthesising a particular LD representation. Aiming to scaffold educators through the co-design of Artful ER projects based on the "FERTILE" Design Methodology, this LD representation adopts a high degree of guidance and a high contextualisation level as indicated by LD tooling research to support educators as designers (Zalavra et al., 2023). Also, aiming to facilitate collaboration practicalities among educators, it provides a set of community-support features that LD tooling research has suggested as necessary for communities of educators as designers (Hernández-Leo et al., 2018). Educators can use the "FERTILE" Community Platform to design Artful ER projects consisting of subject-oriented activities as well as activities that synthesise both subjects, allowing a high degree of flexibility throughout their collaboration.

This paper presents the research in progress for supporting educators of different disciplines to co-design Artful ER projects through the "FERTILE" Community Platform. Aiming to conduct a preliminary evaluation on how such an online environment may support interdisciplinary learning design, we describe a pilot study addressing the research question: "*How are educators supported in co-designing interdisciplinary projects through the FERTILE Design Methodology and Community Platform?*". In what follows, the background section includes an overview of the "FERTILE" Design Methodology's initial version. The Methods section presents the functionalities under evaluation of an "FERTILE" Community Platform prototype. Also, it describes the pilot study conducted with Greek and Spanish educators. The paper then includes the pilot study's findings. Finally, we discuss the findings and determine their implications for refining the "FERTILE" Community Platform towards supporting interdisciplinary learning design.

2. Background: The "FERTILE" Design Methodology

The "FERTILE" Design Methodology provides a structured approach to designing interdisciplinary projects integrating Arts and ER. Following a design-based research approach, we initiated its development process by collecting perceptions from Spanish, Czech, Slovak, and Greek educators across several educational levels regarding the difficulties they experience and the suggestions they have for designing interdisciplinary projects (FERTILE project, 2022). Their feedback and the corresponding needs analysis allowed us to complement the findings hindering ER adoption related to educators' pedagogical and technological competencies reported in educational research (Papadakis et al., 2021) with issues focusing on interdisciplinary collaboration. It triggered us to determine design principles to be further explored with practitioners during the 3-year-long "FERTILE" project.

Figure 1 depicts the design process suggested by the "FERTILE" Design Methodology to address challenges in co-designing interdisciplinary projects. As seen in the left part of Figure 1, the "FERTILE" Design Methodology promotes a holistic view by integrating the contexts of both Educational Robotics (ER) and the Arts. It shows how these disciplines should synthesise their unique contexts into a cohesive joint project. The project categories are classified based on how Art is combined with ER in the final artefact. These categories are defined as "creating artful robots", "programming robots to create or perform Art", and "programming robots to respond to artful triggers". The middle part of Figure 1, depicts the five steps that the "FERTILE" Design Methodology suggests for developing an Artful ER project. The "FERTILE" Design Methodology adopts this sequencing by adapting the Creative Computational Problem Solving (CCPS) model (Chevalier et al., 2020) in an interdisciplinary context. We chose the CCPS model because it focuses on cultivating CT skills by encouraging creative problem-solving through a cooperative, iterative process involving distinct steps. Lastly, as depicted in

the right section of Figure 1, the "FERTILE" Design Methodology suggests that each step is implemented through a synthesis of learning activities that are either disciplinary-oriented or interdisciplinary, facilitating educators to express the context of both disciplines and guiding students towards developing a common artefact. Most importantly, the "FERTILE" Design Methodology incorporates CT skills as the “broker” between disciplines not only through a) the sequence of steps adapted from the CCPS model but also by b) aiming to cultivate CT skills in each activity within each step, thus providing an integrated approach to developing CT.

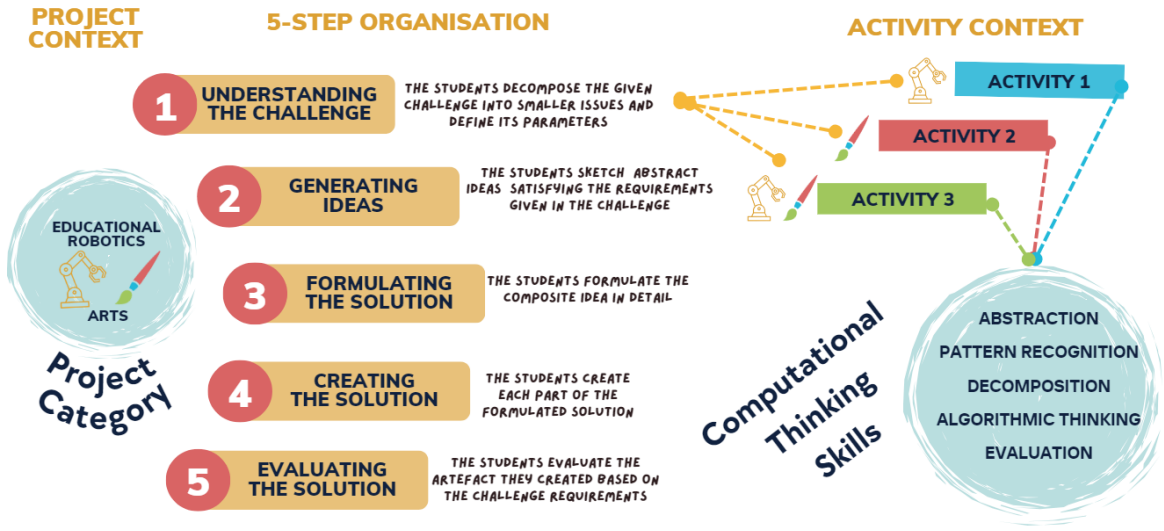

Figure 1: The design process suggested by the "FERTILE" Design Methodology for designing Artful ER projects. Indicatively, the first step includes corresponding learning activities depicting the five steps' design rationale

3. Methods

3.1 Context, Participants, and Procedure

This paper reports a pilot study conducted in two strands with groups of Greek and Spanish educators. The Greek strand, organised by the University of West Attica, emerged from educators participating in an ER course of the master program “Digital Transformation in Education”. The Spanish strand organised by Universidad de Valladolid and Universidad Rey Juan Carlos emerged from educators who responded positively to an open call for participation. The Greek strand spanned over four weeks, utilising three face-to-face meetings, one synchronous online meeting and asynchronous work. The Spanish strand spanned over two weeks, including two face-to-face meetings, one synchronous online meeting and asynchronous work.

Table 1 includes the participants' demographics. Although neither group included participants whose discipline was strictly related to ER and Arts, we asked them to work in pairs so that each member represented the respective disciplines' perspectives while co-designing Artful ER projects. Both strands followed a modular approach, first engaging the participants with the "FERTILE" Design Methodology and then utilising the "FERTILE" Community Platform to co-design Artful ER projects in pairs.

Table 1: The participants’ demographic characteristics (n=21)

Characteristic	Greek Group (n=9)	Spanish Group (n=12)
Sex	1 (11.1%) Male 8 (88.9%) Female	3 (25%) Male 9 (75%) Female
Age (years)	4 (44.4%) 20-30 years old 4 (44.4%) 30-40 years old 1(11.1%) 40-55 years old	8 (66.7%) 20-30 years old 3 (25%) 30-40 years old 1 (8.3%) 55+ years old
Teaching Experience	8 (75%) 0-3 years (novice) 1 (25%) 5+ years (expert)	10 (83.3) 0-3 years (novice) 1 (8.3%) 3-5 years 1 (8.3%) 5+ years (expert)

Characteristic	Greek Group (n=9)	Spanish Group (n=12)
Level of Expertise in LD	7(77,8%) Low 2 (22,2%) Moderate	7(58.3%) Low 3 (25%) Moderate 2 (16.7%) High

3.2 Materials: The "FERTILE" Community Platform

The "FERTILE" Community Platform is an online environment, available as a web application at https://fertile.gsic.uva.es. It comprises an authoring, a community, and a student enactment environment. In this paper, we explore the first one. Co-design teams are scaffolded to author their projects by a representational organisation and format that reflects the "FERTILE" Design Methodology's conceptual, structural, and procedural aspects while facilitating other educators' eventual understanding and reuse.

Figures 2 and 3 depict the representation supported by the "FERTILE" Community platform to facilitate describing a project's context. The authoring window is split into three horizontal sections. The first section, as seen in Figure 2 includes typical fields (project title, description, language, indicative image), enabling designers to describe the general context. Notably, it incorporates the functionality "PROJECT CATEGORY", triggering designers to interweave both disciplines by classifying projects based on how Arts are combined with ER. As seen in Figure 3, the two last sections constitute the "PROJECT DISCIPLINARY CONTEXT" functionality, facilitating designers to elaborate on each discipline's context. The section about Arts includes a field to describe learning objectives set for Arts and another two fields to select the Art forms' categories and subcategories. Likewise, the ER section contains a field describing learning objectives set for ER and five other fields to choose the technology used (robotic kit, programming environment and simulator) and the construction elements (actuators and sensors).

Figure 4 depicts the representation supported by the "FERTILE" Community platform to organise a project, describe an activity's context, and overview a project. The left part of Figure 4 incorporates the "5-STEP-PROJECT ORGANISATION" functionality, aiming to facilitate designers in structuring a project according to the five steps of the "FERTILE" Design Methodology (see Figure 1). The right part illustrates how designers may describe an activity's context. It includes the "ACTIVITY SUBJECT" functionality, enabling designers to define the subject of each activity, whether it is Arts, ER or interdisciplinary. Also, it includes the "ACTIVITY CT SKILLS" functionality, enabling designers to define the CT skills that will be cultivated in each learning activity. Notably, the screenshot depicted in Figure 4 illustrates the guidance provided while determining a particular CT skill. Subsequently, such representation synthesises the "PROJECT OVERVIEW" functionality, describing the interdisciplinarity applied in a project and allowing designers to reflect on how both disciplines are interwoven (note the colouring used for labelling activities: blue for Arts, red for ER, and green for both disciplines).

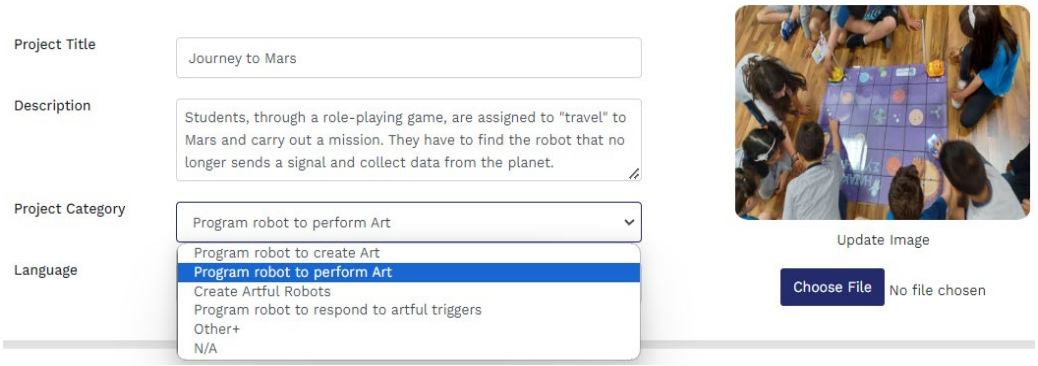

Figure 2: A screenshot of the "FERTILE" Community Platform depicting an Artful ER project's general context description

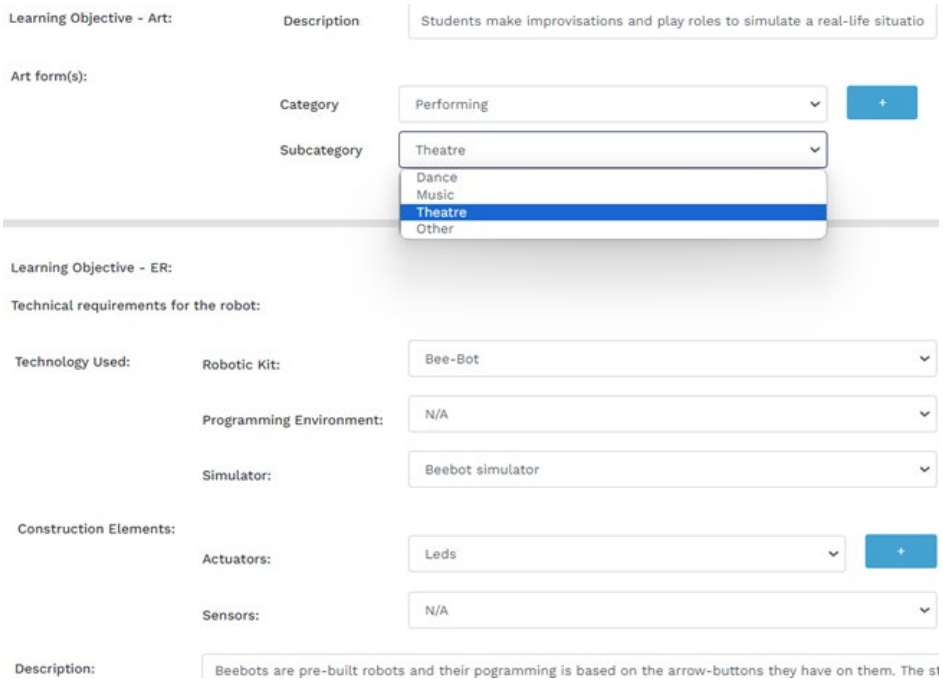

Figure 3: A screenshot of the "FERTILE" Community Platform depicting an Artful ER project's disciplinary context description

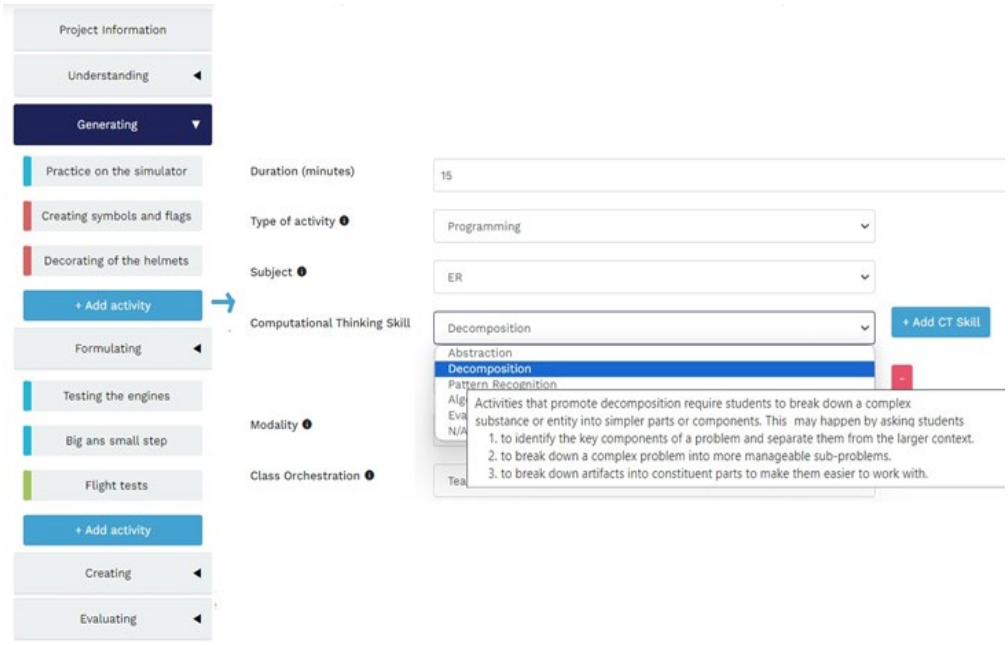

Figure 4: A screenshot of the "FERTILE" Community Platform depicting the representation supported in organising a project, describing an activity's context, and providing an overview of a project

3.3 Research Design, Data Collection and Analysis

To address the research question, "How are educators supported in co-designing interdisciplinary projects through the FERTILE Design Methodology and Community Platform?" we followed a mixed-method research design (Creswell and Plano Clark, 2017), exploring how the participants experienced co-designing projects that integrate ER and Arts in the "FERTILE" Community Platform. We utilised a survey questionnaire to collect participants' perceptions through close-ended questions about the "FERTILE" Community Platform's authoring functionalities reflecting the "FERTILE" Design Methodology's design principles. Also, we triggered participants to comment on their responses to the close-ended questions and provide suggestions through open-ended questions.

To formulate the quantitative feedback, we adopted the Usability Metric for User Experience (UMUX), a model considering usability in terms of ISO 9241-11 and applying four indicators about (1) effectiveness, (2) satisfaction, (3) ease of use and (4) efficiency (Finstad, 2010). In this line, we expressed each close-ended question addressing an authoring functionality as four statements corresponding to the four indicators included in UMUX:

1. "This <functionality> meets my requirements" to indicate perceived effectiveness,
2. "Using this <functionality> is a frustrating experience" to indicate perceived satisfaction,
3. "This <functionality> is easy to use" to indicate perceived ease of use, and
4. "I have to spend too much time designing with this <functionality>" to indicate perceived efficiency.

Each statement is scored on a Likert scale, from 1 (strongly disagree) to 7 (strongly agree). Notably, as the UMUX model requires, the statements were unidimensional. The 1st and 3rd statements were positive-toned, while the 2nd and 4th statements were negative-toned ones. Consequently, the high responses to the positive-toned statements correspond to high usability, while the high responses to negative-toned statements correspond to low usability.

The UMUX provided an excellent alternative to the typical System Usability Scale (SUS) while having a similar high reliability without requiring a minimum number of participants to achieve accurate results (Borsci et al., 2015). Like SUS, we calculated the overall UMUX score per participant for each functionality and then calculated the overall usability (Finstand, 2010) of the "FERTILE" Community Platform's authoring functionalities. Thus, in the findings section, Table 2 presents the average scores and standard deviations of the UMUX score for each functionality and the overall UMUX score.

Furthermore, as suggested by Albo and Hernandez-Leo (2021), the UMUX provided a compact and efficient usability instrument that allowed us to explore the perceived value of each authoring functionality across specific usability indicators. Therefore, we calculated the distribution of participants' responses to the four UMUX statements, presenting this distribution in Table 3. Specifically, Table 3 details the frequency of responses for each UMUX indicator across the authoring functionalities supporting educators in co-designing interdisciplinary projects using the "FERTILE" Community Platform. This detailed breakdown enabled us to assess the usability of authoring Artful ER projects in the "FERTILE" Community platform comprehensively, offering trends of its perceived value as experienced by the participants.

Finally, in the open-ended questions, after translating Greek and Spanish into English, we analysed the participants' responses following a deductive coding process per functionality based on the four indicators addressed in UMUX. Such analysis complemented the quantitative findings, providing insights into the perceived value of each authoring functionality and the participants' suggestions.

4. Findings

First, we determined Cronbach's alpha to be 0.86, which indicates strong internal consistency in measuring educators' feedback (Hulin, Netemeyer and Cudeck, 2001).

Table 2 presents the UMUX scores for each "FERTILE" Community Platform's authoring functionality and overall usability. The average overall score was 86.93 with a standard deviation of 12.49, indicating generally positive usability of the platform's authoring functionalities supporting interdisciplinary co-design. Notably, all functionalities scored close to the overall score, showing high usability across the platform's functionalities. The functionality "Project Overview" stood out with the highest average score of 88.83. However, the higher standard deviations in some functionalities, such as the "Activity CT Skills" (16.18) and "Activity Subject" (15.21), indicate variability in participants' perceptions.

Table 2: The UMUX score for each "FERTILE" Community Platform's authoring functionality and the overall usability

Authoring functionality	PROJECT CATEGORY	PROJECT DISCIPLINARY CONTEXT	5-STEP-PROJECT ORGANISATION	ACTIVITY SUBJECT	ACTIVITY CT SKILLS	PROJECT OVERVIEW	Overall Usability
Average Participants Score	85.98	86.55	86.55	87.50	86.17	88.83	86.93
Standard Deviation	12.63	13.17	13.30	15.21	16.18	14.23	12.49

The distribution of participants' responses in the UMUX indicators per functionality, as presented in Table 3, allowed us to further elaborate on participants' perceptions. The consistently positive trends in all indicators support the high average scores of all functionalities. The "Project Overview" functionality, having the highest average score (88.83), is reflected in distributions in Table 3, showcasing that 63.6% of participants strongly agreed on its effectiveness and the same percentage (63.6%) on its ease of use. On the other hand, functionalities reporting higher variability in Table 2 correspond to more mixed responses in Table 3. For example, 59.1% of participants strongly agreed on the effectiveness of the functionality "Activity CT skills", but a notable percentage (22.7%) questioned its efficiency.

Table 3 shows that most participants expressed positive views on the effectiveness of all functionalities, with approval ratings (5 up to 7 on the Likert scale) ranging from 86.4% to 95.5%. Regarding satisfaction, the participants unanimously found the "FERTILE" Community Platform functionalities to have met their expectations since 100% (1 up to 3 on the Likert scale) disagreed that using them was a frustrating experience. Regarding "Ease of Use" impressions, most respondents indicated that all the "FERTILE" Community Platform's functionalities were easy to use, with approval ratings (5 up to 7 on the Likert scale) ranging from 86.4% to 95.5%. Additionally, more than 80% of respondents perceived the "FERTILE" Community Platform's functionalities as efficient, as indicated by the disagreement ratings (1 up to 3 on the Likert scale) ranging from 81.8% to 90.9% for having to spend too much time using these features.

Table 3: Distribution (frequencies) of participants' responses to UMUX statements

Authoring Functionality	UMUX indicators	Strongly Disagree				Strongly Agree		
		1	2	3	4	5	6	7
PROJECT CATEGORY	Effectiveness	0.0	4.5	4.5	0.0	22.7	18.2	50.0
	Satisfaction	63.6	31.8	4.5	0.0	0.0	0.0	0.0
	Ease of Use	0.0	4.5	0.0	0.0	13.6	27.3	54.5
	Efficiency	36.4	36.4	18.2	0.0	4.5	4.5	0.0
PROJECT DISCIPLINARY CONTEXT	Effectiveness	0.0	4.5	4.5	4.5	4.5	36.4	45.5
	Satisfaction	59.1	36.4	4.5	0.0	0.0	0.0	0.0
	Ease of Use	0.0	4.5	0.0	4.5	13.6	31.8	45.5
	Efficiency	50.0	36.4	4.5	4.5	0.0	4.5	0.0
"5-STEP-PROJECT ORGANISATION"	Effectiveness	0.0	4.5	0.0	0.0	13.6	22.7	59.1
	Satisfaction	59.1	36.4	4.5	0.0	0.0	0.0	0.0
	Ease of Use	0.0	0.0	4.5	0.0	18.2	27.3	50.0
	Efficiency	40.9	31.8	9.1	9.1	4.5	0.0	4.5
"ACTIVITY SUBJECT"	Effectiveness	0.0	4.5	4.5	0.0	4.5	22.7	63.6
	Satisfaction	72.7	22.7	4.5	0.0	0.0	0.0	0.0
	Ease of Use	0.0	4.5	0.0	9.1	0.0	36.4	50.0
	Efficiency	54.5	22.7	9.1	0.0	4.5	4.5	4.5
"ACTIVITY CT SKILLS"	Effectiveness	0.0	4.5	4.5	4.5	0.0	27.3	59.1
	Satisfaction	68.2	22.7	9.1	0.0	0.0	0.0	0.0
	Ease of Use	0.0	4.5	4.5	0.0	22.7	27.3	40.9
	Efficiency	54.5	22.7	9.1	4.5	4.5	4.5	0.0
"PROJECT OVERVIEW"	Effectiveness	0.0	4.5	0.0	4.5	0.0	27.3	63.6
	Satisfaction	68.2	27.3	4.5	0.0	0.0	0.0	0.0
	Ease of Use	0.0	4.5	0.0	4.5	0.0	27.3	63.6
	Efficiency	50.0	27.3	4.5	13.6	0.0	0.0	4.5

The content analysis of the open-ended questions provided insights into participants' perceptions (labelled ESx or GRx as participants of the Spanish or Greek groups, respectively). Regarding the "project category" functionality, the participants asked for "more project categories" (ES5).

Aligning with the highly perceived effectiveness of "the project disciplinary context" functionality, the participants deemed that "it provides a design that is well-oriented" (ES5) and that "All art forms and robotics technologies are included" (GR1). Furthermore, the participants reported that this functionality was "intuitive" (ES10) and "simple" (GR3), thus clarifying its high ease of use ratings. Lastly, the high-efficiency ratings of the "project disciplinary context" functionality are interpreted by quotes such as "allows making projects that cover several areas" (ES8).

Regarding the "5-step project organisation" functionality, the participants found "the proposed steps to be adequate" (ES5) and "appropriate for collecting project characteristics" (ES8), reflecting its high usability score. However, some participants expressed being "perplexed while distinguishing the steps a project should follow" (ES4), indicating their need for guidance.

The participants appreciated the "guidance to describe an activity" (ES8), explaining the high satisfaction and effectiveness ratings of the "Activity Subject" functionality. Although the participants appreciated "selecting the CT skills" (GR1), they commented that "skills separation is not distinct" (GR7), which explains the variability in the effectiveness and efficiency scores for the "Activity CT skills" functionality.

The participants reported that "it is rewarding to see the design take shape" (ES4) through the "Project Overview" functionality" and that it provided "a distinguishable format" (GR8), which provides insights into the high satisfaction and effectiveness ratings.

5. Discussion and Conclusions

To address how educators of different disciplines are supported in co-designing interdisciplinary learning through the authoring environment of the X Community Platform, we conducted a pilot study with 22 Greek and Spanish educators. Following a mixed research design, we explored their perceptions regarding functionalities supporting them to co-design Artful ER projects. The quantitative and qualitative strands adopted four indicators of the UMUX usability scale: effectiveness, satisfaction, ease of use, and efficiency.

The findings indicate high usability for the "FERTILE" Community platform's authoring functionalities, with consistently positive educators' perceptions. The findings' strong internal consistency, coupled with the overall high usability score, demonstrate that the platform's functionalities support interdisciplinary co-design.

The participants responded favourably to two functionalities, allowing them to describe an Artful ER project's context by providing each discipline's context and interweaving both disciplines through a project category. The high level of perceived effectiveness indicates that scaffolding disciplinary elaboration (e.g., Art forms and robot technical requirements in the case of Arts and ER disciplines) and systematising interdisciplinary context (e.g., through project categories) may trigger educators' mutual understanding. Participants proposing to consider more project categories highlight that such practices may promote a synergetic combination of discipline-oriented viewpoints and tackle the disciplinary boundaries reported in educational research (see Warr and West, 2020; McCance and Blanchard, 2024).

Furthermore, the high perceived efficiency and insights about supporting diverse interdisciplinary projects are noteworthy. The participants endorsed two functionalities integrated into an activity's context description, triggering educators to specify the activity's disciplinary or interdisciplinary subject and the CT skills to be cultivated through predefined lists. The endorsement of their effectiveness suggests that the high contextualisation level and degree of guidance are adequate practices for communicating design ideas across disciplinary boundaries. Notably, the participants' request for further guidance on defining CT skills showcases their interest in further exploring the "FERTILE" Design Methodology's introduction of CT skills as interdisciplinary learning's primary outcome, reconsidering the typical discipline and subject-oriented learning outcomes (Stentoft, 2017).

The participants' feedback indicated the value of the "FERTILE" Design Methodology's 5-step sequencing as an adequate method to organise interdisciplinary learning. The perceived value was twofold. On the one hand, the participants praised its effectiveness in structuring an Artful ER project through the representational organisation applied in the "FERTILE" Community Platform. However, they required guidance in distinguishing the steps a project should follow to be fully satisfied. On the other hand, the representational format applied in the "FERTILE" Community Platform was praised for its effectiveness in providing a distinguishable project format.

The participants were also satisfied with this comprehensible overview, which allowed them to reflect on how both disciplines are interwoven.

Although the limitations of this research refer to the small sample of participants, it provides us with a preliminary evaluation of the "FERTILE" Community Platform prototype and its design rationale based on the "FERTILE" Design Methodology. There is conspicuous evidence that the "FERTILE" Community Platform supports educators' collaboration in designing interdisciplinary learning through the design principles of the "FERTILE" Design Methodology and their representation in the "FERTILE" Community Platform. The insights collected through this pilot study allow us to further elaborate on refining the "FERTILE" Community Platform. To this end, we intend to reinforce interdisciplinary co-design by facilitating educators to interweave disciplines as project categories and further the "FERTILE" Community platform with a functionality providing guidance on adopting CT skills as the primary outcome of interdisciplinary learning.

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Microlearning: Innovative Digital Learning for Various Educational Contexts and Groups

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Abstract: Microlearning brings a number of advantages that make it an attractive tool for education. Short and clear lessons minimize the risk of information overload, promote better understanding of the material, and enable quick and easy retention of information. The relevance of microlearning lies in its ability to respond to current educational needs and trends. Microlearning is considered to be a flexible, effective and innovative approach to learning that can be successfully applied in different learning environments, for different learning content and to different target groups. The aim of the research is to describe the impact of microlearning modules on the level of learning outcomes and perceived effectiveness in different target groups. Our research focuses on examining the effectiveness of microlearning on lower secondary school pupils, secondary school students and librarians. In the context of lower secondary schools, specific microlearning units thematically focused on programming and working in Scratch will be presented. This part of the research was carried out using an experiment and a questionnaire survey. In the experiment, the effectiveness of this type of teaching and digital learning materials was investigated. The experiment was conducted in parallel classes of a lower secondary school, and the participants were pupils aged 11 to 12 years old. The aim of the questionnaire survey was to find out the probands' opinions about microlearning. In the context of secondary schools and learning librarians, we conducted a survey of available materials and microlearning modules. In this paper we will introduce general concepts and strategies, with more detailed descriptions of specific modules to be published later. This paper aims to contribute to the growing awareness of the importance of microlearning as an effective educational tool and highlights its potential in different educational settings, especially lower secondary schools, thus providing useful material and inspiration for educators. The results suggest that the implementation of microlearning in lower secondary school settings has led to improved student learning outcomes.

Keywords: Microlearning, Lower secondary school, Pupils, Programming, Experiment

1. Introduction

Since the beginning of the 21st century, there has been an immense increase of the use of digital technologies in education. Developing of new technologies and methods in teaching has been significantly influenced by outbreak of the Covid-19 pandemic in 2020. During the precipitous situation in spring 2020, teachers as well as pupils were pushed to distance learning, which led to use of various platforms providing suitable educational environment. In the Czech Republic, MS TEAMS, Google Classroom (GSuite) and Zoom were used the most, considering the first two as the main environments, because they allow creating individual groups, online blackboards, assigning and evaluating tasks, bult-in applications etc. (Ferdiánová et al. 2021).

Using these platforms both in synchronous and asynchronous teaching appears to be one of the elements in the process of individualizing education needs. For teachers, it is sometimes difficult to cover the diversity of learning needs of all pupils during the problem-solving process. However, general curricula documents in the Czech Republic, e.g. Framework Educational Programme for Basic Education or Framework educational programme for Secondary General Education, demand that teachers should consider specific needs and potential of each pupil, apply differentiation and various patterns of the educational process when achieving the objectives of the given level of education. (MŠMT 2023; MŠMT 2007) These principles thus should be followed when preparing any learning unit.

Moreover, when preparing any learning unit, each teacher, regardless of the subject he or she teaches, should choose such methods and ways which are the most effective and time efficient. As the various educational platforms can be considered as didactic aids which allow us to distribute visual media easily, based on Petty

(2006) visualisation seems to be an effective way for supporting required differentiation. He states that our brain receives 87 % of information by visual perception, 9 % by hearing and 4 % are left for other senses. He also mentions that visualisation is beneficial because it draws attention, supports understanding and remembering.

It is also important to consider the amount of information a teacher wants to address to pupils. As the attention span descends with the duration of the activity, the best option is to use only a small amount of information. Thus, a microlearning can be offered as an effective option.

1.1 Microlearning

Nowadays new teaching strategies and instructional design can assist teachers in teaching and align with students' and pupils´ (learners´) learning preferences at all levels of schools (Rotellar and Cain 2016). From this point of view, microlearning draws upon several theoretical frameworks, including cognitive load theory (Sweller 2011), spaced repetition (Piche 2019), and constructivism (Bransford and Schwartz 1999). The teaching method of microlearning provides learners more regularly the learning task with small, manageable chunk of information (Aldosemani 2019).

According to Maddox (2018) is microlearning

- an approach to learning that process the information about a single, specific idea in a compact and focused manner,
- and also, the learning technique that operates within the learner's working memory capacity and attention span, providing just enough information to allow the learner to achieve a specific, actionable and reachable goal.

According to Leong et al. (2021) microlearning enables learners to gain new knowledge or skills just in time to meet their immediate needs in this fast-changing world; in addition, microlearning can also help these learners to achieve a specific, actionable task.

Microlearning uses in the educational process short learning activities with microcontent (Hug 2007). This art of teaching and learning is realized through small learning units and short-term educational activities. In some organisations microlearning modules are used to deliver just-in-time training on specific tasks or procedures (Kapp 2012). Microlearning belongs to research paradigm intended to explore new ways of responding to the increased need for self-directed, lifelong, and informal learning based on learning on demand. Microlearning was developed for the purpose to focus less on new technologies themselves and more on individual needs of learners (Buchem and Hamelmann 2010). According to Taylor and Hung (2022) along with the interest in microlearning is the assumption that creating more microlearning courses will address challenges in education in educational institutions of all stages. They argue also that the assumed reasoning is that by providing shorter and more focused content according to need, the information is easier to consume and retain from the learners´ perspective. Kapp and Defelice (2019) suggest that microlearning offers numerous benefits, including increased learner engagement, improved knowledge retention, and greater flexibility in learning delivery.

This paper is one of three parts of a larger research project supported by the University of Ostrava. The aim of the full project is to map in detail the effect of microlearning on three different target groups: lower secondary school students, secondary school students and adults in the form of library staff. This paper shall present the section focused on lower secondary school schools. The topic of teaching programming with a focus on working in Scratch was chosen for this part.

1.1.1 Microlearning in lower secondary schools

Microlearning has not been extensively researched in lower secondary school settings, with most of the research primarily being focused on university settings. With the new era of modern technology and the modernisation of teaching at all levels of education, but especially the impact of the Covid-19 pandemic, elements of microlearning are also appearing in lower secondary schools. Therefore, we decided to explore this area, to test the potential of microlearning and the possibilities of its use in the lower secondary school environment.

Prior to the Covid-19 pandemic, this area was addressed by Mohammed et al. (2018). The study concluded that students using microlearning had 18% better learning results compared to regular classes. Since then, however, the situation has changed somewhat and, e.g., videos with a maximum length of 6 minutes, as reported by Mohammed et al. (2018), are already considered long by today's standards, and students cannot keep their attention focused on one video for such a long time. ALshammari (2024) in his study about teaching programming argues, that teachers who use video-based microlearning can expect to see their students develop better programming skills and have a more positive attitude towards learning. It is important to note that the

effectiveness of microlearning may vary depending on the type of microlearning used, the students‘ learning style and the way that microlearning is integrated into the curriculum.

1.1.2 Microlearning in secondary schools

Microlearning in secondary schools (as well as in primary schools) is not a common way of transferring knowledge and skills, and its effect on this target group is not described in detail. However, there are studies that look at the effect of microlearning on students' motivation and learning outcomes in science, but not in the form of a sub-continuous course (Nikou and Economides 2018). With regard to the ongoing trends of digitisation and the introduction of new computer education and building digital competences at all levels of education, the use of appropriate software also has the great advantage of increasing the clarity and dynamism in solving a given problem and the related increase in the knowledge level of pupils and students. The aim of the microlearning course will be to create and validate complex problem sets of selected topics in geometry at secondary school based on the principle of microlearning (i.e. covering a specific need in a short time). The contribution of such tasks will be evaluated in relation to e-learning and traditional teaching without the dominant role of digital technologies.

1.1.3 Microlearning in librarian education

The Standard for a Good Library (Národní knihovna České republiky - Knihovnický institut 2020a) emphasises the need for continuing education for librarians, but according to Pillerová (2022), the current supply of educational programmes lags behind, especially in the area of new technologies. With the transformation of libraries into learning centres (Národní knihovna České republiky – Knihovnický institut 2020b), the requirements for librarians' competencies are increasing, which has led the American Library Association (2017) to define the concept of the ‘teaching librarian’ – a librarian with tutoring knowledge and skills and the ability to transfer knowledge to different target groups. The National Library of the Czech Republic is responding to these challenges by building a team of learning librarian-internal tutors who focus on developing digital and tutoring skills. The upcoming microlearning course aims to strengthen these competencies and support the role of librarians in educating library users.

2. Methodology

We decided to primarily design our research as a quantitative research and chose the method of pedagogical experiment. In the experimental groups, we used a questionnaire survey to investigate the students’ opinion about microlearning and the evaluation of experimental learning. Our research sample consisted of students in one lower secondary school aged 11 to 12 years. Specifically, we worked with three parallel classes. One class served as a control; here we refer to it as the CON group (17 students). The other two classes were experimental – we used a created infographic and a quiz as microlearning elements. The goal of the infographic was to make the material visually appealing and allow students to learn at their own pace. The purpose of the quiz was not only to motivate the students, but above all to contribute to a greater learning of the material through repetition and thus extend the memorisation time. In the first of the experimental groups, the pedagogical experiment was conducted for four lessons. We shall refer to this class as group EX1 (23 students). In the second class, the pedagogical experiment took place in only two lessons, this class will be referred to as group EX2, with a total of 16 students present. This pedagogical experiment was implemented during the second semester of the 2023/2024 school year.

For our research we set four research questions:

RQ1: Does teaching with microlearning elements lead to better learning outcomes than traditional face-to-face teaching?

RQ2: Does the duration of teaching with microlearning elements have an impact on student achievement?

RQ3: What is the students’ opinion on the use of microlearning elements in the classroom?

RQ4: What is the opinion of the students about the implemented microlearning?

The third and fourth questions are descriptive, so we have not set any hypotheses here. The first two questions are causal and we established the following hypotheses based on them:

> *H1: Teaching with microlearning elements does not lead to better learning results than traditional face-to-face teaching.*

H2: The duration of teaching with microlearning elements does not affect the students' learning outcomes.

2.1 Apps Used

To design and implement our pedagogical experiment, we primarily worked with four main applications and platforms. The first was the Google Classroom application, which was used to organise our lessons. The second application we worked with was Scratch, an application that allows students to learn the basics of programming. This application was primarily used by students, where they had to create a program according to a task. For review and practice purposes, we created a quiz in Blooket consisting of 32 questions. Using Canva, we created a total of four infographics representing the overarching theme of programming, three of which are shown in Figure 1.

The first infographic contained theoretical information related to algorithmisation and programming, explaining the concepts and differences between them. The second infographic contained brief instructions for students on how to register for the Scratch platform. Screenshots directly from this application were used. The third infographic was a description of the Scratch user interface. The fourth infographic contained 5 basic activities that can be used in Scratch. This infographic was made up of five short videos that served as a simple guide for the students.

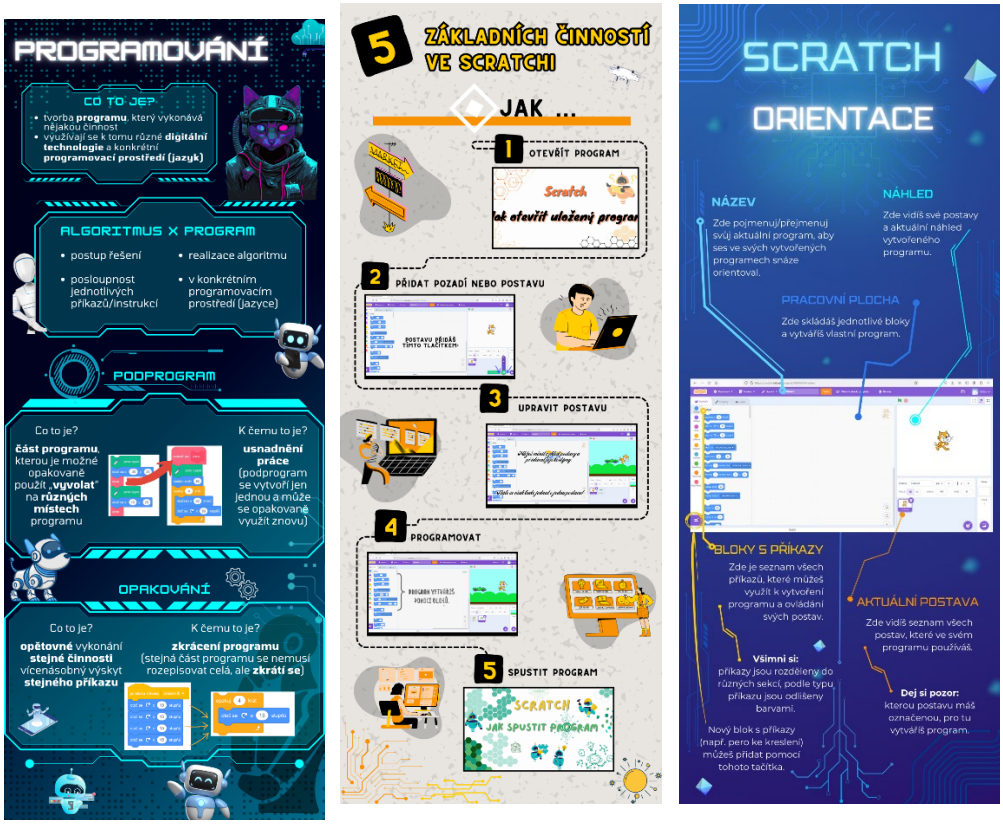

Figure 1: Samples of three infographics

The acquired knowledge was measured via a pre-test and post-test. In terms of the type of questions, we chose mostly closed-ended questions with one correct answer. One question contained a choice of four answers, four questions contained a choice of three answers, and four questions contained a choice of two answers, where students were asked to determine whether the answer was true or false. One question contained an open-ended answer.

At the end of the experiment students completed an evaluation questionnaire. Each questionnaire contained five separate questions comprising four open-ended and one closed-ended question with the possibility of marking multiple answers. In addition, the evaluation questionnaire contained 10 Likert scale questions for the students. In the case of the teacher evaluation questionnaire, it contained 13 Likert scale questions.

2.2 The Course of the Pedagogical Experiment

The implemented pedagogical experiment took place in the EX1 group during four lessons and comprised two two-hour teaching blocks. In the CON and EX2 groups, it took place in only two lessons. One lesson was 45 minutes long. Each lesson was conducted in a computer lab using tandem instruction, which is common in these classes.

Classes in group EX1 started with completing the pre-test. Then the infographics were shared with the students via Google Classroom. Students registered for Scratch and learned about its features at their own pace. At the beginning of the second lesson, the students were given a simple task to add characters, change the background, costume and create a movement program for each character. Thanks to the infographics, each student could choose their own pace, order of learning and completion of tasks. The third lesson involved a summary. The students then practised their knowledge using the Blooket app. The game Fishing Frenzy was selected and the time set to 7 minutes. They were then given a new task (to draw geometric shapes). To conclude, they completed a post-test and an evaluation questionnaire.

Teaching in the EX2 group was carried out in a similar way. In the first lesson, students completed a pre-test and were provided with infographics. Students registered for the application and familiarised themselves with how it works. In the second lesson, the students were given an assignment. This was followed by a retake using Blooket, completing a post-test and an evaluation questionnaire.

In the CON group, the teaching was carried out in a traditional way. After the completion of the pre-test, there was an explanation of the material, followed by an introduction of the Scratch application. Students then registered for the application and worked on the task. Finally, students completed a post-test.

3. Results

If we compare the work in the classroom and the activity of the students between the different groups, the use of the created microlearning materials leads to greater independence of the students. Students in the experimental groups were less likely to ask teachers if they did not know and much more likely to look up the information themselves in shared infographics. The students were also interested in the topic itself and in all groups they tried to discover the features offered by Scratch. In the control group, the students were less focused during the explanation of the material, as a result of which they remembered less of the material.

3.1 Comparison of Study Results

In order to compare the effectiveness of our proposed microlearning materials, we used knowledge-based pre-tests and post-tests. These tests were identical in all groups studied. In Figure 2 you can see the comparison of pre-test and post-test results in all three groups according to the number of points obtained by a given number of students in one group.

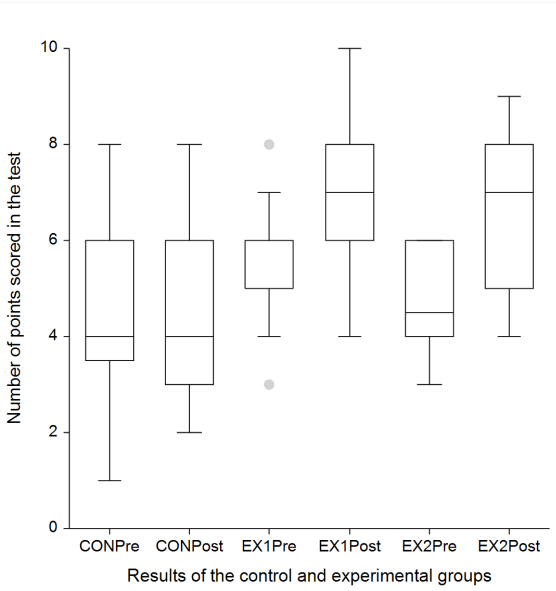

Figure 2: Comparison of pre-tests and post-tests of all groups (CON-control group, EX-experimental group, Pre-pre-test, Post-post-test)

The pre-tests confirmed that the students had not encountered the topic of programming and working in Scratch before. Pre-test success rates were relatively low. When we asked the students afterwards, they confirmed that they had just guessed the questions, so the actual success rate was even lower. Only one student from the CON group stated that he already knew how to use Scratch and one student from the EX1 group had partial knowledge of programming. In Table 1 it is possible to see an illustrative comparison of the characteristics of the data obtained from the pre-tests and post-tests in all three groups studied.

Table 1: Characteristics of the obtained data

Statistic	CONPre	CONPost	EX1Pre	EX1Post	EX2Pre	EX2Post
Count	17	17	23	23	16	16
Mean	4.588235	4.764706	5.478261	7.173913	4.75	6.6875
Standard Deviation	1.804814	1.75105	1.238385	1.40299	1.125463	1.662077
Standard Error	0.4377317	0.424692	0.2582211	0.2925435	0.2813657	0.4155193
Shapiro-Wilk W Normality Test (p-value)	0.8076	0.2348	0.2587	0.1259	0.0065*	0.1248

*) Significance level $\alpha = 0.05$

Table 2 summarises the results of the statistical tests for H1 and H2. The first hypothesis had to be split into two sub-calculations due to the existence of two experimental groups. For both comparisons of the post-test results of the control group (CONPost) with the post-tests of the experimental groups (EX1Post and EX2Post), a statistically significant difference was found using a two-sample t-test. The difference between the post-test results of the experimental groups is not statistically significant.

Table 2: Two-sample t-test

Hypothesis	Representation of the hypothesis	p-value
H1	CONPost – EX1Post	.00002*
	CONPost – EX2Post	.00292*
H2	EX1Post – EX2Post	.32991

*) Significance level $\alpha = 0.05$

3.2 Comparison of Student Motivation

Based on the evaluation questionnaires, we also obtained feedback from the students on the developed microlearning materials, see Table 3. Both experimental groups rated the microlearning materials as easy to understand and partly attractive in appearance. In both groups the opinion that this way of teaching was more enjoyable than classical teaching was clearly prevalent. Students also often reported that the materials they created contributed to a greater understanding and better retention of the material.

Table 3: Students' opinions on the implemented microlearning

Evaluation of microlearning elements by students	Definitely agree	Partially agree	Can't decide	Partially disagree	Definitely disagree
The created materials contributed to a greater understanding of the subject matter than in regular teaching.	15.4%.	53.8%.	20.5%.	5.1%.	5.1%.
I enjoyed working with the created materials more than in regular teaching.	33.3%.	33.3%.	20.5%.	10.3%.	2.6%.
The materials contributed to better retention of the material than in regular teaching.	28.2%.	30.8%.	25.6%.	10.3%.	5.1%.
I found the created materials easy to understand.	23.1%.	28.2%.	23.1%.	15.4%.	10.3%.

Evaluation of microlearning elements by students	Definitely agree	Partially agree	Can't decide	Partially disagree	Definitely disagree
I found the created materials visually appealing.	33.3%.	28.2%.	28.2%.	5.1%.	5.1%.

Evidence that this activity was highly motivating to the students is the fact that the entire class required repetition of the activity after the activity was completed, in both experimental groups. On the other hand, in the control group, students were not very interested in the theoretical part of the curriculum. There was also a lack of a section to practise the material, which was highly motivating in the experimental groups, but above all contributed to a better retention of the material. As for the feedback from the CON group, 6 students did not enjoy the lessons, 8 found them challenging.

3.3 Student and Teacher Views on Microlearning

In the groups studied, we wanted to know the students' opinion about this form of teaching. Most of the students liked this way of teaching more than regular teaching and would like to use it more often in computer class and other subjects. They expressed similar views on the use of these types of educational materials in teaching. Some students also said that this way of teaching helped them to understand the material better. Some students reported that they liked the microlearning because they did not have to make notes in their exercise books, some reported that they understood the material more, it was easier for them, they learned more material in less time, it was more comfortable and fun for them, and they appreciated the smaller amount of text and practice. Other students saw the positive side of microlearning as the actual use of technology in teaching. We were also interested in what type of educational materials the students prefer. Most students (29) chose the option of educational games, followed by pictures (25) and 21 students chose short videos. Surprisingly, 19 students found the traditional text to be suitable, provided it is concise and clear. 22 students chose quizzes and 12 students chose other educational applications. Only 10 students chose audio (podcasts) and 5 students chose infographics.

We also received feedback from two teachers present at these lessons. Both of them are experienced teachers who have been teaching at this school for many years. They evaluated the microlearning materials as understandable and engaging in appearance, but at the same time they wondered whether the graphic elements could distract students from the substance of the material if used excessively. They also felt that the microlearning elements used could have contributed to a greater understanding of the material and its easier retention. They generally deemed microlearning a good way to enhance learning and motivate students, but they also stated: "It should not be used in every lesson so that there is a change of methods and forms of teaching." They consider short videos, educational games and concise and clear text to be the most effective types of educational materials in microlearning. They also added: "The text should be short and clear." They cited the baby-steps-style process as the biggest advantage of microlearning. This principle of teaching was well-received by both teachers. They mentioned geography and science as other subjects suitable for this type of teaching.

4. Conclusion

The biggest problem that teachers in the selected lower secondary school encounter across all forms is low reading literacy, which is confirmed by the results of the Czech School Inspectorate survey (2024) and international PISA surveys (Boudová et al. 2022). Students do not only read assignments and other materials available to them in computer science classes. Therefore, it was important to overcome this problem for the implementation of our pedagogical experiment and to constantly refer students to these materials. It is therefore important not to overwhelm students with a large amount of text. The graphic aspect of the materials created, whether it is an infographic or a classic presentation, is the fundamental motivational element; this was confirmed by the students themselves.

Based on the data obtained, we could reject the null hypothesis H1: Teaching with microlearning elements does not lead to better learning results than traditional face-to-face teaching. At the same time, we cannot reject the null hypothesis H2: The duration of teaching with microlearning elements does not affect the students' learning outcomes. Thus, microlearning leads to better learning results than traditional face-to-face teaching and the length of classes does not affect student learning results. Microlearning can therefore not only be used effectively in universities but also in lower secondary schools, as we have verified in our pedagogical experiment. Many different elements of microlearning can be integrated into face-to-face teaching. Its undeniable advantage lies in its motivational effect. It is essential to engage the students and structure the learning experience so that the students have fun while also learning something. One of the best ways is to harness their competitiveness

and incorporate quiz games into the classroom. For this purpose we have found the Blooket app to be very useful, as it is not only based on the principle of competition, but also contains game and graphic elements that motivate students much more. The app also has the advantage of a greater variety of different game types available, allowing you to vary the activities while keeping the same questions created. However, it should be kept in mind that the methods and forms of teaching should be varied and alternated. These activities should not be involved in every lesson so that students do not get bored and have something to look forward to.

Teachers who participated in our pedagogical experiment decided to continue using Blooket to practise various curriculum topics. They also want to use the Canva app at this school, not only to prepare study materials for students, but also for activities and tasks that students could do using the app.

In our further research we will look in detail at the remaining two target groups, for whom we will create new microlearning educational materials and conduct independent pedagogical experiments. We will focus on microlearning in secondary schools and in librarian education.

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Development of Corporate University Evolution Scenarios

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Abstract: In the changing profile of corporate education and learning, corporate universities are a major force for aiding organizations to actively embrace technological change and upgrade their human capital. This study examines how corporate universities adapt their techniques to keep up with fast-changing technology, making the learning process universal yet personalized. This study also examines the linkages between corporate and traditional academic institutions in terms of strategy, aiming to produce a blending of theoretical knowledge with practical skills (Rhéaume & Gardoni, 2015; Prince & Beaver, 2001). Such combinations increase the relevance and applicability of education programs, helping them to achieve greater conformity with business objectives (Singh et al., 2019; Rademakers, 2001; Philipp et al., 2013). Twelve experts from large companies were chosen for two iterative foresight sessions. With this paper, we report the factors, which affecting the development of corporate universities and which were identified and ranked through a survey of experts (Dealtry & Rademakers, 2005; Rademakers, 2004). Moreover, these factors were combined into a matrix of development 15 scenarios, the main risks that could negatively affect the development of this phenomenon were identified and strategies were provided to prevent these threats. This study not only reflects the current trends of corporate university in the company but also lays the foundation for understanding the factors influencing companies' development.

Keywords: Leadership, Leadership in higher education, Innovation, Foresight, Corporate universities

1. Introduction

In the process of organizational evolution, corporate universities are new and rapidly developing phenomenon. Currently, corporate universities are playing a role in terms of competitive advantage, behind which lies a multi-level concept transformed by technology (Singh, V., Verma, S., & Chaurasia, S. S., 2019). Over the past 30 years, interest in the study of corporate universities has increased markedly. The topics addressed in this research include various issues, such as: the organization format of corporate universities in large companies, comparisons with traditional universities, and the integration into company strategy of educational content. However, factors affecting the development of corporate universities frequently vary widely from one set of circumstances to another. Potential development possibilities are things that have received insufficient attention. These points make this work highly relevant.

This article looks at these two topics, showing how companies have to manage specific elements if they want their own corporate universities to become key drivers behind company strategy, this is a need noted in Gardoni's article (Rhéaume & Gardoni, 2015). In addition, the article develops a matrix on development scenarios; identifies which major risks could affect negatively the phenomenon and provides response strategies for prevention and mitigation. All strategies are illustrated using the example of Eastern European IT company as to show the practical significance of these results.

2. Literature Review

Various studies provide an overview of the factors that need to be monitored for a corporate university to remain relevant in changing business environment: (1) strategy and human resources; (2) knowledge management; (3) technology and e-learning (Sherer & Shea, 2005). In support of aforementioned statements, for developing the competitive advantages of corporate universities requires significant resources, documentation of curricula and strategic goals of the company (Rhéaume & Gardoni, 2015).

We are seeing how the learning process continues under many traditional methods, but also embraces advanced digital tools, outsourcing content and design personnel while moving gradually away from formal classrooms into increasingly flexible and personalized learning environments (Alonso-Gonzalez et al., 2018; Furstenau et al., 2020; Djeki et al., 2022). Corporate university deliberately trained programs that develop its graduates to tolerate the absence of orders or prohibitions. It puts them first, strengthening in them imagination and insight. Moreover, surveys show that graduates from corporate universities not only have stronger abilities for self-management and teamwork, but also enjoy faster promotion within the company. More than half of top management positions in American firms come from corporate universities (Meister, 1998; Rademakers & Huizinga, 2000; Blass, 2001), while others doubt it. There are those who see the difficulties of its data base

entering into policy studies after all, and still more actually measure those strategic impacts to find that they are unpredictable in outcome (Garavan, Costine, & Heraty, 1995).

The debate on whether or not corporate universities and traditional higher education institutions are fundamentally alike persists. Corporate universities bring in to focus learning strategies that become part of corporate change and development, while navigating change remains one of the main success factors (Bagrationi & Thurner, 2023; Bagrationi, Thurner & Gordienko, 2021; Bagrationi, 2023). This phenomenon is clear work education, or work-learning, which trains staff while they are still informally at their desks, as opposed to traditional education (Côté & Allahar, 2011). In recent years, corporate universities have begun to affect efficiency and productivity of the organization that spawned them, some researchers suggest that this is a momentous development (Barley, 2007). Yet, some studies, such as those by Nguyen and Fan (2022), argue that corporate education tends to hinder creative thinking and critical ability; whereas its traditional counterpart emphasizes the socialization of individuals into their work and ways of thinking in particular.

There are studies which ignore the cultural dimensions of the corporate university's success in practice, and given that this is an important part of the overall picture, most of them suffer from methodological shortcomings, especially with regard to providing sound evidence linking cause and effect. The literature lacks reliable models to directly test or measure the direct and indirect benefits of corporatized education on an organization (Tan F. Z., Olaore G. O., 2021). There is thus a need for more locally oriented studies which are able to examine distinct cultural, economic and legal contexts from a Vietnamese perspective (Blass, 2007).

Supporting this idea, developing the competitive advantages of corporate universities with a few resources was written up as a real problem by Schaie and Johnson (1998), however, research about it has often been small and narrow in scope. In support of aforementioned statements, for developing the competitive advantages of corporate universities requires significant resources, documentation of curricula and strategic goals of the company (Rhéaume & Gardoni, 2015). However, this topic has not received all the attention it deserves, yet and the Rhéaume's and Gardoni's study also highlighted the need for further research, and that is why this direction is considered promising for research.

3. Methodology

Through two iterations of foresight sessions, the research identified 20 factors influencing the development of corporate universities and narrowed them down to 5 critical ones through expert validation. The study also involved developing scenario matrices for these factors, with practical application using the corporate university of an Eastern European IT company, including risk analysis and the development of response strategies to mitigate these threats.

In this study, 12 experts working in the strategic departments of corporate universities in major companies across various sectors were selected for the foresight session. After calculating the expert competence coefficient K, an analysis was conducted on 20 experts to develop the method and form this expert group (Almenara, J., Romero-Tena, R., & Palacios-Rodríguez, A., 2020). This tool incorporates both objective and subjective competence indicators, which increases the method's accuracy. To facilitate its organization, this analysis should make it easier for us to work with an expert group in the future foresight session and on top of that indicate whose professional opinions are most pertinent to the subject of corporate universities.

The study utilizes the Rapid Foresight method, a modified Delphi technique (Williams, P. L., & Webb, C., 1994), which allows for forecasting potential solutions to the problem in a moderated group communication process among experts.

Experts were divided into 3 subgroups, each led by a separate moderator. The mini-groups were formed based on preliminary distribution in this study. The described session followed the most common sequence, from identifying factors to exploring threats and opportunities, with the project changes forecast (scenario prediction) conducted in the second session.

During the joint plenary of the first iteration of foresight session, the experts put the proposed factors on different time frames. Their influence was divided into near, medium and distant horizons; and they didn't just list future threats but potential interconnections among different factors as well as opportunities.

The proposed indicators were transformed to a Likert scale to find out which factors were most important; this was then put into a questionnaire format for review. In this scale, experts are given six choices for each question — 1 (strongly disagree) to 6 (strongly agree). To confirm the degree of concordance in experts 'opinions, we use Kendall's concordance coefficient, which characterizes the degree of agreement among experts through ranking.

This calculation of the expert concordance coefficient was necessary to assess the correlation and relevance of expert opinions, as previously demonstrated. Based on these data, the experts selected the 5 most important factors using a questionnaire.

During the second iteration of the foresight session, experts proposed three development scenarios for corporate universities for each 5 factors: positive, realistic, and negative, which were consolidated into a comprehensive matrix. In large companies, corporate university plays a more important role than conventional universities. It is also hard in the development phase of expected scenarios for these corporations to avoid potentially large negative consequences caused by this approach. However, while generating factors and subsequently development scenarios for corporate universities, experts also considered the threats at each point that could turn positive scenarios into negative ones.

To assess the cited risks, a risk register was created. The register came from a survey of five employees from the corporate university at a typical Eastern European IT company. Based on evaluation, three matrices were constructed to appraise the impacts of risks on parameters such as cost, quality and time. This instrument helped to identify the 9 highest-risk factors for the subject.

In order to offset these risks, response strategies were formulated and generalized recommendations for reducing them were put forward.

4. Results

Thus, as part of the research, following the first iteration of the foresight session with 12 experts, 20 factors influencing the development of corporate universities were identified, with experts' qualifications confirmed by the K coefficient. The results of the calculations of the expert competence coefficient are shown in Table 1.

Table 1: Determination of the expert competence coefficient

Expert	Coefficient of subjective assessment of competence (K_s)	Coefficient of objective assessment of competence (K_o)	Coefficient of assessment of competence (K_i)
№1	7,375	0,095	0,700625
№2	6	0,11	0,66
№3	7,75	0,06	0,465
№4	5,875	0,085	0,499375
№5	8	0,07	0,56
№6	8	0,135	1,08
№7	6,375	0,035	0,223125
№8	8,625	0,18	1,5525
№9	8,25	0,065	0,53625
№10	7,25	0,04	0,29
№11	7,5	0,075	0,5625
№12	8,125	0,14	1,1375

Maria Zinchenko, Konstantin Bagrationi, Olga Gordienko

According to the methodology (Almenara, J., Romero-Tena, R., & Palacios-Rodríguez, A., 2020), this study involves 4 highly qualified experts, 6 specialists with medium to high expert competence coefficients, and 2 junior experts.

As a result of the foresight session, 46 factors were proposed: 21 from the first group of experts, 12 from the second, and 13 from the third. After outlier cleaning and joint analysis for semantic repetitions, the number was reduced to twenty.

During the session, the experts put the proposed factors on different time frames. 14 factors are on the near horizon of the future, meaning they are currently in various stages of active development and are expected to have a significant impact by 2025. These factors include: the implementation of artificial intelligence trainers in education; product practices from other companies in the external market; following trends and new teaching methods; adapting education to a blended format (online & offline); motivating employees to learn;

implementing a buddy system in training; customizing education to the company's processes and technologies; promoting the value of education at the company level; showcasing the importance of learning through top management examples; rapid creation of educational courses tailored to company needs; convergence of traditional universities and corporate universities; company employees teaching at universities; competition with external universities and the free course market; and results of team-barometer surveys.

Two factors are on the medium horizon, expected to develop by 2030: personalization of content and training primarily tailored to the corporate culture of the company.

The last four factors—implementing training for specific new tools in the company; positioning work and learning as inseparable processes; focusing employees on self-development; and developing meta-skills among employees—are on the distant horizon of 2035.

In order to define the most influential factors, a Likert scale was used, with the help of which experts selected the 5 most significant factors, with which further research was conducted. In this instance, the following five subjects received highest marks: adaptation of training to a blended format (online & offline) influences the development of corporate universities – 69 points; positioning work and learning as inseparable processes influences the development of corporate universities – 68 points; employee motivation for learning influences the development of corporate universities – 65 points; content personalization influences the development of corporate universities – 65 points; customization of training to the company's processes and technologies influences the development of corporate universities – 64 points.

The collected data were validated using Kendall's concordance coefficient: $W = \frac{14985.5}{\frac{1}{12}\times 12^2(20^3-20)-12\times 1366.5}$ = 0,19, this indicates a low level of agreement among the experts' opinions. The supposed reason for this fact is that the experts were selected from different fields, each with its own specific characteristics. However, in order to confirm or reject the hypothesis of expert agreement and in particular the significance level coefficient, Pearson's concordance index must be calculated: $x^2 = \frac{14985.5}{\frac{1}{12}\times 12\times 20\times(20+1)+\frac{1}{20-1}\times 1366.5}$ = 43.05. The calculated x^2 must be compared with the tabulated value for the degrees of freedom K = n-1 = 20-1 = 19 and at a given significance level α = 0.05. Since the calculated x^2 43.05 ≥ is greater than or equal to the tabulated value of (30.14353) [34], W = 0.19 is a significant coefficient. The ranks are consistent at the given significance level, thus the obtained results and the small value of the concordance coefficient are meaningful, and the hypothesis of a statistically significant relationship between the variables is accepted.

The second stage of the foresight sessions produced 15 different alternative development scenarios between corporate universities: for each of the 5 factors identified earlier optimistic, pessimistic and realistic (Table 2)

Table 2: Generalized development scenarios matrix for corporate universities

Factor	Optimistic Scenario	Realistic Scenario	Pessimistic Scenario
Adaptation of training to a blended format (online & offline)	Scenario 1.1: Growth of distributed teams, balanced integration of online and offline programs, combination of synchronous and asynchronous (self-directed) learning.	Scenario 1.2: Dominance of one format over the other, development of separate online and offline groups for training.	Scenario 1.3: Poor development of the online format, low engagement of online employees, decreased focus of online participants.
Positioning work and learning as inseparable processes	Scenario 2.1: Continuous and rapid learning, increased employee awareness, mechanism for assessing skill improvement.	Scenario 2.2: Development of a totalitarian regime of integrating training into work, training as part of the job description, creation of required courses post-review.	Scenario 2.3: Devaluation of training, employee resistance, rejection of routine processes without achievements.
Employee's motivation for learning	Scenario 3.1: Increased employee interest, mentorship and buddy system, mutual assistance and deep immersion in learning.	Scenario 3.2: Development of employee vision to understand their true motivation, awareness of development prospects.	Scenario 3.3: Dominance of monetary motivation, lack of desire to learn without incentives, motivation driven by management, sanctions for not attending courses.
Content personalization	Scenario 4.1: Individual courses tailored to personal preferences, use of AI, recommendation algorithm.	Scenario 4.2: Long-term development of a platform for selecting personalized content, high workload on the HR	Scenario 4.3: Poor platform development, unsuitable personal recommendations, low content relevance.

Factor	Optimistic Scenario	Realistic Scenario	Pessimistic Scenario
		department, prolonged automation process.	
Customization of training to company processes and technologies	Scenario 5.1: Employees quickly adapt to new tools in the company, courses tailored to specific company needs, external market courses adapted to the company culture.	Scenario 5.2: Mixed format of corporate university work and external market courses, balance of in-house educational courses and external market courses.	Scenario 5.3: Corporate university purchases courses from the external market without adapting them to the company culture, programs are not popular among employees.

Maria Zinchenko, Konstantin Bagrationi, Olga Gordienko

During the session, experts also considered the threats at each point that could turn positive scenarios into negative ones. 15 risks were identified: (1) low employee engagement in online training within a blended format; (2) drop out from courses during training; (3) lack of adaptation of external market training to organizational specifics; (4) outdated educational content in the corporate university; (5) drop in internal employee motivation for learning due to material and non-material rewards; (6) simplification of content in educational programs for conducting courses in a blended format; (7) rejection of long-format training and large conferences by employees due to the trend for quick and short training programs; (8) poor selection of materials in the corporate university due to a bad structured program database; (9) competition with external market courses; (10) high financial costs for customizing training to the company's processes and technologies; (11) decreased work efficiency and increased time for completing tasks; (12) wrong use of artificial intelligence in educational programs, requiring content validation and verification; (13) mismatch between the educational courses offered by the corporate university and the expectations and needs of employees; (14) difficulty in assessing the development of employees' soft skills; (15) lack of motivation among employees to perform routine tasks that do not teach them new skills.

In order to select the most dangerous of these risks, these threats were ranked. As a result, the most dangerous risks are: (1), (2), (3), (4), (8), (9), (10)(11) and (13). In order to offset these risks, response strategies were formulated and generalized recommendations for reducing them were put forward. These include: conducting a thorough analysis of employee motivation before launching courses; integrating training with the company's existing tasks and goals; effectively monitoring course adaptation to the company's current process; regularly updating established courses to suit the requirements of company demand in educational programs designing a detailed curriculum for each program and integrating it into staff work schedules setting clear criteria which specify where in the corporate university learning materials are to be acquired; analyzing trends and educational courses from the external market to gather best benchmarks; creating a gamification system to enhance online employee motivation; integrating the corporate university with major traditional universities; and validating artificial intelligence to generate relevant content for the corporate university.

Another significant result of the research is its practical value: all threats identified could be discussed in terms of an Eastern European IT company's corporate university, and risks were thus determined. For the most critical risks strategies and proposals for response were developed.

5. Discussion

In order to fully consider the results, it is necessary to fit them into the body of existing works written on the topic of corporate universities, comparing the findings with those made by scholars earlier.

For example, a Boston Consulting Group (BCG) report states that one of the main success factors for the long-term existence of a corporate university is (1) **an implementation model** that helps to create a learning environment in line with the needs of the organization (BCG, 2013). The highlighted factor is confirmed by this paper, as many of the factors identified by the experts during the first iteration of the Foresight session relate specifically to the tendency to match the needs of employees and the organization with the creation of educational programs, such as: training adapted to the company's corporate culture, implementation of training for point new tools in the company, personalization of content, customization of training for processes and technologies in the company. Moreover, the Vanderbilt University study states that (2) **meta-skills** - basic human qualities, on the basis of which all other skills are formed - are an important component of quality deep learning (Smith, B., & Brame, C., 2014), which was confirmed by the results of the first iteration of the Foresight session, where the development of meta-skills also became one of the factors for the successful development of a corporate university in the company.

The scenario generation process also revealed that (3) **the use of artificial intelligence** is currently at an early stage of development, resulting in irrelevant content selection for employees (scenario 4.3), but a BCG article states that the use of artificial intelligence tools, to create personalized content allows corporate universities to offer more relevant learning materials, which helps to improve learning effectiveness (Silvio Palumbo, Mario Simon, Will Cornock, Chris George, Yohei Shoji, 2021). During the discussion of the scenarios, an important clarification emerged: this content must be both qualitatively validated and moderated in order for it to remain relevant. One of the scenarios derived from the second phase of the Foresight Session is also (4) **employee resistance to change** (scenario 2.3), which supports the hypothesis from Gardoni's study, which states that there are organizational barriers to learning among employees in a corporation that include internal resistance to change and difficulty integrating external ideas into the corporate culture (Rhéaume & Gardoni, 2015). Resistance to change constitutes a major factor in change management (Aksiutin et al., 2022; Bagrationi, Volkov, 2022; Thurner & Gordienko, 2022). Authors, such as Burnes (2011), speak of a staggering 70 per cent of all change initiatives that fail. Evidence to support this claim is weak, especially as only a few contributions build on own data analysis (Burnes, 2005; Bagrationi & Thurner, 2020). The pessimistic scenario 1.3, which describes the negative situation of online format development, correlates with the results of a study that states that the implementation of blended learning faces (5) **technical difficulties**: lack of competencies among faculty and staff in the use of technology, and problems in accessing the necessary resources and activities during the workshop (Ashraf, M. A., Mollah, S., Perveen, S., Shabnam, N., & Nahar, L., 2021).

6. Conclusion and Further Recommendations

As a result of this study, the following tasks were accomplished: within the foresight session's first committee iteration, 12 experts identified 20 factors influencing the development of corporate universities. The 12 experts were assessed for competence using the K coefficient, including 4 highly qualified experts, 6 specialists with medium competence levels, and 2 junior experts. Using the Likert scale, the experts identified the 5 most significant factors: adaptation of training to a blended format (online & offline); positioning work and learning as inseparable processes; employee motivation for learning; content personalization; customization of training to the company's processes and technologies. With the survey results redirected as an initial input to Kendall's concordance coefficient (0.192) and Pearson's concordance coefficients (43.05), assessment of difficulty on recognizing something nontrivial is now increasing in both importance and severity. During the second iteration of the foresight session with 12 experts, three scenarios for each of the 5 identified factors were developed: optimistic, realistic, and pessimistic, resulting in a custom scenario matrix. For each of the 9 risks identified in the danger zone of the matrices, response strategies were developed using the example of the corporate university of an Eastern European IT company, along with generalized recommendations for risk minimization.

With regard to limitations, the expert sample was limited in size to 12 people from 9 industrial sectors. The 8 major Eastern European companies were not direct business competitors because they are now also predominantly IT firms. The study was limited to Eastern Europe, with emphasis on qualitative analysis and less emphasis on quantitative analysis.

As mentioned earlier, the research field of corporate university is seen as a promising area for future study. The results of this paper lay the foundation for forthcoming research into effectiveness and strategic alignment of corporate universities. This paper invites scholars for further research in this field

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Using Continuous Online Assessment of Learning Outcomes for Grading: a Case Study

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Abstract: In recent years, the problem of the number of students enrolled in STEM courses falling below the minimum required to carry out the courses has worsened. This situation, which used to occur primarily in degree programs at the end of their life cycle, is increasingly happening in active STEM degree programs as well. The declining attractiveness of traditional STEM degree programs and negative demographic trends are seen as the main causes of this problem. To assist students and their teachers in this situation, a novel approach to grading student work based on the level at which students achieve learning outcomes in an online system was explored. Since the focus was on STEM students, math-based tasks were used to assess student knowledge within the online system. In addition to the accuracy of the final results of the tasks, the accuracy of the intermediate results was also monitored. Each result was linked to the corresponding concepts, which in turn were linked to the corresponding learning outcomes. By entering correct intermediate and final results, the online system was able to monitor student success in mastering concepts and learning outcomes. The implemented online system utilizes fuzzy inference to calculate the levels at which students have achieved the learning outcomes. These levels are continuously recalculated during the semester and presented to the students through generated recommendations after each solved task. The proposed approach has positively impacted students' motivation to learn during the semester, as confirmed by an anonymous questionnaire. Additionally, the results have shown that the final level at which students have achieved the learning outcomes within the online system, calculated at the end of the semester, can be used for grading and is comparable to the grades students would achieve in traditional midterm and final exams, thus helping teachers with their workload.

Keywords: E-assessment system, Education recommender system, Learning outcomes, STEM

1. Introduction

In public higher education, a fixed minimum enrollment is often required for ministry funding to support courses. In the Republic of Croatia, this number is set at 10 students. Special permission must be obtained from the Ministry of Science and Education for any study program with fewer enrolled students. If more than 10 students are enrolled in a study program, but the number of students in some courses within that program is less than 10, the courses can be held during the semester, but in this case, the faculty must provide financial resources for them from its own income (Government of the Republic of Croatia, 2019).

Generally, the problem of fewer students enrolled in STEM courses has been observed at the end of their life cycle. When enrollment in the program is discontinued, the faculty is obligated to allow students already enrolled to complete their degree and receive a diploma. Since there are no new students, the number of students in these courses usually drops below the specified minimum of 10 students. This situation can pose a problem for students and teachers in organizing and running a traditional class during the semester. Typically, a consultative teaching approach is used in these cases, where each student works alone and has a set number of meetings with the teacher during the semester. In the past, these consultations were held in person, but today it is more common to organize online consultations. However, online consultations cannot provide the same level of personal experience as face-to-face consultations (Praskac-Salcin, I., 2023). Also, students have to wait for feedback from their teachers until the scheduled consultation session.

With the further development of the Internet, various online systems have been developed to provide the necessary support in such situations. Education recommender systems (ERS) can reduce teachers' workload by helping students with personalized recommendations during their studies (Maphosa, V. and Maphosa, M., 2023). On the other hand, online e-assessment systems (EAS) can help students through formative assessment sessions where quick feedback on their learning performance can be determined (Topuz et al, 2022). In addition, these systems can be used to conduct summative assessments within their current limitations.

In the case study presented here, a hybrid system combining the features of ERS and EAS was used to reduce teachers' workload. The system was designed to provide feedback on the current status of learning outcomes

achieved by students during the semester. This information was used as part of the generated recommendations to help students work independently. The data collected through the students' use of the online system was compared with their final results. The main focus of the research was to investigate the possibility of using this online system for grading students based on the level at which they have achieved the learning outcomes during the semester. At the end of the semester, an anonymous questionnaire was administered to get feedback from students about the impact of the designed online system on their motivation to study during the semester.

This paper is structured as follows. After the introduction, the theoretical background for the research conducted is presented. The research design and methodology are then described in detail, including the participants, the research design, and the approaches to data collection and analysis. Next, the research findings are presented and discussed. The paper concludes with a summary of the research conducted and the results obtained.

2. Theoretical Background

Two basic approaches can be used to assess knowledge: formative and summative (Sri, R. L. and Muthuramalingam, S., 2016). Both approaches can be carried out in the traditional way (tests on paper) or with the help of an EAS.

Formative assessment of students' knowledge is usually conducted continuously during the semester (Hamidi et al, 2013) to provide students with rapid feedback on their mastery of the learning content (Petrovic, J., Tralic, D., and Pale, P., 2015). Using this feedback, students can target areas of the course they haven't yet mastered. Properly designed and implemented formative assessments can positively impact their motivation to continue learning (Shafeek et al, 2019).

On the other hand, summative assessments evaluate students and their work. Because of their purpose, summative assessments can significantly impact both academic progress and future career development (Hernández-Leo, D. and Oliver, V. M., 2014). In STEM higher education, summative assessments typically consist of two to three midterm exams along with a final exam.

Ongoing research explores effective online formative and summative assessment methods, leading to the development and adoption of numerous EAS in higher education. Their main feature is the ability to quickly assess the accuracy of results and provide feedback. Furthermore, teachers can use them to track student progress and tailor teaching activities to individual or group needs (Topuz et al, 2022).

EAS typically consists of five basic parts: User Model, Domain Model, Adaptation Module, Evaluation Module, and Interface. The User Model, essential for the system's operation, stores both modifiable and non-modifiable data, which are updated during system use. The Domain Model contains the tasks used to evaluate user knowledge. The Adaptation Module selects tasks tailored to each user based on predetermined rules, including knowledge, skills, and preferences. The Evaluation Module checks the correctness of the entered task solutions and provides feedback to the user. The Interface facilitates communication between the user and the system (Lukashenko, R. and Anohina, A., 2009).

ERS have been developed to help students find the information they need within the vast amount of available information (Roy, D. and Dutta, M., 2022). These systems enable students to build their own personalized learning environment based on their unique characteristics and needs (Göksel, N. and Mutlu, M. E., 2021).

The basic structure of ERS consists of four parts: User Model, Domain Model, Recommender, and Interface (Wu et al, 2020). As in any online system, the User Model describes the user for the system's operation. It usually has dynamic properties, with data about the user's activities and progress constantly updated (Muhammad, A. H. and Ariatmanto, D., 2021). All recommended content is stored in the Domain Model with additional information about how it can be linked to the user's needs. All algorithms and rules used to generate individual recommendations are part of the Recommender. The generated recommendations are presented to the user via an Interface.

Learning outcomes (LO) are defined as written statements expressing what students should know, understand, and/or demonstrate after completing a learning process. In a study program, LO are determined at the level of the entire program, individual courses, or each lecture. Critical to LO implementation is aligning them constructively with educational elements such as activities, teaching, and assessment methods (Kovac, V. and Kolic-Vehovec, S., 2008). Ensuring constructive alignment requires understanding the relationship between activity time and students' ability to achieve defined LO.

Additionally, appropriate teaching methods and techniques must be chosen to ensure students achieve LO (Njuguna, J., 2020). Assessment of the level at which students have achieved LO is done through appropriate formative and summative assessment approaches (Zhang et al, 2022).

Students benefit greatly from understanding and utilizing LO during their studies, helping them organize study time and anticipate course content for assessments (Pokorni, S. and Kuleto, V., 2022). Ignorance or misunderstanding of LO can lead to weaker results in examinations (Sweetman, R., 2017).

3. Research Design and Methodology

The study explored using an online system combining ERS and EAS features to grade students at semester's end. The system provides individualized recommendations with progress bars and percentages showing LO levels. These levels are based on formative assessment data compared to actual grading levels from two midterms and the final exam.

The research, a quasi-experiment in three courses, used a between-subjects design. This method was chosen due to the small student enrollment, making it impractical to form control and experimental groups. Instead, comparison groups were created from students in the previous academic year. Two research questions (RQ) were proposed:

RQ 1: Did the introduced mandatory formative assessment activities conducted using the online system motivate students to learn continuously during the semester?

RQ 2: How do student grades achieved through the online system compare to traditionally produced final grades (through midterm and final exams)?

3.1 Participants

The research involved courses in Electrical Power Networks, Electrical Substations Equipment, and Power System Protection from the vocational undergraduate program in Electrical Engineering at the Faculty of Engineering, University of Rijeka. Conducted in the 2022/2023 academic year, the experiment included 44 male students (ages 21-23). The comparison groups, from the 2018/2019 academic year, comprised 128 students (123 male, 5 female, ages 21-23), chosen to avoid COVID-19 pandemic-related influences.

Students in both groups were compared based on GPA and final grades from four previous courses. The GPA data distribution was normal, so a parametric t-test with a significance level of $p < .05$ was used. The t-test results showed no significant statistical difference between the groups (Electrical Power Networks: $p = .1417$; Electrical Substations Equipment: $p = .7819$; Power System Protection: $p = .2930$).

Final grades in the four courses did not follow a normal distribution (confirmed using the Shapiro-Wilk test with a significance level of $p < .05$; each dataset had a p-value of $< .005$). Therefore, a non-parametric Mann-Whitney U test with a significance level of $p < .05$ was used for comparison. The results presented in Table 1 show no significant statistical differences between the groups of students analyzed.

Table 1: The results of Mann-Whitney U test

Course	Electric Power Networks	Electrical Substations Equipment	Power System Protection
Mathematics 1	p = .764	p = .271	p = .322
Mathematics 2	p = .204	p = .060	p = .289
Electrical engineering 1	p = .689	p = .112	p = .516
Electrical engineering 2	p = .795	p = .589	p = .928

3.2 Study Design and Procedure

At the University of Rijeka, each course awards 100 assessment points (AP) for the final grade: 70% from semester activities (midterms, lab work, group work) and 30% from the final exam. Teachers assign AP for each activity, and students need over 35 AP from semester activities to qualify for the final exam. Final grades are based on total AP: 0-49.9% (F), 50-59.9% (D), 60-74.9% (C), 75-89.9% (B), 90-100% (A).

The semester has fifteen weekly lectures, each followed by a formative assessment requiring students to solve at least three math-based tasks online within fifteen days. Failure to do so disqualifies them from completing the course that year.

The online system provides individual recommendations and updates on LO achievement through progress bars and percentages. At the semester's end, students see their final LO achievement levels.

Each course includes three midterm exams after specific lectures. The exams match the difficulty of online tasks, with AP distributed as 20 for the first, 30 for the second, and 20 for the third, totaling semester AP. To pass, students need at least 15 out of 30 AP on the final exam.

3.3 Implementation of the ELARS Online System

To implement the proposed approach to assessing student work using learning outcomes (LO), an online system was developed that combines features of Education Recommender Systems (ERS) and E-Assessment Systems (EAS). An ERS called ELARS (E-Learning Activities Recommender System) (Hoic-Bozic, N., Holenko Dlab, M., and Mornar, V., 2015) served as the basis, and the system was extended to include assessment capabilities (Durovic, G., Holenko Dlab, M., and Hoic-Bozic, N., 2019). Given the focus on STEM students, the assessment was designed with math-based tasks for formative assessment.

Each course had a set of math-based tasks (52 for Electrical Power Networks, 95 for Electrical Substations Equipment, 97 for Power System Protection) divided into subsets corresponding to lecture content. Students entered intermediate and final results for each task, linked to concepts and LO as defined by the teacher.

Formative assessments in ELARS allowed continuous monitoring of student progress. Quick feedback indicated correctness, with corrections for errors. Achievement levels for LO were updated and presented in ELARS after each task, and recommendations for the next learning steps were given. Students could choose to ask peers for tutoring, review material, solve more tasks, or move to the next topic. These options were paired in ELARS recommendations, allowing personalized learning.

3.4 Data Collection and Analysis

Both qualitative and quantitative data were collected during the experiment. Information on students' grade point average and final grades in four core courses was used to compare the two groups. Based on the data distribution, both the t-test and the Mann-Whitney U-test were employed.

System logs in the online system tracked students' activities and progress. To calculate the current level at which students achieved learning outcomes (LO), the accuracy of intermediate and final results, as well as the number of solved tasks and average solution time, were analyzed. A fuzzy inference system was designed to model the approach a teacher would take when assessing math-based task solutions. After each attempt to solve a randomly assigned task, the system calculated the current level at which students achieved the LO. This level was continuously presented to them as part of the generated recommendations.

At the end of the semester, an anonymous questionnaire with 15 questions was administered. The questionnaire included a Likert scale (1 - strongly disagree, 2 - disagree, 3 - no opinion, 4 - agree, and 5 - strongly agree) to gather responses for statistical analysis.

4. Research Results

Out of 44 participants, 39 qualified for the final exam. Their total AP were compared with results from the comparison groups. Table 2 shows the results in terms of AP earned for the experimental and comparison groups.

Table 2: Comparison between experimental and comparison groups using earned AP

Course	Academic year	N	Earned at least 35 AP		Number of students who failed the final exam	Mean value of earned AP (overall results)
			N	%		
Electric Power Networks	18-19	36	20	55.55	2	77.06
	22-23	11	10	90.91	1	75.30
Electrical Substations Equipment	18-19	47	21	44.68	0	78.24
	22-23	14	12	85.72	0	78.12
Power System Protection	18-19	45	26	57.78	3	76.74
	22-23	19	17	89.47	0	77.15

System logs were used to monitor the time dynamics of students' work during the semester. To utilize the final results of the levels at which students have achieved LO within the system, it is crucial that students work continuously throughout the semester. Data on daily task completion was collected, as students were required to solve three tasks per lecture within a fifteen-day timeframe. Figure 1 illustrates the time dynamics for all three courses observed.

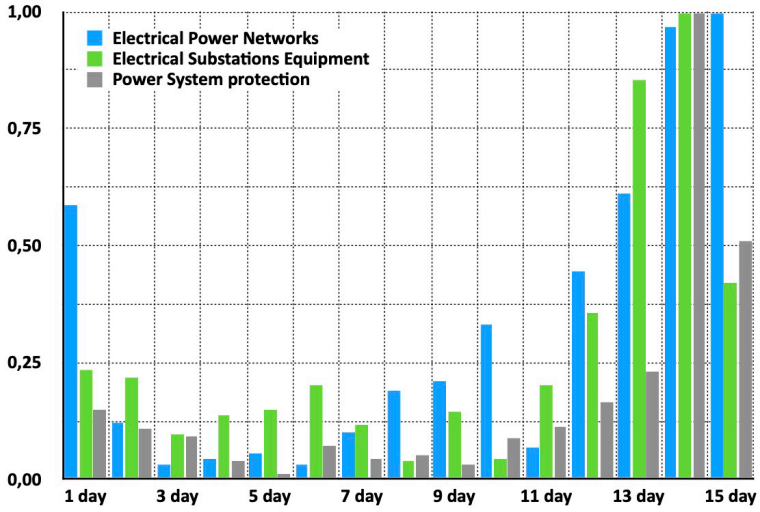

Figure 1: Time dynamics of the students' work during the semester

The online system monitored progress on learning outcomes (LO) by displaying the current percentage completion. Final results were subsequently compared with Assessment Points (AP) earned in midterm and final exams. As mentioned earlier, AP reflect the percentage of grades earned by students throughout the semester and in the final exam. Therefore, the percentage of LO achievement in the online system was converted to points (LO achievement points) and compared with the actual AP earned by each of the 39 students. This comparison is shown in Figure 2.

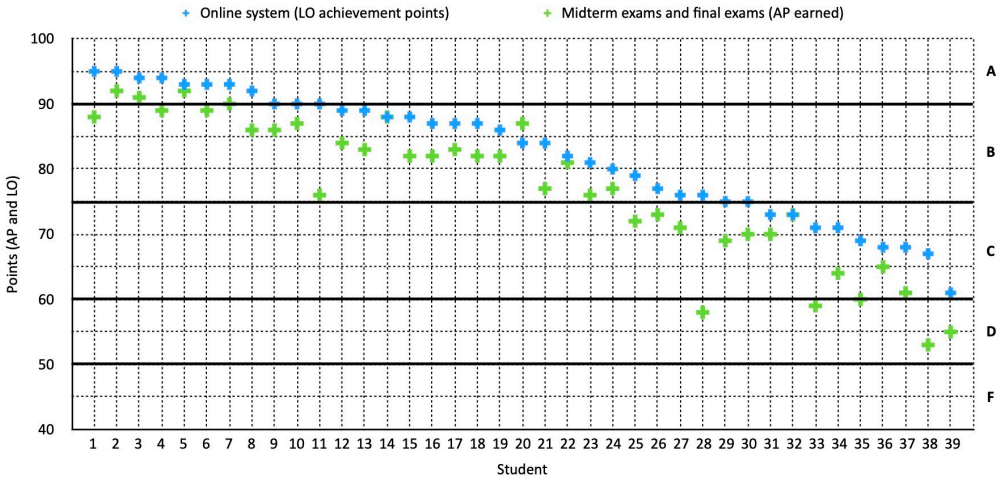

Figure 2: Comparison of AP earned through the exams and LO achieved in the online system

In addition, the earned AP and the achieved LO were compared using the Mann-Whitney U test. The results of the statistical analysis are shown in Table 3.

Table 3: Statistical analysis of the comparison of AP earned and LO achieved using Mann-Whitney U test

Course		Median	Min	Max	p-value
Electric Power Networks	**AP**	74.50	60	92	p = .405
	LO	79.50	68	93	
Electrical Substations Equipment	**AP**	82.00	55	91	p = .165
	LO	87.00	61	95	
Power System Protection	**AP**	77.00	53	92	p = .129
	LO	84.00	67	95	

An anonymous questionnaire was administered at the end of the semester to gather feedback from students on the impact of the introduced mandatory formative assessment on their motivation to study. Out of 44 enrolled students, 42 completed the survey. The most significant results regarding the impact of the online system on their motivation are presented in Table 4.

Table 4: Results obtained through anonymous survey

Question	Likert					Avg	Var	SD
	1	2	3	4	5			
The obligation to continuously solve tasks during the semester had a positive effect on my motivation to study.	0	0	2	6	34	4.76	0.28	0.53
Using the online system, I solved more tasks than I would solve otherwise (without using the system)	0	0	0	14	28	4.67	0.22	0.47

5. Discussion

The RQ 1 was: Did the introduced mandatory formative assessment activities conducted using the online system motivate students to learn continuously during the semester? As shown in Table 2, a comparison of students in the experimental groups with those in the comparison groups based on the number of Assessment Points (AP) achieved during the semester revealed a significant increase in the number of students eligible to

take the final exam. Specifically, there was an increase of 35.36 percentage points for Electric Power Networks, 41.04 percentage points for Electrical Substations Equipment, and 31.69 percentage points for Power System Protection. These results confirm that the proposed method of motivating students to learn continuously during the semester by introducing a mandatory activity related to a minimum number of tasks to be solved within fifteen-day period after each lecture using the online system helped them to achieve better results at the end of the semester. This outcome was also validated through the survey. Students indicated that the introduced mandatory activity motivated them to engage in learning and solve more tasks using the online system (Table 4).

Figure 1 illustrates the time dynamics of students' work during the semester, showing their continuous approach to learning as observed by the daily number of tasks attempted. Students effectively utilized their study time throughout the semester rather than concentrating efforts solely near the mid-term exam dates.

Based on these results, it can be concluded that the answer to RQ 1 is affirmative: the introduction of the mandatory formative assessment activities using the online system motivated students to learn continuously during the semester.

The RQ 2 was: How do student grades achieved through the online system compare to traditionally produced final grades (through midterm and final exams)? At the semester's end, the percentages corresponding to the levels at which students achieved the Learning Outcomes (LO) were converted into LO achievement points. These points were compared with the total number of AP that students achieved after taking the final exam. The result of this comparison for the 39 students who earned the right to take the final exam shows that these scores follow a similar trend, with minor differences in certain cases (see Figure 2). The Mann-Whitney U test comparison (see Table 3) revealed no significant statistical difference between these two sets of data. This result further confirms that the levels at which students achieved the LO within the introduced online system can effectively be used for grading students.

Analysis of individual student data reveals discrepancies in final grades, which could differ if based solely on LO achievement levels in the online system. These differences are noticeable near the established grading thresholds (see Figure 2). However, for the majority of students, these discrepancies do not exceed one grade higher or lower than the assigned grade based on AP earned through midterm and final exams (only one student has a greater difference – student 28).

With these limitations in mind, based on the results obtained, it can be concluded that the answer to RQ 2 is affirmative: Students would achieve comparable final grades if grading was based on the achieved level of LO obtained through the developed online system (when compared with grades achieved through midterm and final exams).

There is a substantial body of research by authors such as Cigdem et al. (2024), Mushtaq et al. (2024), Popovska Dimova and Popovski (2024), and Sun (2018) regarding the use of continuous formative assessments to motivate students, which is directly related to RQ 1. The findings of the research presented in this paper are consistent with these results and build upon them to expand our understanding of the impact of continuous formative assessment on student motivation. However, there is limited research on the use of LO for grading. Authors Cifuentes Gomez and Santelices (2024) have provided a systematic review of institutional contributions to LO, where a small number of research papers connect LO with student grades. The findings presented in this paper enhance our understanding of this connection by exploring new possibilities in using the levels at which students achieve LO to determine their grades.

6. Conclusion and Future Work

When course enrollment is below the minimum required, teachers must adapt their course delivery methods. Online systems can be very useful in such cases. This research introduces an online system combining ERS and EAS features to grade students based on LO achievement levels. These levels, assessed by a fuzzy inference system, evaluated the correctness of math-based tasks completed by students. Continuous semester-long engagement with the system was essential for utilizing the achieved LO levels as proposed.

The research findings confirm that the developed online system effectively motivates students to study continuously throughout the semester and allows for the assessment of their overall performance based on their LO achievement levels. These levels were compared with the actual Assessment Points (AP) scores achieved by students in midterm and final exams, and the data analysis confirmed that there is no significant statistical difference between them.

However, there are limitations to the proposed approach. In some cases, grades based on AP scores differed from those based on LO levels. Additionally, without final exams, students would not have the opportunity to improve any weaker grades earned during the semester. Furthermore, since the proposed method relies on students' work in uncontrolled conditions, the issue of potential academic misconduct during student work also arises.

Future research activities will address these limitations and will be conducted within the project “Support for personalized learning in STEM based on learner personas and recommendations”. Different approaches will be tested, such as reorganizing classes to ensure that mandatory task-solving is carried out in a controlled environment, while still allowing students the option to take the final exam if they are not satisfied with their semester performance. Additionally, there are plans to create learner personas based on observed student work habits in the online system to provide more timely and accurate student descriptions. Also, since in this research a number of participants was relatively small, a larger number of participants will participate in future experiments.

By incorporating these improvements, it should be feasible to provide teachers with an online system that supports them by alleviating their workload, particularly in situations where adjustments to the entire teaching and assessment process are necessary due to low enrollment or course discontinuation. In this way, the research presented in this paper aims to expand understanding of the positive impact that continuous assessment of learning outcomes, conducted using appropriate online systems, can have on learning and teaching processes.

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PhD Research Papers

The Impact of Generative Artificial Intelligence on Education: A Comparative Study

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Abstract: Generative Artificial Intelligence (GAI), also known as creative AI, is a technology capable of independently producing original and creative content, such as text, images, videos, music, or code. It uses machine learning algorithms to analyze and learn from a vast amount of data to generate similar or even innovative content. This type of AI is used in several fields, such as health for the production of new drugs, design to generate adaptive designs, video games to create immersive environments, and artificial intelligence to generate training data for new networks. Seizing the opportunities offered by AI innovations in education is crucial. We cannot afford to let time pass without doing anything and without benefiting from this technique. It is time to enhance traditional learning methods and adopt more innovative approaches that take advantage of the potential of AI, like content and exam generation, and also improve students' learning experience by exploiting their closeness to the technology. This paper aims to answer the question of when and how to use artificial intelligence responsibly, considering it as a technology and limiting its excessive use. Additionally, we present the impact of GAI through a comparative study of student performance in three exam types: a classical MCQ exam written by the teacher, an adaptive MCQ exam generated by GAI from a topic, and a third MCQ exam generated by GAI based on the content of the provided documents. This study is conducted on students undergoing a software testing training program. By evaluating their performance in the AI-generated adaptive MCQ exams and the traditional MCQ exam, we can gain insights into the potential of this technology to enhance educational practices and provide personalized learning experiences. This research will contribute to the ongoing discussion on responsible and effective utilization of GAI in education, paving the way for future advancements in the field.

Keywords: IA, Education, Learning experiences, Generative AI, educational content, Generative artificial intelligence, Adaptive exam, MCQ

1. Introduction

Artificial Intelligence (AI) is a branch of computer science dedicated to developing intelligent machines capable of performing tasks that typically require human intelligence (Lu, 2019). One of its subfields is Generative AI, which utilizes machine learning models to create new and original content, such as images, text, music, and even data for training other machine learning models (Elmourabit et al., 2024). This technology has diverse applications across various fields, including art generation, content creation, and even educational settings, In the realm of education, the use of AI has been increasingly prominent.

AI technologies, including generative AI (GAI), are being integrated into educational systems to enhance learning experiences. GAI in education can be utilized to provide instant access to vast amounts of information, aid diverse learners with different abilities, accelerate exploration and creativity, and improve student outcomes (Walkington et al., 2020). Both students and faculty can benefit from GAI by efficiently completing coursework, generating ideas for brainstorming, improving writing skills, and creating course materials like lesson plans and quiz questions.

The integration of GAI in education has the potential to revolutionize the learning experience by offering personalized learning, efficient content creation, enhanced student engagement, and real-time adaptive assessment and feedback. Personalized learning can be achieved through customized learning materials tailored to individual students' needs, preferences, and learning styles. GAI can assist in creating new teaching materials, such as questions for quizzes and exercises or explanations and summaries of concepts, making content creation more efficient. Additionally, it can create simulations and virtual environments, offering more engagement and interactive courses, and improving students' learning experience. Real-time adaptive assessment and feedback can be facilitated by this technology, allowing students to be challenged at an appropriate level and fostering continuous growth and improvement. As the field of AI continues to evolve (Bert et al, 2023), its applications in education are poised to reshape the future of learning by fostering innovation, efficiency, and improved educational outcomes.

In this work, we present the impact of GAI on the educational system by introducing, in the first section, the benefits of this AI technology in education. These benefits include personalized learning, efficient content creation, student engagement, and real-time assessment and feedback. In this subsection, we present a comparative study in the second section about the impact of adaptive exams generated by GAI and the classical exam on student performance. The third section is dedicated to the ethical implications of GAI as a technology, and nothing else. The paper concludes in the fourth and final section.

2. GAI Benefits in Education

Neural networks, which are intended to mimic the human brain by learning from enormous amounts of data, are the basis for generative artificial intelligence. These algorithms look for relationships, analyze patterns, and produce new outputs that mimic the properties of the training data. With this novel method, generative AI may create customized and one-of-a-kind learning experiences. The integration of GAI into education is transforming the way we teach and learn. Thanks to technological advances, AI can potentially improve educational experiences in different ways:

2.1 Personalized Learning and Content Creation

Personalized learning is a pedagogical approach that adapts teaching and learning experiences to meet the specific needs, interests, and abilities of each learner (Walkington et al, 2020). It recognizes that every student possesses unique learning preferences, strengths, and weaknesses (Bray et al, 2014), and aims to provide a more tailored and personalized learning experience. The goal of personalized learning is to foster increased engagement, relevance, and effectiveness, ultimately maximizing each student's potential for academic success and personal growth. Effective content generation in education requires an understanding of the subject matter (Shemshack et al, 2020), pedagogical best practices, and diverse student learning styles. Generative AI (GAI) models can analyze student data, including their learning speed, strengths, weaknesses, areas of difficulty, and progress over time, to dynamically generate personalized learning materials and activities tailored to individual needs (Ikhlass et al, 2016). This level of personalization has been shown to foster increased engagement, relevance, and effectiveness, contributing to more successful learning outcomes. Furthermore, through process mining techniques (Chanaa et al, 2018), GAI can create personalized learning pathways that adapt to the specific learning pace and challenges of each individual, minimizing dropout rates and ensuring that students receive the targeted support and content they require. Additionally, these models can provide personalized recommendations, such as suggesting relevant, generated content or offering targeted explanations, to further enhance the learning experience (Khazanchi et al, 2024). As the capabilities of GAI continue to evolve, the integration of these technologies into content creation for education holds immense promise for revolutionizing the way we approach personalized learning (Ali et al, 2023), catering to the diverse needs of all students, and helping them reach their full academic and personal potential. (Pataranutaporn et al, 2021) used Generative Adversarial Networks (GANs) to create AI-generated characters that can bring history, science, and art to life, serving as virtual instructors and enhancing learners' motivation, attention, and engagement. These characters can be used in various educational settings, from classrooms to museums, to deliver compelling learning materials and optimize the student-teacher relationship. In another context, (Song et al, 2023) propose a framework utilizing LLMs to enhance text-to-SQL translation, enabling the system to comprehend natural language queries. This work demonstrates effectiveness in constructing a practical AI system. A recent study conducted by Nguyen et al in 2024 has shed light on the patterns of collaboration between humans and AI in the context of AI-assisted academic writing (Nguyen et al, 2024). This research provides insights into how large-scale language model-based AI tools are being integrated into the writing process. It highlights how these technologies complement human skills to enhance productivity, creativity, and efficiency in academic writing tasks.

2.2 Student Engagement

Student engagement is a complex concept that encompasses various dimensions (Groccia, 2018), including intellectual, emotional, behavioral, physical, and social factors that influence learning (Essie, S. 2021). Intellectual engagement refers to the use of strategies that stimulate curiosity and interest in learning, such as providing students with choices or introducing a unit of study with a problem to solve. Emotional engagement involves promoting positive emotions and minimizing negative behaviors to facilitate learning. Behavioral engagement includes establishing routines and using consistent cues to foster behaviors conducive to learning (McFadden et al, 2002). Physical engagement involves using physical activities or routines to stimulate learning and interest (Biddle et al, 2011). Social engagement refers to using strategies that stimulate engagement through social interactions (Ouhaddou et al, 2023), such as pairing or grouping students to work collaboratively on

projects. While the concept of student engagement is straightforward, it can take complex forms in practice, and educators may hold different views on student engagement, defining or interpreting it differently from place to place. Generative AI offers various benefits for student engagement in higher education. Utilizing AI tools like ChatGPT and DALL.E2 can promote experiential learning (Kasneci et al., 2023), student engagement, and collaboration (Bert et al, 2023). This approach involves authentic assessments that require students to apply knowledge and skills in real-world tasks, fostering higher engagement and performance. Additionally, encouraging students to use GAI to generate creative ideas and solutions to complex problems can facilitate both divergent and convergent thinking processes, aiding students in developing, testing, and evaluating innovative solutions. Furthermore, employing AI as a copyediting tool can enhance students' writing and presentation skills. By comparing their work with AI-generated outputs, students can improve their language, style, and tone, which is particularly beneficial for non-native English speakers seeking clarity and expression in their academic work. These applications of generative AI not only enhance student engagement but also foster creativity (El Maazouzi et al, 2023), critical thinking, and problem-solving skills essential for preparing students for the challenges of the future. Al Yakin et al. (Al Yakin et al, 2023) explored the use of the AI chatbot, ChatGPT, to enhance online student engagement in sociology and politics education. The research was conducted with 23 fourth-semester undergraduate students and found that ChatGPT generated enthusiasm and high levels of student engagement. Specifically, ChatGPT facilitated activities such as idea exchange, discussions, analysis, and motivation among the students. The effectiveness of ChatGPT in enhancing student engagement was measured through a questionnaire filled out by the students using a Likert Scale, which included 16 positive statements about ChatGPT. The researchers highlight the potential of AI technology in education, as ChatGPT provides immediate, concise, and relevant responses to students' questions and concerns, allowing for active discussion, feedback, and interaction. However, the study emphasizes that the integration of ChatGPT in education requires well-defined and frequent, quality interaction with instructors to maximize its potential for enhancing student engagement. Recent research published in Nature (Pataranutaporn et al, 2021) has highlighted the potential of Generative Adversarial Network (GAN) architectures to enable personalized learning experiences for students. The study demonstrates how students can significantly enhance their engagement with course material and interactions with their peers through direct virtual interactions with relevant historical figures related to the study context. For instance, when exploring physics, students can now have the opportunity to interact virtually with iconic figures like Albert Einstein. Similarly, during an art class, learners can engage with the likes of the enigmatic Mona Lisa. This innovative approach immerses students in the subject matter by bringing these historical luminaries to life, fostering a deeper connection with the content, and stimulating curiosity and enthusiasm for learning. The researchers highlight that this GAN-powered approach to education represents a significant advancement, as it allows learners to engage with the course material in a more immersive and personalized manner. By facilitating direct interactions with influential historical figures, students can develop a stronger understanding and appreciation for the subject, ultimately leading to enhanced engagement and learning outcomes. Duolingo has unveiled a collaboration with OpenAI on the Duolingo Max project (Duolingo, 2023), which aims to integrate generative AI into its repertoire. This will introduce two new features for learners: "Explain My Answer" and "Role Play." The former provides a chatbot that offers students personalized and timely feedback on incorrect answers. The latter introduces an innovative feature allowing students to engage in unscripted discussions in any language with various characters within the Duolingo app. These new generative AI features aim to enhance the learning experience of Duolingo users by providing personalized support and opportunities for authentic conversational practice.

2.3 Real-Time Assessment and Feedback

Assessment is the systematic way of evaluating how much a student understands from what has been taught and how well they can do when they are given the test. Assessment encompasses collecting, gathering, and analyzing information about what students know (Jackel et al, 2017), understand, and can do. This information is used to identify their educational needs and to monitor their progress. The students can be evaluated academically through formative assessments, projects, tests, assignments, essays, and presentations, while non-academically evaluation can be done through observation. Feedback, derived from the English work feed + back, is the information provided to students about their performance or progress. Effective feedback should be timely, specific, and focused on helping students improve. It can come from teachers, peers, or self-assessment, and it helps students understand their strengths, weaknesses, and areas for growth. Feedback is a crucial part of the learning process, as it guides students in developing their skills and knowledge. Together, assessment and feedback play a critical role in supporting student learning and development in educational settings. GAI can assist in evaluating students' work by examining written assignments, presentations, and spoken responses, providing comprehensive feedback that covers both the textual and auditory elements of the content. Thus,

generative AI is transforming the educational field, making it more interactive and adaptable to the needs of today's learners. Researchers at the University of Georgia (Barrett et al, 2019) have used AI-based virtual teaching assistants to help professors with their administrative tasks, answer student questions, and provide personalized feedback on assignments. The research article (Tenakwah et al, 2023) explores the implications of using generative AI, particularly ChatGPT, in higher education assessments. The authors highlight the potential for academic dishonesty if students use ChatGPT to generate responses and pass them off as their work on exams and assignments. This raises concerns about the intellectual and practical preparedness of future graduates, prompting discussions on the future of higher education assessments. The article suggests that educators must adapt their assessment methodologies to account for these risks and prevent academic misconduct. Educators are encouraged to be aware of the tools available to students, including ChatGPT, and to differentiate their assessment and learning processes accordingly. Additionally, the authors recommend that students who utilize AI systems should be encouraged to acknowledge their contribution to assignments, as a means of improving academic openness and integrity. Overall, the research emphasizes the need for higher education institutions to navigate the complexities introduced by the integration of generative AI technologies into assessment practices. Coursera (Minudri, 2023) used the power of GAI to analyze student submissions and provide automated feedback, including error corrections, tips, and explanations. By receiving immediate feedback, students can identify areas for improvement, rectify errors, and deepen their understanding of the subject. In addition, Coursera Coach is also trying to make the platform more accessible by including machine translation models to allow students to take courses in their language. The blog from (Eklavvya, 2024) discusses the use of AI in generating question papers, offering efficient and automated solutions for this task. It highlights the challenges of manual question paper generation and the benefits of AI tools in streamlining the process. The platform provides features like generating questions based on subject, topic, difficulty level, or specific paragraphs. Additionally, it allows for the import of questions by subject experts, ensuring secure and reliable question paper generation. The system supports the customization of question papers by defining parameters like question type, subject, topic, difficulty level, and marks per question. It also explains how the randomization of questions works to create unique sets of question papers for students automatically.

In the previous section, we presented the benefits of GAI on education, including personalized learning, efficient content creation, improved student engagement, and real-time assessment and feedback, along with some related works in this area. In the next section, we present our comparative study about the impact of GAI through a comparative study between student performance in an adaptive Multiple-Choice Questions (MCQ) exam generated by AI from the given courses and a classical MCQ exam written by the teacher.

3. Study Results and Discussions

In this section, we present the results of our comparative study between student performance on three different types of assessments:

- Exam 1: The traditional, teacher-written classical MCQ exam.
- Exam 2: The AI-generated adaptive MCQ exam without any human intervention or given source material (e.g. course documents, MCQs).
- Exam 3: The AI-generated adaptive MCQ exam was created from the given course materials and sample exercises. This system was developed using GPT language models.

The study was performed with a cohort of 25 students with a computer science background.

For Traditional Exam 1, it takes almost 1 hour to gather the questions and select the correct answer, as well as the incorrect answers which are often similar to the correct one. It also requires materials to grade the students' answer sheets, which takes an additional 30 minutes. In total, the process of preparing and grading the multiple-choice exam takes almost 1 and a half hours. For Exam 2, which is generated by AI, it takes almost 5 minutes to generate the questions from a given topic, such as "Software Testing / QA". For Exam 3, which is also generated by AI, the process takes almost 20 minutes. This involves using provided resources such as short course material and examples from previous exams. It also requires some intervention from the professor.

Table 1: Duration of each exam preparation

Exam Type	Duration (Minute)
Exam 1	90
Exam 2	5

Exam Type	Duration (Minute)
Exam 3	20

This table clearly shows that the AI-generated exams (Exam 2 and Exam 3) take much less time to prepare compared to the traditional exam (Exam 1). This shows that using GAI to generate exams can help reduce the time and effort needed, which can be a significant advantage. The AI-based approaches allow for faster exam preparation and grading, which can be valuable for both instructors and students.

According to the grading scale defined, where scores between 0 and 10 are assigned an F, 10 to 12 a D, 12 to 14 a C, 14 to 16 a B, 16 to 18 an A, and 18 to 20 an A+, the student results on the three exam types are distributed as follows:

Table 2: Student Grades on Each Exam Type.

Exam Type	A+	A	B	C	D	F
Exam 1	1	5	7	5	5	2
Exam 2	-	-	5	6	12	2
Exam 3	5	8	10	2	-	-

For Exam 1, 7 students received a B grade, 5 received a D, 5 received a C, 5 received an A, 2 received an F, and 1 received an A+.

On the AI-generated Exam 2 from a topic, 12 students received a D grade, 6 received a C, 5 received a B, and 2 received an F.

For Exam 3 from resources, 10 students received a B grade, 8 received an A, and 5 received an A+, with 2 receiving a C.

These detailed grade distributions show that while the traditional Exam 1 had a wider spread of grades, the AI-generated exams, particularly Exam 2, saw more students clustered in the lower letter grades. In contrast, Exam 3 generated the highest number of A and A+ grades among the three exam types. Based on this result we can see that the AI-generated exams, when properly implemented with teacher intervention, can indeed promote better student performance compared to the traditional exam.

- For Exam 3, which likely benefited from teacher guidance and curation of the resources used, the grade distribution skews much higher, with the majority of students earning A and A+ grades.
- In contrast, Exam 2, which was created without explicit teacher oversight, resulted in a higher number of lower D grades compared to the other exams.

This suggests that when the AI generation process is coupled with thoughtful teacher intervention - such as selecting appropriate input materials, reviewing the exam content, and providing feedback, the GAI can be leveraged to enhance student learning and better assessment outcomes.

The teacher's role in guiding and refining the GAI exams appears to be a critical factor in unlocking the full potential of this technology to improve educational assessment. With the right balance of human oversight and AI capabilities, the results indicate the possibility of promoting better student performance and learning.

Table 3: Class Average Scores for Each Exam (out of 20)

Exam	Average
Exam 1	13.56
Exam 2	11.80
Exam 3	15.72

As we can see from Table 3, the highest-class average is for Exam 3 at 15.72 out of 20, which was the AI-generated exam from resources. The traditional Exam 1 had a class average of 13.56 out of 20. The lowest class average was for Exam 2, the AI-generated exam from a topic, at 11.80 out of 20. These results further reinforce the observation that when the AI generation process is guided and overseen by the instructor, as was likely the case for Exam 3, the student performance and learning outcomes can be enhanced compared to a traditional exam format. Conversely, the AI-generated exam without sufficient teacher intervention, as with Exam 2, did

not achieve the same level of class performance. The class average scores provide a clear quantitative measure of how the different exam formats impacted overall student learning and mastery of the material.

Exam 2 was generated by the GAI system only according to the given subject, without any direct supervision or curation by the teacher. As a result, the questions of this exam may have been limited in scope, focusing narrowly on certain aspects of the subject. In addition, AI has generated some questions and answers that are even completely removed from the main topic. Since AI generated the exam questions autonomously, without the benefit of the professor's expertise in sequencing, pace, and aligning content to broader learning objectives, the resulting examination was able to test a narrower and inappropriate range of knowledge than expected. This substantial limitation in the relevance and depth of the content of the exam is reflected in the class average score of 11.80, suggesting that greater involvement of teachers in the design process of AI-generated assessments is crucial to ensure alignment and effectiveness.

4. Ethical Implications of GAI as a Technology

The use of GAI in education offers many benefits but also raises several critical concerns that require careful consideration and proactive measures. A major concern is data privacy and security. The collection and analysis of comprehensive student data raises questions about privacy and the prevention of unauthorized access or misuse (Gašević et al, 2023). Ensuring robust data security measures and protecting student privacy is essential to maintaining the integrity of educational processes and maintaining trust.

Another important issue is the risk of bias and discrimination in AI systems (Kizilcec et al, 2022). AI algorithms trained on biased data can perpetuate and amplify these biases, leading to discriminatory outcomes such as biased grades or course recommendations. It is essential to continuously monitor AI models, train them responsibly, and implement measures to reduce bias to ensure equity in educational settings. In addition, concerns about equity and accessibility stem from reliance on AI-powered tools, which can create a digital divide and limit educational opportunities for students from disadvantaged backgrounds, which could exacerbate existing inequalities. Addressing these issues requires a balanced approach that considers ethical implications, promotes equal access, and promotes transparency and accountability in AI-based educational practices.

5. Conclusion

The results of this comparative study on the three types of exams highlight the potential of generative artificial intelligence to improve learning and assessment processes, provided that teachers are closely involved in the process. When AI is used in a complementary way to teachers' pedagogical expertise, as for exam 3, it can indeed promote better performance and deeper learning among students. Teachers play a crucial role in selecting appropriate resources, reviewing the content of assessments, and providing relevant feedback. Conversely, the AI-generated exam without proper supervision, such as exam 2, did not achieve the same levels of success. This highlights the critical role of teachers in guiding and refining the AI generation process so that assessments remain aligned with learning goals. Overall, this study demonstrates that the successful integration of generative AI into education requires a subtle balance between automating tasks and maintaining a central role for the human expertise of teachers. It is on this condition that the full value of this technology can be released to sustainably improve the effectiveness of teaching and learning. To address this, future work aims to develop adaptive-level GAI that can dynamically adjust the difficulty and content of assessments based on individual student performance and learning needs. This approach would allow the GAI system to continuously analyze student responses and automatically adjust the difficulty of subsequent questions in real-time. Challenging questions could be presented to high-performing students to assess the depth of their knowledge while struggling students would receive more scaffolded, lower-difficulty questions. The GAI could also vary the types of questions, mixing in different formats like multiple choice, open-ended, and problem-solving to get a well-rounded evaluation.

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Cultivating Digital Skills: Assessing Trainee Digital Skills and Individual Needs

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Abstract: It is widely recognised that having applicable digital skills is crucial to a lot of professions and is highly relevant to economic growth and digital transformation. Additionally, a lot of digital training does not consider, the specific needs of the individual. As such, this paper presents an adaption for means of digital skills assessment and training readiness, and practical skills appraisals, which allows training to be modified to individual needs. This paper focuses on a skills' assessments (appraisals) for working professionals that are not in traditionally IT specialist roles such as physio therapists and food technicians, specifically in how working professionals can be assessed and better prepared for digital upskilling. An adapted framework is motivated by using concepts of digital skills' assessment by Van Laar et al. (2018), which includes adapting their established set of measures for 21st century Digital skills. The results and findings, to date, are based upon twelve skills appraisals and six short training sessions, across six participants. Resulting in qualitative data in the form of researcher observations and participant narrations over skill-based activities with non-IT based professionals. Participants were recruited primarily from a regional skills support scheme focused upon digital skills' development, for people in employment. The aims of this paper are to report the findings of active research and to provide initial insights regarding strategies for digital trainers. The suggested approaches are intended to highlight areas of interest and focus for trainees. These approaches should benefit skills development and delivery for a large population of non-IT based professionals.

Keywords: Digital skills assessment, Digital training, Individual differences

1. Introduction

As technology and its use in the world changes, it is unsurprising that a lot of businesses need to move with technology to survive (Rayna and Striukova, 2016). However, reliance on technology requires that professionals are at an implicitly presupposed level of digital literacy. The precise employer expectation is rarely articulated and frequently employees require on-hand support. Examples of on-hand support can range from employment inductions, annual CPDs (Continuous Professional Development) to day-to-day live support services. The professionals considered in this paper are exactly those who are non-IT based Professionals (NITBPs) but are presumed to be digitally literate. Examples of NITBPs are working professionals that are not in traditionally IT specialist roles such as physio therapists and food technicians whose work context indirectly benefit from good IT related skills.

Consequently, technological reliance requires that the training given to NITBPs by their employer is understood and meets employer defined standards. Unfortunately, a lot of digital training does not consider the specific needs of the individual, which leaves a lot of gaps in knowledge and skill, necessary to utilise training given (Barbosa et al., 2022). Some of these gaps might have been addressed through already established on-hand support (likely in-person), including getting started hurdles such as connecting securely using a VPN.

Although digital skills training methods and materials have improved in recent years according to the growth of technology (Marra, 2022), identifying individual needs through assessing and baselining digital skills and digital literacy prior to training is still not commonplace (Martínez-Gutiérrez et al., 2023).

The main goal of this paper is to report preliminary findings from active research examining how to identify and meet the individuals' needs. This is achieved by utilising a modified digital skills instrument (DSI) from van Laar and others (2018), and collecting and analysing qualitative observations and, participant narrations. Data from six digital skills appraisals, involving both pre and post training, is focused upon.

This paper introduces a framework being developed by this author, which is currently in progress. Initial findings from that wider work are reported and discussed in this paper.

2. Theory

To understand the impact of "gaps in knowledge" (Barbosa et al., 2022) NITBPs are likely to have, an assessment relevant to the specific individual must be identified. However, the concepts of "individual needs"

and "individual's needs" within the digital training research area often used synonymously while also defined in several ways. Lee et al. (2021) defined individual needs by focusing on the general implementation of learning tools and strategies, including students, technology devices and emerging learning processes. Further, their definition of individuals needs is scoped at the macro level, particularly the "student" entity, not the person, being generalised. Lee et al.'s (2021) approach is useful when assessing a larger volume of participants based on the common interactions had with mobile devices, though this method lacks the granular detail and nuances.

Reyes-Millán et al. (2023) discuss individual needs through focusing on pedagogical approaches such as, follow-up tools and sessions offered to their students and, having digital resource easily available. Their suggestions would support the need for granular detail and afford some customisation to the individual, however that depends on the individual being able to fit in categories where there is resource, and the individuals being able to identify their own needs.

A combination of definitions (Barbosa et al., 2022; Lee et al., 2021; Reyes-Millán et al., 2023) is used to partially identify the generalised individual needs NITBPs would have, for example: a laptop, a user licence to software, or access to learning material which would be common across participants. This includes the specific needs of the individual such as extra tutoring or role specific work instructions. This research focuses on the specific needs of NITBPs. Identifying and addressing identified individual needs, requires a method of assessment and measurement. To achieve this, a boundary for identifications must be set where there is commonality between NITBPs, and a tool widely used by NITBPs. For this research, the tool "Microsoft Excel" was chosen, as working with spreadsheets is common across most industries (Broccardo et al., 2024; Del Val Núñez et al., 2024) and most devices used by professionals being Microsoft based (StatCounter Global Stats, 2024).

Recognising that although gaps in knowledge and individual (NITBP) specific needs, are nuanced to them, some generalisations and assumptions must be made to establish a framework for assessment that can be used across all NITBPs that participate in this research. A further boundary based on common "topical" interactions with spreadsheets, for example, basic arithmetic, data presentation and bookkeeping (Reid et al., 2023) must be defined for this research. Topics in these areas include functions such as "SUM," "AVERAGE," "IF" and, other functions for formatting such as, highlighting and merging cells.

The functions within topics require a delivery method from researcher to NITBPs to check if they can perform the set activities, and then appraise their skills accordingly. However, research shows that references to Excel "functions" by name is often considered technical jargon to NITBPs, even though they may already know how to perform the activity (Amran et al., 2017; Pals, Tolboom and Suhre, 2023). This identifies a need that NITBPs would have to understand the requirements of the task in the same context as the intended delivery. However, ensuring that the context is understood as intended is not guaranteed. A strategy to address this need is to check understanding of the underlying functions through different activities. Consequently, employing this strategy introduces a risk where the researcher should be mindful that stimulus satiation is more likely to occur, and result in diminishing returns (Association for Computing Machinery, 2013).

2.1 Summary

To assess NITBPs individual needs and understand the gaps in their knowledge, a digital skills instrument (DSI) needs to be devised. The DSI would need to be scoped to Microsoft Excel, support multiple areas (topics) that check for fundamental understanding of an Excel function (skill). Additionally, performing these checks through multiple activities (sub-task) that require NITBPs to use the same functions in different contexts to validate gaps.

3. Methods and Methodology

To perform the appraisal, NITBPs were recruited through opportunistic responses to NITBPs enquiries focused mainly upon SMEs where formal training programmes and support mechanisms are less likely. Eligible participants were given an initial skills appraisal to highlight their individual needs. The research results reported later, focuses on the skills appraisal process which is shortened to "the process of setting participants a series of skill-based sub-tasks for the purpose of assessing their digital skills needs." This results in an individualised account of needs and how to identify them by implementing the skills appraisal. To organise, structure and implement the skills appraisal, the skills appraisal was separated into "Blocks." The design and delivery of these blocks were the product of van Laar et al.'s (2018) instrument and modified to address this

paper's aims. The details of block design and delivery are to be reported elsewhere. Here we focus primarily upon findings from the skills appraisals.

3.1 Qualitative Approach

Although the skills appraisal highlights individuals' differences and needs through performance, highlighting individual needs from the perspective of the participant is needed as participants may understand the skills, but lack confidence within their own skills. Observations and participant narrations offer a unique perspective into participants thought process under simulated conditions, to inform areas of focus which may not be objectively skill-based issues.

3.2 Skills Appraisal Development

The skills appraisal was developed based on the digital skills instrument by van Laar et al. (2018) and then refined through piloting. Van Laar et al. (2018) adapted a framework with "core 21st-century digital skills" list, developed by Van Dijk and Van Deursen (2014). The list had seven main topic areas: Technical, Information Management, Communication, Collaboration, Creativity, Critical thinking and, Problem Solving. Each were defined along with operational components such as, "…The skills to use ICT to transmit information to others, ensuring that the meaning is expressed effectively. -Skill: transmitting information…," when defining the "Communication" topic area. Van Laar et al. (2018) 's adapted framework kept some of the topic areas however, they included new and additional topics specific to their interest in creative industry professionals. Some existing topic areas were modified slightly and, a key difference is that they collected their data quantitatively through survey results. This was to measure "skill factors" consistency, while supporting their initial "cognitive interviews" (van Laar et al., 2018).

This paper utilises parts of Van Laar et al. (2018) 's "…digital skills assessment…" framework and approach; however, further developing their framework to the needs of this research. A key difference between this research and, van Laar et al. (2018)'s is the participant focus area. This research focuses on individual differences and needs, and according to the perspective of trainer and trainee. Whereas in contrast, Van Laar et al. (2018) s and Barbosa et al. (2022) focused on the generalised skill and performance metrics.

3.3 Pilot Study

To validate and verify the framework changes and application, a pilot study was conducted. The data gathered was from observations of participants attempting a list of applied spreadsheet problems. The selection criteria for the five pilot participants included that they must work in an IT based profession (e.g. IT Manager). Piloting the framework also allowed task complexity to be reviewed and, the scale and scope of the skills appraisal to be validated.

A discovery in the pilot study showed that, pilot participants were looking up functions and guides using their own mobile devices e.g. laptop and mobile phone, during the skills appraisal. In response to this, more time was added while the skills chosen were simplified. When pilot participants asked which browser to use, the adjustment was made to pre-open apps needed. When instructions and description were accidentally confused, the pilot participants were given instructions in a separate application to Excel.

These discoveries are expanded:

- The initially allocated time is not long enough which was a target time between 5 and 10 minutes.
- Some of the Excel functions chosen were too complicated e.g. XLOOKUP() function.
- The delivery of the appraisal had to be in-person as these participants had used their mobile devices to search for answers or help, which would be difficult to observe via webcam.

Changes were made with each iteration and the result is shown in figure.1. Substantive features were:

- Increased allotted time to 15 minutes to complete the appraisal, providing enough time for the participant to make a realistic attempt and not be rushing.
- Selecting simpler skills and changing topics to be more approachable, so participants would consider an attempt rather than be deterred by the complexity of the sub-task.
- To simplify the appraisal process and prepare for a consistent experiment, participants were handed an appraisal ready Windows laptop. The laptop required no configuration and set-up by participants.

	A	B	C	D
1	Name of Ingredients	Input your sample weights (kg)	Ingredients % Ratio	Actual Weight Requi
2		Kilograms (Number Only)		
3	salt	0.15	=IF(OR(B3="",B8=0,ISTEXT(B3)),0,SUM((B3/SUM(B3:B7))*100))	=SUM((C3*B10)/100
4	sugar	0.6	=IF(OR(B4="",B8=0,ISTEXT(B4)),0,SUM((B4/SUM(B3:B7))*100))	=SUM((C4*B10)/100
5	starch	1.025	=IF(OR(B5="",B8=0,ISTEXT(B5)),0,SUM((B5/SUM(B3:B7))*100))	=SUM((C5*B10)/100
6	yeast	1	=IF(OR(B6="",B8=0,ISTEXT(B6)),0,SUM((B6/SUM(B3:B7))*100))	=SUM((C6*B10)/100
7	onion	0.005	=IF(OR(B7="",B8=0,ISTEXT(B7)),0,SUM((B7/SUM(B3:B7))*100))	=SUM((C7*B10)/100
8	Total	=SUM(B3:B7)	=IF(OR(ISTEXT(B3),ISTEXT(B4),ISTEXT(B5),ISTEXT(B6),ISTEXT(B7)),"No Text, Enter Number",SUM(C3:C7))	=SUM(D3:D7)
9				
10	Base Val (kg):	5		
11				
12			**Assessment check**	
13	**Instructions**	**How hard? 1-5 (5 is high)**	**Notes**	
14	De construct formula in column C			
15	Explain what the recipe calc is doing			
16	Use different user methods or functions to get the result in Col D			

Figure 1: Skills appraisal used and refined in the pilot study.

With these adjustments, the implementation process became: A skills appraisal given face-to-face, on an windows laptop with Microsoft Excel, Word (365) and a Firefox browser open and visible. A windows laptop is given to participants with Excel open on one side of the screen (70%), Word (30%) on the other. Firefox was on top of Excel and Word.

3.4 Skills Appraisal Design and Structure

The skills appraisal involved "Blocks" of exercises and, each block has a shared goal of checking the basics of each skill and, application of the intended skill within each block. The blocks and their components are shown in Table.1-3, and are described below in terms of Topics, Sub-Tasks and Criteria:

Topics are groupings of sub-tasks but within a generalised scope. For example, one topic is arithmetic which has three sub-tasks: adding two whole numbers, finding an average of five numbers, and adding two floating numbers.

Sub-Tasks are the skills assessments' instructions to the participant, completion of which demonstrates a skill. For example: a participant would be asked to find the average of a set of numbers using Microsoft excel functions and formula. Sub-tasks are a key element of the framing of this research, as they are the indicators of individual needs.

Criteria are the correct result of the sub-task instructions and are also per sub-task. Criteria are defined below to give the researcher indication of completion and guidance of skill acquisition. To identify individual needs, criteria is not given to participants as that introduces the risk of participants only focusing on the criteria, rather than the sub-tasks. During the skills appraisal, only sub-task instructions were given to participants, not the criteria.

Following an initial skills appraisal, training was provided to each participant and then a second skills appraisal. The same appraisal process was followed each time and all iterations of skills appraisals given to the participants, are identical in process, instruction, and behaviour, to minimise the variation and influence, while maintaining a consistent experiment. This was done even in cases where the participant timed out for the allotted time (Van Laar et al., 2018). Materials provided for the appraisal are shown in figure.2 and figure.3.

Block A & B	
Questions	
1. Add two numbers	
a.	58 and 98
b.	158+76
2. Find average of 5 numbers	
a	43
b	66
c	34
d	78
e	117
3. Check IF number is below 20	
a.	Floating number
b.	IF(A1<0,yes,no)
c.	Value greater than 120
4. Write a recipe	
5. Format recipe	

Figure 2:Questions given to particpants after refinement

Block C & D			
Name of Ingredients	Input your sample weights (g)	Ingredients % Ratio	Actual Weight Required
	Grams (Number Only)		
salt	150.00 g	6.58 %	65.79 g
sugar	600.00 g	26.32 %	263.16 g
starch	1,025.00 g	44.96 %	449.56 g
yeast	500.00 g	21.93 %	219.30 g
onion	5.00 g	0.22 %	2.19 g
Total	2,280.00 g	100.00 %	1,000.00 g
Base Val (g):	1,000.00 g		

Explain what you think the presented spreadsheet is doing
Check values are correctly calculated
Reproduce any of the formula
Deconstruct the nested IF formula
Correct formula

Note: The below is to demonstrate to research the formula used. The participants only saw Col.A-D			
Name of Ingredients	Input your sample weights (g)	Ingredients % Ratio	Actual Weight Required
	Grams (Number Only)		
salt	150.00 g	=IF(OR(B22="",B27=0,ISTEXT(B22)),0,SUM((B22/SUM(B22:B26))*100))	=SUM((C22*B29)/100)
sugar	600.00 g	=IF(OR(B23="",B27=0,ISTEXT(B23)),0,SUM((B23/SUM(B22:B26))*100))	=SUM((C23*B29)/100)
starch	1,025.00 g	=IF(OR(B24="",B27=0,ISTEXT(B24)),0,SUM((B24/SUM(B22:B26))*100))	=SUM((C24*B29)/100)
yeast	500.00 g	=IF(OR(B25="",B27=0,ISTEXT(B25)),0,SUM((B25/SUM(B22:B26))*100))	=SUM((C25*B29)/100)
onion	5.00 g	=IF(OR(B26="",B27=0,ISTEXT(B26)),0,SUM((B26/SUM(B22:B26))*100))	=SUM((C26*B29)/100)
Total	=SUM(B22:B26)	=IF(OR(ISTEXT(B22),ISTEXT(B23),ISTEXT(B24),ISTEXT(B25),ISTEXT(B26)),"No Text, Enter Number",SUM(C22:C26))	=SUM(D22:D26)
Base Val (g):	1,000.00 g		

Figure 3: The recipe calculator and questions related. Both user and formula view

The *training between* skills appraisals, was the same content for each participant, however with emphasis on the individual's needs to account for their developing skills. Participants often asked for clarification to sub-tasks, which was not given as it would invalidate the experiment. Consequently, almost all participants asked for clarification on some of the intentionally ambiguous sub-tasks which were left to the participants to infer meaning on their own. This was to encourage participant resourcefulness (Reyes-Millán et al., 2023). Once participants realised, they would not get clarification from the researcher, most assumed understanding of the nature of the appraisal and stopped asking the researcher and started exploring functions and tools within their reach. The tables below (Table 1, 2 & 3), are the summarised skills and criteria from figures 2 and 3. Skills are grouped into topics and delivered as sub-tasks to check the skills under multiple contexts. This offers multiple results for the same skill without the participant repeating the same answer. The criteria are only for the assessor as an indication to what the participant can do.

Table 1: Topic area and criteria for questions given to participants.

Block A	**Instructions given within a word document, at the beginning of the appraisal. Checking for basic skills (Maths, functions in general and IF () function specifically)**	
Topic	**Sub-Tasks**	**Criteria**
Arithmetic	Add two numbers	Can add any two numbers
	58 and 98	Can add specified numbers
	158 + 76	Can recognise variation
Tool Functions	Find average of 5 numbers (43,66,34,78,117)	Understands how average works in mathematics
	Write in cell	Can recognise technical jargon and use a cell
	Function	Can use average() function
	Ribbon	Can find and use the average() function from the Ribbon
Core functions	Check IF number is below 20	Can recognise a logical test: IF() Function
	Use a floating number	Can use IF() function with fractions
	IF(A1<0,yes,no)	Can use IF() function with a cell reference
	"IF" Use any value greater than 120	Can use IF() function in their own way

Table 2: A more challenging version of Block A topics.

Block B	**Open ended instruction given at the same time as Block A. Checking for participant awareness of the context. Using Excel functions vs Manual entry**	
Topic	**Sub-Tasks**	**Criteria**
Complexity & Combination	Write a recipe	Can apply knowledge from Block A and write a recipe
Complexity & Dissemination	Format a recipe	Can apply knowledge from Block A and use formatting functions

Table 3: Criteria for Figure 3, for both Blocks C and D.

Block C & D	**Challenging "Recipe Calculator" given to participants after Block B is complete. Checking for transference of skills acquired in Blocks A &B in a new context.** **Block C unit of measurement = Grams** **Block C unit of measurement = Kilograms**	
Topic	**Sub-Tasks**	**Criteria**
Arithmetic	Explain what you think the presented spreadsheet is doing	Show understanding of task being formula based
Tool Functions	Check values are correctly calculated	Understanding the use of cell reference
	Reproduce any of the formula	Understanding of how to build a formula
Core functions	Deconstruct the nested IF formula	Understanding of combining a cluster of formula
	Correct formula	Correcting an issue within the formula

4. Findings and Results

Although the data collection was successful, analysis of observation data showed that some participants did not demonstrate understand of the overall topic within a block but were still able to meet sub-task criteria. This was particularly an issue as it was not clear if participants had guessed and got lucky or, if participants already knew the skill but did not demonstrate or articulate well. Groupings like these examples were noted down and created a theme, such as "Guessing."

4.1 Pre- Analysis and Emergent Themes

As the data is qualitative in the form of researcher notes, observations, and participants narrations, NVivo 14 was used paired with manual (by-hand) thematic coding to check the validity and reliability of data coded in NVivo 14. After performing manual coding by hand on a small subset of data (Patil, 2023), much of the data could then be entered into NVivo 14 for manual (non-AI) tool assisted coding. Tool assisted codes were compared against manual coding to ensure validity and minimise any loss of insights, by confirming consistency between both sets.

4.1.1 Brief analysis of some themes

To understand if individual needs were identified and addressed, coded data is thematically organised and analysed (Patil, 2023). In Appendix-3, emergent themes are outlined and described some of which are analysed below:

Resourcefulness in this research is utilisation of tools and functions available to participants. This includes using Excel in-built functions or searching via the internet. Most participants demonstrated resourcefulness after training given, particularly within Block A: Core Functions, where the "IF()" function as introduced. However, this was expected as the training given demonstrated ways to find and use functions in the sub-tasks, and the "IF()" function was found challenging, due to the vagueness of the function title "... bit vague, what do you mean 'if'?" (P3).

Coping Mechanisms are actions or strategies that participants use when they are unsure of what to do. In the appraisals, coping mechanisms are identifiable through abandoning a sub-task attempt method, in favour for another more familiar strategy. Coping mechanisms are evident across all sub-tasks, for example: participant 4 (P4) could not find the function to complete the average() sub-task within Block A:Tool Functions, P4 expressed the calculation manually, then wrote the answer after "...shrugging their shoulders…".

However, the frequency of the "coping mechanisms" theme poses a commonality issue with a theme later defined: "Given up," as using a different strategy can be interpreted as giving up on a previous strategy.

Given Up is defined as abandoning a sub-task, which was commonly found in more challenging blocks such as block C and block D. This was expected, particularly before training was given, as participants new to those functions and their complexity, would likely attempt the sub-task partially, or not attempt at all. Coincidentally, "skipping" a sub-task could also be interpretated as giving up, for example: after training given, participants ignored sub-tasks they had already done within their first skills appraisal stating "… I've already done this one last time …" (P4&1) and moving on to challenging sub-tasks they did not complete within the first appraisal.

Skipping is defined as not attempting a sub-task at all in skills appraisals and, is an expected theme because of the assumption by participants that the answers within the first appraisal did not need repeating within the second appraisal. Skipping was prevalent within the simpler blocks A and B, during the second skills appraisal.

Manual effort is where participants resorted to manually calculate answer instead of using functions required by the sub-task. This was common with blocks that had simpler arithmetic as some participants, used that manually calculated result to check the validity of an answer using core functions in Excel, such as, mentally adding all the numbers and comparing that result against a result from the SUM() function. P4 commonly described the function and wrote down the answer, as opposed to using the required excel function. However, P3 stated that they did not understand what the task required, but still attempted to use the formula after having an answer to "…work back from…". Although done incorrectly, P3 demonstrated understanding the core concept through manual intervention.

4.2 Findings and Results Summary

Current findings and analysis show that participants do recognise that they are not confident in their abilities, irrespective of actual skill and task completeness. Most observations note that participants revert to what is comfortable when faced with a problem they do not understand. However, counter-intuitively, once participants understand the problem, there is a high chance that when presented with the exact same problem, are likely to intentionally skip repeating the task, and want to focus on an interest area.

An example is when P1 was more interested in further training after the last skills appraisal but specifically for skills they found interesting or fun. Another example is where observations of P5 highlighted an unintended consequence of explanation limitations. P5 was more motivated to fixing a formula issue rather than the meaning behind the task. For instance, P5 had already understood a combination of Excel functions (IF, SUM and ISTEXT), and spent the remainder of the appraisal fixing that combination rather than to move on to the next task which utilised those functions with an example.

Furthermore, identifying individual needs was much simpler once the initial baseline skills appraisal was conducted, and in some cases, the participants recognised their own individual needs because of the appraisal.

5. Discussion and Conclusions

5.1 Framework vs Emergent Themes

When comparing emergent themes against the delivery of the skills appraisal, it is unsurprising that participants that were observed to have struggled the most, attempted the most that they could within the given timeframe and showed more careful thought of the task at face value. Observations noted that they were understandably visibly stressed but they followed through the intended framework. When comparing the sentiment of each theme, the baseline appraisal would be mostly negative, particularly as an explanation as to why participants won't get the "Correct answer", before participants attempted the task.'' I don't know what this means but I know how to add these two. So, which of these are the bit that I need." (P4). However, after the short training session, the sentiment to theme was largely positive, even when the result was failing to solve the task. These participants largely fit into the Coping Mechanisms theme.

Interestingly, the participants that were more confident with Excel, irrespective of their measured skills, guessed more often on the easier sub-tasks and topics to save time. Their efforts were more directed toward the harder challenges they noticed during their initial task appraisal. This resulted in these participants not getting the benefit of the framework structure which is designed to encourage the use of the skills they would need. Some of these participants did not necessarily perform much better than those with lesser knowledge of Excel, though observations note that their confidence and resourcefulness was much higher. The researcher noted that this unintended outcome was surprisingly positive, as these participants were more willing to take the challenge, albeit more difficult as they had skipped the sub-tasks that built the foundations of said skill.

5.2 Why Individual Needs Matter

As expected, each participant had prior knowledge or at least awareness of the core tool Excel. Each participant had unique experience with Excel prior to the appraisal process, which meant that each participant had a unique starting point. For example, some understood the Microsoft 365 design language and could navigate the "ribbon", even though they had hardly ever used Excel, these participants were more likely to be positive as the learning curve appeared to be simpler. Other participants such as P4 had worked in previous versions of Excel so they understood the structure for functions and how to diagnose issues they had, even though they may not have understood the mathematical and logical requirement to each task. However, none of the participants had expressed familiarity with the more complex topics of deconstructing a cluster of formulae.

Every participant within this paper, had at least one topic they struggled to complete or attempt within the baseline skills appraisal. This made the training given relatively linear as it was already obvious to the researcher which topics the participants would focus the most on. Irrespective of the above, all participants received training in the skills in the exact same way. This ensured that all participants could still be measured in an identical fashion for the purpose of this research.

It is important to note that the training given did not address any of the sub-tasks directly, but rather focused on the skill without explicitly stating the skill (Patil, 2023). For example: The researcher demonstrated accessing an IF() statement in three separate ways: Ribbon and then functions menu, typing a basic IF statement within a cell to reference another value (text based instead of arithmetic), using the inbuilt

functions shortcut to access the IF() functions help blurb. Most participants recognised what they had misunderstood or got wrong.

Wider research that this researcher is actively involved in applies an adapted framework on the digital skills training portion as well as the digital skills appraisal, the intention being to target the participants individual needs outlined in both interviews and skills appraisals (Barbosa et al., 2022).

5.3 Face-To-Face VS Online Training

Some of the challenges in providing digital training are the differences in the different versions of the same software as some functionalities vary with each iteration of the Microsoft suite. Additionally, the different experiences of the participants posed a challenge, for example those who are used to Windows versus Mac. To ensure a consistent experience for participants we had to make sure that everyone used the same version of the same software.

The considerations to mitigate the challenges were either; face-to-face via a physical device that is prepared ahead of time and, that is handed to the participant and used exclusively for the allocated tasks, or to have online participation through a virtual machine that simulates the appraisal parameters required. However, the challenges of online training include participant connectivity for virtual assessment could not be guaranteed, which may cause additional stressors to participants, and it would be impossible to know if participants have lost connection or just quit. With these considerations, the appraisal process had to be face-to-face.

Additionally, the appraisal process being face-to-face also allowed recording of observations such as narration of actions and thoughts, monitor physical interactions with the supplied device, keep track of when participants used pen and paper to write out their plan or questions to ask during the training phase of the assessment and finally, when participants did calculations on familiar devices such as a mobile phone.

5.4 Strategies for Digital Trainers

Digital trainers should consider using the following suggestions when formulating their strategies; regardless of experience or profession, making broad assumptions is ill-advised without first ensuring that the demographic knows how to use both the device and applications required. Additionally, results from this study suggest that there are three key problems that need to be mitigated:

5.4.1 Reinforcement of skills

Results suggests that participants that recognise repetition, are likely to skip the necessary step of repeating or practicing the newly acquired skill; as a result, skills should be checked and reinforced through differing topics and contexts.

5.4.2 Language barrier

Technical language is not ubiquitous, meaning that words and phrases could be misunderstood. E.g. “Install an app” could mean tapping on an app icon on a tablet versus using an installation wizard on a desktop. To mitigate this, all communication and instructions should be done so in plain language.

5.4.3 Awareness

Recognising the individual needs that the trainees themselves may not be aware of, or able to articulate, may cause trainees to give up when not addressed. To identify and address these needs, trainee observations should accompany all technical tasks.

6. Limitations / Future Research

For future research, the impact of learning styles and how they affect trainees during the appraisal process and subsequent training given could be considered. For instance, measuring the implications of online learning on trainees that might be kinaesthetic learners. Further, If the appraisal process within this research were to be modified to accommodate online appraisals and training, we would need to consider certain qualifiers such as ensuring that participants can all access the same version of software and are comfortable with the differences between the two methods of delivery.

6.1 Resource Management

An unintended outcome highlighted in 6.1 where participants skipped questions to save time, demonstrated that research parameters introduced a limitation, as in the industry; the appraisal process would likely have more accommodating parameters such as extended allotted time. Removal of this limitation should make the appraisal process versatile enough to accommodate emergent individual needs that are to be addressed within the training process. Consequently, finding a balance of addressing individual needs (versatile) with linear provisions of training becomes a question of resource availability.

6.2 Basic Assumptions and Motivations

In research reported elsewhere, basic assumptions and further identification of weaknesses are partly indicated through key-informant interviews conducted prior to the skills appraisal, which inform the researcher what skills to focus on within the training given. Another aspect to consider in future research is what are the motivations of participants in training and what skill they want to attain. This is also addressed in interviews that were conducted, which will be reported separately.

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Enhancing Geometry Learning with GeoGebra: A Study

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Abstract: This study investigates the integration of GeoGebra software and various digital technologies, including augmented reality (AR), virtual reality (VR), and 3D printing, into geometry courses for future mathematics teachers at the Faculty of Education, University of Ostrava. Conducted over two years using a design-based research (DBR) approach, the study involved first- and second-year students training to become primary school mathematics teachers. The primary objectives were to enhance conceptual understanding, improve spatial reasoning, develop algorithmic and critical thinking, and reduce reliance on formal knowledge through a combination of traditional and digital methods. The teaching model was iteratively developed and refined based on continuous feedback and evaluation. Initial activities combined traditional "pencil and paper" techniques with GeoGebra's dynamic capabilities. Advanced features, including GeoGebra applets, AR, VR, and 3D printing, were progressively incorporated to provide more immersive and interactive learning experiences. Data were collected via questionnaires, classroom observations, and reflective journals, offering comprehensive insights into student engagement and learning outcomes. Findings indicate that integrating GeoGebra and digital technologies significantly enhances student engagement, motivation, and understanding of geometric concepts. Students demonstrated improved spatial reasoning and algorithmic thinking, and future teachers gained valuable skills for creating interactive and effective learning environments. Challenges included initial resistance to digital tools and the need for continuous adaptation based on feedback. The study concludes that incorporating GeoGebra and digital technologies into geometry education can transform traditional teaching methods, making lessons more interactive, engaging, and effective. Future research should focus on long-term retention of geometric concepts, larger and more diverse sample groups, and further integration of advanced digital features and cross-disciplinary applications. This innovative approach holds significant potential for enhancing geometry education and preparing future educators with practical, modern teaching strategies.

Keywords: Augmented reality in education, GeoGebra, Teacher training, Geometry courses, Algorithmic thinking

1. Introduction

Geometry is fundamental in mathematics education, crucial for developing spatial reasoning, problem-solving, and logical thinking. Traditional methods of teaching geometry often rely heavily on "pencil and paper" techniques. While foundational, these methods can limit students' engagement and understanding by focusing on rote learning and procedural tasks. This approach may not effectively convey the dynamic and interconnected nature of geometric concepts, leading to difficulties in visualizing and comprehending abstract relationships. Consequently, students may struggle to apply their knowledge in practical contexts.

To address these challenges, integrating innovative tools like GeoGebra can transform the teaching and learning of geometry. GeoGebra, a dynamic mathematics software, offers a multifaceted approach by allowing students to explore and manipulate geometric figures interactively. This provides immediate visual feedback, fosters a deeper understanding of geometric relationships, and enhances algorithmic thinking and problem-solving skills. Additionally, advanced features such as augmented reality (AR), virtual reality (VR), and 3D printing can provide more immersive and interactive learning experiences.

The primary aim of this study is to develop and refine a teaching model for geometry that integrates traditional methods with the dynamic capabilities of GeoGebra and other digital technologies. This model seeks to reduce students' reliance on formal knowledge, enhance their conceptual understanding of geometry, improve spatial reasoning and algorithmic thinking, and foster critical thinking through dynamic exploration and manipulation. Additionally, it aims to prepare future mathematics teachers with practical skills for creating engaging learning environments.

2. Research Objectives

The primary aim of this study is to develop and refine a teaching model for geometry that integrates traditional "pencil and paper" methods with the dynamic capabilities of GeoGebra and various digital technologies, including virtual reality (VR), augmented reality (AR), applets, and 3D printing. This innovative approach seeks to enhance the overall learning experience and equip future mathematics teachers with the skills and tools necessary for effective teaching. The specific research objectives are as follows:

- *Reduce Reliance on Formal Knowledge*: Traditional geometry education often emphasizes rote memorization and procedural tasks. This study aims to reduce students' reliance on formal knowledge by incorporating GeoGebra's interactive features, which encourage conceptual understanding through exploration and manipulation of geometric figures.
- *Enhance Conceptual Understanding of Geometry*: By using GeoGebra applets, augmented reality, and dynamic visualization tools, the study seeks to improve students' grasp of geometric concepts. These tools help bridge the gap between abstract theories and practical applications, making it easier for students to visualize and understand complex geometric relationships.
- *Improve Spatial Reasoning and Algorithmic Thinking*: The integration of GeoGebra and VR, AR, and 3D printing technologies aims to develop students' spatial reasoning skills by allowing them to interact with 3D shapes and perform dynamic constructions. Additionally, these technologies promote algorithmic thinking by enabling students to experiment with different geometric scenarios and solve problems through step-by-step exploration.
- *Foster Critical Thinking through Dynamic Exploration*: GeoGebra's dynamic environment allows students to engage in inquiry-based learning, where they can pose questions, test hypotheses, and explore geometric properties. This approach encourages critical thinking and helps students develop a deeper understanding of the subject matter.
- *Prepare Future Mathematics Teachers with Practical Skills*: The study aims to equip future mathematics teachers with a comprehensive toolkit of teaching methods and digital tools. By experiencing a variety of teaching techniques and technologies, students will be better prepared to create engaging and effective learning environments in their future classrooms.
- *Create Engaging Learning Environments*: By combining traditional teaching methods with innovative digital tools such as GeoGebra applets, AR, VR, and 3D printing, the study seeks to make geometry lessons more interactive, engaging, and personalized. This approach aims to increase student motivation and participation, ultimately leading to improved learning outcomes.
- *Evaluate the Effectiveness of the Teaching Model*: The study will employ a design-based research (DBR) approach to iteratively design, test, and refine the teaching model. Through continuous feedback and evaluation, the study aims to identify best practices and optimize the integration of GeoGebra and related technologies in geometry education.

By addressing these objectives, the study aims to transform traditional geometry teaching methods, enhance student engagement and understanding, and prepare future educators to effectively use modern digital tools in their classrooms.

3. Theoretical Framework

This study is grounded in the principles of Inquiry-Based Learning (IBL), Design-Based Learning (DBL), and social constructivism.

- **Inquiry-Based Learning (IBL)**: Encourages students to take an active role in their learning through questioning, exploration, and problem-solving, promoting deeper understanding through discovery and hands-on activities (Piaget, 1971; Vygotsky, 1978).
- **Design-Based Learning (DBL)**: Integrates the design process into educational activities, fostering creativity, problem-solving, and practical application of knowledge through iterative cycles of designing, testing, and refining solutions (Haas, Kreis, & Lavicza, 2021).
- **Social Constructivism**: Emphasizes learning through social interaction and collaboration, with knowledge constructed through shared experiences and guided interaction (Kostrub, & Ostradicky, 2019; Vygotsky, 1978).

These frameworks inform the integration of GeoGebra, AR, VR, and 3D printing to create an engaging and effective learning environment that enhances understanding of geometry while developing critical thinking, spatial reasoning, and algorithmic skills (Bohdal, 2019; Dana-Picard et al., 2021; Kusumah, Kustiawati, & Herman, 2020).

4. Methodology

The study employed a design-based research (DBR) approach, characterized by iterative cycles of designing, testing, and refining educational interventions. This approach is particularly suitable for educational settings as

it allows for continuous improvement of teaching practices based on real-time feedback and observations (Lavicza et al., 2022). The DBR process is guided by principles of social constructivism and inquiry-based learning (IBL), ensuring that the interventions are both theoretically grounded and practically relevant (Piaget, 1971; Vygotsky, 1978).

Participants in this study were students enrolled in the Mathematics Education program at the Faculty of Education, University of Ostrava. Each academic year, a single study group consisting of 19 to 25 students participated in the Synthetic Geometry course. These students, training to become primary school mathematics teachers, provided a relevant and focused sample for evaluating the effectiveness of the teaching model in preparing future educators.

Data were collected using a variety of methods to capture a comprehensive understanding of the teaching model's effectiveness. Questionnaires were used to gather students' feedback on their learning experiences, understanding of geometric concepts, and engagement levels. Both pre- and post-intervention questionnaires were administered to measure changes over time. Observations were conducted during classroom sessions to monitor student interactions, use of GeoGebra, and engagement with the tasks. Teacher maintained reflective journals to document their observations and reflections on the teaching process (Kemmis, McTaggart, & Nixon, 2014). Additionally, both students and teacher were encouraged to keep reflective journals, with students reflecting on their learning experiences and challenges faced, while teacher documented their observations, adjustments made to the teaching model, and reflections on its effectiveness (Švaříček & Šeďová, 2007).

The study employed both qualitative and quantitative data collection methods. Qualitative data included feedback from questionnaires, observations, and reflective journals, providing insights into students' experiences, challenges, and perceptions of the teaching model (Kostrub, & Ostradicky, 2019). These qualitative methods allowed for a deeper understanding of the contextual and experiential aspects of the teaching and learning process. Quantitative data included pre- and post-intervention test scores to measure improvements in students' understanding of geometric concepts and their spatial reasoning abilities. Statistical analyses were conducted to evaluate the significance of the observed changes, providing measurable evidence of the effectiveness of the teaching interventions.

The DBR process was implemented in several phases, each building on the feedback and data collected from the previous phase. The initial implementation phase involved introducing GeoGebra and basic training sessions for students, with initial activities designed to combine traditional "pencil and paper" methods with GeoGebra. The refinement phase included adjustments based on initial feedback, with enhanced activities and tasks using GeoGebra to address identified challenges. Additional training sessions were provided to improve proficiency with GeoGebra. The advanced implementation phase involved more complex tasks and projects integrating GeoGebra, the introduction of gamification elements, and collaborative learning activities. Continuous collection of feedback and observations allowed for further refinements (Lavicza et al., 2022).

The development of the teaching model focused on combining traditional "pencil and paper" methods with GeoGebra, emphasizing foundational skills and dynamic visualizations. Students performed manual constructions and used GeoGebra to explore and verify their results, with the model refined through multiple iterations based on feedback from students and teacher. Adjustments included balancing manual and digital tasks, enhancing scaffolding, and integrating advanced GeoGebra features such as AR and 3D printing. In addition to GeoGebra, VR technologies were integrated into the teaching model, allowing students to explore 3D geometric shapes and solve complex construction tasks, thereby enhancing their spatial reasoning and engagement (Kusumah, Kustiawati, & Herman, 2020).

The specific activities and tasks designed for the teaching model included basic constructions where students performed geometric constructions using both traditional methods and GeoGebra, dynamic explorations where students manipulated geometric figures in GeoGebra to explore properties and relationships dynamically, collaborative projects where students used GeoGebra to model and solve complex geometric problems, and gamification activities incorporating game elements to make learning more engaging.

Through this comprehensive and iterative methodological approach, the study aimed to create an effective and engaging teaching model that leverages the strengths of both traditional and digital methods to enhance geometry education.

5. Development of the Teaching Model

The development of the teaching model was an iterative process, leveraging the principles of design-based research (DBR) to continuously refine and improve the integration of GeoGebra and various digital technologies into the geometry curriculum. This process was guided by feedback from students and teacher, ensuring the model remained responsive to their needs and effectively enhanced learning outcomes.

5.1 Initial Model Design

The initial design of the teaching model combined traditional "pencil and paper" methods with the dynamic capabilities of GeoGebra. Traditional methods focused on foundational skills such as manual constructions, proofs, and the development of geometric intuition. These methods are essential for students to grasp the basic principles and logic underlying geometric concepts. However, they often lack the ability to provide immediate visual feedback and interactive exploration. To address these limitations, GeoGebra was introduced as a digital tool to enhance visualization and interactivity.

The initial activities were designed to transition smoothly from traditional methods to incorporating GeoGebra. For example, students started with basic constructions using a compass and straightedge, then replicated these constructions in GeoGebra. This dual approach reinforced their understanding and allowed them to compare the manual and digital processes. Teaching strategies included guided discovery, where students were encouraged to explore geometric properties and relationships independently using GeoGebra. Teacher provided scaffolding through targeted questions and prompts, helping students make connections between their manual constructions and the dynamic models in GeoGebra (Hohenwarter & Jones, 2007).

5.2 Iterative Improvement Process

The development of the teaching model followed an iterative process typical of DBR. This process involved multiple phases of implementation, feedback, and refinement:

- *Pilot Phase*: The initial model was tested with a first group of students to gather preliminary feedback and identify potential issues. This phase focused on evaluating the effectiveness of combining traditional methods with GeoGebra and observing student engagement and understanding.
- *First Iteration*: Based on feedback from the pilot phase, adjustments were made to the activities and teaching strategies. This included refining the balance between manual and digital tasks and enhancing the scaffolding provided by teacher. The revised model was then implemented with a new group of students in the following academic year.
- *Second Iteration*: Further feedback was collected through observations, student questionnaires, and teacher reflections. This data was used to make additional refinements, such as adjusting the complexity of tasks and improving the integration of GeoGebra features. The model was continuously tested and improved over several iterations (Lavicza et al., 2022).

Feedback played a crucial role in the iterative improvement process. Teacher kept reflective journals, noting observations and insights from each lesson. Student feedback was gathered through questionnaires focusing on their experiences and perceptions of the learning activities. This feedback loop allowed for ongoing adjustments and refinements. For example, if students reported difficulty in transitioning between manual and digital methods, additional support and practice activities were introduced. If teacher observed that certain GeoGebra features were underutilized, targeted training sessions were conducted to enhance their integration (Kostrub, & Ostradicky, 2019).

5.3 Incorporation of Advanced GeoGebra Features

As the teaching model evolved, more advanced features of GeoGebra were incorporated to further enhance student learning. These included:

- *GeoGebra Augmented Reality (AR):* GeoGebra AR allowed students to visualize and interact with 3D geometric shapes in their physical environment. This immersive experience significantly improved students' spatial reasoning and made abstract concepts more tangible (Lavicza et al., 2022).
- *GeoGebra for Constructive Tasks*: Digital construction tasks using GeoGebra reinforced students' manual skills while introducing dynamic methods of verifying and exploring their constructions. This promoted critical thinking and precision in their work (Kusumah, Kustiawati, & Herman, 2020).

- *GeoGebra Applets*: Interactive modules enabled students to manipulate geometric figures and observe transformations in real-time, fostering a deeper understanding of geometric relationships (Hohenwarter & Jones, 2007).
- *3D Printing:* Integrating 3D printing with GeoGebra allowed students to create physical models of geometric shapes, providing a hands-on experience that further reinforced their understanding of spatial relationships and geometric properties (Lavicza et al., 2022).
- *GeoGebra with Virtual Reality (VR*): In this phase, we incorporated GeoGebra applets into virtual reality environments. Using VR software, students were able to immerse themselves in 3D geometric worlds, exploring and manipulating shapes in a more engaging and interactive manner. The VR integration significantly enhanced spatial reasoning and provided a unique, immersive learning experience. Additionally, we employed gamification techniques within the VR environment to make learning more engaging. For instance, students participated in virtual challenges and games that required them to solve geometric problems and construct shapes using GeoGebra in VR. This gamified approach not only increased motivation and participation but also reinforced their understanding of geometric concepts through active involvement (Berger-Haladová, & Ferko, 2019).

5.4 Gamification and Collaborative Learning

An innovative element of the teaching model was the incorporation of gamification and collaborative learning. For example, students were divided into groups, each focusing on different geometric shapes like squares, rhombuses, and ellipses. They described these shapes using their characteristic properties and then challenged other groups to identify them based on these descriptions. This playful, competitive element made learning more engaging and reinforced their understanding of geometric properties through peer interaction (Berger-Haladová, & Ferko, 2019).

5.5 Continuous Refinement and Feedback

The iterative nature of the DBR approach allowed for continuous refinement of the teaching model based on feedback from students and teacher. Each phase of implementation provided valuable insights into the effectiveness of the activities and the overall model. Adjustments were made to improve the balance between traditional and digital methods, enhance the scaffolding provided by teacher, and increase the complexity of tasks as students' skills developed. Feedback from reflective journals and questionnaires played a critical role in shaping these refinements (Kemmis, McTaggart, & Nixon, 2014; Švaříček & Šeďová, 2007).

The final iteration of the teaching model demonstrated significant improvements in both student engagement and understanding of geometric concepts. The combination of "pencil and paper" methods with GeoGebra proved to be highly effective, making lessons more interactive, engaging, and personalized. Students not only acquired a deeper understanding of geometry but also developed essential skills such as problem-solving, critical thinking, and collaboration. The positive outcomes of the refined teaching model highlight the potential of integrating digital tools like GeoGebra into regular geometry teaching to enhance educational experiences and outcomes.

6. Activities and Their Impact

The teaching model developed in this study incorporated a variety of activities designed to integrate traditional methods with the dynamic capabilities of GeoGebra and other digital technologies. These activities were carefully crafted to enhance student engagement, understanding, and retention of geometric concepts. The impact of these activities was assessed through continuous feedback and iterative refinements, ensuring their effectiveness in achieving the study's educational objectives.

6.1 Basic Constructions

One of the foundational activities involved basic geometric constructions using both traditional "pencil and paper" methods and GeoGebra. Students initially performed constructions manually, using tools like compasses and straightedges, to develop their foundational skills and geometric intuition. They then replicated these constructions digitally in GeoGebra, which allowed them to explore and verify their results dynamically. This dual approach reinforced their understanding and highlighted the advantages of digital tools in visualizing geometric relationships.

The impact of these basic construction activities was significant. Students reported that the immediate visual feedback provided by GeoGebra helped them grasp concepts more quickly and accurately. They appreciated

the ability to manipulate geometric figures interactively, which made abstract concepts more tangible and easier to understand. This activity also promoted critical thinking and problem-solving skills, as students could test different scenarios and observe the outcomes in real-time (Schmidthaler et al., 2023).

6.2 Dynamic Explorations

Dynamic exploration tasks allowed students to manipulate geometric figures in GeoGebra to explore properties and relationships dynamically. For instance, students could change the dimensions of shapes, transform them, and observe how these changes affected their properties. These tasks encouraged students to engage deeply with geometric concepts, fostering a deeper understanding through active experimentation.

The impact of dynamic explorations was reflected in enhanced spatial reasoning and algorithmic thinking among students. By actively engaging with geometric figures and observing their transformations, students developed a more intuitive understanding of geometric properties and relationships. This hands-on approach also increased their confidence in tackling complex geometric problems and applying their knowledge in new contexts (Hohenwarter & Jones, 2007).

6.3 Collaborative Projects

Collaborative projects were an integral part of the teaching model, promoting teamwork and communication skills. In these projects, students worked in groups to model and solve complex geometric problems using GeoGebra. For example, they might be tasked with designing a geometric structure that meets specific criteria, requiring them to apply various geometric principles and use GeoGebra to visualize and test their designs.

The collaborative projects had a positive impact on student engagement and learning outcomes. Working in groups allowed students to share ideas, learn from each other, and approach problems from different perspectives. This collaborative learning environment fostered a sense of community and support, making the learning experience more enjoyable and effective. Additionally, the projects helped students develop essential skills such as critical thinking, problem-solving, and the ability to communicate mathematical ideas clearly and effectively (Kostrub, & Ostradicky, 2019).

6.4 Gamification Elements

Gamification elements were incorporated into the teaching model to make learning more engaging and interactive. For instance, students participated in competitive challenges where they described geometric shapes using their properties and then challenged other groups to identify them based on these descriptions. This playful, competitive element added excitement to the learning process and motivated students to participate actively.

The impact of gamification was evident in the increased motivation and enthusiasm among students. The competitive and interactive nature of these activities made learning more enjoyable and engaging. Students reported that they looked forward to these challenges and found them helpful in reinforcing their understanding of geometric concepts. Gamification also promoted collaborative learning, as students worked together to solve problems and achieve common goals (Berger-Haladová, & Ferko, 2019).

6.5 Integration of Advanced GeoGebra Features

The teaching model also incorporated advanced features of GeoGebra, such as Augmented Reality (AR), Virtual Reality (VR), and 3D printing, to provide more immersive and hands-on learning experiences. In the AR activities, students used GeoGebra AR to visualize and interact with 3D geometric shapes in their physical environment, enhancing their spatial reasoning skills. In the VR activities, students explored 3D geometric worlds and participated in gamified challenges, further enhancing their engagement and understanding. The integration of 3D printing allowed students to create physical models of geometric shapes, providing a tangible representation of abstract concepts.

The impact of these advanced features was substantial. Students reported that the immersive experiences provided by AR and VR made learning more engaging and effective. The ability to interact with 3D shapes in a virtual environment helped them develop a better understanding of spatial relationships and geometric properties. The use of 3D printing provided a hands-on experience that reinforced their learning and made abstract concepts more concrete (Lavicza et al., 2022).

Overall, the activities designed for the teaching model had a significant positive impact on student engagement, understanding, and retention of geometric concepts. The combination of traditional methods

with the dynamic capabilities of GeoGebra and other digital technologies provided a comprehensive approach to teaching geometry, enhancing the learning experience and preparing students for future success in their mathematical education.

7. Findings

The integration of GeoGebra and various digital technologies into the geometry curriculum significantly improved student engagement, understanding, and retention of geometric concepts. The iterative design-based research (DBR) approach allowed for continuous refinement of the teaching model, resulting in substantial educational benefits.

7.1 Enhanced Engagement and Motivation

The dynamic and interactive nature of GeoGebra, along with the incorporation of advanced features like Augmented Reality (AR) and Virtual Reality (VR), significantly increased student engagement and motivation. Students reported higher levels of interest and enthusiasm during lessons, attributing this to the ability to manipulate geometric figures interactively and explore them in immersive environments. The gamification elements further boosted motivation, as students found the competitive and playful aspects of learning to be exciting and stimulating (Berger-Haladová, & Ferko, 2019).

7.2 Improved Understanding of Geometric Concepts

The integration of GeoGebra significantly enhanced students' understanding of geometric concepts. The immediate visual feedback and dynamic manipulation capabilities of GeoGebra allowed students to explore geometric properties and relationships more deeply. Activities involving GeoGebra applets and dynamic explorations helped students visualize transformations, symmetries, and other geometric operations, leading to a more intuitive and comprehensive grasp of these concepts (Hohenwarter & Jones, 2007). The use of AR and VR further solidified this understanding by providing a tangible and immersive experience, making abstract concepts more concrete and easier to comprehend (Bohdal, 2019).

7.3 Development of Spatial Reasoning and Algorithmic Thinking

The study found that the integration of GeoGebra and digital technologies significantly improved students' spatial reasoning and algorithmic thinking skills. Tasks that required students to manipulate 3D shapes in AR and VR environments enhanced their ability to visualize spatial relationships and understand geometric properties from multiple perspectives. Additionally, the iterative design tasks and problem-solving activities promoted algorithmic thinking, as students engaged in step-by-step exploration and verification of geometric constructions (Haas, Kreis, & Lavicza, 2021).

7.4 Positive Impact on Critical Thinking and Problem-Solving Skills

The teaching model promoted critical thinking and problem-solving skills through activities that encouraged inquiry-based learning and collaborative projects. Students were challenged to pose questions, test hypotheses, and explore geometric properties using GeoGebra's dynamic tools. The collaborative projects further enhanced these skills by fostering teamwork and communication, as students worked together to solve complex geometric problems and share their findings. This collaborative learning environment not only improved their understanding of geometry but also developed their ability to think critically and solve problems effectively (Kostrub, & Ostradicky, 2019).

7.5 Preparation for Future Teaching Careers

Future mathematics teachers who participated in the study developed a comprehensive toolkit of teaching methods and digital tools, preparing them for their future roles as educators. By experiencing a variety of teaching techniques and technologies, they gained practical skills in creating engaging and effective learning environments. The iterative refinement of the teaching model ensured that they were well-equipped to integrate modern digital tools, such as GeoGebra, AR, VR, and 3D printing, into their future classrooms. This preparation is crucial for developing innovative teaching practices that can adapt to diverse educational settings and meet the needs of 21st-century learners (Leoste et al., 2022).

7.6 Challenges and Limitations

While the study demonstrated significant positive outcomes, it also identified several challenges and limitations. One of the main challenges was the initial resistance from some students who were unfamiliar with using digital tools in their learning process. This resistance was mitigated through additional training

sessions and ongoing support, which helped students become more comfortable and proficient with GeoGebra and other technologies. Another challenge was the need for continuous adaptation of the teaching model based on feedback from students and teacher. This iterative process required considerable time and effort to analyze feedback and implement changes effectively (Kemmis, McTaggart, & Nixon, 2014).

A limitation of the study is the relatively small sample size, as the study group consisted of a single cohort of 19 to 25 students each academic year. Future research should include larger and more diverse sample groups to validate the findings and ensure their broader applicability. Additionally, while the study focused on the short-term impact of the teaching model, further research is needed to investigate the long-term retention of geometric concepts taught using GeoGebra and related technologies.

The findings of this study highlight the transformative potential of integrating GeoGebra and digital technologies into geometry education. The teaching model significantly enhanced student engagement, understanding, and retention of geometric concepts, while also developing essential skills such as spatial reasoning, critical thinking, and problem-solving. The positive outcomes demonstrate that combining traditional methods with innovative digital tools can create a more interactive, engaging, and effective learning environment, ultimately preparing future educators to meet the challenges of modern educational settings.

7.7 Detailed Analysis of Feedback Data

The feedback data collected throughout the study provided valuable insights into students' experiences and perceptions of the teaching model. The key trends and conclusions are as follows:

- *Enhanced Understanding*: Most students reported a high level of understanding of the lectures and course requirements, attributed to the clear structure and interactive elements of GeoGebra.
- *Adaptation to Digital Tools*: Initial challenges in adapting to digital tools were mitigated through additional training sessions and ongoing support, leading to increased comfort and proficiency with GeoGebra.
- *Increased Engagement*: Students consistently demonstrated high levels of engagement and motivation, particularly appreciating the hands-on experience provided by GeoGebra and the immersive features of AR and VR.
- *Improved Retention*: There were indications of better retention of geometric concepts, suggesting the effectiveness of the teaching model in promoting lasting understanding.
- *Positive Reception of Advanced Features*: Students found the use of advanced GeoGebra features, such as AR and 3D printing, highly beneficial for enhancing spatial reasoning and making abstract concepts more tangible.
- *Overall Satisfaction*: Satisfaction levels remained high throughout the study, with students highlighting the combination of interactive digital tools and collaborative learning activities as key factors in their positive experience.

Experience with VR in Geometry Learning

- *Immersive Learning*: VR provided a powerful and immersive way to visualize and understand 3D geometric shapes, significantly enhancing spatial reasoning skills.
- *Gamification and Engagement*: The gamified elements within the VR environment made learning more engaging and enjoyable, motivating students to participate actively and collaboratively.

Overall Implications

- *Enhanced Student Engagement and Motivation*: The integration of GeoGebra and VR technologies significantly boosted student engagement and motivation, making learning more enjoyable and accessible.
- *Improved Understanding and Retention of Geometric Concepts*: Students demonstrated a deeper understanding and better retention of geometric concepts, bridging the gap between theoretical knowledge and practical application.
- *Development of Critical Skills*: The teaching model promoted the development of critical thinking, problem-solving, and spatial reasoning skills.
- *Preparation for Future Teaching Careers*: Future mathematics teachers benefited from the comprehensive toolkit of teaching methods and digital tools, preparing them for innovative teaching practices in diverse educational settings.

These positive outcomes demonstrate that combining traditional methods with innovative digital tools can create a more interactive, engaging, and effective learning environment.

8. Discussion and Conclusion

The integration of GeoGebra and various digital technologies into the geometry curriculum has demonstrated significant benefits in enhancing student engagement, understanding, and retention of geometric concepts. The study's iterative design-based research (DBR) approach allowed for continuous refinement of the teaching model, resulting in a robust and effective educational tool.

The dynamic and interactive nature of GeoGebra, augmented by advanced features such as Augmented Reality (AR) and Virtual Reality (VR), significantly boosted student engagement and motivation. The ability to manipulate geometric figures interactively and explore them in immersive environments made learning more enjoyable and accessible. The inclusion of gamification elements further increased motivation, as students found the competitive and playful aspects of learning to be stimulating and rewarding (Berger-Haladová, & Ferko, 2019).

Students demonstrated a deeper understanding and better retention of geometric concepts through the use of GeoGebra. The immediate visual feedback and dynamic manipulation capabilities allowed for a more intuitive grasp of geometric properties and relationships. Activities involving GeoGebra applets and dynamic explorations helped students visualize transformations and symmetries effectively. The use of AR and VR provided a tangible and immersive experience, making abstract concepts more concrete and easier to comprehend (Hohenwarter & Jones, 2007).

The study found significant improvements in students' spatial reasoning and algorithmic thinking skills. Tasks that required manipulation of 3D shapes in AR and VR environments enhanced their ability to visualize spatial relationships and understand geometric properties from multiple perspectives. Additionally, iterative design tasks and problem-solving activities promoted algorithmic thinking, as students engaged in step-by-step exploration and verification of geometric constructions (Haas, Kreis, & Lavicza, 2021).

The teaching model fostered critical thinking and problem-solving skills through inquiry-based learning and collaborative projects. Students were encouraged to pose questions, test hypotheses, and explore geometric properties using GeoGebra's dynamic tools. Collaborative projects further enhanced these skills by fostering teamwork and communication, allowing students to work together to solve complex geometric problems and share their findings. This collaborative learning environment not only improved their understanding of geometry but also developed their ability to think critically and solve problems effectively (Kostrub, & Ostradicky, 2019).

The study effectively prepared future mathematics teachers by providing them with a comprehensive toolkit of teaching methods and digital tools. By experiencing a variety of teaching techniques and technologies, students gained practical skills in creating engaging and effective learning environments. The iterative refinement of the teaching model ensured that future educators were well-equipped to integrate modern digital tools, such as GeoGebra, AR, VR, and 3D printing, into their classrooms. This preparation is crucial for developing innovative teaching practices that can adapt to diverse educational settings and meet the needs of 21st-century learners (Lavicza et al., 2022).

While the study demonstrated significant positive outcomes, it also identified several challenges and limitations. One of the main challenges was the initial resistance from some students who were unfamiliar with using digital tools in their learning process. This resistance was mitigated through additional training sessions and ongoing support, which helped students become more comfortable and proficient with GeoGebra and other technologies. Another challenge was the need for continuous adaptation of the teaching model based on feedback from students and teacher. This iterative process required considerable time and effort to analyze feedback and implement changes effectively (Kemmis, McTaggart, & Nixon, 2014).

A limitation of the study is the relatively small sample size, as the study group consisted of a single cohort of 19 to 25 students each academic year. Future research should include larger and more diverse sample groups to validate the findings and ensure their broader applicability. Additionally, while the study focused on the short-term impact of the teaching model, further research is needed to investigate the long-term retention of geometric concepts taught using GeoGebra and related technologies.

In conclusion, the findings of this study highlight the transformative potential of integrating GeoGebra and digital technologies into geometry education. The teaching model significantly enhanced student engagement,

understanding, and retention of geometric concepts, while also developing essential skills such as spatial reasoning, critical thinking, and problem-solving. These positive outcomes demonstrate that combining traditional methods with innovative digital tools can create a more interactive, engaging, and effective learning environment, ultimately preparing future educators to meet the challenges of modern educational settings.

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Masters Research Paper

The Role of AI-Driven Personalized e-Learning in Enhancing Economic Competitiveness: A Comparative Analysis of Developed And Developing Countries

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Abstract: This study explores the influence of AI-driven personalized e-learning on the Global Competitiveness Index (GCI) across six countries, comprising three developed (USA, Germany, Japan) and three developing (Pakistan, India and Nigeria) nations, over a span of 17 years (2007-2023). Utilizing a least squares regression model, the analysis incorporates key variables including the Artificial Intelligence Global Index (AIGI), Human Development Index (HDI), and R&D expenditure as control variables to assess their impact on GCI. The model demonstrates a robust fit, with an R^2 value of 96.79% and an adjusted R^2 value of 96.50%, indicating that AI-enhanced e-learning is a significant predictor as independent variables of economic competitiveness GCI. The findings underscore the significant role of investment in AI and e-learning technologies, particularly in enhancing economic competitiveness, as evidenced by strong positive correlations between GCI and AIGI, HDI, and R&D expenditure. The results are consistent with IBM's research, which highlights the importance of these variables in driving national competitiveness in the global market. The study concludes that AI-driven personalized e-learning is a critical lever for improving GCI, particularly for developing countries aiming to close the competitiveness gap with developed nations. The implications of this research suggest that targeted investments in AI and e-learning can substantially contribute to sustainable economic growth and international competitiveness. This study offers valuable insights for policymakers and educational institutions aiming to enhance their nation's competitiveness through strategic investments in AI-driven educational technologies.

Keywords: Global Competitiveness Index (GCI), Artificial Intelligence (AI), Developed and developing countries, E-learning, Human Development Index (HDI)

1. Introduction

The society is incorporating Artificial Intelligence (AI) in its all levels and is regarded as the 21st century's most important technological innovation. AI-based personalized e-Learning in education is emerging as a path for developing learning skills that suit individual needs and abilities. Education is being linked to economic competitiveness as the global economy shifts towards knowledge based activities. This research investigates skill-based e-learning's role in improving economic competitiveness, making comparisons between two sets of countries, set one includes United States, Japan, Germany, marked as 'developed' and set two includes Pakistan, India, and Nigeria which are named the developing. This study aims to show how educational progress affects a country's economy by examining the impact of AI-enabled personalized e-learning on the Global Competitiveness Index (GCI). However, understanding its specific effect for job competitiveness shows a significant variation. The relationship between GCI and AI-enabled self-learning has not yet been explored, especially through international comparisons. This study focuses on several important questions: What is the relationship between AI-enabled personal e-learning and GCI in developed and developing countries? What are the challenges facing success of AI-enabled personal learning?

To navigate these questions, the following hypotheses are posited:

> ***H1:*** *AI-driven personalized E-learning significantly enhances economic competitiveness, as measured by the Global Competitiveness Index (GCI).*
>
> ***H2:*** *The impact of AI-driven personalized E-learning on economic competitiveness is greater in developed countries compared to developing countries, due to differences in technological infrastructure and educational systems.*
>
> ***H3:*** *The effectiveness of AI-driven personalized E-learning in improving workforce skills and educational outcomes is a key mediator in the relationship between AI-driven personalized learning and economic competitiveness.*

Countries such as the United States, Germany and Japan, which are known as developed in the context of e-learning systems with high GDP per capita and high Human Development Index (HDI), and robust GCI rankings provide an advantageous environment for the adoption and effective implementation of AI-driven personalized learning. The United States, a leader in AI technology, leverages significant AI applications in education to enhance learning outcomes and maintain its competitive edge. Germany's advanced digital infrastructure and high Programme for International Student Assessment (PISA) scores highlight its integration of AI to foster educational excellence. Japan's substantial investment in AI and educational technology underscores its strategic focus on leveraging AI to sustain its competitive advantage.

In contrast, developing countries like India, Pakistan, and Nigeria face a mix of opportunities and challenges. These nations exhibit lower GDP per capita and GCI rankings but demonstrate growing interest and investment in AI-driven educational technologies. India, with its burgeoning AI sector and increasing ed-tech investments, exemplifies a dynamic environment for AI adoption in education. Pakistan, at the early stages of AI integration, and Nigeria, with its developing digital infrastructure, showcase the nascent yet promising potential for AI to transform their educational landscapes and enhance economic competitiveness.

Learning models have emerged as a revolutionary approach that has the potential to improve educational outcomes and increase economic competitiveness. However, there are differences in the adoption, use and impact of these technologies between developed and developing countries. This study focuses on examining the role of knowledge-based personal e-learning in improving economic competitiveness and compares developing countries (United States, Japan, Germany) with developing countries which are Pakistan, India, Nigeria. This study focuses to elaborate the direct and indirect effects of intelligence in the Global Competitiveness (GCI) study by examining the main factors that support or hinder its profit in different markets. By analyzing these factors and their effects, this research will add value to the international debate for the integration of intellectual skills in academics which benefits businesses and governments to promote economic growth and close the competitive gap between developed and developing countries.

2. Literature Review

Intelligent tutoring systems employing AI methodologies offer customized educational delivery, monitor learner progression, and provide bespoke feedback. These systems emulate the advantages of one-on-one human tutoring, significantly bolstering educational outcomes. By tailoring to the individual requirements and learning styles of students, intelligent tutoring systems can deliver a highly personalized educational experience that surpasses the limitations of conventional classroom environments (Aleven, McLaughlin, Glenn, & Koedinger, 2016). Educational data mining facilitates the examination of extensive datasets to reveal patterns and insights that can shape personalized learning strategies. By harnessing AI, educational institutions can attain a profound comprehension of student behaviors, learning preferences, and academic performance, which can be utilized to customize instruction and support to individual needs (Baker & Yacef, 2009). AI technologies in education possess the potential to offer personalized support, oversee student progress, and adjust instruction to align with individual learner needs. This personalized approach can result in enhanced educational outcomes, elevated student engagement, and a more streamlined learning process (Besterfield-Sacre, Cox, Borrego, Beddoes, & Zhu, 2014). AI applications in education are rapidly proliferating, presenting new opportunities for personalized learning, improved educational management, and heightened student performance. By delivering real-time feedback, adaptive content, and individualized learning experiences, AI can revolutionize traditional educational practices and support the development of 21st-century skills (Chassignol, Khoroshavin, Klimova, & Bilyatdinova, 2018). AI-driven personalized learning platforms are capable of identifying individual student needs and adapting instructional content to optimize learning outcomes. These platforms utilize algorithms to analyze student data, forecast learning trajectories, and provide tailored resources and support, thereby enhancing the overall learning experience (Chen, Cheng, & Lin, 2019). A comprehensive strategy for designing AI-driven personalized learning systems entails considering the learners' cognitive, emotional, and social dimensions. By integrating AI technologies with pedagogical principles, these systems can offer a holistic approach to personalized learning, addressing the diverse needs of students and fostering deeper engagement with the learning material (Chen, Xie, & Hwang, 2020). AI-powered educational technologies can facilitate personalized learning by offering tailored feedback, adaptive content, and individualized learning experiences. These technologies can also promote collaborative learning and peer interactions, creating a more dynamic and engaging educational environment (Grover, Pea, & Cooper, 2015). The integration of AI in education supports personalized learning, data-driven decision-making, and overall efficiency improvements in educational systems. By automating routine tasks and providing personalized instruction, AI can enable educators to devote more time to complex and creative teaching aspects (Hao, Li, & Peng, 2017). AI-driven personalized learning

systems can offer real-time feedback, adapt to students' learning paces, and present customized content, which can enhance educational outcomes and efficiency. These systems also support formative assessment practices, helping educators identify learning gaps and address them promptly (Holmes & Tuomi, 2017). Meta-analytic reviews demonstrate that intelligent tutoring systems, which utilize AI for personalized learning, significantly boost student achievement compared to traditional instructional methods. These systems provide immediate feedback, adjust to individual learning styles, and offer a highly interactive learning experience (Kulik & Fletcher, 2016). The student-centered design of AI classrooms suggests creating an environment where AI supports individualized learning opportunities and encourages student autonomy. Tutoring can provide flexible instruction and immediate feedback, allowing students to take control of their own learning and achieve their learning goals (Luckin, 2008). Education is tailored to the needs and abilities of each student. This approach can improve learning outcomes, increase student engagement, and encourage the development of critical thinking and problem solving (Luckin, Holmes, Griffiths, & Forcier, 2016). AI technology is revolutionizing education by providing more personalized, engaging, and effective learning. These technologies support differentiated instruction, provide immediate feedback, and support the development of 21st century skills (Majumdar, 2015).

Online and blended learning environments, enhanced by AI technologies, offer opportunities for personalized instruction and flexible learning pathways. These environments support self-paced learning, provide immediate feedback, and adapt to individual learning needs, thereby improving educational outcomes (Means, Toyama, Murphy, Bakia, & Jones, 2010).

AI in education can facilitate self-directed learning, work for management, and provide data from insights to inform policy and practice. Schools can increase the efficiency and effectiveness of their work and improve students' overall learning through the use of technology (Miao, Holmes, Huang, & Zhang, 2020). Influence teaching and learning processes so that learning is more flexible and adaptable to the needs of individual students. AI technologies can provide personalized feedback, support independent learning, and foster the development of critical thinking (Popenici & Kerr, 2017). Improving learning outcomes: Adaptive teaching. Through the use of technology, teachers can create a dynamic and interactive learning environment that meets the diverse needs of students (Rose & Woolf, 2008). Education is freedom from traditional education. Schools can provide effective and engaging learning to students by harnessing the power of intelligence (Seldon & Abidoye, 2018). Prepare intervention plans to support student learning. This process can increase the accuracy and efficiency of the assessment process, allowing teachers to better understand and meet the individual needs of students (Shute and Zapata-Rivera, 2012). education to receive personalized education. These technologies support informed decision-making, improve teaching practices, and improve student outcomes (Tsai and Gasevic, 2017). By adapting to students' individual needs and learning styles, these methods provide personalized learning that keeps students engaged and successful (VanLehn, 2011). It is important to improve the teaching and learning process, and smart technologies play a significant role in this change. Artificial intelligence supports the development of students' thinking and problem-solving skills by enabling self-directed and adaptive learning (Wang and Woo, 2007). Artificial intelligence system and providing recommendations. These systems have the potential to transform learning by providing personalized learning experiences that increase student learning and engagement (Woolf, 2010).

AI in higher education enhances self-directed learning and academic achievement by providing personalized learning experiences through predictive analytics and customized feedback (Zawacki-Richter et al., 2019; Zhang et al., 2019). AI systems analyze educational data to tailor learning content and adapt to individual needs, potentially transforming traditional teaching practices into more effective ones. This technology supports diverse learning needs and improves outcomes by creating engaging, adaptive learning environments (Chung & Kim, 2018). However, the integration of AI faces challenges such as resistance from educators and data privacy concerns. Addressing these issues requires collaboration among policymakers, educators, and professionals to ensure effective integration into curricula (Huang & Hew, 2018). AI's potential to revolutionize education includes enhancing personalized learning, providing insightful feedback, and supporting teachers in developing complex teaching strategies, which could lead to improved student outcomes and more engaging educational practices (Spector & Kosslyn, 2018).

3. Data and Methodology

3.1 Data

This paper is based on secondary information and time series analysis for the period 1999-2023. The sources of information used in this research are extracted from the World Development Indicators that are 12 pillars of

global competitiveness for GCI, 6 developing indicators for AIGI and countries' AI adoption and implementation policies

3.2 Model Formation

$$Y_t=\beta_0+\beta_1X_{1t}+\beta_2X_{2t}+\beta_3X_{3t}+\beta_4X_{4t}+\gamma_1C_{1t}+\gamma_2C_{2t}+D_{1t}+\epsilon_t$$

Where:

- Y_t is the dependent variable (GCI) at time t.
- $X_{1t},X_{2t},X_{3t},X_{4t}$ are the independent variables (LAIGI, GCIAI, MHTEM, HTEM) at time $_t$.
- C_{1t},C_{2t} are the control variables (REXP and HDI) at time $_t$.
- β_0 is the intercept term.
- $\beta_1,\beta_2,\beta_3,\beta_4$ are the coefficients for the independent variables.
- $Y_1, Y_2,$ is the coefficient for the control variables.
- D_1 is the dummy variable to compare the developed and developing countries at times.
- ϵ_t is the error term, representing the difference between the observed and predicted values of Y at time $_t$.

4. Empirical Results

Table 1: Descriptive Statistics

Parameters	GCI	LAIGI	GCIAI	MHTEM	HTEM	REXP	HDI	D1
Mean	69.450	-1.636	4644.606	43.385	10.959	1.451	0.692	0.500
Median	75.570	-0.200	4967.880	45.347	10.628	0.725	0.640	0.500
Maximum	92.790	25.560	8184.677	81.531	26.523	3.468	0.950	1.000
Minimum	47.530	-54.760	358.432	0.000	0.000	0.000	0.000	0.000
Std. Dev.	13.986	9.585	1826.702	29.922	8.423	1.416	0.253	0.502
Skewness	-0.124	-3.131	-0.112	-0.1585	0.044	0.202	-0.968	0.000
Kurtosis	1.605	16.724	1.881	1.389	1.480	1.180	3.720	1.000
Jarque-Bera	8.523	967.159	5.536	11.448	9.857	14.768	18.127	17.000
Probability	0.014	0.000	0.0628	0.003	0.007	0.0006	0.0001	0.0002
Sum	7083.890	-166.840	473749.80	4425.242	1117.798	148.015	70.589	51.000
Sum Sq. Dev.	19757.170	9278.673	337,000,000	90,430	7,166	203	6.509	25.500
Observations	102	102	102	102	102	102	102	102

Source: Author's own compilation

Using the provided coefficients from results, the analysis was conducted using a panel least squares method, with the Global Competitiveness Index (GCI) as the dependent variable. The dataset spans from 2007 to 2023, covering 17 periods across 6 cross-sections. This balanced panel includes a total of 102 observations, we can specify the equation as:

Table 2: Regression Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	38.13874	8.063954	4.729534	0.000

AIGI	1.123226	0.108015	10.39882	0.000
MHTEM	0.001699	0.021093	0.080549	0.936
HTEM	0.061719	0.075627	0.816097	0.416
REXP	0.981183	0.619862	1.582905	0.117
HDI(-1)	29.77479	10.64996	2.795764	0.006
D1	12.82874	2.956971	4.338474	0.000
Goodness of fit of regression				
R^2	0.967909	Adjusted R^2	0.964958	

Source: Author's own compilation

The regression analysis focuses on the impact of various factors, including AI-driven personalized e-learning, on the Global Competitiveness Index (GCI) across both developed and developing countries. Let's break down and interpret the results, and compare the effects between developed and developing countries.

β_0: Constant (38.13874) represents the basic GCI score when all other independent variables are equal to 0. It indicates the initial critical level of competition between each country. Competition is very beneficial and beneficial to the GCI. For every 1-unit increase in AIGI, the GCI score will increase by 1.12 points, indicating that the advancement of AIGI has increased the economic competitiveness of countries. Government R&D expenditure (REXP): Coefficient: 0.981183, t-statistic: 1.582905

REXP has a positive effect on GCI, indicating that government R&D expenditure contributes to development competitiveness.

Human Development Index (HDI): Coefficient: 29.77479, t-statistic: 2.795764, p-value: 0.0064

Lagged HDI has a positive and significant effect, beneficial for GCI, indicating that improvements in human development significantly increase future competitiveness.

Interpretation: The dummy variable for developed countries has a large, positive, and statistically significant effect on GCI. This coefficient indicates that being a developed country is associated with an additional 12.83 points in the GCI score compared to developing countries, all else being equal.

The model demonstrates a strong fit with an R-squared of 0.9679, meaning it explains approximately 96.79% of the variability in the GCI. The Adjusted R-squared of 0.9650 confirms that the model maintains high explanatory power while accounting for the number of predictors. The F-statistic of 328.0058 with a p-value of 0 indicates that the overall model is highly significant. The low standard error of the regression (2.6400) underscores the precision of the model's predictions. The Akaike and Schwarz criteria support model selection. Overall, the model provides a robust fit to the data

A retrospective analysis of the key differences in the use of AI-enabled personal e-learning to enhance business competitiveness as measured by the Global Competitiveness Index (GCI) between developed and developing countries. The positive value of the negative variable D1 (12.82874) indicates that developing countries such as the United States, Germany, and Japan have higher GCI scores than developing countries such as Pakistan, India, and Nigeria. This suggests that AI-driven e-learning and technology development are more relevant to developing countries, mainly due to their better infrastructure, more investment, more R&D, and job stability. The findings showed that personal e-learning based on cognitive skills and improvements in the Human Development Index (HDI) play a significant role in enhancing competitiveness. In developing countries, the results show a positive impact on the GCI. The fit of the model is commendable with an R-squared value of 0.9679 and an adjusted R-squared value of 0.9649; This indicates that the model can explain almost 97% of the GCI variation well. These results demonstrate the power of the model and its ability to capture changes by showing the relationship between knowledge, R&D and competition. The impact of personal electronics on education is weaker than in developed countries. The positive coefficient of the Artificial Intelligence Global Index (AIGI) shows that advances in AI have helped increase the competitiveness of these countries. However, the most important change for developing countries is that the impact of AI is not a significant factor in developing economies. This can be attributed to factors such as limited digital infrastructure, poor skill

integration and competitiveness issues that prevent countries from benefiting from technological advances. Personalized e-commerce. These include technologies such as network access, high-speed connections and digital technologies that facilitate the use of intelligence in the learning process. In addition, high levels of government and private sector investment in research and development (R&D) have encouraged continued innovation in AI technology, resulting in more e-learning solutions. The higher Human Development Index (HDI) in developing countries, along with higher education, health, and living conditions, provide fertile ground for the development of AI-driven learning. play an important role. These arrangements often include funding for AI-related measures, regulatory frameworks that support digital transformation, and incentives for schools to adopt AI learning tools. This strategic partnership creates an environment that is conducive to the success of AI-driven personalized e-learning. Limiting the digital process is very difficult because many developing countries do not have good access to the internet and modern computer hardware required for the implementation of AI-driven learning solutions. Underfunding of education and technology further exacerbates the problem, as these countries often lack the financial resources to invest in AI tools and platforms. Low education (i.e. lower HDI scores) inhibits the use of good academic skills. Additionally, cultural and organizational resistance to change, including a lack of trained personnel, makes it difficult to implement and sustain AI systems in education. Developing countries should prioritize investment in digital infrastructure, support capacity building and training in AI skills, and create government incentives to support the adoption of AI in education. International collaboration and local development of AI-focused solutions based on the specific needs of developing countries can drive progress and help these countries benefit from AI technology.

According to the IBM Global AI Adoption Index 2022, AI adoption among businesses has grown to 35%, a 4% increase from 2021, driven by the enhanced accessibility of AI solutions. Companies are increasingly using AI to automate processes and reduce costs, though a significant gap remains between large and small companies. Larger companies are now twice as likely to have implemented AI, a sharp increase from the 69% likelihood in 2021. AI adoption varies across regions and industries, with companies in China and India leading at 60%, while lower adoption rates are observed in countries like South Korea (22%), Australia (24%), the US (25%), and the UK (26%). Notably, the automotive and financial sectors are advancing AI usage more aggressively than others.

Germany, Japan, and the US have moderate AI adoption rates, with larger companies driving the trend, supported by strong digital infrastructures. These countries are also increasingly adopting hybrid or multi cloud environments, with Germany showing a significant 41% adoption of mixed cloud services, while Italy lags at 23%. Globally, 53% of IT professionals reported accelerating AI adoption over the past two years, a marked increase from 43% in 2021, driven by the need for cost reduction and process automation. The evolution of AI technology has made it more specialized, easier to deploy, and supported by a more skilled workforce (38%). Larger companies are 70% more likely to use hybrid cloud environments than smaller firms, indicating a growing focus on sophisticated AI integration within major economies like the US, Germany, and Japan, which continue to lead global AI adoption.

5. Conclusions and Policy Recommendations

This study shows a positive relationship between AI-enabled personalized e-Learning and the Global Competitiveness Index (GCI) of developed and developing countries. In developing countries such as the United States, Germany, and Japan, the impact is greater due to advanced digital technologies, high levels of human development, and supportive government policies. In developing countries, although relations are still good, the impact is greater due to many challenges. The analysis highlights the persistent digital divide between developed and developing countries. Developing countries benefit from strong digital infrastructure, good education, and significant investments in research and development (R&D), which together increase the effectiveness of AI and promote e-learning for competitive development. On the other hand, developing countries face challenges such as poor infrastructure, poor education, and access to technology, which prevent AI from complementing their resources in these areas.): This study highlights the importance of AI-driven e-learning and the Human Development Index (HDI) in mediating economic competitiveness. High Human Development, which means better education outcomes, healthcare, and overall health, can improve a country's ability to develop smart skills in learning, thereby increasing its competitiveness. The key challenges facing developing countries include low technological infrastructure, insufficient funding for education and technology, skills, and reluctance to embrace new technologies. These challenges pose significant challenges for the successful integration of AI-powered personalized e-learning into education.

5.1 Policy Recommendations for Corporate Businesses

Businesses should invest in AI-driven e-learning platforms tailored to the technology and education sectors, enhancing employability and productivity in design and manufacturing. Collaborations with universities can develop skill-focused courses aligned with labor market needs, boosting employment and economic competitiveness. Additionally, corporate social responsibility (CSR) initiatives focused on investing in digital infrastructure and technology education in developing countries help bridge the digital divide, create new markets, and contribute to regional economic growth. Continuous development of programmatic e-learning platforms ensures the workforce remains adaptable in rapidly evolving sectors where technology and competition demand ever-changing skills.

5.2 Policy recommendation for Government

Governments, particularly in developing countries, should prioritize investments in digital infrastructure, such as expanding internet access and equipping schools with AI-compatible technologies. Public-private partnerships can fund skills-focused e-learning initiatives, with governments offering incentives for AI-driven education investments. Regulatory frameworks should promote innovation while safeguarding data privacy. Additionally, investments in healthcare, education, and R&D are essential for fostering an environment where AI can thrive. Expanding AI-focused courses, especially in developing nations, ensures students acquire the digital skills necessary to compete in an AI-driven global economy, enhancing both domestic and global competitiveness.

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Non Academic Paper

Empowering Student Transition and Engaging Students Using *Actionbound:* A Gamified Collaborative Community Learning Platform

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Abstract: Transition to University is a significant milestone for students who are embracing new experiences and challenges. It is particularly vital for international students who have to adapt to a new and different learning environment in the UK. Successful transition and sense of belonging in a new institution lay foundation for students' academic success. However, transition is a process rather than an event. Accordingly, fostering a collaborative community learning environment and facilitate peer networks and community support becomes critical. It enables social interactions and active learning by engaging students in collaborative group activities, which would in turn support students' transition to and belonging in a new learning environment. With the advancement of technology, computer-assisted and computer-supported collaborative learning flourished in 21st century. The emergence of mobile digital technology leads to the design of gamification in learning, known as game-based learning or gamified collaborative community learning in order to engage students in fun and interactive activities. 'Actionbound' is one of the versatile gamification platforms and mobile apps which can engage students in collaborative community learning with gamified activities. It enables users to create, share and participate in interactive scavenger hunts, tours, games and quizzes. It allows users to design custom challenges, incorporate multimedia content and track players' progress in real-time. It engages participants to work collaboratively to solve challenges and complete tasks. At UHBS, we have used Actionbound to support the student transition into the University' learning journey at the start of term. We used scavenger hunt game and quiz functions within Actionbound to direct students to collaborate in teams to solve the challenges and tasks. In this action research, students found Actionbound fun and loved the competitive nature with points and leaderboards. It helped them build network and form friendship. Together, they solved puzzles and tackled challenges which supported their transition and got them prepared for learning in a new environment. Moving forward, as an ongoing action research, we would like to extend the use of Actionbound to term time and in module delivery so to track students' engagement with the collaborative learning platform and investigate the impact on their academic performance.

Keywords: Actionbound, Gamification, University transition, Student engagement, Collaborative community learning

1. Introduction

UK has been the second most popular country for international students followed by US being the first. The latest report from the HESA's (2023) Higher Education Student Statistics UK 2021/22 reports that there were 679,970 international students studying in the UK, with 120,140 being EU students and 559,824 non-EU students in 2021/22 academic year. This was a record total, the 9th consecutive new record with an increase of 37% in 3 years (184,000 students) (Bolton, Lewis and Gower, 2024). As a matter of fact, since 2020/21, the UK government has already met its target of attracting 600,000 international students studying in the UK which was meant to be achieved by 2030. That means the ambition was achieved 10 years ahead of its plan as stated in the UK Government's its International Education Strategy (Crown, 2021). It is interesting to note that majority of the international students are from Asia and Africa with the top 4 sending countries being China (151, 690), India (126,535), Nigeria (44,195) and Pakistan (23,075) (HESA, 2023), which signify a very diverse cultural, societal, and educational backgrounds. Consequently, this became a challenge for many international students when transitioning into the UK Higher Education system.

Collins (2012) states international students studying abroad face challenges of social differences, educational expectations and migration regulations. Students may feel 'fragile' and 'incapable' in their transition to higher education life and studies. As Cheng (2023) rightly stated, although each international student and their experience is different, they all seem to face similar challenges in adapting to a new culture, setting into a different institution, and interacting with a more diverse study body. What is more, Collins (2012) points out an easily neglected characteristics of international students, such as the multi-layered identities which leads to challenges of their sense of belonging and student wellbeing.

In recognition of and response to the international student challenges, most UK universities have set up student transition projects, programmes and guidance to support international students adjust to a new learning and teaching environment (Lu, 2022). Amongst many, the adoption of communication technology seems an effective

tool to help international students communicate and integrate (Collins, 2012). With technological advancement, new educational tools and mobile technology emerge in supporting students' learning and transition, therefore it would only be advantageous for universities to leverage on such tools to connect with students.

This article showcases an effective gamified collaborative learning tool called 'Actionbound' which has been used support international students' transition into university learning environment and a sense of belonging at the University of Hertfordshire Business School (UHBS). This article also demonstrates the design of Actionbound and students' feedback of Actionbound in how it helped their transition and belonging.

2. University Transition and Student Belonging

Studying in the UK presents greater challenge for international students who are alone and coming from a very different cultural and educational background, with lack of familiarity of the campus layout, academic programmes, and the difficulty of making new friendship. All the challenges might lead to feelings of loneliness and anxiety, which prolongs their transition into their academic studies and life, and their continuation and progression with the course. Barriers of belonging may include the quality of interactions between students and academic and support staff, feedback processes, quality of advice about matters related to the course of study and the university policy and procedures.

Montgomery & McDowell (2009) states the values of 'being, belonging and becoming' becomes particularly important at the start of the student learning journey especially for international students. International students who are new to UK higher education system and the academic journey can find it overwhelming. It becomes more critical when it is a first-time experience for them, particularly single-travelling students studying abroad and being away from their home for a long time. Similarly, Meehan and Howells (2019) also highlight the concept of 'belonging' and the importance of fostering a supportive learning environment. That indicates, when students' transition experiences are crafted well, it allows them to quickly and more confidently develop a strong sense of belonging. Ultimately, understanding the multifaceted nature of international students' transitions and the role of belonging within their university experience is crucial. These insights not only inform strategies to better support international students but also emphasise the importance of fostering inclusive academic environments that acknowledge and cater to the unique challenges these students face (Foster and Ecochard, 2017).

However, it is interesting to note the sense of belonging and positive learning experience can be attributed by the supportive community amongst international students rather than integration with home students. With robust support system and guidance, the international student communities can build networks and create engaged academic and social experience (Montgomery and McDowell, 2009; Meehan and Howells, 2019).

In addition, Dost and Smith (2023) highlight that transition into Higher Education is a process rather than an 'event'. It becomes more significant where there is a diverse body of students from different cultures and backgrounds. Therefore, besides a single induction event, engaging students in a wide range of academic, social and cultural events would facilitate the transition and sense of belonging. In addressing the challenges of students' transition to university and sense of belonging, Peacock and Cowan (2019 cited in Dost and Smith, 2023) suggest that active learning environments in higher education facilitate collaboration and social interactions, and any forms of formal and informal interactions amongst new students would help students to settle into the university and feel connected with sense of belonging.

3. Gamified Collaborative Community Learning

Collaborative community learning supports students' transition and belonging because it forms a learning community for new students with peer learning and support. Collaborative community learning is rooted in theories of constructivism and links to social constructionist theories (Bruffee, 1999). The concept of social learning was firstly proposed by Lev Vygotsky (1962), a Russian teacher and psychologist, who stated learning is taking place through communications and interactions with others, such as peers, teachings and other stakeholders. He acknowledges the role of social environments influences the learning process and advises educators to create a learning environment that maximizes the learner's ability to interact with each other through collaboration, discussion and feedback. Meanwhile, Vygotsky (1962) argues that culture is the fundamental factor for learning and knowledge construction. It is the culture which shapes rules, skills and abilities of each individual who are interacting with and learning from one another.

Similarly, in Yang's (2023) historical view of collaborative learning, he highlights the role of collaboration in learning and emphases knowledge is gained in the process of social interaction among communities of

knowledgeable peers. In collaborative learning environment, students learn from each other through conversations and negotiations of individual cultures and boundaries. It focuses on problem-solving and interactive learning activities. Similarly, Bruffee (1999) considers knowledge is constructed amongst people, and education is a process of re-acculturation which challenges the concept of power and authority.

Jean Piaget and Lenard Vygotsky consider playing forms a critical role in knowledge construction and learners' cognitive development (Piaget, 1662 and Vygotsky, 1962 cited in AdvanceHE, 2020). As a matter of face, the importance of learning and playing can be traced back to thousands of years ago when puzzle games, board games and other types of physical board games were employed in education inside and outside classroom setting. With the development of technology and the wide use of computers and internet, collaborative learning has evolved into 'computer-assisted collaborative learning' (Johnson & Johnson, 1983 cited in Yang, 2023) with the emergence of 'Computer-Support Collaborative Learning (CSCL)' and a flourish of research in CSCL in the 21st century (Dillenbourge, et al., 1996 cited in Yang, 2023).

However, collaborative learning can be challenging to implement as there is no single approach. The advancement of digital technology makes gaming a mobile and social activity which enables players to participate from all over the world with no physical constraints. This links to a more recent concept of 'gamification' and 'game-based learning', which is considered fun, motivating, and engaging. It also provides a form of 'edutainment' and an opportunity to change behaviour and learning engagement (Advance HE, 2020). In particular, the competitive feature of games also serves a powerful motivator of engagement and enjoyment. While many HEIs exploring and re-evaluating the use of gamification as part of learning and teaching pedagogy (Niman, 2014 in AdvanceHE 2020), this article will focus on the gamification tool and its use to support international students' transition into UK university life within a collaborative learning environment.

4. The Gamification Platform: Actionbound

Actionbound is a versatile gamification platform and mobile app that enables users to design, share and participate in interactive scavenger hunts, tours, games and quizzes, called 'bounds'. It is a self-explanatory and easy to operate platform. It is easy to design bounds by clicking the + (add) button on the Content page, and different tabs would appear on the right-hand banner, see the design screen in Figure 1:

- The flag sign named 'Stages' creates different parts or sections which serves as section headings,
- The 'Information' sign is to add instructions and guidance,
- The question mark refers to 'Quiz' is to design quiz type of questions, e.g. multiple choice questions,
- The exclamation sign named 'Mission' is to design missions like taking a photo, video and audio,
- A location sign refers to 'Find spots' is to design scavenger hunt with built-in GPS co-ordinate points,
- 'Scan codes' works for pre-designed QR codes which are normally placed at different places,
- The pie chart is to design 'Surveys' and identify the proportion percentage of a population,
- 'Tournament' is for questions that allows players to play against each other at random.

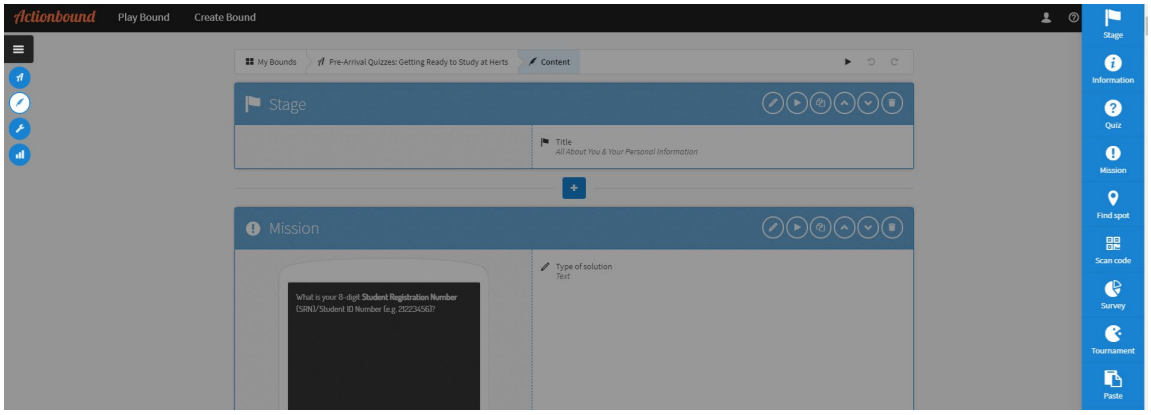

Figure 1: Actionbound Content Page

As described above, Actionbound allows users to design custom challenges, incorporate multimedia content and track participants' progress in real-time. It augments the reality by enhancing peoples' real-life interaction whilst using their smartphones and tablets (Actionbound, 2021). In addition, it engages participants to work individually or collaboratively to solve challenges and complete tasks in a fun and competitive setting.

Actionbound is often used in educational settings to engage students in active social community learning and gamified activities both inside and outside classroom to enhance learning experience. It has been widely applied in different learning and teaching settings amongst a diverse subject and across different countries. To name a few, English language studies in Croatia (Svalina and Truck-Biljan, 2020), construction and building utilities subject in Greece (Rosdiana, et al. 2020), Veterinary Neurology in Germany (Nessler, et al. 2021), history studies in Indonesia (Skaraki and Kolokotronis, 2022) and Chemistry studies in UK (Spencer-Briggs and Rourke, 2023). Moreover, Actionbound has been adopted by many UK universities; however, there is limited research exploring the use of Actionbound in facilitating and supporting international students' transition into UK University study and life.

5. Actionbound in Action: The Design and Application

At University of Hertfordshire Business School (UHBS), we have adopted Actionbound to engage students in an active, fun and gamified setting by taking advantage of the active and experiential learning features of Actionbound so to overcome the challenges that international students facing when they start their UK university learning journey. It is worth noting that Actionbound requires licence and offers institutional licence at a very reasonable cost. An appointed super user can set up 'unlimited' co-users. Users can design their own bound games with their individual account for different purposes with different types of questions. Designed bounds can also be easily copied or shared by one person to another, so they do not have to create it from scratch but to adopt and adapt. At UHBS, we set up each Programme Leader as a co-user who leads their own programme induction. Instead of each Programme Leader designing their own bound from scratch, the Student Experience Team designed the template and shared it with others to edit and update.

5.1 The Bound Content

We started using Actionbound at the Start of Term (SOT) during Programme Induction session with the aim to engage students and support their transition into the University. As demonstrated in Figure 1 above, in the design, we started with a 'Stage' named 'the Starting Line' which features an 'Information' question giving students the instruction about how to use the Actionbound. The second 'Stage' is a 'mission' asking students to take a group photo showing their positive energy. This is followed by the third Stage of basic and essential questions students need to know; they include:

- a 'find spot' question about where 'Ask Herts' information point is,
- a 'mission' question to take a photo of their student ID to show its working when put against a card reader so to ensure their attendance is logged (which shows green),
- a 'survey' question indicating they can see their Timetable,
- a 'quiz' about the purpose of Student Status Letter with options of the wide range of questions

Then it moves to Stage 4 'All about Your Programme' where each individual PL would design their programme related questions. Stage 5 links to general school-wide support services that students are expected to engage throughout of their learning journey, such as academic, pastoral and careers support. Questions are mostly 'find spot', 'mission' and 'quiz' ones so students have to go and visit the respective office, take a photo with the advisers / the timetable. For instance, one of the questions is to visit the library, use the book loan system/machine to find a book and then read a particular page so to answer a quiz question. Moving from School level, Stage 6 is about university-wide information, such as the Student Union, Canteen, Sports Village, Common Rooms, Vice Chancellor Award opportunity for students. The activities are finished with a 'Bonus Questions' Stage which include some tricky questions about a statue and a quotation located across the campus and require attention to details, observation and run-around the campus. The last Stage is 'The Finishing Line' saying congratulations with what's next.

5.2 The Bound Setting

Besides the design of the bound activity questions, the staff can go to 'Setting' section to set up the Bound 'profile' with bound images, description, playing time. In addition, staff can define the Bound 'characteristics' of the play model being a 'single player' or 'multi player'; bound visibility and bound results for being 'public' and 'secret'. In addition, staff can set 'switches' so to enable staff to design questions lead to different streams/categories, for instance, male students switch to stream A while female students switch to stream B questions. Considering the number of students visiting offices for 'find spot' types of questions while playing the bound and also to avoid 'collusion' between teams, there is a 'Sequence of stages' option to set the flow of the Stages/sections of the questions for being 'fixed', 'selectable' or 'random'.

For the start of term bound, we set the bound as 1-hour's 'multiplayer bound' with the idea to get students to know each other and work in team. For the GDPR purposes, we set the bound as 'secret' with results 'hidden'. We also set the sequence being 'random' so to divert the traffic and flow of students playing the bound game. See the Setting screenshot of our 'Semester A Start of Term' bound template in Figure 2.

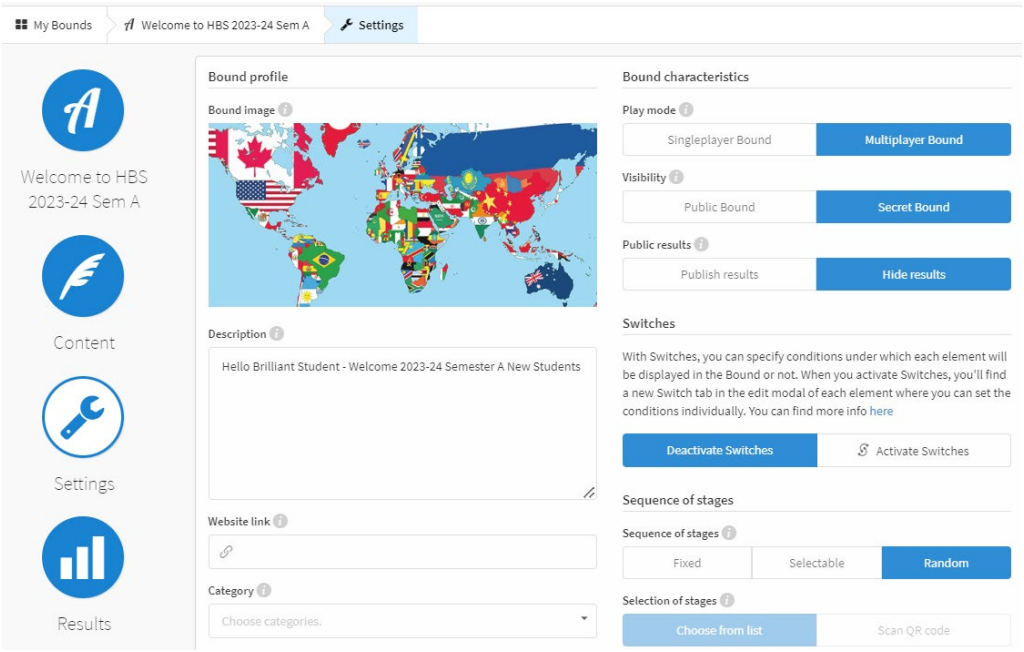

Figure 2: Actionbound Setting Page

5.3 The Bound Test and Publish

Upon completion of the questions, the 'Home' page of the Bound has a 'test' function which enables staff members to test the bound prior to publish. By clicking 'Test', a QR code will be generated which enables staff to run through the test bound using their own mobile phone so to ensure the information and timing is appropriate. Once the test proven to be successful, staff can then 'publish' the bound and make it online for students/users to engage. Then, staff can share the Bound's web page URL or the QR code with their students, supplemented by an instruction page and a QR code download option available to be given to students as demonstrated in Figure 3.

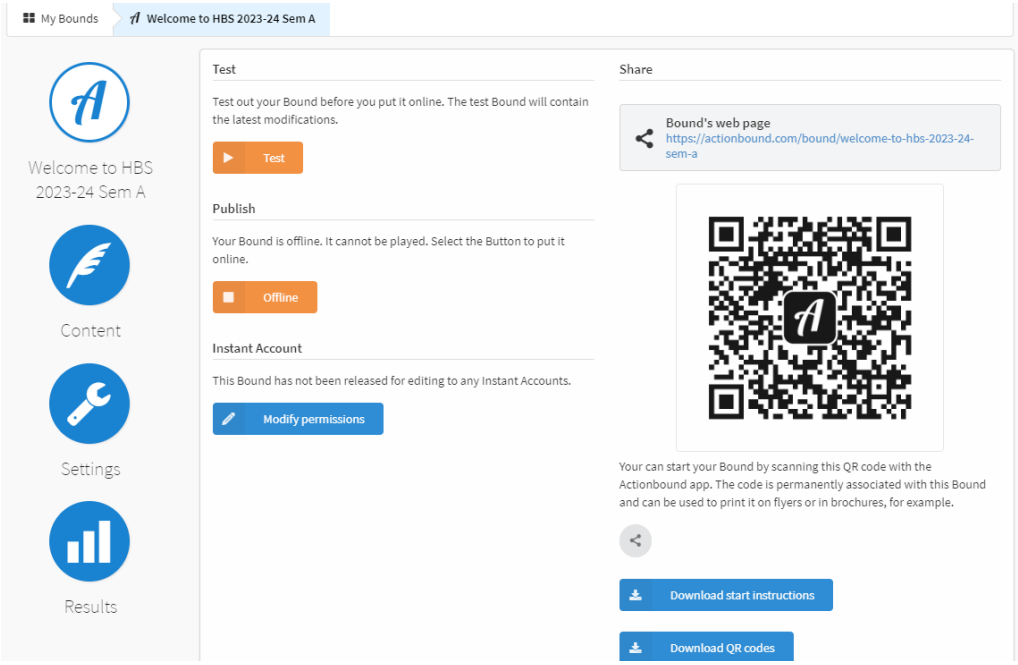

Figure 3: Actionbound Home Page

In UHBS, the QR code of pre-designed multiplayer Actionbound was circulated to students at the end of each Programme's Induction session. Students were asked to form teams of 4-6 member and nominate a team leader who would operate the mobile application that can be downloaded from the Apple Store or Google Playstore. Though the game is set for multi players, it was managed by each team leader rather than all members as this will counter the purpose for collaboration and teamwork. Working as team, while the team leader operating the mobile app, other members were supporting to find answers, clues and solutions to the Actionbound challenges, i.e. quizzes, spots, surveys and missions. To start the game, each team were asked to name their team, put each team member's name and take a team photo as evidence of collaboration. The bound lasts 1 hour and students were told to return back to the Induction room for prizes based on their teamwork performance.

5.4 The Bound Results

Once students complete the bound or the playing time finishes, staff members will be able to review the results and show students under the Results page. Below Figure 4 demonstrates the 'Results' which gives an overview of the bounds including the number of 'finished bounds', total number of players/ 'participants', the date of playing in 'last time played', 'average playing time' and 'average score'. In addition, answers to different types of questions are also categorised into 'quizzes', 'survey', 'images', 'video', 'audios' based on the design in the first place. Staff members can show students the answers by the categories. What is more, each team's final result and performance are also available team by team.

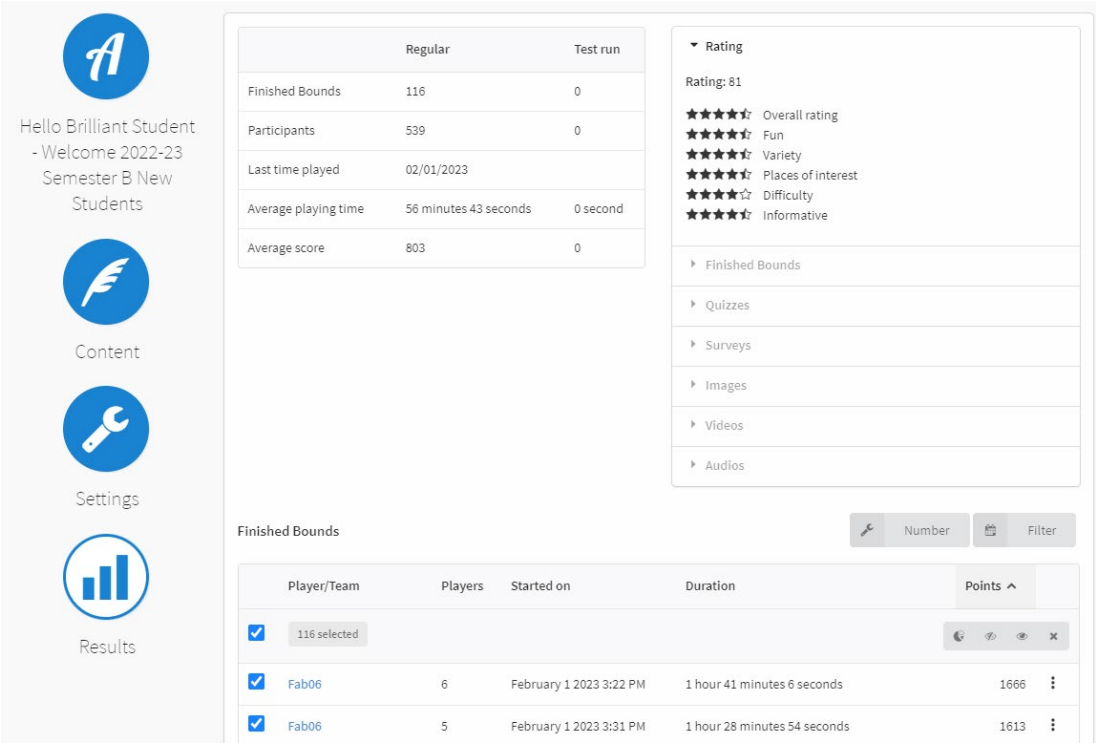

Figure 4: Actionbound Results Page

In UHBS, we showed students the 'images' of their team photo and asked students to vote for the 'best team photo' for a prize. What is more, we have chosen the best team who win the highest score and rewarded them with certificates. It is worth noting that in the Results page, an overall rating of the bound/game is also captured in terms of the 'overall rating', 'fun' element of the game, 'variety' of the questions, 'places of interest' they have visited, 'difficulty' of the questions, and 'informative' nature of the game.

6. User Experience of Actionbound

Actionbound has been the biggest highlight of our Induction. Both students and staff members found Actionbound being useful and effective in engaging and inducting students and supporting their transition into the programme of study learning. Some qualitative feedback of the student and staff experience were collected from the January 2023 intake's Induction, when 539 students from 116 teams participated in the Actionbound game on 02/01/2023. Students have had a good exposure to Actionbound with average playing time of 56 minutes and 43 seconds, and the average score of 803 with the highest team won 1666 points.

6.1 The Student Experience

Students found the Actionbound game being interesting and fun and the game questions being informative. This has been demonstrated in the students' feedback captured by Actionbound's platform with an 'overall rating' of 81%, featured by 4.5/5 for 'fun', 'variety', 'places of interest' and 'informative', and 4/5 for 'difficulty'. Overall, students found the game was fun with a wide variety of questions which are informative and direct them to different places across the campus, and they do not find as difficult to explore.

Speaking to students after the Induction prize giving session, it was noted that students expressed a heightened sense of ease and self-assurance when it came to navigating the campus and engaging with their peers. Students found it an interesting approach to introducing facilities and services available on campus as they were asked to mobilise around the campus and explore. For instance, students were required to connect and engage with support services team, find where and who is at academic skills support team and to capture a photo of their support timetable or with a staff member. Rohit commented that *"It was so much fun to visit the campus and offices and explore the support services with a group of friends. We get to learn so many things by playing the game."*

By working in teams, it helped students to make friends on their first days on campus. In the Actionbound game, it required the team to come up a team name, input each team member's name, so even the most introvert student needed to communicate and support the team to complete the mission/challenge. In turn, this activity facilitated initial social interaction and fostered the development of strong relationships within the team. This is evidenced by students' praises of teamwork and friendship formation, such as *"I am so excited that I made friends on my first day on campus" (Usam). "I learnt a lot from my group on how to find information and use the app" (Rishi). "It was so good to work together with my team members and visit different offices and meet academic staff together. I don't think I would be able to do that myself at the start of my studies" (Haq).* It is hoped that the establishment of friendship and network would support their holistic well-being and academic achievement later on.

In addition, with the competitive nature of the Actionbound which features a limited time frame and prize rewards, students seemed to be more collaborative with a strong team spirit. Setting up a time limit was part of the rational to enhance motivation and engagement, students have to work around the time set up for the questions. Students developed problem solving and time-bound decision-making skills as the challenge are set with a time constrained completion. Upon completion of the game, the winning teams would be rewarded by Amazon vouchers and school merchandises. The prizes not only enhanced the game's competitiveness and enjoyment, but also served as an extra motivation for students to actively participate in the activities. Suvash excitedly cited that "*What a great start of learning journey in the UK, I couldn't be believe that I won prizes on the first day of my university. This motivates me to do my best in the future…. Of course, congratulations to my team members as well. Hope we remain the friendship moving forward.*"

Alongside the excitement of the activities, it is worth noting that the use of mobile technology was also a great introduction to the student transition into their learning and teaching the UK where many more technological tools such as Zoom, Teams, Menti and Padlet would be utilised alongside the student learning journey in the UK. This coins to Sian's comment *"Using mobile phone to learn new things is eye opening. We never did it back home because we always learn from books. I am really looking forward to what else the studies will bring.*" Actionbound has definitely introduced them to the digital-based active based experiential learning experience at the start of term and highlights the importance of digital skills in the time to come.

Above all, entertainment and enjoyment appear to be the main experience of Actionbound which was also the intention of the adoption of Actionbound. The gamified setting of Actionbound introduces a factor of amusement to the educational process, rendering it a more enjoyable and less stressful experience. This is because it can be an overwhelming experience for most of the students studying abroad for the first time and travelling from afar. Featuring the Induction Day with fun activities using Actionbound, beyond sitting back and listening to talks, has made a real difference to students' start of term experience. Phrases like *'fun', 'lovely', 'interesting', 'great'* seem to be the mostly referred terms. Wasil concluded *"…love the game and it was so much fun… Actionbound is the best part of the Induction."* Actionbound also introduces students to the UK academic learning expectations which require independent active learning and teamwork.

6.2 The Staff Experience

Similarly, it has been a very enjoyable and rewarding experience for staff members who designed and run the Actionbound activities. The super user of Actionbound, Suzie commented that "*designing Actionbound can be*

very addictive as you always feel there are so much more you can do with it… Personally, I have been running around the campus myself to take the latest photos to be embedded in Actionbound so they resemble the scene when students come to play with it… You can hardly finish with the design of Actionbound because there are always times that you come across with something, and then you think it would be good to add to Actionbound." The MBA Programme Leader Ghayda who adapted and adopted Actionbound said "*it was much easier to design and use than I thought… well the pre-designed template has definitely helped as I only needed to add the part (Stage) about my programme. Also, the QR code and downloadable instruction was super easy to embed in my Induction slides*". The Deputy Programme Leader of MSc Management Bobby said *"I love the final part of the Induction when I show students the Actionbound results, going through some of the photos and videos with the students; it brought smiles into everyone's face. It was so funny to see they are laughing and teasing each other for funny moments captures in the photos…. Letting students vote for the 'best team photo' was so interesting, because every team wants to win…. Hahahaha… I absolutely love giving prizes and certificates out… what a great way to finish their first day on campus."*

Moreover, University colleagues who witnessed students playing Actionbound also spoke very highly about it, in particular as they notice the active collaborative learning nature of it. Staff members in the Academic Skills team found themselves very popular for being visited, requested to take photos with and asked interesting questions. Mary, the Head of Academic Skills commented: "*previously, we have always been part of the new students' Induction and into their Induction sessions to introduce our support services to students. However, there was hardly any students follow us up or ask questions. The Actionbound has made a real difference. After the Induction, they came to find out us in our office, spoke to us to ask for photos and enquired whether our timetable would change so they can fit around their own timetable."* Likewise, the Library staff was surprised to see so many students came to the library to use the book loan machine, find books on the self, read, and make notes on their first day on campus. *"I really loved the energy and enthusiasm of the new students, and their passion for learning…"* said the Head of Library and Computing Services. A Campus Security staff who was patrolling commented "*it was so nice to see student groups running around the campus, laughing and talking to each other. Their presence, smiles and laughter made a real difference to campus.'*

7. Discussion and Conclusion

In conclusion, this action research demonstrates the design and use Actionbound and the role of it in engaging them in their start of term activities and supporting their transition into UK university life. As explained, start of term is a crucial period for students as they navigate a new academic and social environment. For many students, particularly first-generation and international students, getting settled and feeling a sense of belonging can be challenging due to unfamiliarity with the educational system and cultural differences. In contrast to the conventional induction techniques which normally include informational workshops and campus tours, gamified collaborative community learning tools like Actionbound offer an alternative approach to creating a more advanced engaging and dynamic induction and transition experience.

The gamified active and collaborative learning nature of Actionbound has revolutionised the traditional induction. It was easy to use, fun and engaging; it helped students to form friendships, communicate to each other, collaboratively solve problems and find answers together. Actionbound has also acted as an effective ice-breaker tool for students, who are culturally and/or individually shy from socialising and served as an efficient tool to tackle all the challenges for new students settling into a different learning environment. It introduced students to digital technology and gamification and engaged students to foster the essential sense of belonging for integration into the university community.

As students reported that the experience was fun and engaging, active and practical, with several noting that they appreciated the opportunity to interact with their peers in a less formal setting and learnt a lot from their peers. While the student feedback is subjective, it aligns with the growing body of literature which suggests gamified collaborative community learning support communication and interaction, enhance engagement and motivation. However, it is worth noting that this article is not an empirical research paper but rather a report on the use of Actionbound and the author(s) observations and users' feedback.

Moving forward, the study of Actionbound will be developed further through ongoing action research. Future research will explore the use of Actionbound throughout the student learning journey and examine its impact of the gamified collaborative community learning tool on students' engagement and academic performance.

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Work in Progress Papers

Strengthening Teacher Agency: Supporting the Orchestration of Ethical Dilemmas With EthicApp

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Abstract: Developing ethical reasoning as a competence is gaining relevance in higher education settings influenced by the current demands of society. One approach to achieve this competence is to propose realistic ethical dilemmas to the students. Nevertheless, educators need help in integrating ethics education effectively in higher education due to curricular constraints and a lack of supportive structures. EthicApp is a social platform that aims to support teachers in designing and enacting learning scenarios to foster ethical reasoning. However, the introduction of a new tool such as EthicApp may have undesired consequences for teachers' agency. The notion of teacher agency is complex and not sufficiently studied in Technology Enhanced Learning contexts. For this reason, we propose to study the implications of the use of EthicApp for teacher agency in the light of the metaphor of orchestration. The metaphor of orchestration in TEL offers a holistic approach to studying how teachers integrate technologies into their practice. This paper presents preliminary findings from a case study in which three higher education teachers orchestrated learning designs supported by EthicApp. Early findings indicate that, although managing the learning scenarios in real-time was perceived as demanding, EthicApp empowered the participant teachers to design innovative learning scenarios, raise awareness, and inform the adaptation of the learning scenarios.

Keywords: Ethics education, Orchestration, Teacher agency, Higher education, Case study

1. Motivation

Current societal demands are causing higher education institutions to reconsider how to integrate ethics education into their curricula to better prepare students for facing real-world dilemmas (Rodríguez-Galván et al. 2023). Apostolou et al. (2013) advocate for an across-the-curriculum approach that considers skills like ethical reasoning and decision-making, among others, as core elements of academic curricula. However, there are barriers to incorporating ethics such as the perception that the course content is not related to ethics or curricular constraints (Smith et al., 2023), as well as the lack of resources (e.g., research-based information and/or tools) to help teachers redefine their methods for implementing problem-solving activities (Choi and Lee, 2009). Computer-Supported Collaborative Learning platforms such as EthicApp, which implements a pedagogical model based on dilemmas to teach ethical reasoning, can help to address this challenge. EthicApp[1] enables students to analyse ethical cases and answer individually or as a group (which can be anonymous and formed based on heterogeneity criteria) allowing teachers to monitor in real time students' work (Álvarez et al., 2024). However, the introduction of new tools may pose challenges to the achievement of teacher agency in Technology Enhanced Learning (TEL) contexts. Teacher agency is achieved when educators strive to control the curriculum by leveraging their pedagogical stances, future goals, and current constraints and opportunities (Jenkins, 2020; Priestley et al., 2015). Approaching the study of technology integration in the classroom through the lens of teacher agency helps to understand teachers' positioning on innovations, while illuminating how technologies can enhance their educational practice (Albion and Tondeur, 2018; Ketelaar, 2013).

[1] https://www.ethicapp.info/

Despite existing research, teacher agency remains understudied in TEL contexts. There are challenges to study how teachers navigate through complex interactions among the tool and students at different levels. We propose to use the orchestration metaphor to characterize the implications of teacher agency in TEL settings. The orchestration metaphor offers a comprehensive approach to studying how teachers integrate technologies into pedagogical practices, including designing and managing multiple activities and social levels (Prieto et al., 2015). Studying how teachers orchestrate ethical dilemmas with EthicApp can provide valuable insights for strengthening teacher agency and supporting ethics education. Hence, this study aims to explore the following Research Question (RQ): *To what extent does EthicApp support teacher agency when orchestrating learning scenarios based on ethical dilemmas in higher education?*

2. Methods

To study the aforementioned RQ, we conducted a case study guided by the interpretive research paradigm, whose aim is to achieve a deep comprehension of concrete phenomena. To structure the inquiry, we deployed an anticipatory data condensation process (Miles et al., 2014) based on four orchestration activities within the revised orchestration framework proposed by Prieto et al. (2015): design, management, awareness, and adaptation.

This case study was conducted at the Universidad de Valladolid (Spain) and encompassed three learning scenarios (see Table 1). Three different teachers orchestrated each of the learning scenarios in which the participants were students from the Bachelor's degree in computer engineering (S1), the Master's Degree in Applied Research in Education (S2), and a training course on Ethics for doctoral students (S3). Two experts who designed the dilemma-based ethics teaching model that is implemented in EthicApp, participated in several meetings with the teachers to assist them in preparing the learning scenarios. Additionally, the experts provided support to the teacher in scenario S3. The underlying goal of the learning scenarios was to develop students' critical thinking and argumentation skills through collaborative knowledge construction. The learning scenarios included several phases in which students had to judge the dilemmas posed, first individually and then in pairs or small groups.

Table 1: Synthesis of the three learning scenarios

Learning scenario code	Educational level	Number of participant students	Delivery mode	Temporalization
S1	Undergraduate	70	Onsite	1 session. 2 dilemmas. 2 hours overall
S2	Master	14	Onsite	1 session. 2 dilemmas. 2 hours overall
S3	Doctoral	20	Online	2 different sessions. 1 dilemma per session. 40 minutes per dilemma.

Data collection techniques for this paper involved observations and document analysis. The first author of this paper observed the design meetings that the teachers shared with the EthicApp experts to craft the learning scenarios ([DO] - design observation) and the enactment of each learning scenario ([EO] - enactment observations). Document analysis included the learning design template ([LD] - learning designs) as well as notes and reflections that teachers wrote or communicated orally pre- and post-enactment ([NR] - notes and reflections).

3. Results

This section reports the preliminary findings regarding the orchestration of the learning scenarios, organized according to the four activities of the orchestration framework presented by Prieto et al. (2015). The data source of each evidence is indicated in brackets, as presented in the method section.

Design: The study revealed that the three involved teachers could design [LD] and implement [EO] learning scenarios in which students were asked to exercise their critical thinking, argumentation, and peer-debate skills [LD]. EthicApp was used across different educational levels and contexts, with the key distinction being its use in onsite versus online settings. This shows how the tool enables teachers to carry out onsite and online learning scenarios. The support provided by the two experts helped the teachers to refine their learning scenarios in several iterations [DO]. This support was perceived as beneficial for reinforcing the pedagogical value of the learning situations as the S2 teacher declared: "*In these previous sessions, I had the opportunity to share, in 3 iterations, my design ideas with the experts. These sessions helped me get feedback on whether the*

dilemmas were relevant and fit well with what could be done with the tool. It has also helped me to identify better how the questions need to be formulated to add some tension to turn the case into a dilemma. Ultimately, these iterations have helped me improve and refine the designs thanks to their recommendations" [NR]. While teachers perceived the co-design meetings with experts as beneficial, a more pragmatic approach could have helped reduce the co-design phase's duration. These meetings were crucial for teachers as they were novice regarding this tool. Nonetheless, in future iterations, they may view them as less relevant since they will be familiar with the system. Being less dependent on the expert's help would make the educators more autonomous in the design process [NR, DO].

Management: The enactment of the different learning situations was perceived as demanding by the teachers due to the cognitive load required. While the teachers had prepared a script (based on a template defined ad-hoc for EthicApp) outling all the phases and details of the activities to be presented to the students, the instantiation had to be done manually by entering the data into the system in real-time[2]. For example, this task entailed copy-pasting information from the script and setting range options for closed-ended questions (see the teacher interface in Figure 1). Performing this task in real-time was perceived as stressful as noted by the S2 teacher: "*I felt that I was getting confused about what to do when editing the design. This loss of concentration or nervousness at times, because I did not want the students to waste time waiting between phases, made me make several mistakes in the session when instantiating the design*"[NR]. This circumstance limited the teachers' time to reflection or engaging with students at a deeper level (e.g., making sense of students' responses). In the S3, the teacher received support from the experts for assisting students with different casuistries through the chat of video conferencing. This assistance diminished his orchestration load, allowing him to focus on performing concrete actions with EthicApp or reflecting on the learning process as the evidence shows: "*As I had [the support] of the expert who was explaining other things at the same time, I did not have the same cognitive load of giving instructions, solving problems and at the same time looking at what is going on, which is one of the problems of orchestration*" [NR].

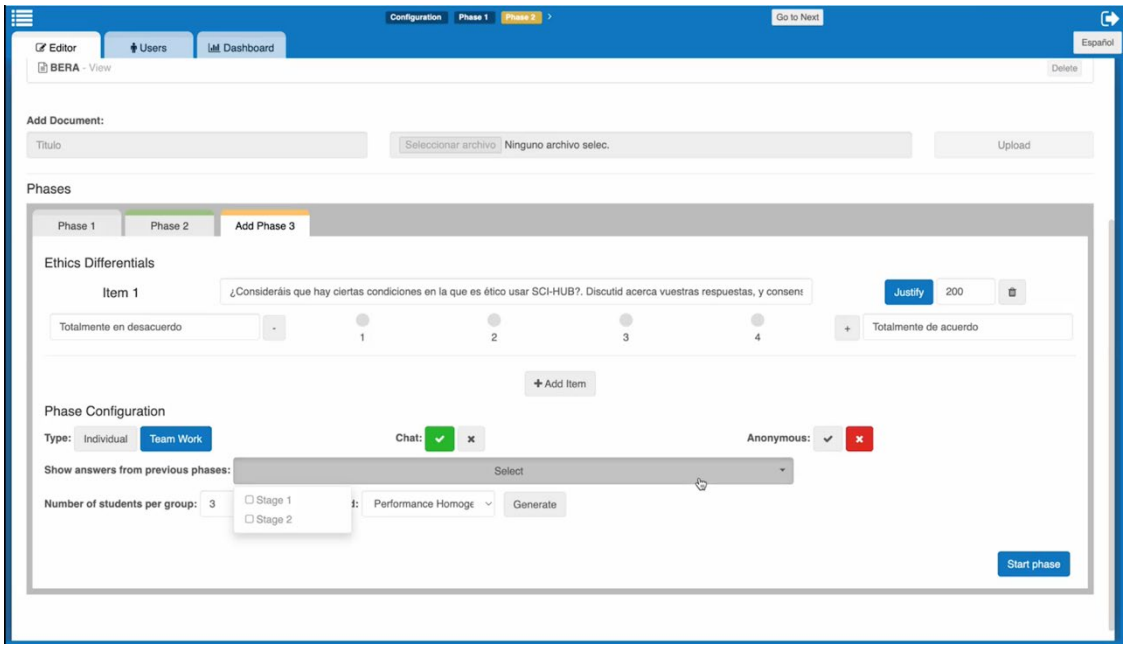

Figure. 1: Screenshot of the teacher interface of EthicApp. It shows the editor tab when the teacher was configuring phase 3 of the learning design of the master education learning scenario

Awareness: The teacher dashboard integrated in EthicApp allowed teachers to monitor students' progress (e.g., whether they have already submitted their answers) and to review their arguments in real time [EO]. This feature assisted teachers in real-time management (e.g., informing when students were ready to move to the next phase) and to adapt their commands (e.g., asking students to reformulate their answers if these were too vague or they were not progressing in the expected direction).

[2]This video provides a general demonstration of how a teacher configures the phases of a learning scenario.

Adaptation: The data that teachers could interpret in real-time allowed them to envision how the whole class debriefing could be. In the S1, the teacher used some of the student's arguments that she checked in the dashboard [EO] "*After a check of the dashboard, the teacher uses - without explicitly telling the students that this is one of her answers - a response to illustrate [for the whole class] a poorly constructed argument*" [EO]. While in S3, the teacher took notes of some of the students' answers to enrich the debriefing of the second session [EO].

4. Conclusions, Limitations and Future Work

This work-in-progress paper reports preliminary findings of a case study in which three teachers integrated EthicApp in their courses. EthicApp's functioning required teachers to generate well-structured instructional designs to foster students' critical thinking through multilayered ethical dilemmas. The collaboration with the experts who proposed the dilemma-based ethics teaching model implemented in EthicApp helped teachers to maximize the pedagogical value, leaning towards agency achievement (Priestley et al., 2015). As a result of real-time support, teachers could also adapt their guidance during the learning scenarios, which can already be interpreted as a manifestation of their agency (Bandura, 2018). This alignment between the learning design purposes and the tool's support enhanced the teachers' ability to orchestrate ethical dilemmas effectively with EthicApp, fostering their agentic orientation in course redesign.

This paper, which reports preliminary findings, has several limitations. Data analysis is still ongoing, and complementary data sources (such as in-depth evaluation interviews and follow-up inquiries) should be also considered for triangulation. The findings are specific to the context studied, reflecting the uniqueness of the realities observed. Future work aims at providing a detailed understanding of how teacher agency manifests through orchestration activities when teachers design and implement learning scenarios supported by EthicApp.

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Bucco-kid®, an Innovative Tool for Learning Oral Hygiene at School

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Abstract: Numerous studies have shown that socio-economic background, parents' professional status and geographical location are determining factors in access to oral health care and awareness of its importance. In view of the significant social and territorial disparities observed in children's oral health (Anastasio, Laventhal & Amadon, 2022), schools are an ideal place to take action and reduce these inequalities (Ministry of Education, 2021). Indeed, schools enable us to reach all pupils, whatever their socio-economic background. On that perspective, Bucco-kid® project was conceived, drawing on the advantages offered by e-digital technologies. Bucco-Kid® platform provides elementary school teachers with a set of scripted teaching resources, constantly updated by oral health professionals (dentists). These resources, in line with school curricula, cover the key points of oral hygiene, such as discovering the mouth, nutrition, brushing, the role of the dentist and trauma management. They enable teachers to carry out a complete 5-step awareness-raising program with their pupils. The aim of this study is to analyze the usability of the platform from the point of view of teachers' user experience (UX), and actual use of the tool in classroom situations. Data are very positive about its implementation and democratization on the studied context.

Keywords : Children's oral health, Digital learning, Usability tests, User experience

1. Context and Issues

Since the late 1980s, children's oral health in France has overall improved, with a noticeable decrease in the prevalence of tooth decay. Several combined actions have contributed to these advances: dental check-ups starting at the age of 3-years-old and the presence of fluoride ions in toothpaste. While the presence of cavities has significantly decreased in France, there are still significant disparities and inequalities in the field of oral health from a very young age (Anastasio, Leventhal, & Amadon, 2022; DREES, 2022).

These inequalities, especially in access to care, lead to delayed cavity detection. In kindergarten, 4% of children from executive backgrounds have at least one untreated cavity, compared to 23% of children from working-class families. Additionally, it is observed that 20 to 30% of children account for 80% of all cavities. Despite relatively good oral health among residents in European countries compared to other continents, oral health inequalities persist across all European nations (Forster et al., 2018). Socio-economic background, parents' professional status, and territorial location (urban vs. rural areas) are determining factors in both access to care and understanding the importance of oral health. Schools appear to be important actors in reducing social health inequalities, particularly in terms of oral health prevention, as all children can benefit.

School dental health education positively affects children's oral health, knowledge, and behavior (Priya, 2019), but repetition and reinforcement are crucial for its effectiveness (Haleem, 2016). Most school-based oral health interventions are single 1.5-hour sessions led by professionals, students, or parent dentists, which overwhelm students with too much information in a short time, leaving teachers unable to revisit the concepts.

The materials and resources available for teaching children about dental health have several limitations: (i) Children's literature tends to be moralistic and provides static content (e.g., "you shouldn't eat too many candies"). (ii) Existing applications often use the same scenario, where the child plays a dentist focusing on aesthetic treatments. (iii) Board and card games lack real educational objectives.

It is in this context that the Bucco-kid platform was designed to enable teachers to conduct oral health prevention sessions themselves by providing a variety of scientifically validated resources.

2. Theoretical Framework

From a instructional design perspective, Bucco-kid® is based on a participatory and iterative collaborative approach involving children (ages 6 to 8), their parents, volunteer teachers, and dentists and/or future dentists (Dinet, 2015, 2020; Dinet, Bauchet & Hoareau, 2019). These participants contributed throughout the

development process to both substantive aspects (content, activities, etc.) and formal aspects (graphics, modes of interaction, etc.). The platform (free) consists of a playful environment with simple activities and content tailored for children and families (e.g., using age-appropriate vocabulary) (cf.fig 1 and 2).

The Bucco-kid® scenario is grounded in the Theory of Planned Behavior (TPB) (Ajzen, 1985, 1991), which suggests that behavior is driven by the intention to engage in it. Stronger intentions lead to greater effort and higher likelihood of performing the behavior (Nigbur, Lyons & Uzzell, 2010). TPB includes three key components: (1) Attitude toward the behavior (positive or negative). (2) Subjective norm (perceived social pressure). (3)Perceived behavioral control (perceived ease or difficulty of the behavior).

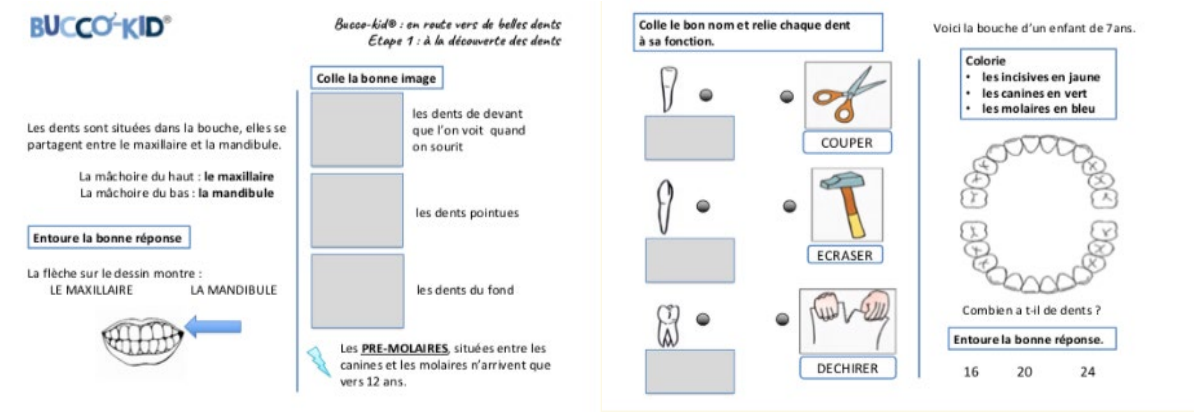

Figure 1: Examples of Bucco-kid® exercices

The Bucco-kid® digital platform for teachers was designed using a user-centered design approach, which involves considering user characteristics and needs and actively involving end users (Norman & Draper, 1986; Karat & Bennett, 1991). The Technology Acceptance Model (TAM) by Davis (1989) and other theories such as SAMR (Puentedura, 2009) and ASPID (Karsenti, 2013) were also utilized. The platform follows these technological principles: (1) Clarity and simplicity: Information should be concise and well-structured (Lallemand, 2018); (2) Ease of navigation: Users should easily find information through a thoughtful structure and visible menus (Lallemand, 2018; Brangier & Gérard, 2021); (3) Adaptability to different devices: The site must be responsive across computers, tablets, and smartphones (FasterCapital, n.d.); (4) Accessibility: Features like alternative descriptions for images and keyboard navigation should be included (Brangier & Gérard, 2021); (5) Visual coherence: Consistent use of colors, fonts, and graphics contributes to a professional user experience (FasterCapital, n.d.).

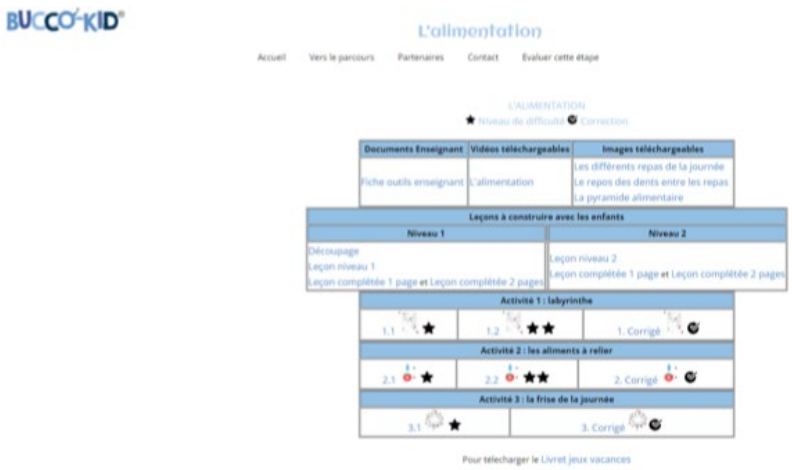

Figure 2: Example of Bucco-kid® screenshots

This educational platform offers a five-step oral health prevention course (corresponding to the five terms of a school year in France) covering the fundamental points of oral health: discovering the mouth and cavities, diet and the role of sugar, brushing, the role of the dentist, and the prevention and management of dental trauma in case of a fall (cf. fig. 3).

Figure 3: Example of 5-steps-path in Bucco-kid®

3. Problematic and Hypothesis

Bucco-kid® consists of an oral health prevention course designed for children aged between 6 and 8-years-old, intended to be conducted by a teacher in a classroom setting. This solution appears to be more “cost-effective” compared to "conventional" oral health prevention actions, which typically involve a one-hour intervention in the classroom led by dental students or practitioners. While enjoyable for children, this “conventional” practice has several limitations: (1) the amount of information to be transmitted to children is difficult to assimilate in a single one-hour session; (2) territorial inequalities pose a significant issue due to the lack of human resources; (3) the health crisis has shown the value of a "turn-key" preventive course that can adapt to the specific needs of each class; (4) as mentioned earlier, existing resources and materials are often irrelevant and poorly adapted.

From these observations, we pose the following question: how do teachers utilize these digital tools to raise awareness of oral hygiene among children aged between 6 and 8-years-old?

Based on this question, we propose the following hypotheses:

> *Hypothesis 1: The characteristics of the Bucco-Kid® platform, in terms of perceived usability and perceived use experience, influence its acceptance and actual use by teachers. It is the aim to understand if the platform actually improved oral-health teaching and learning.*
>
> *Hypothesis 2: The Bucco-Kid® platform, designed to enhance a quickly and effectively access to educational contents and tools for conducting their lessons, is therefore effectively used by teachers. Here the aim is to understand if the learning content are adequate to the learning purposes.*
>
> *Hypothesis 3: The use of the Bucco-Kid® digital platform in an ecological context, incorporating interactive and playful features tailored to young audiences, makes learning about oral hygiene more engaging for pupils aged 6 to 8. The aim is here to observe the actual benefit of the use of the platform in a real context.*

4. Methods and Data Collection

The aim of this study is to analyze the usability of the platform from the point of view of teachers' user experience (UX), and actual use of the tool in classroom situations in order to improve the quality of the learning aspects of the platform. On that perspective we designed a qualitative protocol allowing us to observe the use of this platform on two different levels: at first a usability test, to identify the possible improvement of the platform; second, we will observe the real use of the platform in a actual class by teacher and theirs pupils.

1. Usability Test:

- Sample: 10 teachers have been selected from different schools, half of them including Bucco-kid in their curriculum and the other half not using them. The number of subjects has been defined after the works of Nielsen (1993) explaining that to evaluate 85% of the usability issues of a digital platform, five participants from the same target user category would be needed.

- Observation Methods: First, an UX-type exploration (Brangier & Gérard, 2021) of the platform and execution of instructions given by the researcher. The navigation was video-recorded using a videoconferencing tool. The data was anonymized and a consent form was signed. Then, semi-structured interviews were conducted to delve into the teachers' perceptions and discuss their feedback.

2. Usage Test:

- Sample: 4 teachers, 1 class of 6-7-year-old pupills, and 3 classes of 7-8-year-old students, totaling 86 pupils.
- Observation Methods: In-person observations were conducted in real classroom settings. During these in situ observations, an observation grid was used to take notes on several aspects: the modalities of platform use by the teacher, the teacher's interactions with students concerning the digital content, students' reactions, behaviors, and verbalizations regarding the platform, any technical or pedagogical difficulties encountered, and other relevant contextual elements. Additionally, some sessions were video-recorded to capture the full course of activities, verbal exchanges, interface manipulations, and more.

Duration of the study**:** The four-month study consisted of three phases: (1) Protocol Development and Teacher Recruitment: Initial phase. (2) Remote Usability Testing: Conducted via 45-minute individual sessions on Webex, recorded on video, following Hammontree, Weiler & Nayak's (1994) framework. This approach allows detailed usability evaluations without geographical constraints. (3) In Situ Usage Study: Two-hour classroom sessions.

5. Results

The usability tests identified several ergonomic challenges to address: the incompatibility of the interface with vertical menu scrolling on the tablets used in class (issue with responsiveness); the insufficient visibility of certain key resources (“vacation booklet” and brochure on dental trauma). The ecological user test revealed issues related to printing some materials, which necessarily have to be in black and white in schools. This significantly degrades their readability, and thus their attractiveness and clarity for students. Observations in real teaching situations showed that the most utilized resources are the lessons and explanatory videos. However, the proposed practical activities are less frequently implemented. Despite this, an encouraging element was noted: students show great enthusiasm when exposed to the various contents (notably the videos), demonstrating the platform's motivational potential. While most teachers rely on the provided resources, some also choose to integrate their own supplementary materials, illustrating the pedagogical freedom offered by the digital tool. Finally, it appears that the platform is still primarily used as a lesson design tool rather than as an in-class animation support. Its potential for interactivity and dynamic implementation of learning thus remains to be further developed.

The main results of this study, in connection with our initial hypotheses and the theoretical framework established at the beginning of our research, offer interesting perspectives on the use and effectiveness of the Bucco-Kid® platform in teaching oral health.

Concerning the first hypothesis, The identified ergonomic challenges influence the acceptance and usage of the platform. However, its use in lesson planning suggests a certain level of acceptance. Further evaluation is needed to assess improvements in teaching effectiveness.

Concerning the second hypothesis: Teachers do effectively use the platform to access educational content, primarily lessons and videos. However, the underutilization of practical activities suggests that not all aspects of the platform are fully utilized. The alignment of content with learning objectives requires further evaluation.

Supported by extensive observations, students' enthusiasm towards the content, especially videos, demonstrates the motivational potential of the platform. However, its use in the classroom as an interactive teaching aid needs further development to fully exploit its potential in a real-world context.

6. Conclusions et Perspectives

This study shows that the Bucco-Kid® digital platform, despite some areas for improvement identified, receives an overall very positive and enthusiastic response from both teachers and students. Teachers expressed satisfaction with the content and functionalities provided, which greatly facilitate the preparation of their lessons, even on topics where they sometimes lack specific expertise. Some even observed good assimilation of the concepts by the students thanks to the digital tool. This very favorable feedback from the end users suggests

a sustainable adoption of the platform by the teaching staff. The next development steps will involve optimizing the platform based on the feedback and improvement points highlighted during our study. We will aim to enhance interactivity and teacher engagement so that the platform can be fully utilized in real-world settings while leveraging the benefits of digital environments. The goal is to create a solution that is both tailored to the needs of teachers in their classrooms and offers the richness and performance of an innovative online tool. Given that this is a "work in progress" contribution, we will deepen our study of the platform by analyzing the process of “didactisation” of the topics conducted by the teachers.

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Analysis of the Learning Achievement Gap Between Courses Adapted to Virtual Modality and Courses for a LMS in Undergraduate Studies

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Abstract: The purpose of this research was to determine if there is a gap between a course adapted from a face-to-face to a virtual format and a course specifically designed to be taught in a virtual environment through an LMS. The results showed a gap of more than 10%, with the experimental group obtaining an average final grade 23% higher than the control group. A 24% improvement in grades was observed with the increase in supervisory activities in one unit of the course. The tutor-teacher's expertise and willingness to help students were key elements to the success of undergraduate students.

Keywords: LMS, Virtual teaching, Learning platform, Virtuality

1. Introduction

Distance education has been an inclusive mechanism supported by educational materials for individual study and self-learning. With the emergence of online learning, it was possible to include instruction with teachers and peers without the need for physical presence (Guadalupe & Rivera, 2021). The Covid-19 pandemic accelerated the virtualization of courses in higher education, leading many institutions to adapt face-to-face material without an adequate instructional design for virtual platforms (Valverde, 2021; Guadalupe & Rivera, 2021). This process, according to Bates (2019) and Boulos (2022), sacrificed the quality of the content to save costs. This problem needs to be evaluated from a professional and scientific educational perspective (Valverde, 2021). Villafuerte (2020) highlights that the controlled structure of a school cannot be replicated online, evidencing the need for differentiated educational proposals in virtual environments.

The research question arises: Is there an achievement gap between an adapted virtual course and one designed specifically for an LMS? What is that gap? The instructional design proposal in Peruvian universities is usually based on adapting face-to-face syllabuses to virtual modalities without an adequate instructional design for such platforms (Brenis-García et al., 2021). The temptation to virtualize courses to save costs has led to a reduction in educational quality by not using adequate tools and not training teachers (Bates, 2019).

An LMS (Learning Management System) is a virtual space that provides services and tools for a student to build their knowledge and includes hardware and software elements to create and distribute educational content and manage learning (Butum et al., 2018). The Covid-19 pandemic forced teaching-learning to shift to 100% online, using LMS platforms such as Google Classroom, Zoom, Google Meet, among others (Mishra et al., 2020). Learning achievements are results achieved by students after significant learning experiences, based on self-reflection and teacher accompaniment (Fernández Leandro et al., 2022). There is a positive correlation between the quality of the education system, ease of use, and satisfaction with online learning (Giday & Perumal, 2024). Boulos (2022) suggests that it is possible to achieve comparable levels of effectiveness between online and face-to-face instructional formats. This is measured by Learning Effectiveness. Effectiveness is the ability to achieve the desired effect, interpreted as the achievement of competencies in online education (RAE, 2023). An effective teacher achieves formative results feeling prepared and motivated (Infeanyi, 2023; Mishra et al., 2020). Success in online learning varies depending on how teachers deliver sessions and the effectiveness of the instructional techniques used (Butnaru et al., 2021).

In light of the above, the general purpose of this research is to know if there is an achievement gap between an adapted virtual course and a designed one, it is necessary to study whether the achievement gap is significant between an adapted virtual course and one designed specifically for a LMS, and if the achievement gap between an adapted virtual course and a designed one is greater than 10%. This goal may persuade universities to give more importance to professor capacitation and more time to instructional design.

2. Methodology

Following the quasi-experiment method analyzed by Creswell (1994) and executed by Chen & Huang (2024) in 48 fifth-grade students in a primary school in Taiwan, we aim to analyze the learning achievement in a course designed for a Learning Management System (LMS), compared to a course without LMS design.

2.1 Participants

Following Creswell's (1994) methodology for quasi-experimental processes, the study took 94 university students from two classes of the AD2454 Project Management course, 47 of them grouped in the KS85 section and the other 47 in the MX86 section, both virtual modalities. The grouping process took place during enrollment at the beginning of the semester. The course was taken for convenience, after the researcher was authorized by the university to carry out the research with two of his classes. Without affecting the composition of the classes, one of them was randomly chosen to become the experimental group, and the other the control group. In the experimental group, the learning methodology linked to the specific design for a LMS will be applied. The control group will follow the traditional method of learning, simulating a face-to-face class only that the sessions will be remote online. All participants agreed to the research process voluntarily. To ensure that the groups were equivalent, an entrance test was taken to measure prior knowledge of the AD2454 Project Management course.

2.2 Experimental Design

The study was conducted in two classes of the AD2454 Project Management course, each with 47 students enrolled. Both groups are taught the content in 4 learning units, during the 4-month span of the 2024-2 semester. The experimental group develops the learning units by attending the class sessions and carrying out the 13 learning activities designed in the EVA. Activities such as forums and the portfolio of deliverables are carried out throughout the semester, and the other 11 activities are specific to the achievement of each learning unit. Each teaching unit also has graded activities to measure learning achievement. For the control group, the same achievement assessment activities established for all 12 sections of the course, both face-to-face and virtual, were considered.

2.3 Experimental Process

The experimental procedure of this study includes a pre-test stage, an experiential stage, and a post-test stage. In the pre-test, the knowledge of the course of the students enrolled in both classes, MX86 and KS85, was evaluated. On a 20-point rating, the MX86 class achieved an average rating of 7.78 and variance of 3.820, and the KS85 class achieved an average rating of 7.85 and a variance of 3.413. This ensures that both groups are equivalent. (Bono Cabré, 2014). In the experimental stage, during the first session, both groups were explained the course content, the activities per unit and the corresponding learning assessments per unit. Both groups will receive the same course content throughout the semester; The experimental group will perform a greater variety of learning activities per unit and both groups will take the same partial assessments to measure the learning achievement of each unit. Table 1 presents the group of activities per unit for both the experimental and control groups.

Table 1: Learning activities by unit

EXPERIMENTAL GROUP			CONTROL GROUP		
With LMS Program	Entry test	Unit 1	Without LMS Program	Entry test	Unit 1
	Forum about Stakeholders				
	Reading Control 1			Reading Control 1	
	Case study about cost management	Unit 2			Unit 2
	Quiz about quality				
	Parcial Essay			Parcial Essay	
	Case study about risk management	Unit 3			Unit 3
	Reading Control 2			Reading Control 2	
	Final Essay Presentation			Final Essay Presentation	
	Final Essay			Final Essay	
	Final Exam			Final Exam	
	Performance Evaluation			Performance Evaluation	
	Portfolio of partial essays	Longitudinal Achievement			

3. Results

Since this experiment is being carried out between the months of August-November 2024, only the pre-test measures are available. The following will be carried out during the academic calendar of the current semester. We present preliminary test results based on what was achieved in previous research carried out by the author where the analysis was carried out for the Marketing course virtual modality, where the achievements by learning units and achievements of the course in general were analyzed. The results obtained from the T-test for the final averages of the course show that the difference between the means is statistically significant. With a 90% confidence interval, the observed difference between the means is not zero, indicating that the course

designed specifically for VAS outperforms the adapted course in effectiveness. The p-value of significance yielded 0.015, being lower than the alpha significance level of 0.05, supports this conclusion. (Quevedo 2018). This implies that although the learning process between the two groups is successful, the achievements are more significant if a specific teaching-learning proposal for the LMS is worked on. Similar results linked to achievement in online classes were found in (Geng & McGinley, 2021).

Table 1: T-test for means of final grades.

Dimension 4 **Confidence Interval for the difference between means 90% [-3.761, -0.450 [**	
Difference	-2.106
T (Value observed)	-2.626
|t| (Critic Value)	2.064
LD	24.000
p-Value (bilateral)	0.015
alpha	0.050
The number of degrees of freedom is approximated by the Welch-Satterthwaite formula	
Interpretation:	
H0: The difference between the means is equal to 0. Ha: The difference between the means is different from 0. Since the computed p-value is less than the alpha=0.05 significance level, the null hypothesis H 0 must be rejected, and the alternative hypothesis Ha accepted.	

Note. USMP Qualifications. Own elaboration. T-test for two related samples / Bilateral test. Taken from Quevedo G. (2018, p82)

4. Preliminary Conclusions

As seen in table 1, the results for dimension 4, as for the other three dimensions not shown used in the preliminary research, there is statistical evidence to establish that the significant difference in the achievement of competencies between the control and experimental groups. Depending on the instrument used in the learning achievement of each unit of study, it shows a greater gap, therefore it is evident the importance of establishing the most appropriate learning tools according to the objective to be achieved, and that better learning results will be achieved by doing so. The results underscore the relevance of the teacher's role in virtual education (Brenis-García et al., 2021), the notable improvement in grades with the increase in teacher interaction and their proposed activities, is crucial for student engagement (Woo et al., 2021). In addition to this, it suggests the idea of strengthening the education and training of teachers who participate in online teaching, to ensure that they are prepared to offer the necessary support to their students (Marciniak & Gairín Sallán, 2017; Nortvig et al., 2018).

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Tapping into Gen Z Ways to Enhance e-Learning and Meaningful Connections

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Abstract: Generation-Z born 2000-2009 (Australian Bureau of Statistics 2024) are comfortable with digital technology and connecting with one another using social media platforms. Regardless of this proficiency they may still experience challenges engaging with online learning especially around social cohesion, wellbeing and learning success. Other challenges they may encounter are communicating and interacting face-to-face in the workplace, which is a vital 21st Century graduate attribute. A growing societal concern is staff shortages and unfilled vacancies within the health sector. There are many factors influencing health care workforce shortages, but Generation-Z may be a good fit due to their growing awareness of societal concerns and willingness to upskill. This study seeks to investigate the enablers and barriers impacting Generation-Z nursing students' ability to successfully engage with e-learning and to communicate effectively in face-to-face interactions within the workplace environment. Furthermore, this study seeks to explore the ways Generation- Z nursing students communicate and interact with each other on social media. The study will use a qualitative, social constructionism (making meaning in a social context) methodology. Methods include three focus group discussions with students aged 18-24 years, enrolled external/online in an undergraduate nursing program, with a minimum of one clinical placement completed or attempted. Data will be analysed using thematic analysis process proposed by Braun and Clarke (2022). Findings will inform e-learning design strategies that address the identified barriers and use the enablers to help Generation-Z successfully transfer their social media communication knowledge and skills to better engage with online learning, leading to higher satisfaction and completion rates. These strategies include supporting the transference of their fluent online social media communication skills to build and use meaningful connections relevant to the healthcare workplace that further supports the enablement of the graduate attribute, effective communicator.

Keywords: Effective communication, E-learning engagement, E-learning design strategies, Generation-Z, Human connection, Nursing education

1. Introduction

There is a global shortage of healthcare workers. Focussed collaboration is needed to prioritise efforts towards a refreshed strategy to attract, educate and train individuals to grow the healthcare workforce. The World Health Organisation (2024) projected a shortfall of 10 million health workers by 2030. In Australia, Generation-Z is the largest age group consistently graduating from nursing programs each year (Australian Nursing and Midwifery Federation 2023). However, a recent Australian Government, Department of Education Cohort Analysis 2005-2022 Report (2024) found nursing program completion rates were consistently in the mid 70% range placing the growth of the future health workforce at further risk. Additionally, completion rates were consistently lower for external/online students compared to internal and multimodal students. Indicating some students regardless of discipline are experiencing challenges. Future e-learning research on Generation-Z students, health disciplines, and bridging the divide between traditional learning platforms and social media is needed (Ferguson et al, 2016; Natarajan & Joseph, 2021; Shorey et al, 2021).

2. Aim

This study aims to investigate a) the enablers and barriers impacting Generation-Z nursing students' ability to successfully engage with e-learning and to communicate effectively in face-to-face interactions within the workplace environment and b) the ways Generation- Z nursing students communicate and interact with each other on social media.

2.1 Implications for Practice

Findings from this study will inform the development of e-learning design strategies that address the barriers and use the enablers to help Generation-Z transfer their social media communication knowledge and skills to better engage with online learning, leading to higher satisfaction and completion rates. These strategies include supporting the transference of their fluent online social media communication skills to build and use meaningful connections relevant to the healthcare workplace that further supports the enablement of the graduate attribute, effective communicator.

The following sections detail the theoretical framework, literature review, methodology, methods and analysis.

3. Theoretical Framework

Maslow's theory of motivation and hierarchy of needs and two interrelated nursing philosophies, person-centred care and holistic care will frame this study. Maslow's theory (1943) lists five needs in pre-potency order; physiological, safety, love, esteem, and self-actualization. Person-centred care is founded on respect, effective communication, deep value for the person and their personhood (Kitson et al, 2012). Holistic care includes physical, intellectual, socio-cultural, emotional, spiritual and environment (Dempsey, 2014). These theories are relevant in establishing connections with others and in e-learning practice (Bandhu et al, 2024), and in supporting nursing students to form therapeutic relationships vital for the workplace (Lawrence & Reedy, 2019). These theories will inform the questions posed to each research aims and analysis to increase the understanding of Generation-Z nursing students lived experience of online learning and their existing social media skills.

4. Literature Review

4.1 Generation-Z Learners' Preferences, Drivers and Challenges

Generation-Z learners preferences include a mobile learning approach with concise content that suits their on-the-go lifestyle, interactive content, games, Web 2.0 and social media platforms and sharing and collaborating with peers (Chicca & Shellenbarger, 2018; Issacs et al, 2020). They are purpose-driven and motivated by recognition and rewards (Savithri et al, 2024), preferring real-world scenarios and social causes (Manzoni et al, 2020). Student engagement includes teacher presence and connection, and a sense of belonging for students created through collaboration and supporting students (Berry, 2019). Many students continue to report dis-satisfaction with learning online (Asad et al, 2020; Reedy et al, 2013). Challenges include quality and standardisation of online instruction, teacher presence, engagement, authenticity of learning activities, internet stability, and organisational information communication technology (ICT) support (Mosteiro-Diaz et al, 2023; Odikpo et al, 2024).

4.2 Effective Communication and Forming Meaningful Connections

Generation-Z have mature social media communication fluency (Issacs et al, 2020), however many nurses and some Generation-Z nursing students struggle with forming therapeutic relationships with their clients (Kordkolaee et al, 2024; Smyth et al, 2023). Communication is vital in providing safe, quality person-centred care (Australian Commission on Safety and Quality in Health Care 2021). Training in effective communication is known to improve the patient/family care experience and health outcomes (Banerjee et al, 2017) and is a vital inclusion in nursing curriculum to prepare students for the health care workplace (Lawrence & Reedy, 2019). There are gaps in the literature in how to support Generation-Z nursing students' to transfer their social media communication skills into the workplace.

5. Design

The study design will use a qualitative, social constructionism (making meaning in a social context) methodology.

5.1 Ethics

Ethics ID for this project is ETH2024-0829. Ethics approval will be sought from the University Ethics Committee prior to commencing this study.

5.2 Methods

Three focus groups consisting of 4 to 6 nursing students will be conducted at a university in Queensland, Australia, with Generation-Z nursing students enrolled external/online in an undergraduate nursing program, aged 18-24 years with a minimum of one clinical placement completed or attempted. Volunteer participants will be recruited using convenience sampling.

6. Analysis

Data will be de-identified and transcribed verbatim and member checked prior to analysis. Data will be analysed using thematic analysis detailed by Braun and Clarke (2022) and the theoretical framework informing this study and will be conducted by two research members to ensure validity and reliability. Each transcription will be read independently by these two research members, data coded, and initial themes identified. Themes will be presented to all research team members and discussed until final themes agreed.

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Digital Open Library Development: A Real Path Towards Sustainable Math Education

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Abstract: After the globally atypical year of 2020, distance cooperation and experimentation with virtual and blended learning opportunities are becoming a standard in all educational levels. Digital teaching/learning materials are at the forefront of this movement, presenting many advantages, since these can be innovative, engaging, interactive, and can even be tailored to meet the students' and teachers' needs. In this context, Open Educational Resources (OER) are a powerful concept for sharing the world's resources for the common good, reflecting the international commitment to Education For All (EFA). In the past few years, the development of OER has grown exponentially, however, several are quite "closed" and few have the necessary scientific and pedagogical quality certification as real "educational" resources, particularly in the Mathematics area. This was the main idea behind an Erasmus + Project, that brought together six Higher Education Institutions (HEI) from five European countries. This project, still in development, has emerged from a practical need for hybrid and remote teaching and learning open support. Its main goal is developing an Open Digital Library of Mathematics OER in seven distinct languages, encouraging its open dissemination and use, building a truly sustainable Math education promotor. An overview of the project and its main objectives will be presented, as well as its several operational and progress challenges as well as the results that have been accomplished thus far. This project entails several distinct but complementary features that started with the construction of an OER assessment model, culminating with the development of a multilingual OER bank and its continuous sustainability. This can only be achieved with the future establishment of an OER developer's community among Math teachers and students from several education levels, that will be engaged in other project programmed activities, as Teachers' Trainings, Users' International Challenge and Students' International Competition. This Project progress and success is largely based on the interaction, input and participation of all stakeholder groups.

Keywords: OER, Online learning, Mathematics learning, Multinational cooperation projects, Technology enhanced learning

1. Introduction

Mathematics in the STEM (science, technology, engineering and mathematics) field is considered as a necessary instrument to be able, through the applied exercises, to decipher the closest environment and represent various facts, be they social, scientific, or technical that occur in today's world (Williamson, 2018). However, Mathematics appears abstract to students mainly because teachers put more emphasis on the process of mathematics content than on the necessity of the content. Learning mathematics coupled with the effective application of mathematical e-learning can enhance meaningful learning of mathematics and make the subject more stimulating (Ahn & Edwin, 2018; Wæge, 2009). The interest motivates the student to put more effort into learning the content and stimulates its creative thinking, promoting creativity, autonomy development, self-esteem and entrepreneurship improvement (Titilope & Idiong, 2017). Mathematics and mathematical modeling facilitate the understanding of various phenomena, be it social reality itself, economic aspects, or historical facts, among others (Carvajalino, 2018) and by working with interactive open content asynchronously and at their own pace, students can build their own learning path, promoting the development of competencies that allow them to function independently in both personal and social life (Paechter et al., 2017).

Digital learning resources offer several specific advantages according to students' needs, as these materials can be engaging, interactive, and tailored to meet student needs. Research indicates that digital resources can significantly enhance learning outcomes by providing personalized learning experiences and fostering student engagement (King & South, 2017; Means et al., 2010). In this context, Open Educational Resources (OER) are a

powerful concept for sharing existing resources worldwide, for the common good, echoing the international commitment to Education For All (EFA) (UNESCO, 2002). In recent years, the development of OER has grown exponentially, with a notable increase in their use and creation across educational institutions globally (Hilton, 2016; Weller, 2014). However, it is evident that several materials labeled as "OER" available online are far from being truly "open" and few have the necessary scientific and pedagogical certification to be considered genuine "educational" resources, particularly and specifically in the field of Mathematics (Atkins et al., 2007; Miao et al., 2016; Wiley & Green, 2012).

2. Motivation

Recognizing the common need for certification and clarification regarding the concept of OER, a consortium of Higher Education Institutions submitted, an Erasmus+ project under the Key Action - Cooperation Partnerships in Higher Education, obtaining its approval. This consortium, comprising six Higher Education Institutions (HEIs) from five European countries (Austria, Estonia, Portugal, Romania, and Spain), is developing an 'Intelligent Library' of OER (Smart Library) under the label Gate2Math - Smart library for OERs in mathematics teaching (G2M).

3. Objectives, Target Audience and Expected Results

The main goal of G2M is to implement and put into service for the international educational community an efficient Gate2Math smart library for the optimal selection of open and multilingual educational resources in the field of mathematics teaching in the context of engineering. The scope of the content is wide-ranging and includes open resources such as videos, infographics, games, applets, presentations, animations, artifacts, blogs, bibliographic references, questionnaires, databases, wikis, courses and treatises from a theoretical point of view, practical, applied and assessment, covering the contents of Algebra, Calculus, Geometry, Statistics and Probability and their applications in STEM teaching.

The first and hardest project objective was to develop a general, intuitive and applicable OER Assessment Model. This is already in its "beta" version and with practical application, leading and supporting another G2M objective regarding the OER quality certification, specifically in Mathematics.

A final and global objective, that aligns with the project main goal, is to establish an OER developer's community among Math educators and students. The project is supporting digital transformation of secondary, vocational and higher education institutions. To increase the capacity and readiness of these institutions through the purposeful use of digital technologies, the consortium is creating quality learning materials in mathematics and preparing both teachers and students to create and use these types of learning materials through the implementation of several training and collaborative actions, namely: Teachers' Training, Users' International Challenge and Students' International Competition. To this end, a BIP (Blended Intensive Program) has already been developed for teachers and a BIP for students is scheduled for November.

As previously mentioned, the target audience are teachers and students from several levels of education, especially Higher Education, who are and will continue be involved in the evaluation and sustained development of OER, contributing to the growth of the library that is being developed, namely (Gate2Math, 2023):

- Mathematics teachers in secondary, vocational and higher schools, including visually impaired and color-blind teachers
- Students from the last years of secondary or vocational education to the first years of STEM-adjacent degrees, including visually impaired and color blind-students
- Fellows-researchers in the field of technology-assisted learning, online learning and STEM pedagogy

Regarding the project expected outcomes several can be pointed (Gate2Math, 2023):

- The smart library platform for OER in the field of Mathematics
- Research report on the typologies and characteristics that make an OER efficient and development of a standardized quality criterion for an OER.
- Inclusive and inter-connected smart library of high quality open and multilingual educational resources (which are accessible for visually impaired and color-blind students either) with the creators' community in the field of mathematics
- Training materials and trainings of how to create high quality OER
- Student competition based on the knowledge acquired from the Gate2Math smart library
- Teacher challenge for creating new learning materials

- New knowledge and skills of project partners and other teachers in mathematics and intercultural communication

4. Final Comments

G2M stands for a real international interaction, input and collaboration, reflecting the engagement and commitment of all the stakeholders to an Education for All, as its main goal is to build an OER library in seven different languages - German, Catalan, Spanish, Estonian, English, Portuguese, Romanian. As mentioned above, G2M arises from the need to promote sustainable teaching, making use of good OER. However, following extensive research, it appears that several of these resources have licenses that do not allow them to be used freely, complying with the 5Rs "model" related to OER (Wiley, 2014). It must always be kept in mind that an online digital content is frequently not an OER! The G2M Project aspires to share and alert to the existence of (real) open licenses that allow the use and reuse of good materials, contributing to true sustainability and universality in teaching, in all its areas.

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Technological Aspects of Gamification: Criteria for the Selection of Digital Tools and Platforms

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Abstract: This work-in-progress paper describes research conducted as part of the ongoing project "Enhancing Motivation for Learning Through Gamification", whose main aim is to develop a pedagogical-technological gamification framework to help high school teachers design and implement gamification activities. The research will be conducted using the Design-Based Research (DBR) methodology. Currently, the project is focussing on researching the technological aspects of the gamification framework. This paper proposes criteria to consider when selecting digital tools and platforms for gamification and presents the results of analysing selected tools. The main contribution of the paper lies in its own categorisation of the gamification criteria based on the MDA framework, in which the gamification categories are described according to Mechanics, Dynamics and Aesthetics. As an example of the application of the categorisation, the analysis of the gamification tool Kahoot! is described in detail.

Keywords: Gamification in education, Digital tools and platforms for gamification, MDA framework, Gamification framework

1. Introduction

Gamification in education is the application of game design elements and game principles in the classroom with the aim of increasing students' motivation, interest and engagement so that they learn more effectively (Dichev and Dicheva, 2017; Osatuyi et al, 2018). It differs from the application of game-based learning because it is sufficient to include only some elements of the game such as virtual points, badges, leaderboards, avatars and use accessible digital tools and platforms for teachers such as LMS and quiz tools (Vrcelj et al, 2021).

Despite the potential for the implementation of gamification at different levels of education, a review of the existing literature shows that it is more commonly used in higher education institutions than in schools (Vrcelj et al, 2023). The first step in encouraging teachers in schools to design and implement gamification activities is to help them select appropriate digital tools for gamification.

This paper describes research in this direction conducted as part of the project "Enhancing Motivation for Learning Through Gamification". The main aim of the project is to develop a pedagogical-technological framework for gamification to help high school teachers design gamification. The research is conducted using the DBR methodology. The first DBR phase, the analysis, was carried out in preliminary studies in 2023 (Vrcelj et al, 2023). In the current research phase, the design of solutions for the analyzed problem, the first step is to develop the technological aspect of the framework.

This paper proposes criteria to consider when selecting digital tools and platforms for gamification as a prerequisite for the development of the future pedagogical-technological gamification framework for secondary education.

2. Related Work

Although technological gamification frameworks have been developed for different domains, it is evident that there is still a lack of frameworks that would be suitable for secondary education and that the frameworks are intended for gamification designers rather than teachers, as they do not sufficiently address pedagogical aspects that would complement the technological aspects of gamification. Furthermore, the existing frameworks (Toda, et al, 2020; Mora, et al, 2017; Bernik, 2021) are too extensive and therefore too complicated for secondary school teachers.

It should be emphasised that frameworks for digital games were developed before the gamification frameworks, one of which is the most famous and widely used MDA framework (Hunicke et al, 2004). MDA is an acronym that refers to three framework elements: Mechanics, Dynamics and Aesthetics. This model helps game designers to focus on the fundamental elements of the game to create a satisfying experience for players and can also be successfully applied to gamification (Kusuma et al, 2018).

The MDA framework served as a starting point for creating the technological part of our own framework, the fundamental feature of which is that the elements describing gamification were chosen to be applicable to teachers in schools, as they might find complicated and detailed systems demotivating. The MDA framework was chosen because it adapts well to education and the learning process and can be used effectively to motivate students (Kusuma et al, 2018; Pratama and Kusuma, 2022; Angelia et al, 2020).

3. Categorisation of Gamification Criteria

When selecting the criteria for the categories, their suitability for schools was considered. We used the literature review and the results of a preliminary study conducted as a systematic literature review (Vrcelj et al, 2023) to propose our categorisation (Table 1).

Table 1: Categorisation of gamification criteria

Mechanics	
Points	Users can collect numerical points that are automatically awarded for achievements.
Badges	Virtual medals awarded to the user as a sign of success, or for achieving goals.
Leaderboards	Ranking of users based on the results achieved, mostly points accumulated.
Levels	Completing a certain number of tasks, users are allowed to move up to the next level.
Progress bar	It shows the user's progress and guides them through the system.
Dynamics	
Prizes/rewards	Additional virtual rewards or recognition can be awarded for user achievements.
Feedback	Quick feedback on the user's current engagement.
Adaptation	The system changes depending on the user's actions and data.
Puzzle	Solving additional games, puzzles, etc.
Quiz system	Solving quizzes with different types of questions, usually multiple choice.
Synchronous use	The use of gamification in the classroom, e.g. during the teacher's presentation.
Asynchronous use	Gamification during the user's independent learning.
Aesthetics	
Avatar	The participant can choose his own character and/or nickname.
Live reactions	The participant can react (e.g. like) with emoticons, pictures, or stickers.
Challenge	An element whose aim is to encourage the user to perform tasks.
Competition	Competition with other users using gamification elements.
Cooperation	Cooperation with other users in teams and possibility to select a team.
Storyline/narrative	Creating a fictional narrative.
Fantasy	Using sound, dynamic graphics, a 3D virtual world and/or AI to create a fantasy.
Other	
Reports	The teacher has access to student data on participation in gamified activities.
Lessons	Lessons can be created as presentations and training materials.
Classes	The teacher can create virtual classes and enrol their students.
AI tools	Availability of AI tools to create questions, check errors, etc.

In the proprietary categorisation of gamification criteria, the *Mechanics* refers to specific game elements embedded in gamification tools to drive student behaviour, including common game design elements such as points, levels and leaderboards. The *Dynamics* of gamification describe how the basic elements of mechanics are applied and combined to influence student behaviour, considering the types of interactions that are appropriate for learning. The *Aesthetics* in this categorisation refer to the emotional and motivational aspects, i.e. the experiences that students gain from participating in a gamified system. This includes satisfaction, sense of achievement, social interaction and other emotional aspects. In addition to the three categories formed following the MDA framework, a fourth category, *Other*, was added with other elements that are useful for gamification in education.

4. An Example of Using Categorization

To validate the categorisation, an analysis of popular digital tools and platforms that enable gamification was carried out. The tools selected were those that are successfully used in schools according to literature review (Vrcelj et al, 2023): Kahoot!, PeerWise, ClassDojo.

As an example of analysing a gamification tool using the proposed categorisation, this paper focuses on Kahoot!, a popular platform used to test students' knowledge, provide formative assessment or take a break from traditional classroom activities (Wang & Tahir, 2020). Kahoot! enables teachers to create, share and run quizzes (called kahoots) in real time.

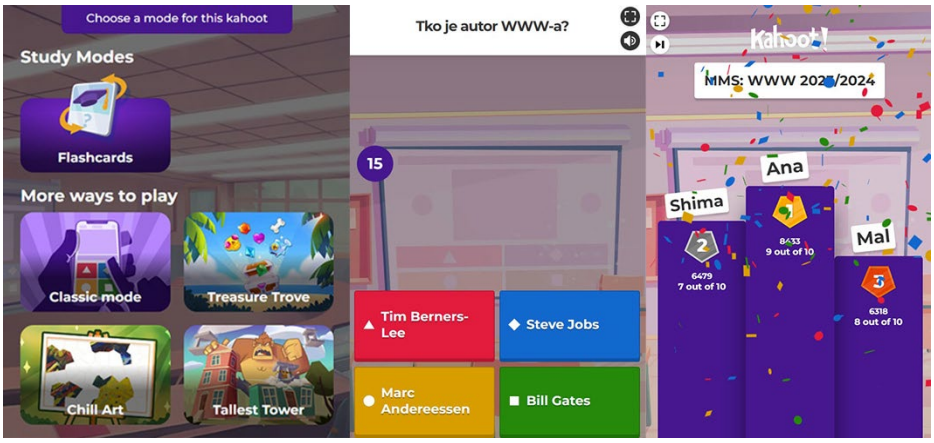

Figure 1: Kahoot! screens for game modes, question answering, and podium

Of the elements in the *Mechanics* category, Kahoot! uses points and leaderboards. Students earn numerical points for answering questions, which are awarded based on accuracy, but also on the speed of the answer. At the end of the quiz, a podium (leaderboard) is displayed with the 3 students who have scored the most points.

In the *Dynamics* category, it is important to point out that the quiz system is the basic way of using Kahoot!. Regarding puzzle, additional games are offered for some subjects. Students receive immediate feedback after answering a question. Synchronous use is the basic type of use, as the quiz questions are solved in class under the guidance of the teacher, but the system also allows asynchronous use (student-paced kahoots). The adaptation element (personalised kahoots) is supported.

All elements of evaluation are represented in the *Aesthetics* category. The student can choose an avatar (theme character), students can react with emojis (live reactions). In addition to the basic challenge of the quiz (answer correctly as quickly as possible), there is also an additional challenge to solve the quizzes independently. When solving the quiz questions, students can compete independently against other students, and teams can compete against other teams. Students can be divided into teams and solve the quizzes together. Achieving a fantasy in Kahoot! is that the classroom is temporarily transformed into a game show where the teacher is the quizmaster of the quiz and the students are the contestants. In addition, imaginative stories have been developed for some of the Kahoot! game modes, for example *Treasure Trove*.

Of the other elements used for gamification, the reports on student results are available to teachers, slides with questions can be created, and the teacher can create courses and join students. There are also AI tools, for example for generating questions.

To summarise, Kahoot fully contained 2 elements in *Mechanics*, 6 in *Dynamics* and 7 in *Aesthetics*. As for the other tools analysed, PeerWise was found to have fully included 3 elements in *Mechanics*, 3 in *Dynamics* and 1 in *Aesthetics*. For ClassDojo, 2 elements are fully included in *Mechanics*, 4 in *Dynamics* and 6 in *Aesthetics*.

We recommend that teachers who want to use digital tools for gamification analyse them based on the elements of all 4 categories. It is particularly important that they select the tools with sufficient implemented elements in the *Aesthetics* category, as student satisfaction when using gamified activities in the classroom will have an impact on learning success.

5. Conclusion and Future Plans

This paper presents a preliminary study on the use of gamification, proposing a categorisation of gamification criteria for the selection of digital tools and platforms based on the MDA framework.

It was validated that the categorisation can be successfully applied to the analysis of gamification tools, such as Kahoot!. This result will play an important role in the subsequent research steps, i.e. in the further development of the technological part of the gamification framework.

In the further course of the research within the project, the categorisation of the gamification criteria as the technological part of the future framework will be expanded to include additional pedagogical aspects related to the successful realisation of learning outcomes and student motivation. Furthermore, we plan to develop our own digital tool for gamification that can be used by teachers in schools, conduct an experimental part of the research consisting of a series of iterative DBR cycles, and analyse the results to create the final version of the gamification framework.

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