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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