A Proposed Framework for the Classification of Game-Based Learning in Construction Management

Yara Elenany and Vian Ahmed
American University of Sharjah, UAE

yelenany.main@gmail.com
vahmed@aus.edu

Abstract: As the construction industry heads towards the Fourth Industrial Revolution, the gap widens between industry demands and fresh graduate capabilities. Much of this is owed to the traditional Construction Management (CM) pedagogy. Therefore, there is a pressing need for a paradigm shift in our approach towards CM education. As such, to meet both industry demands and student expectations, integrating game-based learning (GBL) can substantially enhance the learning experience for CM students in higher education. Although the body of knowledge recognises Game-Based Learning (GBL) as tools that facilitate active learning in engineering disciplines in general, their utilisation remains limited in construction management. Thus, the aim of this paper is to conduct a systematic literature review of past GBL studies in Construction Management via Scopus database with an attempt to classify these studies into three broad categories: Tabletop games, digital games, and computer-assisted games. First, this paper will explain the key features, strengths, and limitations of each category. Second, this paper will identify the trends in game characteristics, learning objectives, data collection methods, and game evaluation approaches. Finally, this paper will present a classification framework that summarises the findings to facilitate selecting effective GBL strategies for CM higher education. Thus, this study will provide a wide-lens view of the research trends, gaps, and future research recommendations in this field as well as present design parameters for effective GBL integration.

Keywords: Game-Based learning, Simulation games, Construction management, Higher education, Experiential learning

1. Background

As the construction industry heads towards the Fourth Industrial Revolution, the gap widens between industry demands and fresh graduate capabilities (Castronovo et al., 2022). In today's fast-paced digital age, there are three key industry needs for construction managers: strong theoretical understanding, adept technical skills, and transferable soft skills (Ojiako et al., 2011, Castronovo et al., 2022). This demand is compounded by the increasing difficulty of continuing professional development after employment due to the intensive work demands of the industry (Wall & Ahmed, 2008). As such, the challenges and limitations of traditional CM pedagogy have gained considerable attention and scrutiny in recent years to ascertain the necessary changes for bridging the gap between academic training and industry demands (Ojiako et al., 2011, Pereira & Thom, 2022).

Past studies investigated this phenomenon in an effort to understand the causes behind this gap. For example, Lee, Samad, and Goh (2020) attributed this struggle to passive teaching methods where a plethora of information is presented abstractly. Similarly, Herrera et al. (2019) stated that the lack of immersion in the subject was a major detriment of traditional lecturing, especially for students without prior exposure to the industry. In addition, Dancz et al. (2017) and Pereira & Thom (2022) recognised the pressure on the curriculum itself to continually improve its evaluation methods, provide practical training opportunities, and train communication skills for students of diverse learning backgrounds. Moreover, a survey conducted by Ojiako et al. (2011) revealed that the expectations of the 'digital native' student, who grew up with digital technology, have changed significantly in line with contemporary industry demands. Most notably, respondents of the survey placed high importance on the development of transferable skills and the effective use of virtual learning tools (Ojiako et al., 2011). Therefore, there is a pressing need for a paradigm shift in the way we approach teaching CM, and integrating simulation games can substantially enhance students' learning experience in higher education.

Game-Based Learning (GBL) is a teaching practice under Experiential Learning Theory (ELT). It describes learning as a unique process for every learner rather than a shared outcome (Kolb & Kolb, 2017). From their modern guide for experiential educators, Kolb and Kolb's (2017) model for the ELT learning cycle comprises of four stages: concrete experience/abstract conceptualisation for grasping experience and active experimentation/reflective observation for transforming experience. Although hands-on learning is used interchangeably with experiential learning, the authors clarified that experience represents only one stage of the learning cycle. In traditional CM pedagogy, class lectures, assignments, group projects, and internships offer half of the learning cycle (concept and experience) but often lack qualitative feedback (reflection) or

experimentation (action) without adversely affecting their class performance grade. On the other hand, integrating game-based learning allows students to transform new knowledge in a risk-free environment with personalised feedback (Oo & Lim, 2016, Perini et al., 2018). Thus, CM education can greatly benefit from this holistic approach, which complements the nuanced and multidisciplinary nature of the CM field.

Within ELT, there are several practices documented in the literature, of which simulation and gaming is one of them (Kolb & Kolb, 2017). Simulation and gaming refer to a pedagogical approach that uses a serious game or simulation model that emulates a system or process to better recognise its underlying principles and mechanisms (Kriz, 2017). This paper focuses on one genre of games called simulation games. A simulation game models a real-life system or process and adds game objectives to visualise the underlying principles in an interactive and engaging environment (Kriz, 2017). Furthermore, simulation games vary in complexity and realism, and they have supported educators, policymakers, and researchers for several decades (Kriz, 2017). For students in CM higher education, this paper argues that simulation games are the most suitable form of experiential learning due to their visual, interactive, adaptive nature.

Simulation games greatly complement the CM discipline. Primarily, they allow learners to interact with complex systems in a controlled and simplified manner (Fumarola, van Staalduinen, & Verbraeck, 2012). In the workplace, experimentation comes with high cost, uncertainty, and risk (Miettinen et al., 2016); likewise, grade penalties create a barrier to experimentation in academic settings (Dib & Adamo-Villani, 2014). On the other hand, working in a virtual environment encourages students to unlock their creativity and explore new paths that may never see real implementation otherwise (Perini et al., 2018). For example, learners can test different decision paths and witness their subsequent outcomes (Dib & Adamo-Villani, 2014). Moreover, simulation games provide immediate and personalised feedback (Hassan, Haghighi-Rad, & Abtahi, 2021). According to Castronovo et al. (2022), engaging students to test their hypotheses and strategies in fast cycles motivates and helps them gain problem-solving skills and awareness of their own learning.

Lastly, simulation games give students first-hand experience interacting with the subject material in-context which reinforces their theoretical knowledge (Oo & Lim, 2016). Therefore, simulation games are valuable tools for teaching the underlying principles of a complex system in a visual, interactive, and practical way with low risk. The type of game also has an influence on the experiential skills being trained. Multiplayer games can foster collaboration and healthy competition among students, as they rely on active communication and group problem-solving (Perini et al., 2018). On the other hand, single-player games require students to rely on their own decision-making to reach the end-goal (Perini et al., 2018). As such, it is important to consider the learning objectives before deciding what kind of game to use.

The intention of this paper is to explore the use of simulation games in CM higher education and identify the key characteristics of effective GBL integration. As such, this paper studies different types of games found in the literature alongside their learning objectives and target audience. Moreover, this paper identifies the game evaluation strategies and data collection methods used in previous studies.

2. Simulation Games for Construction Management Higher Education

In this study, a systematic review of literature is carried out through the Scopus database. The purpose of this search is to identify the different approaches to game-based learning in construction management in order to understand the parameters that influence the effectiveness of GBL in this field. The initial keywords used were “construction management” AND “game-based learning” OR “simulation games”, which yielded 21 total search results. To expand the search, similar keywords and synonyms were used, leading to 50 total search results. As a result of screening, 14 articles were selected for in-depth reading (see figure 1).

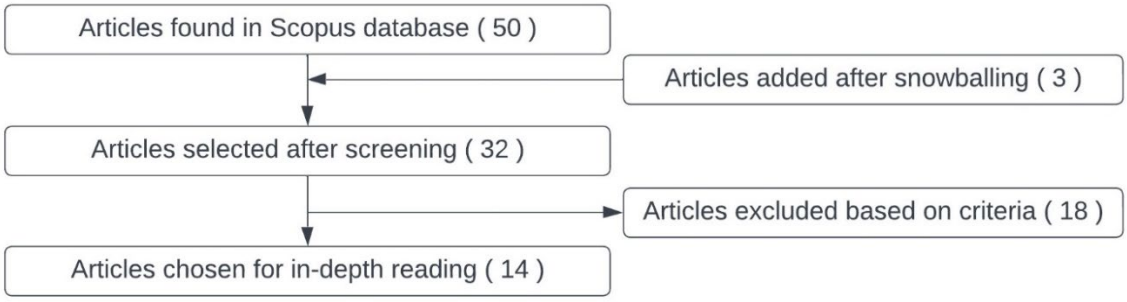

Figure 1: Literature selection process

The key features looked for in these studies were game mode, game genre, target players, subject material, learning objectives, data collection methods, and evaluation approaches. Based on these features, this paper discusses some of the studies' design choices, their pedagogical implications, and the factors that influence their effectiveness. Lastly, this paper presents a framework building on these factors to aid researchers with selecting the most effective GBL strategy in future studies. The selected literature was broadly classified into tabletop games, digital games, and computer-assisted games. The following sections discuss the unique strengths and limitations of each game mode, which in turn suit different learning needs and different stages of higher education.

2.1 Tabletop Games

Tabletop games are games that can be played on a flat surface using paper and pen, board games, or card games. They are quick to set up, and they do not require digital devices to run. Moreover, they are inherently multiplayer games, which require at least 2 players. For example, Oo and Lim (2016) developed a paper-based bidding game that 100 students from two Australian universities participated in. In this study, one group of students competed individually, and the other group of students competed in teams. According to the post-game surveys, more students preferred team-based gameplay over solo.

In addition, tabletop games allow students to share and build on their existing knowledge by cooperating with and competing against their peers. For instance, Gonzalez et al. (2015) developed *LEBSCO,* which was a management simulation game designed for a graduate CM course about Lean Construction principles. The purpose of the game was to show a comparison between traditional management and Lean Construction methods. In this case study, sixty students were formed into teams and assigned unique stakeholder roles. The game received positive feedback from the students, and the survey comparison demonstrated significant improvement in students' understanding of Lean principles.

The duration of each tabletop game may vary, but it is recommended that the full game session ends in one sitting. An example of this is in Herrera et al.'s (2019) study, where graduate students played three simple games on Lean Construction principles during their class. First, the instructor introduced the subject through lecturing followed by the game exercises. The games were paper-based, and each one reinforced a different set of Lean principles. The first game introduced the concept of systems thinking and the importance of communication. The second game built on this idea and added lean principles to the gameplay. The final game presented a construction site scenario, where the student teams analysed site activities using one of the principles called work sampling. After each game, the students reported their level of understanding of each principle. According to their results, the authors noticed that students' confidence of understanding improved significantly across all principles. Thus, the researchers concluded that these simple games complemented their lectures as a form of subject reinforcement. According to ELT, this can be explained by saying that the games provided a concrete experience for the students to apply their conceptual understanding.

One unique study on using tabletop games for CM was the *Game Design Module* presented by Dancz et al. (2017), where all four modes of the ELT learning cycle were present. The study took place over 4 semesters with 180 participating bachelor's students enrolled in Building Methods, Materials, and Equipment. The course project required students to modify an existing board game or creating their own based on the course material specified by the instructor. Following the ELT model, the new concrete experience was playing the role of board game designers, and the abstract conceptualisation involved translating the material of the course into a game format. During the semester, the students reflected on their design process through journaling, and they refined their games based on feedback collected from their peers over the semester (i.e., active experimentation). At the end of each semester, the students and the instructor evaluated each team's game for accuracy, enjoyment, and effectiveness. The creative and collaborative nature of the game design module was well received by the students, and a great majority of them reported enjoying the learning process and feeling more confident with the course material as a whole.

Below, Table 1 summarises the key characteristics of the GBL studies discussed earlier. The table is organised by year in descending order. Under game genre, the games were either tagged as single player, multiplayer, cooperative (Co-op), and/or competitive (VS). For target audience, the tags used were undergraduate (UG), junior or higher undergraduate (UG+), graduate (G), and employee (E). Also, the desired learning objectives were linked to either technical or transferable skills. Moreover, the effectiveness of the games was measured either through user assessment or game design evaluation. Perini et al. (2018) explained that assessment measures the users' learning after interacting with the game while evaluation judges the game design itself. There were three aspects of game evaluation explored in past studies: game design feedback from learners, impact on

learning and motivation, and observations of learner behaviour. In addition, there was a mix of quantitative, qualitative, and mixed methods data collection methods across the selected literature.

Table 1*:* Description of Tabletop Games

Article	Game genre	Players	Subject	Learning Objectives	Data Collection	Evaluation Approach
(Herrera et al., 2019)	Multiplayer, Co-op	G	Lean Construction	**Transferable skills**: communication	Questionnaire	Learning behaviour
(Dancz et al., 2017)	Multiplayer	UG	Construction materials	**Transferable skills:** communication, game design	Questionnaire, Course grades, Journal entries	Game feedback, Motivation, Knowledge gain
(Oo & Lim, 2016)	Multiplayer, VS	UG+	Bidding	**Transferable skills:** problem-solving, communication	Questionnaire	Game feedback, Motivation
(González et al., 2015)	Multiplayer, Co-op	UG+	Lean Construction	**Transferable skill**: communication	Questionnaire	Knowledge gain

However, tabletop games suffer certain limitations. Primarily, tabletop games are best kept simple. As the game's complexity increases, it takes longer to explain the rules of the game and becomes harder for the moderator to manage the game over several independent groups. As such, this paper argues that tabletop games are more effective for learning objectives focused on group effort and communication and for students already familiar with the subject material (e.g., senior-level bachelor's students and master's students).

2.2 Digital Games

Digital games are fully virtual environments supported by audio-visual feedback, a graphic user interface, and artificial intelligence. In this review paper, all mentioned digital games were computer games unless otherwise stated. They allow for a broader range of complexity than tabletop games and can be played on computers, tablets, phones, and consoles. On the one hand, digital games can recreate tabletop games that can be accessed from anywhere in the world; on the other hand, their design can also extend beyond the limitations of physical games. For example, the web-browser simulation game by Miettinen et al. (2016) called the *Engineering Procurement Construction Management (EPCM)* game was developed as a job training tool to teach new employees about decision-making in project management. The game covered human resource management and change control. In their article, they explained how they were able to simulate the interdependent relationships of different inputs using a series of equations. As such, they were able to achieve an impressive level of realism, which in turn added complexity to the decision-making process.

Digital games elevate the visual, interactive, experimental, and adaptive aspects of GBL. Furthermore, they encourage experimentation and strategic planning by offering players different options and hints to their potential consequences. In Dib and Adamo-Villani's (2014) *The Sustainability Challenge*, the goal was to teach their CM undergraduate class about sustainable building design principles. The objective of the game was to reduce the carbon footprint of newly designed and retrofitted buildings. In this game, the gameplay loop consisted of three segments: identify problems, make decisions, observe the effect of those decisions. The game awarded points following the LEED rating system for green buildings, and the students received feedback on areas of improvement at the end of the game.

Regarding interaction, the following digital games showed various approaches to achieving that. Perini et al.'s (2018) *Life Cycle Assessment (LCA)* game was an active learning exercise conducted in class after a standard lecture. In the game, students interacted with different stakeholders and objects to gain information, which they then used to create an in-game report to the virtual CEO. Another form of interaction was that between the students themselves, both cooperatively and competitively. This idea was best utilised in Misfeldt's (2015) attack-defence project management game called *The Challenge Game*. The game consisted of two distinct phases: Planning and challenging. In the planning phase, a team of players handled the managerial tasks surrounding their construction site. In the challenging phase, the same team was given the opportunity to create obstructions for another team's construction project, and the same was done onto them. This gameplay flow

created an interesting blend of collaboration and competition. Post-game interviews revealed that the students were able to identify the learning value from the game without confusing it with the fictional game aspects. Likewise, Castronovo et al.'s (2022) study on their single-player *Virtual Construction Simulator* game revealed that digital games can help students develop higher-order thinking processes. These processes are the type required for tackling ill-structured problems, meaning those with multiple solutions rather than one definitive answer—common particularly in CM. Thus, both studies also suggested that students do play educational digital games with insight (i.e., understanding that the game's objectives align with the intended learning objectives).

Lastly, some researchers explored using other game-based technologies that could further support students' learning with more visualisation, immersion, and interactivity. For example, Kandi et al.'s (2020) *Design Review Simulator* game was a Virtual Reality (VR) game used as an in-class active learning exercise whose game objective was to identify design mistakes in a building's design. The undergraduate class was split into two groups to compare the effects of the VR game against the traditional drawings-based design review on paper. When students correctly identified a design mistake in the game, it responded with a description of that particular mistake. Afterwards, the students that played the game performed better design reviews on paper than the other groups did. Thus, the authors concluded that VR's first-person experience and full immersion can support students' development of spatial reasoning skills.

Below, Table 2 summarises the key characteristics of the digital games discussed in this section. As most studies involved single-player games, this paper argues that digital games would appeal to both beginners and veterans of CM in educational settings as independent learning spaces. This is because single-player digital games provide immediate and personalised feedback that identifies each student's strengths and weaknesses (Kandi et al., 2020). In addition, it is also the most suitable mode for modelling information-intensive disciplines like project management (Fumarola, van Staalduinen, & Verbraeck, 2012). Finally, digital games are most effective for introducing new concepts to students with little to no background on the subject due to their visual, interactive, experimental, and adaptive capabilities. Regarding limitations, making games proved to be a time-consuming process in the past. Although the 21st century saw a rise in free and dedicated software known as game engines to streamline the game development process, digital games require more resources and multidisciplinary skills than their tabletop counterparts.

Table 2*:* Description of Digital Games

Article	Game genre	Players	Subject	Learning Objectives	Data Collection	Evaluation Approach
(Castronovo et al., 2022)	Single player	UG+	Construction management	**Technical CM skills:** planning, scheduling, and executing plans, resource allocation **Transferable skill:** Problem-solving	Analysis of think-aloud statements	Learning behaviour
(Kandi et al., 2020)	Single player, Co-op	UG	Architectural building design	**Technical Architectural skills:** Reviewing building design and catching errors. **Transferable skill:** Critical thinking	Post-game test, Control vs Experiment results	Knowledge gain, Learning behaviour
(Perini et al., 2018)	Single player	G	Life-cycle assessment	**Transferable skills:** independent learning, information-gathering	Questionnaire, Pre-game/ Post-game tests	Knowledge gain, Motivation
(Miettinen et al., 2016)	Single player	E	EPCM dynamics	**Technical CM skills:** Labor resource allocation **Transferable skills:** Systems thinking, Problem-solving	Unstructured interviews	Game feedback, Knowledge gain

Article	Game genre	Players	Subject	Learning Objectives	Data Collection	Evaluation Approach
(Misfeldt, 2015)	Multiplayer, VS	E	Construction management	**Technical CM skills:** project planning and control, addressing site issues **Transferable skills:** Problem-solving, decision-making	Post-game semi-structured interviews	Game feedback
(Dib & Adamo-Villani, 2014)	Single player	UG	Sustainable building design principles	**Transferable skills**: problem-solving, decision-making	Questionnaire, Pre-game/ Post-game tests, Unstructured interviews	Knowledge gain, Motivation

2.3 Computer-Assisted Games

A computer-assisted game combines features from digital games and tabletop games. It allows for greater complexity than traditional tabletop games and uses software more familiar to the workplace such as Microsoft Excel. For example, Pereira and Thom's (2022) simulation game tasked students with allocating resources for a road project and responding to random risks that triggered throughout the project duration. The game ran on Microsoft Excel with a Macro controlling the game based on the students' input. The project's success was defined by the duration and cost performance, which were directly influenced by the students' decisions. In general, the experience was met with positive feedback from the students, saying that the immersive experience helped contextualise key concepts in scheduling, planning, and control. However, using data management software alone risks being less engaging if not supported with some kind of audio-visual feedback. As such, the authors mentioned that they would look into developing a graphical user interface to improve the game's immersion, usability, and feedback system.

As in tabletop games, communication is key in computer-assisted games. As such, this paper suggests that computer-assisted games are more effective for multiplayer games, due to focusing on the role-playing aspect of simulation games. Role-playing is where players are assigned roles and sometimes unique responsibilities, working together towards a common goal (Hassan, Haghighi-Rad, & Abtahi, 2021). One example is evidenced by Dallasega et al.'s (2020), who studied the use of new technological tools to enhance graduate students' understanding of Lean Construction Management. The game assigned different roles to the students— construction manager, assistant, data collectors, and subcontractors— in a collaborative game setting. In this study, the students were given virtual and augmented reality devices during one of the rounds to compare their work efficiency with and without them. As a result, the students gave generally positive feedback regarding the game exercise, reporting improved clarity and confidence in the subject material.

A similar case was presented in Hassan, Haghighi-Rad, and Abtahi et al.'s (2021) collaborative simulation game called the *Construction Project Management Simulation (CPMS)* game, consisting of a board game and a Microsoft Excel interface. In this study, the premise of the game was that a team of decision-makers—project owner, executive engineer, and supervisor engineer—must manage the four phases of a residential building project. In addition, they were presented with opportunities and threats at each stage, and their decisions affect the outcome of the project. Although computer-assisted games are excellent tools for engaging big groups of students, they do carry some limitations. As with tabletop games, it is recommended that students possess some familiarity with the subject material before initiating the game. In this way, students' focus leans towards applying their theoretical understanding and exercising their decision-making and problem-solving skills (Hassan, Haghighi-Rad, & Abtahi, 2021). The same authors also asserted that feedback during and after the game session is a pivotal element of effective learning, corresponding to the reflection stage of the ELT learning cycle. For a summary of the GBL studies described in this section, refer to Table 3.

Table 3: Description of Computer-Assisted Games

Article	Game genre	Players	Subject	Learning Objectives	Data Collection	Evaluation Approach
(Pereira & Thom, 2022)	Multiplayer, Co-op	UG	Highways, drainage systems, CM	**Technical CM skills:** scheduling, planning and control **Transferable skills**: Communication and Critical thinking	Unstructured interviews	Game feedback, Motivation
(Hassan, Haghighi-Rad, & Abtahi, 2021)	Multiplayer, Co-op, Role-playing	G	Construction management	**Technical CM skill(s)**: Planning skills, Cost estimation, addressing site issues, resource allocation **Transferable skills:** Decision-making, problem-solving, and communication	Questionnaire, Pre-game/ Post-game tests	Knowledge gain, Game feedback
(Dallasega et al., 2020)	Multiplayer, Co-op, Role-playing	G	Lean Construction	**Transferable skills**: communication and coordination with others	Unstructured Interviews	Game feedback

In some cases, game sessions can be long, often needing more than one sitting to reach the end. One example of this was the simulation game designed by Loughborough University in the United Kingdom called *MERIT,* which takes place over 6 months in tandem with students' final undergraduate year (Wall & Ahmed, 2008). Moreover, these games require a moderator to monitor the students' progress throughout the game and more resources than tabletop games to develop a smooth experience. Thus, this paper argues that computer-assisted games are more suited for job training purposes, as this game mode is most effective in simulating the work environment.

2.4 A Classification Framework for GBL

This review revealed some interesting insights regarding the relationship between the choice of game mode and effective learning. Based on these findings, this paper argues that each game mode is effective for different sets of parameters. These parameters are the target audience, learning objectives, game duration, unique strengths, and limitations. The findings are summarised in a classification framework (see Figure 2), which can be used as selection criteria on a course-by-course basis or as design recommendations. For example, a theory-based course would be information-intensive, and a project-based course would depend on communication. An introductory course encourages individual skill-building while a higher-level course prepares students for the workplace environment. Although the following framework was designed in relation to construction management, further research can adapt this concept to other disciplines.

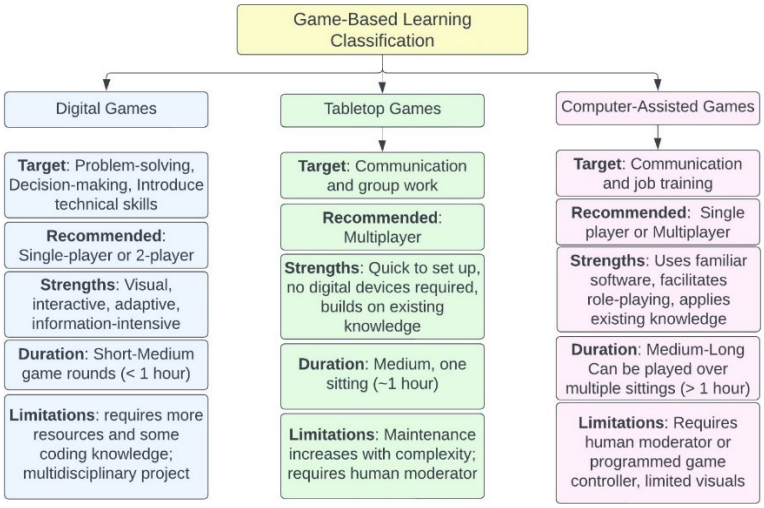

Figure 2*:* Classification Framework for GBL

Moving forward, future research will focus on developing digital games for construction management students. The reason for this choice is to capture students' interest in CM from the beginning of their higher education journey. Moreover, recent advancements in technology and accessibility improved the game development workflow for those with limited programming knowledge, which is a major boon for the research community.

3. Conclusions and Future Work

Game-based learning shows great potential in bridging the gap between guided and independent learning. In addition, integrating GBL in CM will require a collaborative effort between subject experts, educators, and end-users. Although it has gained widespread recognition across multiple disciplines, their utilisation remains limited in construction management. Thus, this paper systematically reviewed past GBL studies in CM higher education and classified them into three broad categories: Tabletop games, digital games, and computer-assisted games. Using this classification, this paper observed patterns that highlight the strengths and limitations of each category. The paper also highlighted different game evaluation methods. These findings will support future research to expand on the ranges of topics covered under CM. In addition, further assessment of students' learning behaviour and the pedagogical differences between traditional and GBL-supported teaching methods will be investigated using qualitative and quantitative analysis. Another promising research area would be exploring the use of mixed reality technologies.

References

Castronovo, F., Stepanik, N., Van Meter, P. N., & Messner, J. I. (2022). Problem-solving processes in an educational construction simulation game. *Advanced Engineering Informatics*, *52*.

Dallasega, P., Revolti, A., Sauer, P. C., Schulze, F., & Rauch, E. (2020). BIM, Augmented and Virtual Reality empowering Lean Construction Management: a project simulation game. *Procedia Manufacturing*, *45*, 49–54.

Dancz, C. L. A., Parrish, K., Bilec, M. M., & Landis, A. E. (2017). Assessment of Students' Mastery of Construction Management and Engineering Concepts through Board Game Design. *Journal of Professional Issues in Engineering Education and Practice*, *143*(4).

Dib, H., & Adamo-Villani, N. (2014). Serious Sustainability Challenge Game to Promote Teaching and Learning of Building Sustainability. *Journal of Computing in Civil Engineering*, *28*(5).

Fumarola, M., van Staalduinen, J.-P., & Verbraeck, A. (2012). A Ten-Step Design Method for Simulation Games in Logistics Management. *Journal of Computing and Information Science in Engineering*, *12*(1).

González, V. A., Orozco, F., Senior, B., Ingle, J., Forcael, E., & Alarcón, L. F. (2015). LEBSCO: Lean-Based Simulation Game for Construction Management Classrooms. *Journal of Professional Issues in Engineering Education and Practice*, *141*(4).

Hassan, A. F., Haghighi-Rad, F., & Abtahi, A.-R. (2021). Enabling construction project managers through a management game. *Industrial and Commercial Training*, *53*(4), 343–365.

Herrera, R. F., Sanz, M. A., Montalbán-Domingo, L., García-Segura, T., & Pellicer, E. (2019). Impact of Game-Based Learning on Understanding Lean Construction Principles. *Sustainability*, *11*(19).

Kandi, V. R., Castronovo, F., Brittle, P., Mastrolembo Ventura, S., & Nikolic, D. (2020). Assessing the Impact of a Construction Virtual Reality Game on Design Review Skills of Construction Students. *Journal of Architectural Engineering*, *26*(4).

Kolb, A. Y., & Kolb, D. A. (2017). *Experiential Learning Theory as a Guide for Experiential Educators in Higher Education*.

Kriz, W. C. (2017). Historical Roots and New Fruits of Gaming and Simulation. *Simulation & Gaming*, *48*(5), 583–587.

Lee, Y. Y. R., Samad, H., & Miang Goh, Y. (2020). Perceived Importance of Authentic Learning Factors in Designing Construction Safety Simulation Game-Based Assignment: Random Forest Approach. *Journal of Construction Engineering and Management*, *146*(3).

Miettinen, T., Salmi, J., Gupta, K., Koskela, J., Kauttio, J., Karhela, T., & Ruutu, S. (2016). Applying Modelica Tools to System Dynamics Based Learning Games: Project Management Game. *Modelling and Simulation in Engineering*, *2016*, 1–13.

Misfeldt, M. (2015). Scenario Based Education as a Framework for Understanding Students Engagement and Learning in a Project Management Simulation Game. *Electronic Journal of E-Learning*, *13*(3), 181–191. https://www.proquest.com/docview/1697743389/fulltext/AF7F016DFE1343C1PQ/1?accountid=16946

Ojiako, U., Ashleigh, M., Chipulu, M., & Maguire, S. (2011). Learning and teaching challenges in project management. *International Journal of Project Management*, *29*(3), 268–278.

Oo, B. L., & Lim, B. T.-H. (2016). Game-based learning in construction management courses: a case of bidding game. *Engineering, Construction and Architectural Management*, *23*(1), 4–19.

Pereira, E., & Thom, N. (2022). Teaching Construction Project Planning and Control Using a Management Game Approach. In *Lecture Notes in Civil Engineering*, Vol. 247, pp. 59–69. Springer.

Perini, S., Luglietti, R., Margoudi, M., Oliveira, M., & Taisch, M. (2018). Learning and motivational effects of digital game-based learning (DGBL) for manufacturing education –The Life Cycle Assessment (LCA) game. *Computers in Industry*, *102*, 40–49.

Wall, J., & Ahmed, V. (2008). Use of a simulation game in delivering blended lifelong learning in the construction industry – Opportunities and Challenges. *Computers & Education*, *50*(4), 1383–1393