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Toward Sustainable Digital Literacy: A Comparative Study of Gamified and Non-Gamified Digital Board Games in Higher Education

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Abstract

This study examines the effects of gamified and non-gamified digital board games on students' digital literacy and engagement. A total of 98 undergraduate students (n = 98) were randomly assigned to one of two conditions: gamified or non-gamified. The digital board game, designed to simulate real-world digital literacy scenarios, was implemented in a classroom setting. Students' digital literacy performance was assessed through pre- and post-tests, and their engagement was measured using the Game Engagement Questionnaire. The results revealed that students in the gamified condition significantly outperformed those in the non-gamified condition in digital literacy post-test scores (p = 0.039). Additionally, the gamified group showed significantly higher engagement scores in flow (p = 0.039), enjoyment (p = 0.033), immersion (p = 0.042), and social interaction (p = 0.030). These findings highlight the effectiveness of gamified learning environments in enhancing digital literacy skills and multidimensional engagement.

Keywords: digital literacy; gamification; digital board games; educational technology; student engagement; knowledge acquisition

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1. Introduction

Digital literacy has become a critical competency for students navigating today's information-rich and technology-driven world. It encompasses a range of skills, including evaluating online content, producing and sharing digital information ethically, and engaging safely in digital communication (Churchill, 2020; Tomczyk, 2020). However, research suggests that many university students still lack adequate digital literacy, particularly in areas such as information credibility assessment and online safety (Hunter, 2018). Traditional lecture-based teaching often fails to equip students with these practical skills, as it tends to emphasize theoretical knowledge while offering limited opportunities for active learning and critical application (Chan, 2004). This gap has prompted educators to explore alternative, more engaging instructional strategies to support digital skill development.

One promising approach is gamification, which involves incorporating game elements—such as points, challenges, leaderboards, and avatars—into educational contexts to enhance motivation, engagement, and learning outcomes (Kapp, 2012; Sanchez et al., 2020).

Gamification supports learners' autonomy, competence, and social interaction, making it particularly suitable for student-centered learning environments (Deci & Ryan, 2000). In recent years, digital board games have emerged as effective platforms for applying gamified principles. When educational content is embedded into gameplay, learners are more likely to engage with material deeply and apply it in realistic scenarios (Lin et al., 2021). Research has shown that gamified digital learning tools can significantly improve attention, participation, and knowledge retention (Lee et al., 2021; Pozzi et al., 2024), yet few studies have examined their impact specifically on digital literacy education.

This study addresses that gap by exploring how gamified digital board games can enhance university students' digital literacy skills in a classroom setting. It investigates the effect of game-based learning on knowledge acquisition, engagement, and behavioral outcomes, focusing on core competencies such as information evaluation and online safety. By integrating educational content with interactive game mechanics, this research aims to demonstrate how gamification can transform passive learning environments into dynamic spaces that promote critical digital skills. The findings contribute both theoretical insights and practical guidance for educators and instructional designers seeking to develop effective, engaging digital literacy interventions.

2. Related Works

2.1. Digital Literacy

The rapid advancement of Information and Communications Technology (ICT) significantly influences the education system. Emerging technologies demand digital literacy skills for effective information, communication, and collaboration among the 21st century workforce. These skills encompass the ability to acquire, process, assess, produce, and communicate information effectively (Radovanović et al., 2015). It is generally believed that digital literacy is fundamental for securing employment in the contemporary age. Consequently, universities must implement strategies to foster and evaluate students' digital literacy skills, ensuring they acquire the competencies sought after by employers in Industry 4.0 (Karakose et al., 2021). Given the current circumstances and the potential of ICT in education, there is an increasing urgency to enhance digital literacy within schools. Various factors, such as students' socio-economic background, the type of school they attend, the availability of digital infrastructure, and teachers' confidence in their own digital abilities, all play pivotal roles in the attempt to upraise digital literacy (Kim et al., 2021). Within the school setting, as observed by Lindstrom and Niederhauser (2016), digital literacy is associated with the utilization of devices and services on digital platforms and online platforms, integrated into both learning and teaching endeavors (Lindstrom & Niederhauser, 2016). The essence of digital literacy primarily lies in the technical proficiency required to navigate forms of hardware such as interactive boards, computers, tablets, and smartphones, which serve as educational tools (Lamanauskas, 2017). While the technical aspects of digital literacy undoubtedly hold significant importance, it is crucial to recognize the equally relevant social dimensions (Al-Qallaf & Al-Mutairi, 2016).

Thus, digital literacy is conceptualized holistically as encompassing both technical skills and social awareness. The ability of students to critically evaluate online content, access digital platforms, and follow safe digital behaviors is the operational definition of digital literacy for this study. This study highlights the broader cognitive and social aspects of digital literacy, such as information evaluation and knowledge of online safety, even while technical competency with technology (such as computers, tablets, and smartphones) is also crucial (Mendoza, 2018; Tomczyk, 2020). Three key competencies define digital literacy: (1) formal operational skills, which include finding and identifying relevant data; (2) information evaluation skills, which include determining the reliability of digital content;

and (3) knowledge production and sharing, which includes producing and effectively disseminating digital content (Alt & Raichel, 2020; Hunter, 2018). In the realm of ICT, including tablets, young individuals are involved in various activities, such as gaming, reading, listening, and content management, which can enhance their digital literacy (Aarsand, 2019). Tablets provide an engaging way to engage in these activities, fostering competence growth in a positive technological environment. With intuitive designs and a range of devices, software, and online applications, educational settings provide diverse formats for content creation (Andersson & Sofkova-Hashemi, 2016). Technological devices hold significant potential as resources for educational programs, particularly if designed with gamification principles, potentially leading to greater success, especially among young learners. As digital literacy plays a crucial role in education, integrating engaging methodologies like gamification can further enhance learning outcomes.

2.2. Gamification for Education

Gamification is increasingly recognized as a transformative approach in education, leveraging game elements such as points, rewards, leaderboards, and real-time feedback to enhance student motivation and engagement (Kapp, 2012). While behaviorist theories emphasize positive reinforcement through feedback and rewards (Bíró, 2014), Self-Determination Theory (SDT) provides a more in-depth understanding of motivation. According to SDT, human motivation is driven by three fundamental needs: autonomy, competence, and relatedness (Deci & Ryan, 2000). Gamification supports these needs by allowing learners control over their learning paths (autonomy), presenting challenging yet achievable goals (competence), and fostering collaboration through multiplayer dynamics (relatedness) (Duran et al., 2024). Recent studies highlight that gamification strategies incorporating adaptive learning, artificial intelligence, and augmented reality are particularly effective in increasing intrinsic motivation and cognitive engagement in higher education (Wannapiroon & Pimdee, 2022). Additionally, research suggests that gamification enhances cognitive effectiveness and efficiency in digital game-based learning, particularly when scaffolds are integrated to regulate learners' emotions and cognitive processing (Chang & Yang, 2024).

Empirical research confirms gamification's effectiveness across multiple disciplines. Bovermann and Bastiaens (2018) demonstrated that leaderboards and rewards in distance learning significantly increased student engagement. Denny et al. (2018) found that badges in online learning platforms improved goal-setting behaviors and led to a 23% increase in exam performance among highly engaged learners. Huang et al. (2019) showed that gamification in flipped classrooms enhanced content mastery and sustained participation, particularly when digital badges and real-time feedback were included. Recent studies further emphasize that gamification techniques using active learning models can enhance STEM education by fostering creativity, problem-solving skills, and self-directed learning (Duran et al., 2024). Additionally, research by Jansukpum et al. (2024) suggests that immersive virtual reality gamification combined with learning analytics significantly improves knowledge retention and engagement in professional and formal education contexts.

While gamification is widely recognized for enhancing engagement and motivation, recent research has also highlighted its potential downsides. Yang and Li (2021) identified that competitive and interactive elements in gamification can lead to privacy invasion, social overload, and ultimately gamification exhaustion, especially in contexts involving continuous participation. Similarly, Kwon and Özpolat (2020) found that assessment-driven gamification can negatively impact student performance by increasing anxiety and narrowing the learning experience to reward-based outcomes. Liu et al. (2023) further emphasized that excessive focus on competition may lead to technostress, burnout, and

reduced autonomy, particularly when gamified environments fail to match individual learning preferences. These findings underscore that while gamification can enhance educational experiences, it must be implemented thoughtfully to avoid unintended psychological strain.

2.3. Digital Board Game

The rise of digital technology and mobile devices has significantly increased the accessibility of and engagement with digital board games, making them valuable tools in modern education (Pozzi et al., 2024). These games combine interactive digital elements with traditional board game mechanics, enhancing student motivation and learning experiences (Agca & Özdemir, 2013). Digital board games have been shown to positively influence students' attitudes toward learning, improve academic performance, and enhance cognitive engagement (Wu & Su, 2025). The incorporation of structured challenges, strategic problem-solving, and interactive feedback in these games fosters critical thinking, peer collaboration, and self-regulated learning (Premthaisong & Srisawasdi, 2020).

Digital board games integrate physical and virtual components such as cards, dice, and player avatars, offering a multisensory learning experience that caters to diverse learning styles (Boghian et al., 2019). These games provide scaffolding mechanisms to help students understand abstract concepts and apply knowledge in practical contexts. Recent research underscores the importance of integrating digital board games with educational strategies to optimize learning outcomes in STEM and computational thinking education (Wu & Su, 2025). Additionally, digital board games support game-based learning models in sustainability education, demonstrating their potential to develop interdisciplinary skills and long-term knowledge retention (Llanos-Ruiz et al., 2024). New studies highlight how crucial it is to combine educational techniques with digital board games in order to optimize learning results (Chiotaki et al., 2023). Table 1 includes an overview of the educational board game approach.

Table 1. An overview of the educational board game approach.

Year	Board Game Name	Objective	Gamification Application	Summary
Zheng et al. (2018)	The Organ Savior Game	To teach elementary school students about health and physical education	No	This study showed that students improved their academic performance when they studied health knowledge and human internal organs (Zheng et al., 2018).
Ali et al. (2018)	N/A	To teach university students about learning the English language	No	Most of the participants considered that playing digital board games helped them develop their vocabulary. Rather than having the pupils memorize new terminology, they might explore it by playing a digital board game (Ali et al., 2018).
Da Silva Júnior et al. (2021)	Reactions	To educate students about organic reactions	No	This form of game would be a useful teaching aid for helping students understand chemical responses in greater detail (Da Silva Júnior et al., 2021).

Table 1. *Cont.*

Year	Board Game Name	Objective	Gamification Application	Summary
Tsai et al. (2021)	Be Blessed Taiwan	To educate high school students about sustainable development	No	There was a significant improvement in students' scores, particularly in biodiversity and biological conservation concepts. The results highlighted the difficulty students faced in achieving all four ESD goals through gameplay (Tsai et al., 2021).
Parekh et al. (2021)	Pollutaplop	To engage young people in understanding environmental issues	No	Creating board games in authentic contexts helped youths develop models and systems thinking. Enthusiastic gamers, including youths, may be particularly well-suited to grasping the complexities of both games and their real-world contexts (Parekh et al., 2021).
Li et al. (2022)	Chemistry	To enhance students' understanding of how elements combine to form chemical compounds	No	Playing the game improved students' grasp of element combination concepts. Students showed high engagement with and acceptance of the game, particularly when it featured components made from different materials (Li et al., 2022).
Cardinot and Fairfield (2019)	N/A	To support the teaching and learning of astronomical themes from the new Irish Science Syllabus	No	The outcomes demonstrated how much the game enhanced students' attitudes toward scientists and their comprehension of astronomy subjects. The game was shown to be a useful teaching tool and a way to improve social skills (Cardinot & Fairfield, 2019).
Vita-Barrull et al. (2022)	N/A	To educate high school students in the chemical course	Yes	Students in the gamified learning activity outperformed those in the lecture-based teaching approach regarding the achievement of learning objectives (Vita-Barrull et al., 2022).
Vita-Barrull et al. (2022)	N/A	To assess how gamification affects the executive function behaviors of students who are prone to social exclusion	Yes	The outcomes showed a major decrease in behavioral difficulties related to executive functions between pre-intervention and post-intervention. The non-gamified group mostly accounted for the observed decrease (Vita-Barrull et al., 2022).

Table 1. *Cont.*

Year	Board Game Name	Objective	Gamification Application	Summary
Arboleya-García and Miralles (2022)	The Game of the Sea	To educate primary and secondary students on the fundamentals of marine ecology	Yes	Children and adults' awareness of the marine environment improved, with young people showing a slightly greater improvement and the game teaching its players how valuable the marine environment is and the significance of conserving it (Arboleya-García & Miralles, 2022).
Yusa and Hamada (2023)	N/A	To teach and learn about the optimal mix of national power sources on energy and sustainability courses in higher education	No	Students expressed great enjoyment of the game and confirmed its potential as a useful tool for energy and environmental studies in high schools and colleges, according to a post-game survey (Yusa & Hamada, 2023).

Despite a growing body of research on gamification and digital learning, many studies have focused on standard video games or generic learning apps, with limited attention to gamified digital board games as structured tools for enhancing digital literacy. Moreover, prior research often lacks clear comparisons between gamified and non-gamified versions using controlled experimental designs. Few studies have simultaneously assessed both cognitive outcomes and affective engagement using validated instruments. To address these gaps, this study introduces a classroom-based digital board game with and without gamification elements, and employs both pre/post testing and the Game Engagement Questionnaire to examine learning and engagement outcomes. This dual focus provides a more comprehensive understanding of the effectiveness of gamified learning environments in digital literacy education.

2.4. Conceptual Model

This study adopts a conceptual model grounded in SDT to explain how gamification influences psychological outcomes and, consequently, digital literacy learning (see Figure 1). The model integrates three core domains: Game Design, Psychological Outcomes, and Learning. In the Game Design domain, the digital board game is structured around digital literacy content, particularly the CRAAP test (Currency, Relevance, Authority, Accuracy, and Purpose) and incorporates key game elements such as progression, randomness, rewards, and challenges. These elements function as motivational design strategies aligned with SDT principles. According to SDT, learning environments that support autonomy, competence, and relatedness enhance intrinsic motivation. The Psychological Outcome domain reflects this mechanism by proposing that the gamified board game fosters these three psychological needs through interactive and immersive experiences. These psychological states are, in turn, hypothesized to enhance learner motivation and engagement, which mediate the effects on educational outcomes. The Learning domain encompasses two essential indicators of digital literacy development: information access and the ethical use of sources. These competencies are aligned with the CRAAP test framework embedded in the game content and are critical for effective participation in the digital age.

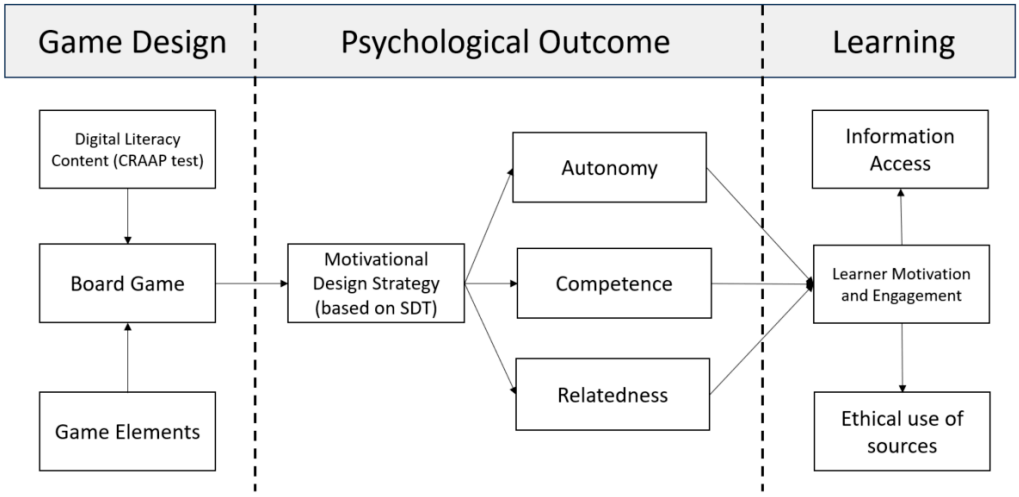


Figure 1. Conceptual model linking gamified board game design, motivational outcomes (based on SDT), and digital literacy learning outcomes.

3. Objective of Study

The primary aim of this research is to explore the design and effectiveness of a digital board game in enhancing digital literacy skills among university students within a classroom setting. This study specifically investigates the incorporation of gamification elements into the game's design and assesses their impact on knowledge acquisition (Sureephong et al., 2024; Taspinar et al., 2016), engagement (Lee et al., 2021), and behavioral outcomes (Epstein et al., 2021). This investigation is grounded in SDT (Deci & Ryan, 2000), which posits that intrinsic motivation arises when learners experience autonomy, competence, and relatedness. In the context of gamification, digital game features such as avatars, leaderboards, and interactive gameplay are designed to fulfill these psychological needs. This theoretical lens guides the formulation of our research questions and hypotheses, which are as follows:

- RQ1: How does the implementation of a digital board game affect knowledge acquisition in digital literacy among students in gamified versus non-gamified learning environments?
- RQ2: What are the differences in game engagement between students interacting with the gamified and non-gamified versions of the digital board game?
- RQ3: What behavioral outcomes emerge from the use of a gamified digital board game compared to a non-gamified version, and how do these outcomes reflect digital literacy learning?

These research questions are designed to shed light on the efficacy of digital board games with gamification for digital literacy education. RQ1 assesses whether gamification enhances knowledge acquisition, a key factor in determining the educational value of game elements. RQ2 explores the impact of gamification on student engagement, which is vital for evaluating whether game-like features effectively boost learner motivation and participation. RQ3 examines the behavioral effects of gamified learning, including motivation improvement and skill application, offering insights into gamification's wider implications for student learning behaviors and attitudes towards digital literacy. Together, these questions provide a comprehensive framework for evaluating the pedagogical potential of gamified learning tools, potentially guiding the creation of more effective digital literacy curricula.

- H1: Students using the gamified version of the digital board game will exhibit significantly higher levels of digital literacy knowledge acquisition than those using the non-gamified version, demonstrating the effectiveness of gamification in learning.

- H2: Engagement levels, as measured by the Game Engagement Questionnaire (GEQ), will be significantly higher in the experimental group (gamified) compared to the control group (non-gamified), indicating the motivational impact of gamification elements.
- H3: Behavioral outcomes, including increased motivation, persistence, and application of digital literacy skills, will be more pronounced in students interacting with the gamified digital board game, highlighting the behavioral benefits of gamification in educational contexts.

The formulated research questions and hypotheses are pivotal for understanding the multifaceted impact of gamification in educational digital games. By focusing on knowledge acquisition, engagement, and behavioral outcomes, this study aims to provide insights into how digital games can be effectively designed and implemented to enhance learning experiences. The comparison between gamified and non-gamified learning environments will contribute to educational technology by identifying key elements that foster an engaging and effective learning atmosphere. Moreover, understanding the behavioral outcomes will offer valuable information on the broader implications of gamification in education, potentially guiding future design and implementation strategies for digital learning tools.

4. Research Methodology

This study adopted a quasi-experimental design (Maciejewski, 2018) to assess the impact of gamification design elements on the utility of a digital board game as an educational tool for enhancing digital literacy among university students. Participants were divided into two groups for this comparison: a control group and an experimental group. The control group engaged with a non-gamified version of the digital board game, which lacked any gamification features, thereby serving as a baseline for the study. In contrast, the experimental group used a gamified version of the board game, which included various gamification elements such as avatars, leaderboards, badges, and points. These gamification elements were strategically integrated with the aim of boosting motivation, engagement, and the overall educational efficacy of the digital literacy tool.

4.1. Sample of Participants

This study sampled 98 undergraduate students from Chiang Mai University, all of whom were enrolled in either of two sections of the course "Information Literacy and Information Presentation." This course is typically taken by 500–1000 students annually from various academic disciplines. To ensure a homogeneous baseline of knowledge in information literacy, these particular sections were selected for the study. Participants were allocated into two groups. The Gamified Group comprised 50 students (21 males and 29 females), while the Non-Gamified Group consisted of 48 students (22 males and 26 females). Prior to the study's commencement, informed consent was acquired from all participants. The consent form elaborated on the study's objectives, procedures, and potential risks, and the confidentiality of the data collected.

4.2. Instruments

4.2.1. Game Engagement Questionnaire

The Game Engagement Questionnaire was used to assess participants' engagement levels across four dimensions: immersion, flow, social interaction, and enjoyment. Originally designed for video games, the GEQ has demonstrated strong construct validity and internal consistency. Brockmyer et al. (2009) established its validity by correlating GEQ scores with behavioral and self-report indicators of game engagement, including measures of presence and flow. The interactive and immersive nature of the digital board game used in this study—featuring real-time interaction, competitive dynamics, and structured

gameplay—makes it an appropriate context for applying the GEQ. The overall reliability of the instrument in this study, measured using Cronbach's alpha, was $\alpha = 0.87$. The questionnaire consisted of 12 items, with 3 items each dedicated to immersion, flow, social interaction, and enjoyment. These subscales align with prior research utilizing the GEQ to measure player engagement across a variety of gaming environments (Rebhi et al., 2023; Rashed et al., 2025).

4.2.2. Digital Literacy Assessment

To evaluate digital literacy skills among participants, both pre-test and post-test assessments were conducted, focusing on key areas such as information literacy, digital content creation, and online safety. The assessment instrument, comprising 40 short-answer questions, was developed by faculty members at Chiang Mai University and is widely used in the Information Literacy and Information Presentation course. Each question was worth one point, with scores normalized to a 40-point scale for consistency. To establish content validity, the instrument was reviewed by three subject matter experts who assessed the relevance of each item to the assessment objectives. Their evaluations were used to calculate the Item-Objective Congruence (IOC) index, yielding a value of 0.85, which indicates a high level of agreement on item relevance. After incorporating expert feedback, the instrument was pilot-tested with a group of students to ensure clarity and usability.

4.2.3. Game Analytics

Comprehensive game analytics were meticulously collected for both the Gamified and Non-Gamified groups to objectively assess player engagement and interaction with the digital board game. Key metrics monitored included session length, the number of sessions each participant played, and the average time spent per session. For participants in the Gamified group, additional metrics were recorded to delineate the impact of gamification elements more clearly. These included the frequency of interactions with gamification features such as points earned, badges obtained, and levels completed. The detailed analytics not only served as a quantifiable measure of participant engagement but also allowed for a nuanced analysis of how gamification elements influenced learning outcomes and user experience. Data for both groups were monitored through in-game tracking logs to measure player activity and engagement levels.

4.2.4. Design of Board Game for Digital Literacy

The board game titled "Spot the Fake News" is designed to enhance digital literacy by incorporating various elements that educate students on recognizing misinformation and critically understanding digital content. Inspired by the classic Monopoly game by Orbanes (2007), "Spot the Fake News" cleverly adopts a similar layout and gameplay mechanism. It features a series of pathways analogous to Monopoly's track, where each square presents specific challenges to collect points and offers an opportunity to apply the CRAAP test (Muis et al., 2022), a method for evaluating the credibility of sources. The point acquisition system uses a non-linear progression model based on three levels of task difficulty: easy tasks award 5 points, medium tasks 10 points, and hard tasks 20 points. This system encourages players to engage with more cognitively demanding content by offering higher rewards for complex digital literacy challenges. Level 1 focuses on basic digital literacy concepts, Level 2 addresses intermediate skills such as evaluating biased sources, and Level 3 involves advanced tasks, including critically assessing complex scenarios involving misinformation. Players are challenged to discern whether news is authentic or fabricated, emphasizing critical aspects of digital literacy such as identifying reliable sources, detecting biased information, and distinguishing facts from opinions. The board game design concept is shown in Figure 2.



Figure 2. The board game for digital literacy.

The overall visual design of the game employs a vibrant and appealing color palette, using warm, inviting hues such as shades of brown, orange, and teal (Figure 3). These colors not only attract attention but also create a friendly, engaging user experience (Sherin, 2012). This choice of colors is intended to reduce visual strain and foster a welcoming atmosphere that encourages prolonged engagement without overwhelming the players. Players move around the board by rolling a die, landing on various squares that present digital literacy challenges (Figure 4). These challenges are delivered through cards drawn from a deck, each designed to simulate scenarios that players might face in actual digital environments like social media platforms and online news portals. The game includes penalty and reward squares to add dynamic interactions, providing immediate feedback based on the players' decisions.



Figure 3. The Gamified Digital Board Games version includes avatars.



Figure 4. The elements of profile, leaderboard, and challenge applied in the Gamified Digital Board Games version.

The objective of the game is for players to compete to be the first to reach 2000 points. Learning outcomes are enhanced by the gameplay, which involves players rolling a die to land on "knowledge squares" located in the middle of each side of the board. These squares feature two types of cards: "Challenge Cards," which include 50 questions requiring players to identify whether news items are true or false within 15 s, with incorrect answers resulting in penalties and correct answers earning points added to or deducted from the player's score; and "CRAAP Test Cards," which are designed to teach players how to evaluate the credibility of sources using the CRAAP test, offering rewards only for correct answers, with a total of 10 such cards available. Additionally, players have the opportunity to obtain bonus cards that allow them to take strategic actions against other players if they land on the top left or right corners of the board, such as forcing a player to skip a turn or answer a question.

4.2.5. Design of Board Game for Non-Gamified and Gamified Digital Board Games

To evaluate the impact of applying gamification concepts to digital board games, we developed two versions: a non-gamified and a gamified digital board game. This approach aims to investigate knowledge acquisition, game engagement, and behavioral outcomes among students. It is influenced by several studies that applied gamification concepts to board games (Ezezika et al. (2023) and Sousa (2022) (see Figures 3 and 4, and Table 2)). Notably, the leaderboard updates in real time, allowing players to instantly see changes in their ranking as they progress. This real-time refresh mechanism is intended to enhance competitive motivation by providing immediate performance feedback, fostering a dynamic sense of competition, and encouraging sustained engagement throughout gameplay.

Additionally, badge unlocking was tied to task performance based on specific cognitive competencies. Players earned badges according to the type of skill demonstrated in each challenge: the "Source Detective" badge recognized tasks involving remembering and understanding (e.g., identifying credible sources); the "Fact Checker" badge was awarded for applying and analyzing information (e.g., comparing digital content using the CRAAP test); and the "Critical Evaluator" badge was granted for challenges requiring evaluating and creating (e.g., constructing an argument about whether an article is misleading). This multidimensional badge system reflected diverse digital literacy skills and reinforced the

educational goals embedded within the game design. Finally, both versions of the digital board game were implemented using the Unity game engine version 2021.4 and deployed on the Android 13 system on Samsung Galaxy Tab S9. The 2D graphics were developed using Adobe Photoshop CC 2020. It is important to note that both versions utilized the same content and visual assets, with the primary distinction being the incorporation of gamification elements in the gamified version.

Table 2. Game elements applied to Gamified Digital Board Games.

Game Elements	Definition	Description in Board Game	Learning Objective	Gamified	Non-Gamified
Board progression	A structured path that guides player movement and task sequencing (Oliveira et al., 2023).	A standard board game mechanic using a path-based layout, where each move advances the player to a specific task square.	Enhances competence by allowing learners to see progress and complete tasks in stages.	Yes	Yes
Randomness	Unpredictable outcomes introduced via dice rolls or randomized card draws (Demirel & Alanyalı Aral, 2025).	A standard mechanic in board games, introducing variability and simulating real-world unpredictability in digital decision-making.	Stimulates curiosity and situational engagement, helping students manage decision-making under uncertainty.	Yes	Yes
Leaderboard	A visual display of players' rankings based on their performance (Oliveira et al., 2023).	Real-time rankings and scores, motivating players to strive for higher positions and enabling competition among groups.	Promotes extrinsic motivation, competence, and social comparison, potentially increasing persistence and goal striving.	Yes	No
Avatar	A graphical representation that a player can customize to represent themselves in the game (Oliveira et al., 2023).	Players can choose and customize avatars, personalizing their gaming experience and expressing their identity.	Fosters autonomy and self-expression, enhancing emotional connection and intrinsic motivation.	Yes	No
Challenges	Specific tasks or objectives given to players to accomplish within the game (Khaldi et al., 2023).	Challenges are embedded throughout the game, requiring players to solve problems or complete tasks.	Supports competence and increases engagement through meaningful challenge.	Yes	No
Profiles	User-specific pages that track individual gaming history, preferences, and achievements (Krath et al., 2021).	Each player has a profile where their achievements and preferences are stored, enabling a tailored experience and facilitating progress tracking.	Supports relatedness and self-reflection, helping learners feel connected to the game and reinforcing ownership of learning.	Yes	No

4.2.6. Research Procedure

This study was executed in four distinct phases, as illustrated in Figure 5, designed to assess the effects of gamification on knowledge acquisition using a digital board game.

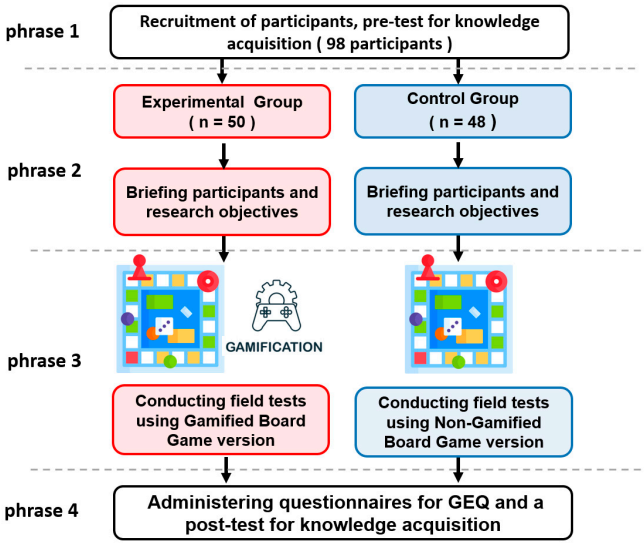


Figure 5. The research methodology.

Phase 1: Participant Recruitment and Pre-Testing. Initially, 98 participants were recruited for the study from two sections of the "Information Literacy and Information Presentation" course at Chiang Mai University. To assess participants' baseline knowledge of digital literacy, a pre-test was administered. This preliminary step was crucial to ensure that any improvement in knowledge could be confidently attributed to the experimental intervention, rather than to pre-existing differences in understanding.

Participants were then randomly assigned to either the gamified or non-gamified condition using a simple randomization process based on a randomized student ID list. Blinding of participants was not possible due to the visible differences between game versions. However, students were not informed of the study's hypotheses or which condition was expected to yield better outcomes, minimizing potential expectation bias. The gamified board game group (n = 50) engaged with a version of the digital board game augmented with gamification elements such as avatars, leaderboards, badges, and points. Conversely, the non-gamified board game group (n = 48) used a version of the board game that was stripped of these features. This clear delineation between the two groups was pivotal to the investigation of gamification's role in enhancing learning outcomes.

Phase 2: Briefing. During the second phase of the study, participants in both groups received a comprehensive briefing on the research objectives and the procedures involved. This briefing was crucial to ensure informed participation, as it clarified the aims of the study, the expectations set for participants, and the specific characteristics of the digital board game they would be engaging with. Furthermore, the research team prepared 20 tablets for each group to facilitate the gameplay. Participants were afforded the flexibility to form pairs within their respective classes for the purpose of collaborative play. This approach not only simulated a natural learning environment but also allowed the investigation of potential social dynamics arising from pair interactions during the gameplay.

Phase 3: Field Testing, conducted as the study's third phase, allowed participants to interact with either the gamified or non-gamified version of the digital board game within a controlled setting, as shown in Figure 6. The gamified group used a version of the game enhanced with gamification features points, badges, and leaderboards designed to increase

engagement and motivation. Conversely, the non-gamified group interacted with a version that, while lacking these gamification elements, contained the same educational content focused on digital literacy. Significantly, participants were encouraged to freely engage in pair-play with other participants during each round to foster social interaction and augment the interactive experience. The gameplay sessions were allocated a three-hour window from 13:00 to 16:00. Throughout this period, extensive game analytics were collected, providing insights into key metrics such as session lengths, score points, and the number of rounds played. These analytics are crucial for objectively assessing participant engagement and determining the game's effectiveness in enhancing the learning process.



Figure 6. Field testing of non-gamified board (**left**) and gamified board group (**right**).

Phase 4: Post-testing and Questionnaire Administration. Upon the conclusion of the field testing, a post-test was administered to all participants to evaluate the knowledge acquired through interaction with either the gamified or non-gamified version of the digital board game. The assessment aimed to determine the effectiveness of each game version in facilitating digital literacy skill development. Simultaneously, participants were directed to complete the Game Engagement Questionnaire, delivered via a digital Google form accessible on their mobile phones. The GEQ was designed to measure the participants' engagement levels, providing insight into their subjective gaming experience. This instrument played a crucial role in drawing connections between game engagement, in both the gamified and non-gamified scenarios, and the educational outcomes of the digital literacy game. Participants were allocated approximately 30 min to complete this phase of the study.

5. Results and Data Analysis

5.1. Results of Digital Literacy Assessment

This study evaluated the impact of gamification on the acquisition of digital literacy skills among university students by comparing outcomes from a control group, using a non-gamified version of a digital board game, to those from an experimental group, engaging with a gamified version, as illustrated in Figure 7 and detailed in Table 3. Initial evaluations showed comparable baseline digital literacy knowledge between the control group (n = 48; 22 males, 26 females) and the experimental group (n = 50; 21 males, 29 females), with mean pre-test scores of 9.60 (SD = 3.11) and 9.56 (SD = 3.16), respectively. Following the intervention, both groups demonstrated improvements in digital literacy skills, with the experimental group showing a more significant enhancement. The post-test scores for the control group averaged 21.45 (SD = 6.34), compared to 24.42 (SD = 7.40) in the experimental group. The mean increase from pre-test to post-test was 11.85 (SD = 5.50) for the control group and 14.86 (SD = 8.35) for the experimental group. This notable difference, underscored by a p-value of 0.039 and a medium effect size (Cohen's d = 0.423), indicates a significant impact of gamification on learning outcomes. The effect size suggests that the

gamified digital board game had a moderate positive influence on students' acquisition of digital literacy skills. These results affirm that gamification elements within the digital board game markedly enhanced the acquisition of digital literacy skills, with a significance level of $p < 0.05$.

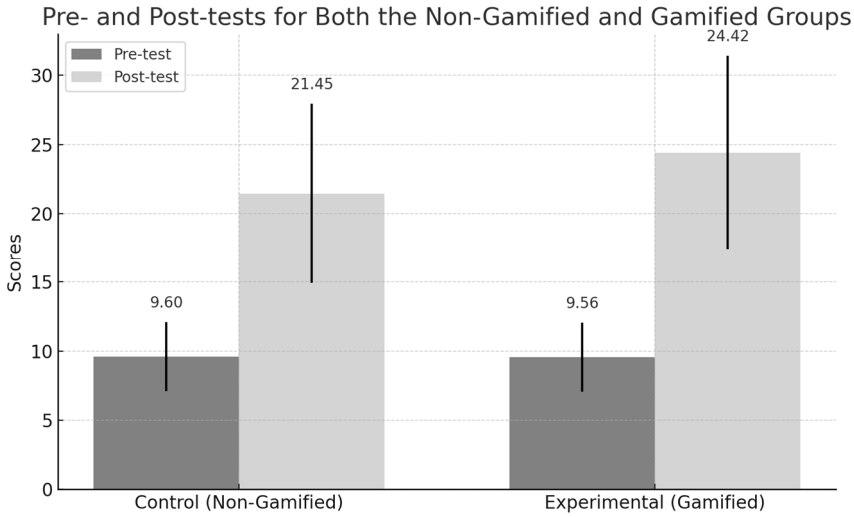


Figure 7. Results of T-tests for pre- and post-tests for both the non-gamified and gamified groups.

Table 3. Results of T-tests for pre- and post-tests for both the non-gamified and gamified groups.

Group	n	Pre-Test (*SD*)	Post-Test (*SD*)	Mean of Post-Pre (*SD*)	Mean Difference	Sig. (2-Tailed)	Cohen's *d*
Experimental Group	50 (M = 21, F = 29)	9.56 (3.16)	24.42 (7.40)	14.86 (8.35)	−3.005	0.039 *	0.423
Control Group	48 (M = 22, F = 26)	9.60 (3.11)	21.45 (6.34)	11.85 (5.50)			

Note: * $p < 0.05$.

5.2. Results of Game Engagement Questionnaire

The Game Engagement Questionnaire was administered to evaluate engagement levels across four dimensions, Immersion, Flow, Social Interaction, and Enjoyment, among participants utilizing either the gamified or non-gamified versions of a digital board game, as illustrated in Figure 8 and summarized in Table 4. The analysis indicated that participants in the experimental group, who interacted with the gamified version, reported higher levels of engagement across all measured dimensions. In particular, immersion scores were significantly higher in the experimental group, with a mean of 3.86 ($SD = 0.88$), in comparison to the control group's mean of 3.47 ($SD = 0.04$), yielding a statistically significant mean difference of −0.380 ($p = 0.042$), with a medium effect size (Cohen's $d = 0.417$). Flow experiences were also favored by the gamified version, with the experimental group achieving a mean score of 3.78 ($SD = 0.86$) against the control group's 3.35 ($SD = 1.13$), indicating a meaningful difference ($p = 0.039$), with Cohen's $d = 0.422$. Social interaction scores further demonstrated increased engagement among the experimental group, with a mean of 3.76 ($SD = 1.02$) compared to the control group's 3.31 (SD = 0.99), and a significant mean difference of −0.447 ($p = 0.030$), with Cohen's $d = 0.444$. Enjoyment mirrored this pattern, with the experimental group expressing higher enjoyment levels, evidenced by a mean of 3.86 ($SD = 0.72$) versus the control group's 3.43 ($SD = 1.16$), and a notable mean difference of −0.422 ($p = 0.033$), with Cohen's $d = 0.437$. These effect sizes indicate that the

gamified version had a moderate impact on all four engagement dimensions, reinforcing the effectiveness of gamification in educational game contexts. These outcomes highlight the beneficial impact of gamification on fostering engagement within educational digital games, supported by statistically significant enhancements across all evaluated dimensions of game engagement.

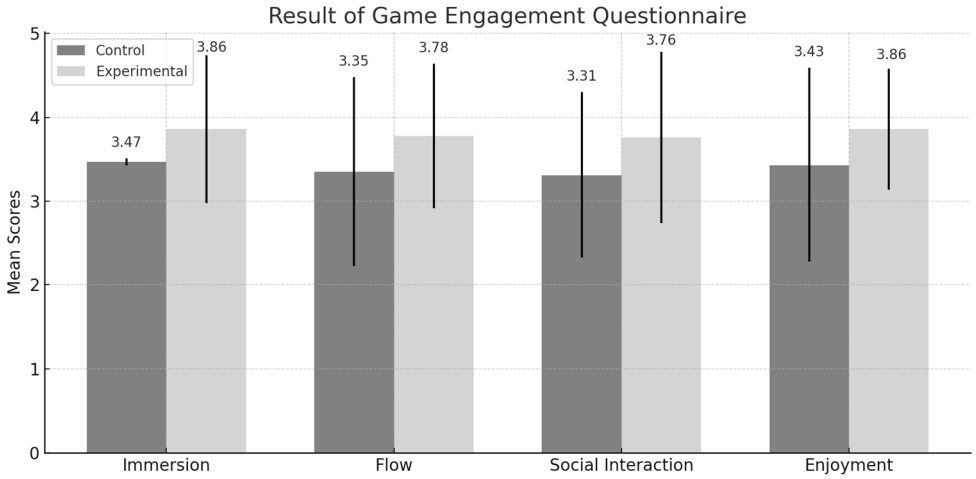


Figure 8. Result of game engagement questionnaire.

Table 4. Result of game engagement questionnaire.

GEQ Questionnaires	Group	n	Mean (SD)	Mean Difference	Sig. (2-Tailed)	Cohen's *d*
Immersion	Experimental	50	3.86 (0.88)	−0.380	0.042 *	0.417
	Control	48	3.47 (0.04)			
Flow	Experimental	50	3.78 (0.86)	−0.425	0.039 *	0.422
	Control	48	3.35 (1.13)			
Social Interaction	Experimental	50	3.76 (1.02)	−0.447	0.030 *	0.444
	Control	48	3.31 (0.99)			
Enjoyment	Experimental	50	3.86 (0.72)	−0.422	0.033 *	0.437
	Control	48	3.43 (1.16)			

Note: * $p < 0.05$.

5.3. Result of Game Analytics

The game analytics analysis underscored significant variances in player engagement and performance between the control group, which engaged with a non-gamified version of the digital board game, and the experimental group, which used a gamified version, as detailed in Table 5. Engagement levels, as evidenced by the total number of rounds played, were markedly higher in the experimental group. Participants in this group played a cumulative total of 243 rounds, averaging 4.86 rounds per player, distinctly more than the control group's total of 132 rounds, or an average of 3.20 rounds per player. This differential strongly suggests that incorporating gamification elements into the digital board game substantially increased player engagement. Moreover, the performance metrics, exemplified by the game scores, reinforce the premise that gamification positively affects outcomes. The experimental group not only engaged more with the game but also achieved superior performance, amassing a total game score of 175,948, which breaks down to an average of 3518.96 per player. In contrast, the control group accumulated a total score of 125,952, with an average score per player of 2624.00. These findings illuminate the efficacy of gamification in enhancing not only the level of interaction with the educational content but also the quality of outcomes achieved through this increased engagement.

Table 5. Results for game analytics of total rounds played and game score.

Group	n	Total Number of Rounds Played	Average Rounds Played per Player	Total Game Score	Average Game Score per Player
Experimental	50	243	4.86	175,948	3518.96
Control	48	132	3.20	125,952	2624.00

6. Discussion

6.1. Impact of Gamification on Knowledge Acquisition

The results indicate that gamified digital board games significantly enhance students' knowledge acquisition (RQ1), as measured through pre-test and post-test assessments. Students who engaged with the gamified version demonstrated a greater increase in digital literacy scores compared to those in the non-gamified condition. This improvement aligns with findings from previous studies, which suggest that interactive and immersive learning environments promote better content retention and cognitive engagement (Wu et al., 2018; Tan et al., 2022). The structured challenges within the game required students to evaluate scenarios, assess information credibility, and apply digital safety principles, thereby encouraging higher-order thinking and reinforcing knowledge application (Khaldi et al., 2023).

Among the specific game mechanics, the leaderboards may have contributed to enhanced performance by fostering a sense of achievement and competition (Amo et al., 2020; Park & Kim, 2021). Students felt more motivated to perform well when their rankings were visible to peers, which encouraged repeated attempts and greater attention to detail during gameplay. Similarly, avatars possibly supported personalization by allowing students to identify with their in-game representation. This emotional connection increased immersion and ownership of learning, particularly among students who valued self-expression. Meanwhile, challenge cards served as mini-assessments, each with a limited response time, which helped simulate real-world decision-making and sharpened students' ability to process information under pressure. The time constraints created a balance between urgency and accuracy, pushing students to apply knowledge quickly and effectively.

Informal reflections by the researchers during gameplay sessions suggest that these gamification elements may have influenced learners differently based on individual characteristics. The researchers informally noted that students with a competitive disposition seemed to respond positively to the leaderboard feature, displaying increased effort and persistence during gameplay. These students often attempted multiple rounds to improve their rankings, suggesting that visible performance metrics can serve as strong external motivators. In contrast, more reserved or less competitive students exhibited signs of discomfort or disengagement when their performance was publicly displayed. Similarly, the avatar customization feature appeared to foster deeper emotional connection and engagement for students who valued personalization, whereas others interacted with this element minimally, indicating varied relevance across learner profiles. However, not all students benefit equally from competition-based or time-constrained mechanics, and offering flexible or customizable gamification features could help ensure more inclusive and effective learning experiences.

6.2. Influence of Gamification on Engagement and Motivation

Findings from the Game Engagement Questionnaire revealed that gamified digital board games significantly improved immersion, flow, social interaction, and enjoyment (RQ2). Leaderboards, avatars, and challenge-based tasks were especially effective in sustaining engagement, reinforcing prior research suggesting that gamification can activate

both extrinsic and intrinsic forms of motivation (Lee et al., 2021; Sanchez et al., 2020). Each game element contributed uniquely to student engagement. For example, leaderboards stimulated competition by displaying real-time rankings, which prompted many students to revisit questions and attempt to outperform their peers. This visibility not only created a sense of urgency but also incentivized higher performance through social comparison (Hashim et al., 2023).

Avatars, on the other hand, played a more intrinsic motivational role by enabling students to customize their in-game identities. This personalization deepened students' emotional connection to the game, fostering a sense of ownership and commitment to their progress (Qiao et al., 2023). Several students reported that seeing their customized avatars evolve during the game created a feeling of continuity and personal growth. Challenges within the game were often timed or structured around problem-solving, which helped maintain focus and promoted what students described as a "flow state." The progressive difficulty of tasks also helped maintain an optimal balance between skill and challenge, a core principle of cognitive engagement.

Researcher observations further indicated that the effectiveness of individual gamification elements varied depending on learner characteristics. Students with competitive tendencies responded positively to the leaderboard feature, often demonstrating increased participation, persistence, and strategic gameplay. These students appeared highly motivated by real-time ranking visibility, frequently revisiting tasks in an effort to improve their standings. Conversely, students who displayed more reserved or introverted behaviors showed signs of hesitation or reduced engagement in response to public performance comparisons, suggesting that the leaderboard mechanic may have had a demotivating effect for some. Similarly, while the avatar customization feature was associated with higher emotional investment and engagement for students who actively engaged with personalization, others interacted with it minimally, indicating that its motivational impact is not universal. The challenge-based tasks were generally effective in sustaining focus, particularly among students who demonstrated strong problem-solving approaches and adaptability under pressure.

6.3. Behavioral Outcomes and Student Interaction Patterns

The game analytics revealed that students in the gamified condition played significantly more rounds, revisited content more frequently, and exhibited greater persistence compared to those in the non-gamified group (RQ3). The use of badges and progress tracking provided structured rewards that encouraged sustained participation and knowledge reinforcement (Alsawaier, 2018; Huang et al., 2019). These behavioral trends suggest that gamified digital board games promote self-regulated learning, with students becoming active participants in their own education rather than passive recipients of information. The increased interaction time and frequency of gameplay indicate that gamification is not merely an attention-grabbing tool but a mechanism that sustains long-term engagement and motivation.

Researcher observations supported these findings, with students in the gamified group demonstrating visibly higher levels of persistence, enthusiasm, and peer interaction during gameplay. Many participants revisited earlier challenges voluntarily, seeking to improve their performance or explore alternative strategies, indicating an internalized motivation to engage with the content. Notably, students were often seen discussing game strategies and sharing tips, suggesting that the gamified environment facilitated informal peer learning and collaborative problem-solving. In contrast, students in the non-gamified group were more likely to disengage after completing tasks once, with minimal interest in repetition or further exploration.

However, the observations also revealed variability in engagement levels based on prior gaming experience (Dehghanzadeh et al., 2023). Students who were familiar with digital games adapted quickly to the game mechanics, navigating the interface confidently and responding intuitively to challenges. Those with limited gaming exposure often required more time to understand the game rules, interface navigation, and reward systems, occasionally leading to initial hesitation or reliance on instructor support. This underscores the importance of providing differentiated forms of scaffolding, such as guided tutorials or adaptive gameplay settings, to ensure that all learners, regardless of gaming background, can engage equitably with gamified learning tools. While these behavioral patterns provide valuable context for interpreting the quantitative data, it is important to note that they are based on informal researcher reflections rather than systematic observational data collection. These impressions are included to support future hypotheses about learner variability in response to gamification.

6.4. Limitations

Despite its promising findings, this study has several limitations that should be considered. First, the study was conducted with undergraduate students from Chiang Mai University, which limits the generalizability of the results to other age groups, educational backgrounds, and cultural contexts. Gamification effectiveness may vary depending on students' prior gaming experience, learning preferences, and familiarity with digital tools. Future studies should include a more diverse participant pool across different institutions and educational levels to determine whether the findings hold in broader contexts. Additionally, this study primarily focused on short-term engagement and learning outcomes, leaving the long-term effects of gamification uncertain. While the results demonstrate immediate benefits, the potential for gamification fatigue, fluctuating engagement, or diminishing motivation over time remains unknown. Future research should conduct longitudinal studies to examine whether the impact of gamification persists over extended periods and influences long-term knowledge retention.

Another key limitation is individual differences in learning preferences and cognitive styles, which may have influenced the results. While some students thrive in gamified environments, others may find them distracting or demotivating. Factors such as intrinsic motivation, competitiveness, and digital literacy may mediate the effectiveness of gamification, making a one-size-fits-all approach less effective. Future research should explore adaptive gamification strategies that allow personalized learning experiences based on students' preferences and engagement levels. Furthermore, this study primarily relied on self-reported engagement measures, which can be subject to bias and subjectivity. Although the game analytics provided behavioral data, incorporating qualitative methods such as interviews and observational studies could offer deeper insights into how gamification influences student engagement and learning behaviors. Lastly, the digital literacy assessment used in this study was a self-developed questionnaire tailored to the CRAAP framework. While it ensured alignment with the game content and learning objectives, the absence of a standardized instrument limits the external validity of the findings. Future studies should consider incorporating established digital literacy measurement tools, such as those based on the Digital Competence Framework or the ICILS assessment model, to improve comparability and generalizability.

7. Conclusions

This study contributes to the growing body of research on gamification in education by providing empirical evidence that gamified digital board games can significantly enhance student engagement, knowledge acquisition, and behavioral outcomes. The in-

tegration of game elements such as leaderboards, avatars, and challenges was shown to foster more immersive and motivational learning experiences compared to non-gamified approaches. These findings reinforce the pedagogical value of gamification in digital literacy instruction for university students. In particular, this study highlights that gamified digital board games can increase learner motivation, encourage repeated interaction with learning content, and improve knowledge retention outcomes supported by pre- and post-test assessments, engagement metrics, and game analytics. The practical implications of this research are especially relevant for educators and instructional designers seeking to improve student engagement through active learning tools. By offering a structured model for applying gamification to digital literacy instruction, this study can inform the development of targeted learning resources and classroom strategies. The insights may also guide curriculum enhancements aimed at promoting critical digital skills through interactive, student-centered methodologies.

8. Research Suggestions

The exploration of digital board game design, especially focusing on gamification, has uncovered essential elements that significantly enhance their effectiveness as educational tools. The strategic inclusion of gamification features such as avatars (Zhao & McClure, 2024), badges (Ortega-Arranz et al., 2019), and leaderboards (Puritat, 2019) is crucial for boosting student engagement and facilitating knowledge acquisition. The effectiveness of specific game elements in fostering a competitive environment, highlighted by leaderboards and points, is well-supported in the academic literature (Alkurdi, 2021; Far & Taghizadeh, 2022). Furthermore, badges and avatars are celebrated for providing intrinsic motivation, making the educational journey within board games both enjoyable and fulfilling (Koivisto & Hamari, 2019). This study demonstrates that the optimal design of educational digital board games surpasses simple aesthetic appeal and rudimentary mechanics. It requires a careful combination of elements that promote active learning, motivation, and interactive engagement. Such design principles are vital for creating digital board games that not only captivate students but also substantially enhance their learning experience.

For instance, points and badges serve not merely as markers of achievement but also as incentives for students to engage more deeply with educational content. Leaderboards encourage a positive competitive atmosphere, inspiring students to surpass their achievements. Additionally, the game's design must ensure that educational content is seamlessly woven into the gameplay, making the learning process both engaging and meaningful. Based on our research and expertise, we advocate for researchers, educators, and game designers to include key gamification elements such as leaderboards, points, and avatars due to their established influence on student behavioral outcomes. Consequently, the design of digital board games for educational purposes should prioritize the integration of gamification elements that align with pedagogical goals. Future research should further investigate the effectiveness of each game element within the context of educational board games.

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Informed Consent Statement: The informed consent was obtained from all participants.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author due to restrictions. The data are not publicly available.

Conflicts of Interest: No potential conflicts of interest are reported by the authors.

Abbreviations

The following abbreviations are used in this manuscript:

GEQ	Game Engagement Questionnaire
ICT	Information and Communications Technology
SDT	Self-Determination Theory

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