Enhancing Student Engagement and Knowledge Retention Through Game-Based Learning: A Comprehensive Framework Integrating Game Design and Learning Theories

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Abstract: Game-based learning (GBL) has emerged as a transformative educational approach, using interactive game elements to enhance student engagement and knowledge retention. Although research underscores the potential of GBL, challenges persist in aligning game elements with learning theories to optimise learner engagement and knowledge retention. This study addresses this challenge by proposing a comprehensive framework that integrates game elements through the lens of established learning theories, such as Cognitive Load Theory. The framework emphasises the interplay of game elements to foster engagement and retention, offering actionable insights for educators and serious game designers. Obtaining learner engagement and knowledge retention, key recommendations from this study include embedding adaptive challenges to balance skill and difficulty and personalising feedback through serious game mechanics. The study also highlights the critical role of real-world relevance in the design of GBL. Although the framework provides a solid foundation, future research should explore long-term efficacy across diverse educational contexts, age groups, and emerging technologies such as augmented reality. By bridging theoretical rigour with practical application, this work advances GBL as a tool for fostering meaningful, adaptive, and inclusive learning experiences.

Keywords: Engagement, Knowledge retention, Game design theory, Learning theory, Player characteristics

1. Introduction

The integration of game-based learning (GBL) into educational settings has gained significant momentum in recent years as digital technologies (such as cell phones and virtual reality headsets) continue to develop, improve and become more commercially available. GBL uses the engaging and interactive nature of games to create immersive learning experiences that improve student motivation and knowledge retention (Qian & Clark, 2016). Research on GBL has shown that well-designed educational games can foster critical thinking, problem solving skills, and collaboration among learners (Plass et al., 2015). GBL also plays a pivotal role in fostering engagement and motivation and aligns the three core pathways to engaged learning: (1) encouraging active participation and collaboration among students, (2) focusing on individual student needs and learning styles, and (3) adapting to contemporary teaching methods and technologies (Sung & Hwang, 2018; Shu & Liu, 2019; Murillo-Zamorano, López Sánchez, Godoy-Caballero & Bueno Muñoz, 2021). Despite its potential, the effective implementation of GBL remains challenging due to many theories on improving player engagement and knowledge retention for serious games (Rye & Sousa,2025). The number of possible theories that currently exist seems limitless, which can become a nightmare for designers and educators, especially when they want to implement specific and relevant theories to address issues related to engagement and knowledge retention in GBL. For example, Krath *et al*. (2021) conducted a systematic review of the theories generally used for gamification, serious games, and game-based learning. The study identified 118 different theories used for research to address these aspects. The researchers categorised the theories associated with game-based learning into five different groups. These include theories on motivation and affection, learning processes, behavioural change and intervention, player engagement and social interaction, and cognitive load and learning efficiency. Krath et al. (2021) present an integrative framework for game-based learning by synthesising multiple theories that explain how games can foster educational outcomes. Their framework is organised into several thematic domains, as seen in Figure 1 hereafter.

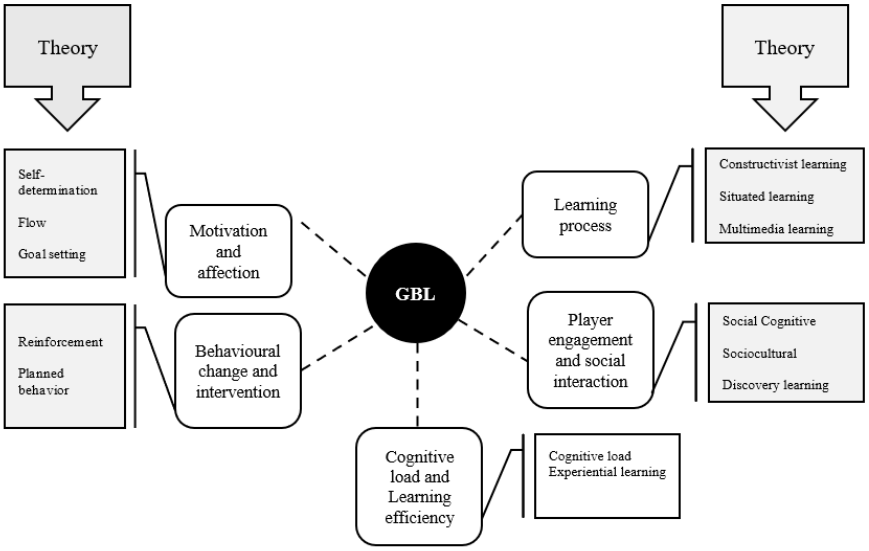

Figure 1: Theories in Learning Engagement (adapted from Krath *et al.,* 2021)

Krath *et al.* (2021) argue that these theoretical foundations provide complementary insights into the multifaceted impacts of GBL. By addressing motivational drivers, learning processes, behavioural interventions, social interactions, and cognitive efficiency, their framework offers a holistic view of how digital games can be designed to enhance educational experiences. This integrative approach is instrumental in understanding both the potential benefits and the practical challenges involved in the effective implementation of GBL in diverse educational settings. Recent research has further validated the application of these theories in GBL, demonstrating their effectiveness in fostering engagement and knowledge retention (Sailer & Homner, 2020; Nietfeld et al., 2019). Additionally, they also provide a solid foundation for understanding how learners interact with game-based environments and identify the key factors that contribute to successful learning experiences.

2. Problem Statement

Despite the growing evidence supporting the benefits of GBL, its effective implementation in educational contexts remains problematic. The rapid evolution of digital technologies has introduced a wealth of opportunities for GBL; however, the practical adoption of these strategies is hindered by the sheer number of theoretical frameworks available to guide design and evaluation. This multiplicity creates ambiguity for educators and designers who struggle to determine which specific theories are most relevant and how to integrate them cohesively into instructional practice. As a result, there is a critical need for an integrative framework that not only streamlines the application of these diverse theoretical perspectives, but also provides clear, evidence-based guidelines for enhancing learner engagement and knowledge retention in GBL environments. This research aims to address the theoretical complexity and practical challenges by evaluating and synthesising key frameworks, ultimately proposing a coherent model to inform the effective design and implementation of GBL in modern educational settings.

3. Research Questions

Based on the introduction and the identified gaps from the background, the research question is established:

RQ1: How can game-based learning frameworks, grounded in Cognitive Load, Flow, and Self-Determination Theories, be utilized in real-world scenarios to enhance engagement?

RQ2: What specific elements of game design interact with different player characteristics, theories, and environmental factors in terms of engagement and knowledge retention?

These questions directly address the challenge of navigating the extensive array of existing theories, the need for an integrated approach that aligns these theories with practical design and implementation strategies, and ultimately a goal of improving learner engagement and effectiveness within the GBL contexts.

4. Methodology

This study used a systematic literature review to investigate the intersection of game-based learning (GBL), game design, and learning outcomes such as student engagement and knowledge retention. Due to the fast paced development in game design and serious game development, this review will only focus on the latest literature published between 2020 and 2025 in order to keep the discussion on available theories and their application current. A structured search strategy was used across academic databases, primarily Google Scholar, supplemented by the AI-powered research assistant, Elicit, to improve the breadth and organisation of search results. The following keywords and combinations thereof guided the search: *"Game-Based Learning," "Student Engagement," "Knowledge Retention," "Game Design,"* and *"Learning Theories."* The review followed these steps:

1. Search and Identification

- Elicit AI generated an initial pool of 50 peer-reviewed articles by cross-referencing the above keywords and filtering for relevance to educational outcomes, theoretical foundation, and GBL application.

2. Inclusion and Exclusion Criteria

- The pool of 50 articles was reduced to include criteria: (a) were published between 2010 and 2025, (b) were Q1 and Q2 journal articles, and (c) addressed GBL in formal education contexts.
- Exclusion criteria: Articles were excluded if (a) they focused solely on entertainment games, (b) were opinion pieces or editorials, or (c) lacked methodological rigour or theoretical grounding.

3. Screening and Selection

- A final set of 10 articles most cited from the Q1 and Q2 journals was selected for in-depth analysis. See Tables 1 to 3.

4. Data Extraction and Thematic Analysis

- Key data points were extracted: publication year, context, methodology, elements of game design, learning theories, and reported results.
- A thematic synthesis approach was applied to identify recurring patterns, gaps, and theoretical alignments in the literature.

This systematic approach ensured a balanced and comprehensive review, integrating both empirical findings and theoretical perspectives relevant to game-based learning and its educational impact. Additional manual searches on Google Scholar were conducted to ensure coverage of seminal works and any studies potentially missed by automated tools (see Tables 1 through 3).

5. Literature Review

From the literature review conducted, Tables 1-3 provide an overview of the key theories underlying GBL organised by category. It also outlines the core concepts of each theory and describes how they are applied within GBL contexts. The purpose of the tables is to succinctly present the various theoretical frameworks that inform the design and evaluation of GBL.

Table 1: Understanding how theory contributes to student participation and knowledge retention

Theory & Category	Key Concepts	Application in GBL	References
Self-Determination Theory (Motivation & Affection)	Emphasis on intrinsic and extrinsic motivation. Highlight three psychological needs: autonomy, competence, and relatedness.	GBL environments that allow player choice, present challenging tasks, and foster social collaboration support these needs, improving intrinsic motivation and engagement.	Goole Scholar: Deci & Ryan (1985); Ryan & Deci (2020); Habgood & Ainsworth (2011); Hwang & Chen (2021). Elicit: Xu, Luo, Zhang, Xia, Qian, & Zou, X. (2023).

Theory & Category	Key Concepts	Application in GBL	References
Flow Theory (Motivation & Affection)	Describes the state of deep, focused engagement when the task challenge aligns with the skill levels.	Adaptive game design adjusts difficulty to maintain player flow state, increasing engagement, and improving learning outcomes.	Goole Scholar: Csikszentmihalyi (1990); Hamari et al. (2016). Elicit: Bado (2022).
Goal Setting Theory (Motivation & Affection)	Clear, specific, and challenging goals enhance performance.	Setting goals (such as levels or achievements) in GBL motivates students to continue learning.	Goole Scholar: Locke & Latham (1990). Elicit: Abdul Jabbar & Felicia (2015).
Constructivist Learning Theory (Learning Processes)	Learners actively construct knowledge by integrating new information with previous experiences.	GBL facilitates hands-on interaction and reflection, allowing meaningful connections between prior and new knowledge.	Goole Scholar: Piaget (1973); Vygotsky (1978); Garrick (2021). Elicit: Barz, Benick, Dörrenbächer-Ulrich & Perels (2024).
Situated Learning Theory (Learning Processes)	Learning occurs in authentic contexts and communities of practice.	Simulated GBL contexts mimic real-world scenarios and foster social interaction, deepening understanding.	Goole Scholar: Brown, Collins & Duguid (1989); Lave & Wenger (1991); Huang & Liaw (2020). Elicit: Dahalan, Alias & Shaharom (2024).
Multimedia Learning Theory (Learning Processes)	Combining text, images, and sound helps reduce cognitive load and improve retention.	Effective multimedia integration in GBL reinforces learning through multiple sensory channels.	Goole Scholar: Paivio (1971, 1986); Mayer (2001, 2009, 2014).
Cognitive Load Theory (Cognitive Load & Learning Efficiency)	Distinguishes between intrinsic, extraneous, and germane cognitive loads.	Game design that reduces extraneous load and manages cognitive effort improves retention.	Goole Scholar: Sweller (1988).
Experiential Learning Theory (Cognitive Load & Learning Efficiency)	Learning through concrete experience, reflection, conceptualisation, and experimentation.	GBL engages learners in cycles of experience and reflection to deepen their learning.	Goole Scholar: Kolb (1984); Kolb & Kolb (2017). Elicit: Tavares (2022).
Discovery Learning Theory (Cognitive Load & Learning Efficiency)	Exploration and problem solving with scaffolding support learning.	Open-ended game scenarios promote inquiry and critical thinking, supported by scaffolding.	Goole Scholar: Bruner (1961); Shen & Ke (2021). Elicit: Bado (2022).

Source: Own research

Table 1 outlines the foundational learning theories and their applications in GBL. *Self-Determination Theory* and *Flow Theory* emphasise motivation, autonomy, and balancing challenge with skill to sustain engagement. *Constructivist* and *Situated Learning Theories* focus on active knowledge construction through hands-on, context-rich tasks, while *Cognitive Load* and *Experiential Learning Theories* optimise retention by managing mental effort and embedding reflection cycles. *Multimedia Learning Theory* uses dual coding (text, visuals, sound) to reduce cognitive load and reinforce understanding. Researchers suggest that environmental factors, such as learning context and social dynamics, are critical components for the successful implementation of GBL interventions. Furthermore, game elements include an engaging narrative, various game mechanics, progression or levelling-up in the game, collaborating with other players, personalisation ability of players, using real-world examples, multimedia usage, and encouraging exploratory learning.

Table 2: GBL Design Elements Associated with Knowledge Retention

Design Element	Description and Source(s)
Clear Learning Objectives	Ensures topics align with desired outcomes and assessments track understanding (Deterding et al., 2011; 2020). Include real-world scenarios to enhance relevance and retention (Foster & Shah, M, 2020).
Feedback	Encompasses instant, summative, and peer responses (Hattie & Timperley, 2007). Immediate feedback helps students understand their progress and areas for improvement, reinforcing learning, and aiding retention (Bado, 2022).
Scaffolding	Provides step-by-step guidance and visual aids to support learning (Squire, 2005; Bado, 2022).
Assessment and Reflection	Incorporating spaced repetition for better retention of information over time, as it encourages revisiting concepts and, therefore, assessment is continuous (Shute, 2008; Plass, Homer, & Kinzer, 2015).
Accessibility	Supports diverse learners with formats and tools tailored to different needs (Al-Azawei, Serenko & Cater, 2016). For example, customising learning experiences based on individual progress can help maintain engagement and improve retention by addressing specific learning needs (Foster & Shah, 2020).

Source: Own research

Table 2 identifies elements of the GBL design linked to knowledge retention, such as *feedback mechanisms* (timely guidance to correct mistakes), *scaffolding* (step-by-step support for complex tasks) and *spaced repetition* (revisiting concepts over time). These elements align with theories like Cognitive Load Theory (reducing extraneous load) and Experiential Learning (reflection), ensuring learners internalise knowledge through structured, contextually relevant practice.

Table 3: GBL Design Elements Associated with Engagement

Design Element	Description and Source(s) Google Scholar	Description and Source(s) Elicit
Narrative	Features relatable characters and structured plots for emotional connection (Barata, Gama, & Jorge, 2013).	Research in game-based learning (see, e.g., Plass, Homer, & Kinzer, 2015) indicates that narrative elements not only increase emotional engagement but also support deeper cognitive processing.
Game Mechanics	Using points, challenges, and rewards to motivate learners (Gee, 2003).	A systematic review (Abdul Jabbar & Felicia, 2015) underscores that well-designed game mechanics are essential to maintaining engagement. When game mechanics are properly aligned with instructional goals, they lead to improved cognitive outcomes and participation (Barz et al., 2024).
Progression	Involves levels and skill advancement to maintain motivation (Gee, 2007).	Dahalan et al. (2024) report that structured progression models, which include clearly defined levels and skill increments, enhance learner motivation and support continuous skill development.
Collaboration and social interaction	Encourage teamwork and competition through leaderboards (Johnson & Johnson, 1999).	Findings from teacher education research (Foster & Shah, 2020) suggest that collaborative elements in game-based environments enhance peer-to-peer interaction and active learning. Social interactivity, whether through competition or teamwork, builds communication skills and fosters a community of practice among learners, which in turn can translate into better overall learning experiences.

Design Element	Description and Source(s) Google Scholar	Description and Source(s) Elicit
Personalised Gameplay	Allows topic selection, personal goals, and content adaptation (Kapp, 2012).	Research in specialised fields such as medical education (Xu et al., 2023) and in broader instructional settings (Tavares, 2022) shows that personalisation can lead to improved engagement and knowledge retention.
Multimodal Learning	Engages different learning styles with multimedia and interactivity (Aldrich, 2005).	Garcia et al. (2020) reveal that multimodal approaches in game-based learning help address various cognitive processes and foster the development of soft skills.
Real-World Linkages	Connects content to practical examples like case studies (Gee, 2007).	Incorporating real-life scenarios or case studies is shown to bridge the gap between theoretical content and practical application. Bado (2022) emphasises that using real-world contexts enhances learning transfer by making academic content more relevant and applicable, which can boost both learner motivation and the overall impact of the educational intervention.
Challenging Tasks	Includes realistic and progressively difficult challenges (Csikszentmihalyi, 1990).	As noted in systematic reviews (Abdul Jabbar & Felicia, 2015), well-calibrated challenging tasks promote states of "flow" where learners become fully immersed. This balance of task difficulty with learner ability helps develop critical thinking and problem-solving skills while preventing boredom or frustration.
Tangible Rewards	Reinforce learning with incentives like certificates (Hamari, Koivisto, & Sarsa, 2016).	Barz et al. (2024) report that rewards can reinforce learning outcomes by providing clear goals and immediate feedback. This extrinsic reinforcement complements intrinsic motivation, thereby producing a more comprehensive incentive structure in learning environments.
Exploration	Foster engagement through content discovery (Piaget, 1976).	Emphasising open-ended exploration supports inquiry-based learning, where learners actively discover information on their own. Based on Piaget's constructivist theory, this approach has been shown - through studies like Dahalan et al. (2024) and Abdul Jabbar & Felicia (2015) - to increase participation and deepen understanding.
Visual and Interactive Elements	The use of rich visuals and interactive components can make learning more appealing and engaging, encouraging students to actively participate.	Dynamic visuals and interactive features capture attention and enhance information processing. Research (see, e.g., Aldrich, 2005; Garcia et al., 2020) demonstrates that these multimodal elements reduce cognitive load and cater to varied learning styles, promoting active participation.

Source: Own research

Table 3 highlights the elements of GBL that drive engagement, such as narratives (emotional storytelling), game mechanics (points, levels), and collaboration tools (team challenges). These are rooted in theories like Social Learning (peer interaction), SDT (autonomy through choice), and Flow Theory (adaptive difficulty). Personalisation and multimodal learning cater to diverse preferences, while real-world linkages and tangible rewards bridge gameplay with practical relevance, sustaining interest and effort.

6. Findings and Discussion

The focus of this study is to establish a framework (Figure 2) that addresses (i) theories in learning engagement, (ii) how each theory contributes to student engagement and knowledge retention, (iii) elements of the GBL design associated with knowledge retention, and (iv) GBL design elements associated with engagement (Table 4).

Table 4: Toward setting a framework integrating game design and learning theories.

Theory/Principle	Game Element (Mechanism)	Outcome	Connection to GBL Framework
Self-Determination	Customisable avatars (completely relatedness & emotional connection)	Sustains intrinsic motivation	Engagement: Social interaction drives emotional investment.
Flow Theory	Adaptive Difficulty (Balances challenge and skill)	Masters learning outcomes	Engagement: Maintains the "flow state" for focused learning.

Theory/Principle	Game Element (Mechanism)	Outcome	Connection to GBL Framework
Constructivist Learning	Explore the Game World (Encourages experimentation)	Builds understanding via application	Knowledge retention: Active construction embeds knowledge.
Situated Learning	Real-World Scenarios (Immersive case studies)	Links knowledge to practice	Knowledge retention: The contextual application aids transfer.
Cognitive Load Theory	Scaffolding & Feedback (Guided skill progression)	Reduces mental overload	Knowledge retention: Optimises effort for retention.
Experiential Learning	Scenario-based missions (concrete experiences + reflection)	Solidifies learning through reflection	Knowledge retention: Reflection reinforces concepts.
Social Learning	Peer Review Systems (Teamwork & observational learning)	Reinforces concepts via discussion	Both: Collaboration increases engagement and retention.
Multimedia Learning	Diverse Learning Styles (Supports visual/auditory/kinesthetic)	Accommodates learner diversity	Engagement: Inclusive design maintains motivation.
Goal-Oriented Design	Motivation & Affection Systems (Skill development focus)	Mastery of objectives	Both: Clear goals drive effort and retention.

Source: Own research

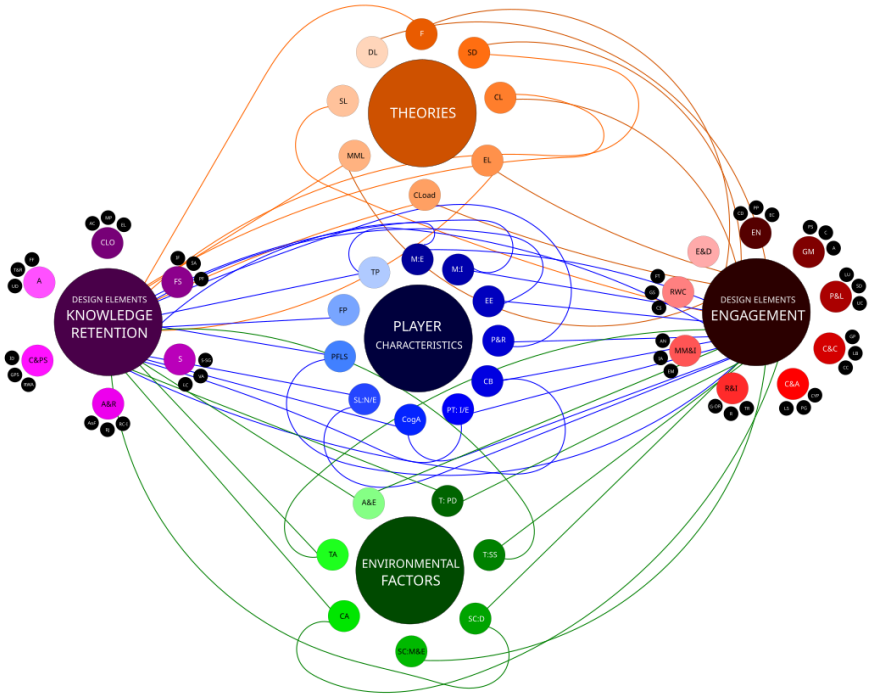

Figure 2: Framework Integrating Game Design and Learning Theories

Figure 2 operationalises the research question and directly addresses the problem statement by visually synthesising diverse learning theories with targeted GBL design elements. It consolidates theories into a coherent framework that highlights their specific contributions toward enhancing both student engagement and knowledge retention. By mapping theoretical constructs to practical design strategies, such as adaptive challenge levels, integration of real-world scenarios, and personalised feedback—the figure offers educators and game designers a clear pathway to mitigate the complexity and ambiguity inherent in selecting multiple theoretical approaches, thus streamlining the effective implementation of GBL in educational contexts.

7. Conclusion, Limitations, and Recommendations

In summary, this study highlights the advantages of GBL in enhancing student engagement and knowledge retention. By merging established learning theories with effective game design, the proposed framework offers valuable insights for educators and developers. The framework is purely theoretical, and future empirical studies

(e.g., randomised and controlled trials under experimental conditions) to test its efficacy are suggested. Future research should also investigate GBL's long-term effects (such as completion rates of games, replayability, etc.) across various contexts and technologies, ensuring its continued relevance and potential to transform education into a more engaging and adaptive experience for all learners.

Ethical clearance: This work is solely a literature review involving no new data collection from human or animal subjects; nevertheless, umbrella ethical clearance for the broader research project was obtained. All sources consulted are publicly available and have been properly cited in accordance with academic standards.

AI declaration: The original article content was condensed to meet the submission's page-limit guidelines through the use of an AI language model, GPT-4o-Mini. Figures included in this manuscript were generated with assistance from the AI tool Napkin.AI. All AI-assisted outputs were reviewed, edited, and validated by the authors to ensure accuracy, clarity, and alignment with the study's scholarly standards.

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