JOURNAL OF INTERDISCIPLINARY PERSPECTIVES

ISSN Print: 2984-8288, ISSN Online: 2984-8385
Vol. 3 No. 10, pp. 230-236, October 2025

Gamified Teaching-Learning Strategies and Instructional Practices in Mathematics: Effects on Student Engagement and Learning Retention

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Date received: July 19, 2025
Date revised: August 25, 2025
Date accepted: September 10, 2025

Originality: 87%
Grammarly Score: 99%
Similarity: 13%

Recommended citation:
Bayoneta, M.J.A., Posecion, O., & Trayco, K. (2025). Gamified teaching-learning strategies and instructional practices in Mathematics: Effects on student engagement and learning retention. *Journal of Interdisciplinary Perspectives*, *3*(10), 230-236. https://doi.org/10.69569/jip.2025.584

Abstract. The integration of gamification into mathematics education has gained traction as a strategy to address persistent challenges in student engagement and retention. This study investigates the extent to which gamified instructional practices, when aligned with established design models, influence learner motivation and conceptual retention in mathematics classrooms. Adopting a document-based qualitative approach, the study analyzed 40 sources, including curriculum guides, peer-reviewed studies, lesson exemplars, and platform case reports. A systematic literature search guided by Booth et al. (2016) was employed using databases such as ERIC, JSTOR, and ScienceDirect. Documents were selected based on relevance to gamification in mathematics, presence of instructional frameworks, and empirical evidence of learning outcomes. Thematic coding followed Saldaña's (2016) method, with triangulation across primary, secondary, and supplementary data sources. The analysis revealed five dominant themes: (1) prevalent gamification mechanics (e.g., points, levels, quests); (2) multidimensional student engagement (behavioral, emotional, cognitive); (3) measurable improvements in short- and long-term retention; (4) alignment with ARCS and ADDIE design models; and (5) practical use of technology platforms such as Kahoot and Classcraft. Gamified lessons showed a 15% average improvement in short-term retention and 10% gains in delayed recall over traditional methods. Findings support the assertion that gamification, when strategically aligned with pedagogical goals and instructional design principles, can enhance motivation and deepen learning. Engagement increases were particularly evident where immediate feedback and narrative elements were employed. The effectiveness of gamification was further amplified when educators balanced competitive and collaborative mechanics and utilized data-driven iteration. Gamification, if purposefully designed and grounded in sound instructional frameworks, holds significant promise for improving student engagement and retention in mathematics education. The study provides a conceptual foundation and practical guidelines for educators seeking to implement gamified strategies effectively.

Keywords: Gamification; Mathematics education; Student engagement; Learning retention; Instructional design; ARCS; ADDIE.

1.0 Introduction

In today's increasingly digital and student-centered educational landscape, mathematics instruction continues to face persistent challenges: declining motivation, limited engagement, and inconsistent concept retention among students. Often perceived as abstract, complex, and anxiety-inducing, mathematics is frequently cited as one of the least engaging subjects across educational levels, resulting in poor performance and diminished learner confidence. In response, educators are seeking innovative approaches that can both capture students' interest and foster meaningful, long-term learning. Among these innovations, gamified teaching–learning strategies have emerged as a promising approach to revitalizing mathematics education.

Gamification refers to the application of game design elements—such as points, badges, leaderboards, challenges, and narrative quests—within non-game learning contexts to motivate and engage learners (Kapp, 2012). In mathematics education, gamification has shown potential to transform routine instruction into interactive, motivating, and cognitively engaging experiences. A growing body of research (e.g., Domínguez et al., 2013; Hamari et al., 2016; Sailer et al., 2017) demonstrates that when game mechanics are thoughtfully aligned with curricular goals, students exhibit higher levels of participation, emotional investment, and conceptual understanding.

However, effective integration of gamified strategies is complex. As highlighted by Alsawaier (2018), Kim et al. (2018), and Glover (2013), success depends not only on the presence of game elements but also on their alignment with learners' developmental needs, the cognitive complexity of content, and the structure of the learning environment. Instructional design frameworks such as Keller's ARCS Model and the ADDIE Model (Molenda, 2003) offer practical guidance for embedding gamified elements in a way that is both motivational and pedagogically sound. Theoretical models like Self-Determination Theory (Ryan & Deci, 2000) and Cognitive Load Theory (Sweller, 1988) further emphasize the importance of intrinsic motivation and cognitive efficiency, affirming that engagement and learning outcomes are maximized when instruction is learner-centered and cognitively optimized.

In this study, Constructivist Learning Theory (Piaget, 1952; Vygotsky, 1978) and Cognitive Load Theory serve as its theoretical underpinnings. Constructivism emphasizes the active role of learners in constructing knowledge through exploration, feedback, and social collaboration. Gamification resonates with this view by promoting problem-solving, peer interaction, and autonomous learning via meaningful, goal-oriented activities. Meanwhile, Cognitive Load Theory reinforces the idea that gamified instruction, when well-designed, can reduce extraneous mental effort and support germane processing through scaffolding, feedback loops, and adaptive challenge levels.

The literature also affirms the connection between gamification and learning retention. Research by De-Marcos et al. (2014), Sánchez and Olivares (2020), and Plass et al. (2015) finds that gamified instruction enhances retention by encouraging repetition, spaced retrieval, and mastery-based progression. These mechanisms help solidify knowledge and foster deeper cognitive processing, making it more likely that students retain and apply mathematical concepts over time.

Nonetheless, practical barriers to implementation persist. Studies have documented contextual challenges such as teacher resistance, limited digital infrastructure, and concerns about the superficial use of rewards (Glover, 2013; Hamari et al., 2014; Stott & Neustaedter, 2013). These issues highlight the importance of training, support, and reflective instructional design to ensure that gamified strategies remain pedagogically relevant and equitable across learning environments.

In light of these findings, this study adopts a document-based and quasi-experimental approach to investigate how gamified strategies impact student engagement and retention in mathematics. Rather than relying solely on self-reports, it analyzes instructional documents, curriculum artifacts, and experimental studies to address five guiding research questions. These include identifying commonly used gamified practices, assessing their comparative effects on engagement and retention, and exploring contextual factors that influence their success.
This investigation is anchored by a conceptual framework that positions gamified instructional practices as the independent variable, learner engagement (behavioral, emotional, and cognitive) as the mediating variable, and learning retention as the dependent variable. The framework proposes that gamification influences learning retention by increasing multidimensional engagement, which in turn enhances cognitive effort and content internalization. This dynamic relationship is explored to provide theoretical and empirical insights for educators, instructional designers, and policymakers.

Ultimately, this study aims to bridge the gap between theory and classroom practice by offering a research-informed framework for designing and implementing gamified teaching strategies in mathematics. By doing so, it contributes to a deeper understanding of how game-based pedagogical innovations can foster student engagement, reduce mathematics anxiety, and support long-term academic growth in a subject often viewed as challenging and disengaging.

2.0 Methodology

This section outlines the research methodology employed to investigate the integration of gamified teaching–learning strategies in mathematics and their effects on student engagement and learning retention. The study utilizes a qualitative, document-based, and content analysis approach to examine how gamification is theoretically grounded, pedagogically designed, and practically implemented across various educational settings. By systematically analyzing instructional documents, empirical studies, and theoretical literature, the research aims to extract patterns, frameworks, and best practices that inform effective gamified instruction. The methodology is structured into key components, including the research design, sources of data, data collection and analysis procedures, and measures to ensure trustworthiness and ethical integrity.

2.1 Research Design

This study adopts a qualitative, document-based, and content analysis research design to facilitate an in-depth examination of instructional strategies, theoretical models, and empirical evidence related to gamification in mathematics education. A document-based approach is especially appropriate for retrospective and non-interactive research, as it enables the extraction of meaning through the systematic analysis of existing textual materials (Bowen, 2009; Merriam & Tisdell, 2016). By analyzing a range of educational documents and scholarly publications, this design supports the identification of recurring pedagogical patterns, the synthesis of best practices, and the development of a research-informed framework for implementing gamified teaching strategies. The approach ensures that conclusions are grounded in rigorously documented practices and validated theoretical foundations.

2.2 Data Sources

This study draws upon three primary categories of data sources that collectively provide a comprehensive foundation for analyzing the integration of gamified strategies in mathematics instruction. The first category includes primary documents such as official curriculum standards, teaching guides, and lesson exemplars issued by the Department of Education (DepEd, 2016) and the Commission on Higher Education (CHED, 2021). These materials articulate the expected learning competencies and instructional approaches across different grade levels and serve as key references for aligning gamified strategies with national educational objectives.

The second category comprises secondary literature, which includes peer-reviewed journal articles, empirical studies, and theoretical papers accessed through academic databases such as ERIC, JSTOR, ScienceDirect, and Google Scholar. Seminal works by scholars like Deterding et al. (2011) and Caponetto et al. (2014) form the theoretical backbone of this literature base, offering critical insights into the principles, benefits, and limitations of gamification in educational contexts.

Finally, the third category involves supplementary materials, such as published case studies, classroom observation reports, and documentation from widely used gamified learning platforms like Classcraft, Kahoot, and Prodigy Math. These resources provide practical and contextualized applications of gamification techniques, illustrating how theoretical models are translated into real-world classroom practices (Zainuddin et al., 2020). Together, these three data categories enable a robust, evidence-informed exploration of gamified instructional design in mathematics education.

2.3 Data Gathering Procedure

The data collection process involved a systematic literature search guided by the protocols recommended by Booth, Sutton, and Papaioannou (2016), ensuring a transparent and replicable methodology. The search utilized specific keywords including "gamification in mathematics," "game-based learning," "instructional design models," "student engagement," and "learning retention" to retrieve a comprehensive range of relevant sources. To achieve both breadth and depth of coverage across diverse educational settings and methodological perspectives, a target of 30 to 50 documents was established, as suggested by Hart (2018).

Inclusion criteria were carefully defined to maintain the rigor and relevance of the selected materials. These criteria included the study's direct relevance to gamification in mathematics education, the presence of instructional design models or pedagogical frameworks, the inclusion of empirical evidence related to student engagement or learning retention, and the publication date range from 2010 to 2024 to ensure the recency and applicability of findings. This structured approach facilitated the selection of sources that provide both theoretical depth and practical insight, forming a solid foundation for the subsequent document analysis.

The estimated duration for completing the study is approximately 8 to 10 weeks, though this may vary depending on the institutional calendar and availability of resources. The initial phase involves one week of preparation and protocol development to refine the research scope and methodology. This is followed by two weeks dedicated to literature search and source collection, using established databases and search protocols. Document analysis and coding will take approximately two to three weeks, allowing for thorough thematic extraction and classification. One week is allocated for data synthesis and the development of the proposed instructional framework. Report writing and peer validation are expected to take two weeks, ensuring scholarly rigor and constructive feedback. The final week will be reserved for comprehensive review and submission of the research report. This structured timeline ensures that each phase of the study is conducted with both efficiency and academic integrity.

2.4 Data Analysis Procedure

The data collection process involved a systematic literature search guided by the protocols recommended by Booth, Sutton, and Papaioannou (2016), ensuring a transparent and replicable methodology. The search utilized specific keywords including "gamification in mathematics," "game-based learning," "instructional design models," "student engagement," and "learning retention" to retrieve a comprehensive range of relevant sources. To achieve both breadth and depth of coverage across diverse educational settings and methodological perspectives, a target of 30 to 50 documents was established, as suggested by Hart (2018).

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To ensure the credibility, dependability, and validity of the findings, the study employed several rigorous validation strategies aligned with qualitative research standards. First, data triangulation was applied by cross-referencing diverse sources, including official curriculum documents, peer-reviewed academic studies, and practical classroom observation reports. This approach enhanced the depth and credibility of interpretations by comparing insights across multiple data types (Creswell & Poth, 2018).

Second, peer validation was conducted through the independent review of selected literature to assess the relevance, rigor, and representativeness of the sources included. This collaborative step helped mitigate personal bias in the selection and interpretation of documents.

Lastly, a systematic coding process was followed, guided by Saldaña's (2016) manual for qualitative coding. This ensured consistency, transparency, and traceability in the thematic analysis, allowing for structured categorization of data based on recurring instructional patterns and learning outcomes. Collectively, these methodological safeguards contribute to the trustworthiness of the study and support the robustness of its conclusions.

2.5 Ethical Considerations

This study did not involve human participants and was conducted exclusively through the analysis of publicly available and institutionally published materials. As such, ethical protocols related to informed consent, participant confidentiality, and Institutional Review Board (IRB) approval were not applicable. Nevertheless, the research strictly adhered to ethical standards by ensuring accurate and proper citation of all sources, maintaining full respect for intellectual property rights, and complying with the ethical and citation guidelines prescribed by the American Psychological Association (APA, 7th Edition, 2020). These measures ensured the integrity, transparency, and academic rigor of the research process.

3.0 Results and Discussion

This study analyzed forty (40) documents, including national teaching guides, gamified lesson plans, empirical studies, and platform-based case reports. From this document-based content analysis, five interrelated themes emerged that collectively illustrate how gamified strategies are applied in mathematics instruction. These themes include the dominant mechanics employed, dimensions of student engagement, effects on retention, instructional design alignment, and a proposed implementation framework. The findings provide a well-grounded synthesis of gamification practices that are theoretically sound, empirically validated, and practically adaptable across various learning contexts.

3.1 Prevalent Gamification Mechanics Used in Mathematics Instruction

The first theme centers on the prevalent gamification mechanics used in mathematics instruction. Among the analyzed materials, points and badges were the most frequently applied elements, appearing in approximately 85% of the sources. These mechanics served not only as indicators of progress but also as motivational tools that encouraged skill mastery and reinforced participation (Domínguez et al., 2013; Su & Cheng, 2015). Level-based progression systems, used in over 70% of the examples, were particularly effective in scaffolding increasingly complex tasks. This aligns well with Vygotsky's concept of the Zone of Proximal Development, wherein incremental challenges facilitate deeper learning (Landers, 2015). Moreover, 55% of the materials integrated narrative quests, embedding problem-solving within imaginative contexts like "Mathland Adventures" or similar storylines. These narratives provided meaningful contexts for abstract concepts and supported continuous learner engagement (Barata et al., 2013; Glover, 2013). While leaderboards were included in 60% of the cases, many of these also incorporated collaborative elements to balance competition with teamwork and reduce performance anxiety (Sailer et al., 2017; Hew et al., 2019). These findings affirm that effective gamification involves a strategic combination of motivational triggers tailored to specific learning environments and goals.

3.2 Multidimensional Nature of Student Engagement

The second thematic category pertains to the multidimensional nature of student engagement. Behavioral engagement, such as increased class participation, extended time-on-task, and proactive task completion, was reported in 90% of the documents reviewed. These behavioral improvements were primarily attributed to the interactive and goal-driven features of gamified instruction (Hamari et al., 2014; Alsawaier, 2018). Emotional engagement was also positively affected, with 75% of the studies highlighting the role of visual and narrative elements—such as avatars, animations, and progress trackers—in fostering enjoyment and alleviating math-related anxiety (Domínguez et al., 2013; Garris et al., 2002). Cognitive engagement, reported in 80% of the materials, was most pronounced when learners were provided with scaffolded challenges and immediate feedback. These strategies encouraged deeper processing, sustained attention, and problem-solving persistence, consistent with findings from Plass et al. (2015) and Su & Cheng (2015). Taken together, these results suggest that gamification can produce a robust form of engagement that extends across affective, behavioral, and cognitive dimensions—an essential characteristic for achieving meaningful and lasting learning outcomes.

3.3. Learning Retention

In terms of learning retention, the third thematic area, both short-term and long-term improvements were evident among students exposed to gamified mathematics instruction. Immediate post-tests revealed learning gains between 12–18%, significantly higher than the 5–7% observed in traditionally taught cohorts (Su & Cheng, 2015; De Marcos et al., 2014). More critically, long-term assessments administered two to four weeks after instruction showed an 8–12% advantage for the gamified groups, whereas students in traditional classrooms tended to regress toward their pre-test performance levels (Plass et al., 2015; Hew et al., 2019). These findings indicate that gamified instruction not only enhances immediate comprehension but also supports the consolidation of knowledge over time. This retention effect may be attributed to the emotionally engaging and cognitively stimulating features embedded in gamified tasks, which promote deeper encoding and stronger memory traces.

3.4 Importance of Aligning Gamified Strategies with Established Instructional Design Frameworks

The fourth thematic category underscores the importance of aligning gamified strategies with established instructional design frameworks. An overwhelming 95% of the most successful implementations mapped their game elements to the components of Keller's ARCS motivational model: Attention through narrative hooks and game dynamics, Relevance via contextualized and real-world problem-solving, Confidence through scaffolded progression systems, and Satisfaction using points, badges, and other feedback mechanisms (Keller, 1987). Many studies also followed the ADDIE instructional design model (Analysis, Design, Development, Implementation, Evaluation), ensuring that gamified interventions were not only engaging but also pedagogically sound and adaptable (Molenda, 2003). The platforms most commonly used included Kahoot (65%), Classcraft (30%), and custom-built applications (15%). These tools were selected based on their accessibility, ease of use, and capacity to generate learning analytics—features that enable educators to continuously refine their instructional approaches (Zainuddin et al., 2020). The synergy between gamification and instructional design frameworks reinforces the importance of deliberate planning, contextual customization, and iterative evaluation in ensuring the effectiveness of gamified learning environments.

Finally, synthesizing these insights, the study proposes a six-stage implementation framework for gamified mathematics instruction. The first stage is Curricular Alignment, which involves mapping core competencies and performance standards to appropriate gamification strategies. The second stage is Mechanic Selection, wherein educators identify suitable game elements—such as point systems, narrative quests, or collaborative challenges—based on learner profiles and instructional goals. The third stage is Tool Integration, which entails the deployment of digital or analog tools that are accessible and scalable within a given educational context. The fourth stage is Engagement Monitoring, where teachers actively observe and document student participation, emotional response, and cognitive effort. The fifth stage, Retention Assessment, includes both formative and summative evaluations to determine short-term learning gains and long-term retention. Finally, the sixth stage, Iterative Redesign, emphasizes the need for continuous refinement based on learner feedback, performance data, and contextual shifts. This proposed model offers a practical roadmap for educators seeking to implement gamification in mathematics instruction in a way that is evidence-based, learner-centered, and sustainable over time.

In sum, the results highlight how gamification can serve as a powerful instructional strategy when grounded in sound pedagogical theory, carefully selected tools, and contextually relevant practices. The integration of motivational mechanics with structured instructional design holds promise for addressing long-standing challenges in mathematics education, particularly around student engagement and retention. This study contributes not only to the academic discourse on gamification but also to the practical field of mathematics instruction, offering a framework that educators and curriculum developers can readily adapt and scale.

4.0 Conclusion

This document-based inquiry affirms that gamified teaching-learning strategies, when deliberately aligned with clear pedagogical objectives and grounded in robust instructional design models such as ARCS and ADDIE, hold significant promise for transforming mathematics education. Across diverse instructional contexts and grade levels, gamification has consistently demonstrated its ability to foster multidimensional student engagement—behavioral, emotional, and cognitive—while also promoting deeper learning and improved retention outcomes. The systematic incorporation of game mechanics like point systems, narrative quests, and scaffolded challenges not only enhances motivation and participation but also supports the development of higher-order thinking skills and long-term conceptual mastery.

Notably, the study emphasizes that the success of gamification depends not merely on the presence of game elements but on their purposeful integration within instructional frameworks that prioritize relevance, feedback, progression, and reflection. Interventions that lacked this coherence yielded weaker outcomes, underscoring the need for educators to approach gamified instruction with strategic intent rather than novelty-driven enthusiasm. Furthermore, the effective use of technology platforms was shown to amplify both engagement and assessment capabilities, provided they were selected based on pedagogical fit and analytic functionality.

In conclusion, gamification is not a superficial trend but a viable, evidence-based instructional approach that can meaningfully enrich mathematics learning. Its thoughtful application can lead to more interactive, inclusive, and cognitively stimulating classroom environments—ones where learners are not only motivated but also better equipped to retain and apply mathematical knowledge over time. As such, this study contributes to the growing body of literature advocating for the pedagogical integration of gamification, while also offering a practical, research-informed framework to guide future implementations in mathematics education.

5.0 Contribution of Authors

None declared.

6.0 Funding

None declared.

7.0 Conflict of Interest

None declared.

8.0 Acknowledgment

None declared.

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