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MOTIVATION AND STUDENT ENGAGEMENT THROUGH GAMIFICATION IN MATHEMATICS LEARNING: A MINI REVIEW

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Abstract:

This mini-review synthesizes current evidence on the use of gamification in multiplication learning, focusing on how game-based elements influence motivation, engagement, and math fact fluency. The purpose of the review is to clarify which gamification strategies are most effective, assess their benefits and limitations, and highlight ongoing gaps in the field. A comprehensive literature search was conducted on 28 November 2025 across Scopus, Web of Science, and Google Scholar, using keywords related to gamification, mathematics education, engagement, and practice. Peer-reviewed original studies, systematic reviews, meta-analyses, and case studies published in English were included, while non-English, non-peer-reviewed, or non-gamification-focused articles were excluded. Overall, the findings suggest that gamification is associated with increased learner motivation, increases time on task, and supports short-term retention of multiplication facts through points, badges, levels, adaptive challenges, and immediate feedback. Interactive math apps and game-based platforms depict strong potential to improve participation, particularly among younger learners. However, limitations persist, including inconsistent long-term outcomes, overreliance on extrinsic rewards, unequal access to digital tools, and variability in instructional design quality. Ongoing debates concern which game elements are most pedagogically meaningful and how to balance extrinsic incentives with conceptual understanding. The review concludes that while gamification can meaningfully support multiplication learning, its effectiveness depends on purposeful design and integration with

curriculum-aligned, evidence-based practices. Hence, future research should prioritize longitudinal studies, culturally responsive and inclusive game design, and standardized evaluation frameworks. In addition, hybrid instructional models that combine gamified practice with strong conceptual teaching are needed to ensure equitable and sustainable implementation.

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Keyword:

Educational Technology, Game-Based Learning, Multiplication Fluency, Math Fact Retention



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Introduction

Multiplication fluency is a foundational mathematical skill that supports learners' later success in areas such as division, fractions, algebra, and multi-step problem solving. Nonetheless, many children struggle to memorize multiplication facts through traditional drill-and-practice methods, often experiencing boredom, frustration, and a decline in interest in mathematics. As digital learning tools become more widely integrated into classrooms, gamification, the incorporation of game elements such as points, badges, narrative challenges, and instant feedback, has emerged as a timely and increasingly popular approach to re-energize mathematics learning (Adharsh et al., 2024). Its growing use reflects a broader educational trend toward the design of learning environments that are more interactive, motivating, and responsive to student needs. However, despite its rapid adoption, the effectiveness of gamification in supporting multiplication learning remains an evolving area with unanswered questions and varying interpretations in the research community. Furthermore, while some studies report improvements in motivation, engagement, and retention of multiplication facts, others caution that gamification may lead to overreliance on extrinsic rewards, inconsistent transfer of learning, or marginal benefits when poorly aligned with pedagogical goals (Yang & Kang, 2020). There are also differing views on which game elements matter most, whether gamification benefits all learners equally, and how its impact compares with more established instructional practices. Findings of this study can be discussed in relation to several key theories and models underpinning the research, namely the Cognitive Theory of Multimedia Learning, Self-Determination Theory (SDT), the ARCS Motivation Model, McClelland's Theory of Needs, and Game-Based Learning Theory. In alignment with the Cognitive Theory of Multimedia Learning proposed by Mayer, the observed increase in students' motivation following the use of gamification can be attributed to the presentation of multiplication facts through visual and interactive means, which reduce cognitive load and support active

processing within working memory. The incorporation of visual, manipulative, and immediate feedback elements in gamification is expected to facilitate the construction of meaningful understanding of multiplication concepts, as opposed to reliance on rote memorization alone. This focused mini-review is to synthesize current evidence on the role of gamification in multiplication learning, with a specific focus on understanding how and why gamified elements immediate outcomes (motivation and engagement), learning outcomes (fluency and retention), long-term sustainability and equity issues. Specifically, this review addresses several key gaps: (1) the lack of clarity on which gamification strategies are most effective for strengthening multiplication fluency, (2) limited consensus on the mechanisms through which gamification influences learner motivation, and (3) scarce comparative analyses of gamified learning versus traditional or blended instructional approaches. The review is organized around three thematic areas: (1) theoretical and motivational foundations of gamified multiplication learning, (2) empirical evidence detailing its benefits and limitations, and (3) design considerations and open research challenges. Collectively, the article concludes that while gamification holds promise for enhancing student motivation and improving mastery of multiplication, its success depends heavily on purposeful design, appropriate integration with curriculum goals, and sensitivity to learner differences. This mini review, therefore, aims to offer a clear, accessible synthesis for educators, researchers, and developers seeking to understand the current state of knowledge and the remaining questions surrounding gamification in multiplication learning.

Methods

A comprehensive literature search was conducted using Scopus, Web of Science, and Google Scholar. Notably, keywords such as (gamification AND mathematics education AND practice OR engagement) were utilized to identify relevant articles within the time range between 2020 until 2025. Various 124 article types, including original research, systematic reviews, meta-analyses, and case studies, were considered for this mini review. The search date was completed on 28 November 2025. The process for selecting articles in this systematic literature review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines began by searching three main databases mentioned above. This search records for studies included about 57 documents in total. Studies that were not in English, published before 2022, or were book chapters, conference proceedings, or in-press articles were excluded, removing 67 records in total. The inclusion and exclusion criteria applied in this review are presented below.

Inclusion Criteria

Studies discussing various aspects of multiplication learning, including math fact fluency, learner motivation, cognitive reinforcement, and classroom implementation, consistently demonstrate that gamification enhances engagement and short-term performance. This is achieved by integrating rewards, challenges, and interactive tasks into multiplication practice. Studies focusing on the application of gamification technologies in mathematics education, such as digital games, point-based systems, interactive platforms, and adaptive game mechanics, highlight increased learner participation and sustained interest, particularly among early-grade students.

Studies analyzing the strengths, limitations, and potential applications of gamification in multiplication learning reveal clear benefits, namely increased motivation, immediate feedback, and higher retention of multiplication facts. However, limitations include inconsistent long-term learning outcomes, overreliance on extrinsic rewards, unequal access to digital resources, and variability in instructional design quality across platforms.

Studies published in English collectively exhibit that while gamified tools are promising, gaps remain in long-term efficacy, teacher integration strategies, and standardized evaluation frameworks. The current literature also exhibits inconsistencies in defining what constitutes “effective gamification,” making it difficult to compare results across studies. Future research should explore longitudinal impacts, culturally adaptable game design, optimal reward structures, and the combination of gamification with evidence-based pedagogy to advance understanding and refine practical application in multiplication learning.

Exclusion Criteria

Studies published in languages other than English were excluded to maintain consistency, accessibility, and analysis accuracy.

Studies that discussed mathematics education or multiplication learning without explicit reference to gamification were excluded, as they did not address the central concept under review and fell outside the scope of the targeted inquiry.

Grey literature (e.g., conference abstracts, unpublished reports, articles in press) was excluded to ensure that only peer-reviewed, high-quality, and fully validated research contributed to the mini-review's evidence base.

Discussion And Results

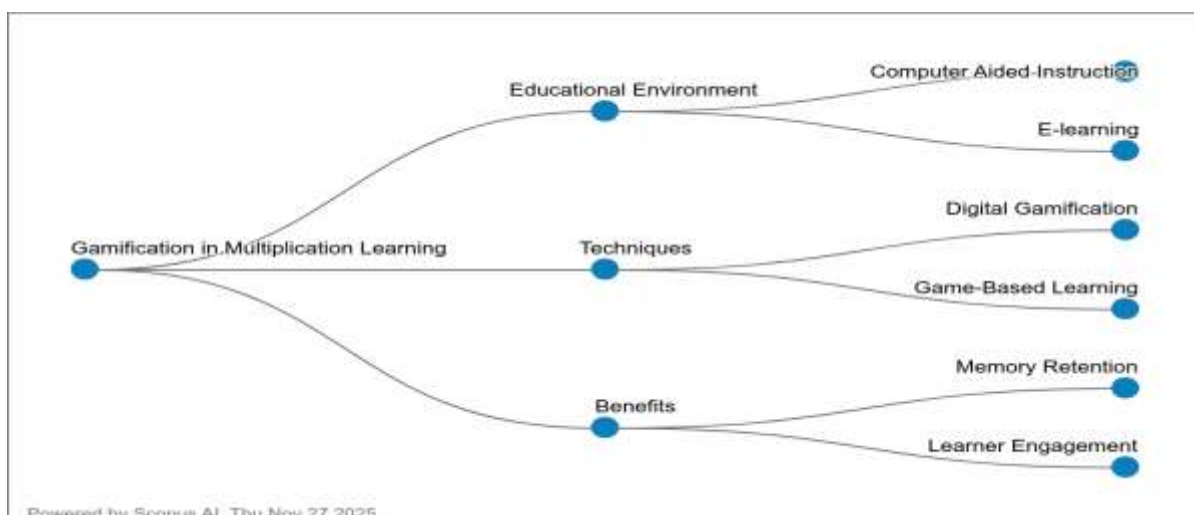


Figure 1: Concept Map Generated with Scopus AI for Motivation and Student Engagement through Gamification in Mathematics Learning

Current Status of Gamification In Multiplication Learning Based On Educational Environment

Gamification has emerged as a significant educational innovation, reshaping the learning environment by integrating game-like elements, such as points, challenges, and rewards, to enhance motivation and engagement (Jutin et al., 2024). Within today's rapidly evolving educational landscape, characterized by digital integration and learner-centered approaches, gamification is increasingly used to support foundational skills, particularly multiplication fluency in early mathematics education. Notably, current findings reveal that gamified tools can improve motivation, increase time-on-task, and strengthen retention of multiplication facts. However, challenges remain, including overreliance on extrinsic rewards, variable design quality, and unequal access to digital resources. Key technologies used in this domain, interactive math apps, adaptive platforms, digital badges, and game-based learning systems, demonstrate strong potential but indicate inconsistencies in long-term effectiveness and pedagogical alignment (Yusri and Zainal 2025). Additionally, practical applications highlight successful integration in classrooms where teachers incorporate gamified drills, collaborative challenges, and individualized practice, though debates persist about balancing gameplay with conceptual understanding. Future directions point toward culturally responsive game design, hybrid models combining gamification with evidence-based instruction, and longitudinal studies assessing sustained learning outcomes. As a result, addressing these gaps will strengthen the theoretical foundation of gamified mathematics education and support the development of more equitable, engaging, and pedagogically meaningful tools for multiplication learning.

Current Status Of Gamification In Multiplication Learning Based On Techniques

Gamification techniques, such as point systems, badges, leaderboards, and interactive challenges, have become increasingly relevant in modern education as digital tools seek to enhance motivation and reinforce core skills (Soemantri et al., 2025). In multiplication learning, these techniques support repetitive practice, provide immediate feedback, and foster a sense of progress, making them well-suited to early mathematics instruction. Key technologies, including adaptive math apps, game-based platforms, and classroom management tools with embedded reward systems, offer promising gains in student engagement and fact fluency (C et al., 2024). Nevertheless, debates persist regarding the balance between extrinsic incentives and deeper conceptual understanding. Moreover, while benefits include increased motivation and improved accuracy, challenges include inconsistent design quality, potential distractions, and limited access to reliable digital devices. Practical applications exemplify that gamified multiplication tasks, such as timed quests, collaborative team challenges, or personalized game paths, can meaningfully supplement traditional teaching when integrated thoughtfully by educators (Chukwu, 2024). Future directions call for research examining long-term learning retention, the role of intrinsic motivation, culturally responsive game design, and the integration of gamification with evidence-based pedagogical frameworks. Addressing these gaps will help refine the use of gamification techniques, ensuring they support engagement, sustained mathematical understanding, and equitable learning outcomes.

Current Status of Gamification in Multiplication Learning Based on Benefits

Furthermore, gamification offers notable benefits in multiplication learning, providing motivational support, increased engagement, and improved retention of math facts through interactive, reward-based activities (Del Olmo-Muñoz et al., 2023). As educational environments increasingly adopt digital tools, gamified learning aligns with current developments that emphasize active participation and personalized learning experiences (Hayati, 2025). Key technologies, such as adaptive math games, badge systems, and interactive quiz platforms, demonstrate consistent improvements in student focus and accuracy. Nonetheless, debates continue regarding the long-term impact of extrinsic rewards on intrinsic motivation (Alt, 2023). Challenges also include unequal access to technology, inconsistent game quality, and limited evidence of sustained conceptual understanding. Additionally, practical applications reveal that teachers effectively use gamified multiplication tasks, including timed missions, level-based progression, and collaborative challenges, to reinforce repetitive practice and support diverse learners. However, despite encouraging results, gaps remain in understanding optimal design features, culturally responsive gamification, and the integration of game elements with established instructional methods. Thus, future research should explore longitudinal outcomes, identify game mechanics that promote intrinsic motivation, and evaluate hybrid instructional models that combine gamification with conceptual teaching. Addressing these areas will advance both theoretical and practical frameworks, ensuring gamification serves as a sustainable, equitable, and pedagogically sound approach to improving multiplication learning.

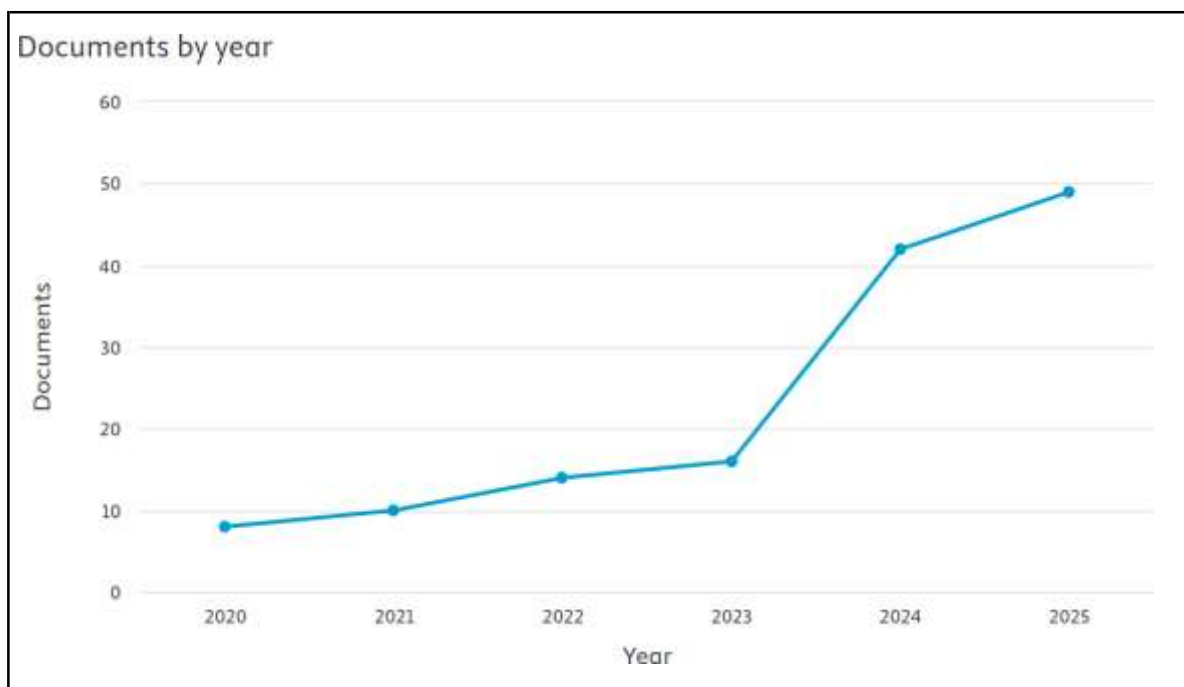


Figure 2: Document by Year from 2020 until 2025, adopted from Scopus AI

Figure 2 illustrates a sharp rise in documents after 2023, indicating growing research interest in gamification for multiplication learning. Early years present gradual exploration, but the post 2023 surge suggests an increasing empirical focus, broader technological adoption, and

recognition of its pedagogical value. Nevertheless, long-term effectiveness and implementation quality remain critical gaps.

Conclusion

In summary, this mini review highlights that gamification meaningfully reshapes the educational environment for multiplication learning by promoting motivation, engagement, and improved fact fluency. It achieves this through interactive techniques such as points, challenges, feedback loops, and adaptive digital tools. Moreover, across the reviewed literature, gamified approaches consistently demonstrate benefits in fostering active participation, sustaining interest, and supporting short-term performance gains. However, their effectiveness is strongly influenced by contextual factors such as instructional alignment, design quality, and learner diversity. Notable limitations remain, including uneven long-term outcomes, overreliance on extrinsic rewards, limited teacher guidance on integration, and persistent gaps in access to digital resources. Ongoing debates also concern which game elements are most pedagogically meaningful and how best to balance gameplay with deeper conceptual understanding. Therefore, future research should prioritize longitudinal evaluations, culturally responsive and inclusive game design, clearer frameworks for evaluating gamification effectiveness, and hybrid models that combine gamified practice with evidence-based instructional strategies. Addressing these challenges while leveraging the identified opportunities will be essential to advancing both the scholarly understanding and the practical application of gamification in multiplication learning.

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Ethics Statement: The author confirms that this article is a mini-review and does not involve any experimental research on human or animal subjects. Therefore, ethical approval from an institutional review board or ethics committee was not required. All sources of information and data used have been clearly cited and acknowledged in the reference list.

Author Contribution Statement: The review concludes that while gamification can meaningfully support multiplication learning by enhancing motivation, engagement, and short-term fluency, its effectiveness depends on purposeful design and pedagogical alignment. The review fills a critical gap by synthesizing fragmented evidence on how specific gamification strategies influence learning outcomes and motivation. It focuses on multiplication due to its foundational role in mathematics and persistent learning difficulties, thereby providing targeted insights to inform effective, equitable, and sustainable instructional practices in early mathematics education. All authors read and approved the final version of the manuscript prior to submission. The author would like to acknowledge and extend special gratitude to the mini-review team, Assoc. Prof. Dr. Hafizul Fahri Hanafi for his guidance and expert input in the review process.

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