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# The Role of Gamification in Increasing Motivation to Learn Mathematics: A Scoping Review

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## ABSTRACT

Low motivation to learn mathematics is still a global challenge in modern education, although various pedagogical innovations have been developed to address it. One of the approaches that is now widely used is gamification, which is the application of game elements in the context of non-game learning to increase student engagement and motivation. This study aims to systematically examine how gamification is implemented in mathematics learning and evaluate its impact on students' learning motivation based on the results of international research published between 2010 and 2022. The study used a Systematic Literature Review (SLR) design with PRISMA guidance and the PICOC approach, searching articles from the Scopus, Web of Science, ScienceDirect, SpringerLink, Taylor & Francis, and ERIC databases. A total of 30 articles met the inclusion criteria after going through the identification, screening, and eligibility stages. The results of the synthesis showed that gamification consistently increased students' intrinsic motivation, engagement, and perseverance in learning mathematics with moderate to high effects. Elements such as points, badges, leaderboards, and challenges have been proven to strengthen students' sense of competence and autonomy, in accordance with the principles of Self-Determination Theory. However, its effectiveness is influenced by the game design, duration of the intervention, level of education, and cultural context. In conclusion, gamification has the potential to be an effective pedagogical strategy to increase motivation to learn mathematics, with practical implications for teachers, media developers, and education policies in creating a more engaging and meaningful learning environment.

**Keywords:** Gamification; Learning Motivation; Mathematics Education; Game-Based Learning; Systematic Literature Review

## 1. INTRODUCTION

In the last two decades, advances in digital technology have brought significant changes to the practice of mathematics learning at various levels of education. This transformation not only changes the way students access and interact with subject matter, but also raises new challenges related to students' low motivation to learn mathematics, which is still a global issue in 21st-century education (Attard & Holmes, 2020; OECD, 2019). Mathematics is often perceived as a difficult and abstract field of study, leading to a decrease in students' emotional engagement and intrinsic motivation, especially at the secondary school level (Middleton et al., 2018). Therefore, various pedagogical innovations have been developed to address this problem, one of which is through a gamification approach that aims to create a more engaging and meaningful learning experience through the application of game elements in non-game contexts (Deterding et al., 2011).

Conceptually, gamification is defined as the application of game mechanics and dynamics such as points, badges, leaderboards, challenges, and rewards to improve learners' motivation, engagement, and learning outcomes (Hamari et al., 2014). In the context of mathematics education, gamification is considered to be able to facilitate active learning by stimulating a sense of competence, autonomy, and social connectedness as described in Self-Determination Theory (Deci & Ryan, 2000). Several empirical studies show that the use of gamification can increase students' intrinsic motivation as well as lower the level of anxiety towards mathematics (Su & Cheng, 2015; Le & Wang, 2019). Gamification is also believed to strengthen the growth mindset and foster an unyielding attitude in the face of conceptual difficulties (Barata et al., 2013). Thus, the application of gamification is not only recreative, but also has a strong theoretical foundation in motivational psychology and constructivist learning theory.

Various international studies have traced the impact of gamification on motivation to learn mathematics with mixed results. An experimental study by Su and Cheng (2015) in Taiwan showed that the integration of game-based learning in

geometry learning increased intrinsic motivation by 27% compared to the control class. Meanwhile, a study in Finland by Sailer and Homner (2020) found that gamification that focuses on social achievement through leaderboards is more effective at fostering extrinsic motivation than intrinsic motivation. Different results were reported by Lin et al. (2021), who stated that gamification design without narrative context or intrinsic meaning actually lowers students' focus on learning. These differences in results indicate that there are moderator factors that affect the effectiveness of gamification, such as intervention design, duration of implementation, education level, and learning culture. Therefore, systematic mapping of empirical evidence is important to understand the general patterns and limitations of the effectiveness of gamification in the context of mathematics learning.

Although the study of gamification in education has grown rapidly since 2010, there is still a research gap that needs to be bridged. Most previous studies have focused on the cognitive effects of gamification on learning outcomes, while affective aspects such as learning motivation have not been explored in depth (Nah et al., 2014; Caponetto et al., 2016). In addition, many studies have used short-term interventions, so they have not been able to explain the long-term effects on the sustainability of mathematics learning motivation (Sailer & Homner, 2020). Cross-cultural research is also still limited, with the dominance of East Asian and European contexts, while regions such as Southeast Asia or Africa are relatively underrepresented (Lopez & Tucker, 2019). Another gap lies in methodological limitations, such as the use of small samples, varied motivational instruments, and a lack of control over contextual variables that influence outcomes.

In the context of the development of mathematical learning theory, gamification offers integrative potential between cognitive and affective principles. Through the application of structured game elements, students can experience a flow experience (Csikszentmihalyi, 1990) that increases concentration, sense of achievement, and emotional involvement in mathematical tasks. Pedagogically, this approach is in line with constructivist learning and experiential learning theories, which emphasize the active role of students in building meaning through interaction with experiential learning environments (Kolb, 2015). However, the effectiveness of gamification relies heavily on the fit between game design and instructional objectives, which demands a deep understanding of student characteristics as well as the complexity of math material.

Based on preliminary reviews, although a number of meta-analyses have discussed gamification in general education (Majuri et al., 2018; Subhash & Cudney, 2018), there has been no systematic study that specifically explores how gamification is implemented to increase learning motivation in the context of mathematics education in the 2010–2022 time frame. Therefore, this research is here to fill this gap by synthesizing the results of relevant empirical research in a systematic manner. The Systematic Literature Review (SLR) approach is used to identify patterns of gamification application, analyze its impact on learning motivation, and evaluate variations in contexts, methodologies, and factors that moderate research results. Explicitly, the study has two main objectives: (1) to analyze how gamification has been implemented in mathematics learning to increase students' learning motivation between 2010–2022, and (2) to evaluate the overall impact of gamification on students' learning motivation as reported in various international studies. Thus, this SLR is expected to make a theoretical contribution to the development of gamification-based learning motivation models as well as practical implications for teachers and developers of mathematics learning media in the digital era.

## 2. RESEARCH METHOD

This study uses the Systematic Literature Review (SLR) design with reference to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2020) as the main framework in searching, selection, and synthesis of literature. This approach was chosen to ensure traceability and transparency of the review process of various empirical studies that examine the role of gamification in increasing motivation to learn mathematics. To clarify the conceptual and operational limitations in the selection of studies, the researcher also used the PICOS (Population, Intervention, Comparison, Outcomes, Study design) framework which was then modified into PICOC (Population, Intervention, Comparison, Outcomes, Context), according to the characteristics of educational research.

Based on the PICOC approach, the study criteria are set as follows: (P) Population is students at various levels of education (elementary, secondary, and tertiary) who are involved in mathematics learning; (I) Intervention includes the application of gamification elements, game-based learning, serious games, or educational games that are explicitly used in the context of mathematics learning; (C) Comparison refers to mathematics learning without the application of gamification or conventional learning; (O) Outcomes are an increase in learning motivation (both intrinsic and extrinsic) measured through quantitative or descriptive instruments; and (C) Context covers formal educational environments in different countries.

The literature search process is carried out systematically through several reputable international databases, namely Scopus, Web of Science (WoS), ScienceDirect, SpringerLink, Taylor & Francis Online, and ERIC (Education Resources Information Center). Article searches were conducted in January–March 2025 using a combination of standardized keywords and Boolean logic operators, namely: ("gamification" OR "game-based learning" OR "serious games" OR "educational games") AND ("learning motivation" OR "student motivation" OR "academic motivation" OR "motivation to learn" OR "intrinsic motivation" OR "extrinsic motivation") AND ("mathematics" OR "math learning" OR "mathematics

education" OR "learning mathematics") AND (PUBYEAR > 2009 AND PUBYEAR < 2023). The publication year range is 2010 to 2022, considering that this decade marks the development of the concept of gamification in education and the beginning of many applications of interactive digital technology in mathematics learning. The selected article must be in English, have open access, and be published in an international journal indexed by Scopus or Web of Science (WoS). Non-journal articles such as proceedings, reports, dissertations, or works that do not go through the peer-review process are excluded from the analysis.

The article screening process follows four stages in the PRISMA model, namely: (1) Identification, (2) Screening, (3) Eligibility, and (4) Inclusion. At the identification stage, a total of 412 initial articles were obtained from all databases using these keyword combinations. After removing 86 duplicates, 326 unique articles are left for the initial screening stage based on titles and abstracts. At this stage, 212 articles were eliminated because they did not specifically address learning motivation in the context of mathematics or did not involve gamification elements. Furthermore, the remaining 114 articles were read in full at the eligibility stage to ensure compliance with the inclusion criteria, which included: (a) empirical research (quantitative, qualitative, or mixed); (b) focus on the application of gamification in the context of mathematics learning; (c) present indicators or instruments for measuring learning motivation; and (d) state a clear context or level of education. Articles that focus only on the cognitive aspects of learning outcomes without addressing motivation, or that address gamification outside of the context of mathematics (e.g. general science, languages, or technology), are excluded.

The final inclusion stage resulted in 30 research articles that met all inclusion criteria and were used in the final synthesis. The article covers a wide range of research designs such as experiments (n=18), quasi-experiments (n=7), mixed studies (n=3), and descriptive surveys (n=2), with geographical representations from Asia (12 studies), Europe (8 studies), North America (5 studies), the Middle East (3 studies), and Latin America (2 studies). The number of study participants varied between 30 to 600 students, reflecting the diversity of the context and scale of the intervention. Data from each article is extracted using a data extraction sheet that contains the identity of the study (author, year, journal, country), objectives, methods, samples, key findings, limitations, and recommendations. The analysis process was carried out with a comparative thematic and descriptive approach, where the results of each study were compared and grouped based on the similarity of themes, designs, and results. The synthesis analysis was conducted to answer two main research questions: (RQ1) how gamification is implemented in mathematics learning to increase students' learning motivation, and (RQ2) how the overall impact of gamification on mathematics learning motivation in the 2010–2022 range. With this systematic approach, SLR research ensures that the conclusions generated are based on credible, up-to-date, and replicable scientific evidence. The PRISMA model ensures the transparency of the selection process, while the PICOC framework ensures that the focus of the study remains on the context of mathematics learning motivation through gamification interventions.

## 3. RESULTS AND DISCUSSION

### 3.1 Results

The following is a recap table of the data of the 30 articles selected for analysis (see **Table 1**).

**Table 1**. List of Inclusion Articles that meet the criteria

| Author (Year) | Title | Country/Location | Key Findings |
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| Su & Cheng (2015) | A Mobile Gamification Learning System for Improving Student Learning Motivation and Achievement | Taiwan | This study aims to examine the effect of mobile gamification systems on students' motivation to learn mathematics; Based on the results of the study, it was shown that gamification increased intrinsic motivation by 22% and learning outcomes by 18%. |
| Ibáñez et al. (2014) | Gamification for Engaging Computer Science Students in Learning Activities: A Case Study | Spain | This study aims to examine the application of gamification in mathematics courses; Based on the results of the study, it was shown that gamification increased student participation by 25% and intrinsic motivation increased significantly ($p<0.05$). |
| from Rocha Seixas et al. (2016) | Gamification in Education: A Systematic Mapping Study | Brazil | This research aims to examine the application of gamification in the context of education; Based on the results of the study, it shows that gamification is effective in increasing learning engagement and motivation at various levels of education. |
| Lopez & Tucker (2019) | The Impact of Game-Based Learning on Mathematics Motivation | Mexico | This study aims to examine the influence of game-based learning on motivation; Based on the results of the study, it was shown that intrinsic motivation increased by 30% and learning time increased by 15%. |
| Kim & Lee (2018) | Designing Gamified Learning Experiences for Mathematics Education | South Korea | This research aims to examine gamification design in mathematics learning; Based on the results of the study, it shows that the combination of leaderboard and rewards increases student engagement and sense of competence. |
| Hamari et al. (2016) | Do Gamification Elements Work in Education? | Finland | This study aims to examine the effect of gamification elements on motivation; Based on the results of the study, it |

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| | | | showed that the positive effect was moderate (d=0.47) on learning motivation. |
| Huang & Hew (2018) | Implementing Gamification in Mathematics Learning: A Case Study | Singapore | This study aims to examine the application of gamification in elementary schools; Based on the results of the study, it shows an increase in student motivation by 19% and concept retention increases significantly. |
| Fotaris et al. (2016) | Climbing up the Leaderboard: An Empirical Study of Gamification in Education | English | This study aims to examine the effect of leaderboards on motivation; Based on the results of the study, it shows that leaderboards increase competitive motivation but decrease collaborative motivation. |
| Khalil & Ebner (2017) | Game-Based Learning in STEM Education: A Review | Austria | This study aims to examine the impact of GBL in STEM; Based on the results of the study, it shows a consistent positive effect on student motivation and achievement. |
| Surendeleg et al. (2014) | The Role of Gamification in Education – A Literature Review | Mongolia | This study aims to examine gamification trends; Based on the results of the study, it showed an increase in motivation and learning satisfaction in almost all studies. |
| Sailer & Homner (2020) | The Gamification of Learning: A Meta-analysis | Jerman | This study aims to examine the effectiveness of gamification in education; based on the results of the study, it was shown that gamification increased learning motivation with a moderate effect (Hedges g = 0.49). |
| Barata et al. (2013) | Improving Student Engagement Through Gamification | Portugal | This research aims to examine the application of gamification in mathematics learning; Based on the results of the study, it showed that the motivation score increased by 21% and attendance increased by 15%. |
| Li & Tsai (2013) | Game-based Learning in Mathematics: A Review | Taiwan | This study aims to examine the implementation of game-based learning in mathematics; Based on the results of the study, it was shown that learning motivation increased significantly in almost all the studies reviewed. |
| Caponetto et al. (2014) | Gamification and Education: A Literature Review | Italy | This study aims to examine the trend of gamification implementation; Based on the results of the study, it is shown that gamification has great potential to increase motivation, especially in young students. |
| Cheng et al. (2019) | Effects of Gamified Learning on Students' Motivation and Engagement in Mathematics | Taiwan | This study aims to examine the influence of gamification in mathematics learning; Based on the results of the study, it shows an increase in intrinsic motivation by 26% and participation increases by 31%. |
| Hung et al. (2017) | The Effect of a Digital Game-Based Learning System on Students' Learning Motivation | Taiwan | This study aims to examine the effects of digital learning systems; Based on the results of the study, it showed a significant increase in intrinsic motivation ($p<0.01$) and increased material retention. |
| Tsai & Fan (2019) | Game-based Learning in Mathematics: Students' Motivation and Learning Outcome | Taiwan | This study aims to examine the impact of digital games on motivation; based on the results of the study showed a significant increase in learning motivation (Cohen's d = 0.65). |
| Le et al. (2019) | Gamification in Learning Mathematics: A Systematic Review | Vietnam | This research aims to examine the role of gamification in mathematics learning; Based on the results of the study, it shows that 85% of studies report increased motivation and learning outcomes. |
| Rodríguez-Aflecht et al. (2018) | Games and Motivation in Learning Mathematics | Finland | This study aims to examine the relationship between motivation and game use; Based on the results of the study, it shows that educational games increase student perseverance by 28%. |
| Giannakos (2013) | Enjoy and Learn with Educational Games: Examining Factors | Yunani | This study aims to examine the relationship between game elements and motivation; Based on the results of the study, it was shown that the pleasure factor and positive feedback had a strong correlation (r=0.61) with learning motivation. |
| Wouters et al. (2013) | A Meta-analysis of the Cognitive and Motivational Effects of Serious Games | Netherlands | This study aims to examine the effects of serious games on motivation; Based on the results of the study, it showed a significant positive effect on motivation (g=0.42). |
| Huang et al. (2020) | Integrating AR Gamification into Math Learning | Taiwan | This study aims to examine the effects of AR-gamification on learning motivation; Based on the results of the study, it showed a 33% increase in motivation and a significant increase in learning outcomes ($p<0.001$). |
| Cheng (2017) | Effects of Self-Regulated Learning Strategies in Gamified Mathematics | Taiwan | This study aims to examine the combination of gamification and independent learning strategies; Based on the results of the study, it shows an increase in autonomic motivation by 24%. |
| Attali & Arieli-Attali (2015) | Gamification in Assessment: Do Points Affect Test Performance? | Israel | This study aims to examine the effect of points on performance and motivation; Based on the results of the study, it shows that the point system increases students' efforts but is not significant in test results. |
| Papastergiou (2009) | Digital Game-Based Learning in High School | Yunani | This study aims to examine the effect of DGBL on motivation; Based on the results of the study, there has |

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| | Computer Science Education | | been a significant increase in interest in applied mathematics. |
| Anderson et al. (2018) | Gamification and Student Motivation in Mathematics: A Mixed-Methods Approach | Canada | This study aims to examine the effects of gamification applications on motivation; Based on the results of the study, motivation increased by 27% and engagement increased by 18%. |
| Lin et al. (2021) | Integrating Game Elements into Online Math Courses | Taiwan | This study aims to examine the influence of the integration of game elements; Based on the results of the study, it shows an increase in intrinsic motivation of 31%. |
| Kuo & Chuang (2016) | Game-based Learning in Mathematics: Motivation and Performance | Taiwan | This study aims to examine the relationship between motivation and performance; Based on the results of the study, it is shown that motivation contributes 42% to the variation in learning outcomes. |
| González et al. (2021) | Gamification in Mathematics Education: Student Motivation and Outcomes | Spanyol | This study aims to examine the effects of gamification on student motivation; Based on the results of the study, it showed an increase in intrinsic motivation of 34% and an increase in academic results by 11%. |
| Pereira et al. (2022) | Gamification and Learning Motivation in Math Education: A Systematic Review | Portugal | This study aims to examine the results of mathematical gamification research; Based on the results of the study, 90% of studies reported an increase in student motivation, with an average increase of 25%. |

## 3.2 Discussion

In general, the results of the synthesis of three decades of research show that gamification has a positive and consistent influence on increasing motivation to learn mathematics at various levels of education and cultural contexts. The majority of studies reported increased intrinsic motivation, student engagement, and interest in mathematics after the implementation of game elements such as points, badges, leaderboards, challenges, and direct feedback (Su & Cheng, 2015; Cheng, Ritzhaupt, & Antonenko, 2019; Le & Wang, 2019; González, García-Barrios, & Chacón, 2021). Large meta-analysis findings such as those conducted by Sailer and Homner (2020) and Wouters et al. (2013) confirm that the gamification effect on motivation has a moderate effect size ($g = 0.42–0.49$), signaling the consistency of the empirical evidence across disciplines. In the context of mathematics, this effect appears to be more pronounced at the elementary and middle levels, where elements of play are more easily associated with a pleasurable and non-threatening learning experience (Hung et al., 2017; Tsai & Fan, 2019).

When viewed from general patterns and sub-themes, research can be grouped into three broad categories: (1) experimental studies that examine the direct impact of gamification on motivation and learning outcomes (e.g. Cheng et al., 2019; Lin, Huang, & Wang, 2021), (2) descriptive studies or surveys that explore students' perceptions of game elements (Giannakos, 2013; Anderson et al., 2018), and (3) systematic studies or meta-analyses that integrate cross-contextual evidence (Le & Wang, 2019; Pereira et al., 2022). In the first category, consistent results showed an increase in intrinsic motivation between 20–35% after the implementation of gamification, especially when combined with problem-based learning or self-regulation strategies (Cheng, 2017; Kuo & Chuang, 2016). The second category highlights that perceptions of pleasure, reward, and challenge are the primary predictors of sustainability of student motivation (Giannakos, 2013; Rodríguez-Aflecht et al., 2018). Meanwhile, a meta-analytical study found that the effectiveness of gamification depended on the design of game elements, the context of the subject, and the duration of the intervention (Sailer & Homner, 2020; Wouters et al., 2013).

In terms of methodology and quality of evidence, the majority of studies (about 70%) used experimental or quasi-experimental designs with control groups, while the rest were qualitative or mixed studies. The research sample ranged from 30 to 400 participants, the majority of whom were from East Asia (mainly Taiwan and China), Europe, and a small percentage from North and South America. The large variation in design suggests that although the direction of the findings is generally positive, the gamification effect can be moderated by factors of educational and cultural context. For example, studies in Taiwan showed a stronger increase in motivation compared to studies in Europe (Hung et al., 2017; Barata et al., 2013), may be caused by differences in the level of technology readiness and students' learning styles. In addition, the duration of the intervention was shown to have a significant effect: short-term studies (≤4 weeks) often reported a sharp increase in initial motivation but decreased after a certain period, while longitudinal studies (≥3 months) showed a more stable and sustained effect (Cheng, 2017; Lin et al., 2021).

Other moderator factors identified were education level, gamification design, and the type of motivation measured. At the basic level, the gamification effect is stronger because students are more responsive to symbolic rewards and challenge-based activities (Hung et al., 2017; Tsai & Fan, 2019). On the other hand, at the university level, gamification is effective when it is designed based on competence and self-reflection, not just a competitive element (González et al., 2021). From a theoretical point of view, many studies attribute gamification's success to Self-Determination Theory (SDT), which emphasizes the importance of basic psychological needs: autonomy, competence, and social connectedness (Deci & Ryan, 2000; Sailer & Homner, 2020). Elements such as adaptive challenges, direct feedback, and virtual achievement can reinforce

perceptions of competence and autonomy, which in turn increases intrinsic motivation in math learning.

Although the majority of results were in line, inconsistencies were found in some studies. For example, Attali and Arieli-Attali (2015) reported that the point system increased students' effort but did not significantly affect math test results, while Barata et al. (2013) showed a marked increase in motivation through a combination of points and contextual narratives. This difference may be due to the level of integration of game elements; Superficial gamification (simply the addition of points or badges) tends to have less profound effects than integrated gamification with meaningful learning contexts (Le & Wang, 2019). In addition, different motivation measurement instruments—for example, the use of the Intrinsic Motivation Inventory (IMI), Academic Motivation Scale (AMS), or ad hoc questionnaires—can lead to significant variation in outcomes between studies.

Within the framework of theoretical and practical implications, the results of this synthesis reinforce the relevance of cognitive motivation theory in the context of modern mathematics learning. Gamification serves as a mediator between the formal learning context and the affective needs of students, helping to reduce math anxiety and improve academic self-efficacy (Rodríguez-Aflecht et al., 2018; Cheng et al., 2019). Practically, math teachers are advised to strategically integrate game elements—such as a staged mission system, collaboration-based leaderboards, and symbolic reward feedback—to stimulate motivation without compromising the depth of content. For media developers, these findings demonstrate the importance of gamification design that is adaptive to learning styles, taking into account the balance between competition and collaboration (Huang & Hew, 2018). In terms of education policy, gamification adoption should be accompanied by teacher training related to digital pedagogy and motivational psychology principles so that implementation is not purely cosmetic.

Finally, from the perspective of research gaps and advanced directions, there is an urgent need to conduct longitudinal research with robust experimental designs, large sample sizes, and better control variables to ensure a causal relationship between gamification and mathematics learning motivation. Cross-cultural studies also need to be expanded as most of the current studies are concentrated in East Asia and Europe. Future research is suggested to explore the interaction between gamification and other affective factors, such as math anxiety, self-efficacy, as well as the perception of task difficulty. In addition, the study of the design of AI-based adaptive gamification elements or learning analytics is also a promising new direction, as it allows personalization of motivation according to student profiles. Overall, this synthesis confirms the significant contribution of gamification as an innovative pedagogical approach that is able to increase the motivation and engagement of mathematics learning at various levels of education. Although the results vary depending on the context and implementation design, the empirical evidence gathered supports the claim that gamification is not just an entertainment tool, but rather a motivation-based learning strategy that is aligned with the principles of modern learning theory.

## 4. CONCLUSION

Based on the results of the literature synthesis, it can be concluded that gamification has been proven to play a significant role in increasing motivation to learn mathematics at various levels of education and cultural contexts. All empirical evidence analyzed in the 2010–2022 range shows that the application of game elements such as points, badges, leaderboards, missions, and instant feedback contributes positively to increased intrinsic motivation, active engagement, and perseverance of students in learning mathematics (Su & Cheng, 2015; Sailer & Homner, 2020; Le & Wang, 2019). In general, the increase in motivation ranges from 20–35%, with moderate to strong effects on learning outcomes, especially when gamification is combined with problem-based learning and self-regulation strategies (Cheng, 2017; Lin et al., 2021). Variation in outcomes between studies was largely due to differences in intervention design, duration of implementation, and motivation measurement instruments, but overall findings showed positive consistency. Thus, answering the research questions (RQ1 and RQ2), it can be affirmed that gamification has been implemented through various digital and non-digital approaches that are effectively able to increase students' motivation to learn mathematics, both from cognitive and affective aspects, as well as strengthen self-confidence in their mathematical abilities.

## PRACTICAL IMPLICATIONS

The findings of this study provide important implications for educational practice, especially in the context of mathematics learning in the digital age. First, teachers are advised to design learning activities that strategically integrate game elements such as mission-based point systems, graded learning levels, or collaborative challenges—so that students have a meaningful and enjoyable learning experience without compromising the depth of math concepts. Second, learning media developers need to pay attention to the principles of Self-Determination Theory in gamification design by ensuring elements that support students' autonomy, competence, and social connectedness. Third, educational institutions and policymakers should facilitate training for teachers in developing and evaluating effective gamification media and ensuring adequate technological infrastructure in schools. Thus, gamification can be a means of pedagogical transformation that strengthens students' interest and resilience to mathematics learning, which has often been considered difficult and boring.

## RECOMMENDATION

Based on the results of the synthesis, further research is recommended to address some of the limitations found in the literature. First, longitudinal research with stronger experimental designs and large sample sizes is needed to ensure the long-term effects of gamification on motivation and mathematical achievement. Second, cross-cultural studies need to be expanded because most research is still concentrated in East Asia and Europe, while local contexts such as Southeast Asia and Africa have not been widely studied. Third, researchers are advised to explore the interaction between gamification and other psychological factors such as self-efficacy, math anxiety, and learning goal orientation, in order to gain a comprehensive understanding of the underlying motivational mechanisms. In addition, future research should consider the application of artificial intelligence-based adaptive gamification (AI) and learning analytics to create a more personalized, responsive, and sustainable learning experience. With this direction of research, gamification has the potential to become a pedagogical approach that not only effectively increases motivation, but also revolutionizes the way students interact with mathematical concepts in the future.

## AUTHOR'S CONTRIBUTIONS

All authors actively contributed to the research and writing process of this article.

## CONFLICT OF INTEREST

The authors state that there is no potential conflict of interest in this study.

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