Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran
Volume 16 (1) 25 – 43, 2026
ISSN: 2088-5350 (Print) / ISSN: 2528-5173 (Online)
Doi: 10.25273/pe.v16i1.29
The article is published with Open Access at: http://e-journal.unipma.ac.id/index.php/PE

Gamification in primary school mathematics: findings and implications from a systematic literature review

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Abstract: Gamification is increasingly applied in primary school mathematics, yet evidence on the consistency of its effects on students' learning outcomes and affective responses remains unclear. This systematic review analyzes the gamification elements and platforms used in primary school mathematics and their reported effects on learning. Following the PRISMA 2020 guidelines, Scopus, Web of Science, and journals accredited by SINTA (Indonesia's national accreditation system) were searched, with the final search conducted on October 20, 2026. English-language empirical studies published between 2016 and 2026, including journal articles and conference proceedings, were screened against predefined inclusion and exclusion criteria. Eleven studies involving students in grades 1–6 were included. The review protocol was developed in advance but not formally registered. Data extraction and quality assessment were performed independently by three researchers, and the findings were synthesized narratively. The results indicate that gamification can support mathematics achievement, engagement, motivation, and interest through points, badges, levels, challenges, and immediate feedback delivered via both digital and non-digital platforms. However, its effect on learning outcomes is not consistent across studies, and evidence on reducing mathematics anxiety remains limited. Heterogeneous designs and interventions, together with small samples in several studies, limit the strength of these conclusions. Gamification therefore holds promise as a supporting strategy in primary school mathematics, but its implementation should be aligned with learning objectives and student characteristics and evaluated through more rigorous research.

Keywords: gamification; mathematics learning; primary school; learning motivation; systematic literature review

Received 5 October 2026**; Accepted** 29 October 2026**; Published** 10 November 2026

Citation: Surya, A., Salimi, M., Hidayah, R., Wahyudi, A. B. E., & Wahyono. (2026). Gamification in primary school mathematics: Findings and implications from a systematic literature review. *Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran, 16*(1), 25–43. https://doi.org/10.25273/pe.v16i1.29

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INTRODUCTION

Mathematics plays an important role in equipping students with the 21st century skills such as critical thinking, problem-solving, creativity, communication, and collaboration (Toheri et al., 2019; Whitney-Smith et al., 2022). By using various approaches like problem-based learning and contextual problem-solving, this subject is expected to strengthen students' numerical literacy and prepare them to address the complexity of 21st century life challenges (Smit, 2016; Szabo et al., 2020). In the primary education context, mathematics helps cultivate skills that are also applicable to other learning disciplines (Chang et al., 2021; So et al., 2023). Therefore, early mathematics learning is believed to have a long-term impact on students' educational and developmental qualities (Bodovski & Youn, 2011; Cerezci, 2020).

However, this belief is not reflected in actual conditions. International studies like Trends in International Mathematics and Science Study (TIMSS) in 2015 report that fourth-grade primary school students in Indonesia achieved an average mathematics score of 397—well below the international average of 500 (Mullis et al., 2015). Consistent with these findings, Andrijati et al. (2020) reported that the mathematical reasoning ability of fourth-grade primary school students in Tegal City remains low to moderate, with 53% of students falling into the low category. Studies in different countries like South Africa and Kuwait also support this issue, highlighting that primary school students' achievement in mathematics is still relatively low (Al-Mutawa et al., 2021; Isdale et al., 2017). This condition reflects poor mastery in mathematical basic concepts.

In addition to cognitive issues, students' perception towards mathematics also emerges as one of the barriers to achieve the learning objectives (Howard & Whitaker, 2011). Students often perceive mathematics as a difficult subject (Akhter & Akhter, 2018; Amanatallah & Safa, 2023; Barnes & Raghubar, 2014) and suffer from mathematical anxiety. Mathematics anxiety can interfere with cognitive processes—specifically the use of working memory—when solving mathematical problems (Ashcraft, 2002). This anxiety hinders individuals from solving mathematical problems in various situations, both in classroom contexts and in daily life contexts (O'Leary et al., 2017). This non-cognitive factor has been reported to significantly lower students' achievement because it causes lower self-confidence and problem-solving initiatives, and weakens their ability to draw connections among mathematical domains (Blazer, 2011; Zakaria & Nordin, 2008; Zhu et al., 2024). Consistent with these findings, Ramirez et al. (2018) summarize evidence indicating that mathematics anxiety is linked to lower mathematical achievement, though this relationship may be bidirectional. Therefore, mathematics anxiety should be addressed as early as possible to mitigate its negative impact on students' learning development. This is particularly important in the primary education context where children are still in concrete thinking stage, need enjoyable learning experience, and are significantly influenced by their environment in order to develop self-confidence (Muthivhi, 2015).

Children at this age also tend to learn through interactive activities like games (Hsieh et al., 2015; Kim et al., 2017) and can understand a concept better when presented in the form of direct, interactive, and playful experiences (Fletcher et al., 2024). They also often have a high level of curiosity and a need for positive affirmation. In addition, children's inclination toward competition and collaboration makes games effective means for improving their learning engagement (Evans et al., 2023). A learning approach that integrates play elements may be aligned with the characteristics of children at the primary education level. Such an approach also has the potential for reducing anxiety while developing intrinsic motivation to learn mathematics (Divjak & Tomić, 2011; Fadda et al., 2022; Partovi & Razavi, 2019).

Gamification is among various innovative pedagogical approaches to address children's characteristics. It integrates gaming elements like points, levels, challenges, rewards, and narratives into non-gaming contexts, including mathematics learning (Deterding et al., 2011; Ružic & Dumancic, 2015; Yadav & Yadav, 2024). Gamification has been proven to improve cognitive outcomes, motivation, and engagement, in addition to a more enjoyable learning experience perceived by students (Alsawaier, 2018; Hamari et al., 2014; Koivisto & Hamari, 2019;

Sailer & Homner, 2020). It has also been reported to develop the socio affective aspects relevant to the 21st-century learning (Figueroa-Flores, 2016).

Several previous studies have conducted systematic reviews on gamification and digital games in mathematics education. Vrcelj et al. (2023) reviewed gamification in primary and secondary education across various subjects; however, they did not specifically address its characteristics and impact within the context of primary school mathematics. Yan and Matore (2023) mapped research trends in gamification within mathematics education—along with its effects on affective, cognitive, and psychomotor aspects—but their scope was not limited to the primary school setting. Fadda et al. (2022) provided quantitative evidence regarding the influence of digital games on the mathematics motivation of K–12 students, though their work was not intended to synthesize a broad range of mathematics learning outcomes. Dan et al. (2024) focused on digital game-based learning in primary school mathematics, mapping out mathematical topics, methodologies, research findings, as well as the types and modes of games used. Meanwhile, Jutin and Maat (2024) examined the effectiveness of gamification in mathematics learning, reporting its potential benefits for engagement, motivation, retention, academic performance, social and cognitive skills, and mathematics anxiety.

Although several previous systematic reviews have examined gamification and game-based learning in mathematics, this review offers a more focused analysis specifically on mathematics education in primary schools. The contribution of this review lies in three aspects. First, it focuses specifically on primary school students. Second, it maps the gamification elements and strategies employed and examines their connections to cognitive and affective dimensions. Third, it encompasses empirical research published during the 2016–2026 period. By integrating these three aspects, this review provides a targeted synthesis regarding the application of gamification and its impact on mathematics learning outcomes at the primary school level. Thus, this review contributes through its specific focus on primary school mathematics education, the mapping of gamification elements and strategies, and an analysis of their links to cognitive and affective dimensions over the 2016–2026 period. To clarify the scope of the study, this review is guided by the following three research questions: 1) What gamification elements and platforms are used in mathematics education in primary schools? 2) How does the application of gamification in mathematics education affect the mathematics learning outcomes of primary school students compared to instruction without gamification or alternative pedagogical approaches (where a comparison group is available)? 3) How does the application of gamification in mathematics education relate to the affective dimensions of primary school students—specifically their motivation, engagement, interest, and attitudes toward mathematics?

METHODS

Research Design

The method used in this study was a systematic literature review (SLR). A systematic literature review is a method for synthesizing scientific evidence in a comprehensive and structured manner, aimed at answering specific research questions through transparent, explicit, and replicable procedures (Lame, 2019). This study employs a systematic literature review (SLR) method to examine empirical research on the application of gamification in mathematics instruction within primary schools. A review protocol was developed, outlining the criteria for article selection, search strategies, data extraction, and data analysis procedures; however, this systematic review protocol was not formally registered.

Information Sources and Search Strategies

The literature search was conducted using three information sources: Scopus, Web of Science, and national scholarly journals accredited by the Science and Technology Index (SINTA) in Indonesia. Scopus and Web of Science were used to identify international scholarly publications, while SINTA-accredited journals were used to capture research published in Indonesian

national journals. Utilizing these three sources ensures comprehensive coverage of relevant research on the application of gamification in mathematics education at the primary school level.

The search strategy was developed using a combination of keywords related to gamification, primary education, and mathematics learning. The keywords employed included "gamification," "primary school," "elementary school," "primary education," "mathematics learning," and "mathematics education." These keywords were combined using the Boolean operators AND and OR to identify publications aligned with the research focus. For the search within SINTA-accredited national journals, Indonesian-language keywords—such as gamifikasi (gamification), matematika sekolah dasar (primary school mathematics), and pembelajaran matematika (mathematics learning)—were also used to capture relevant publications.

The search was limited to publications from the years 2016–2026, in accordance with the established eligibility criteria for the articles. The search strategy, applied limitations, and the final search date (October 20, 2026) were recorded for each information source to ensure the search process remains traceable and replicable. The identified articles were subsequently screened based on the inclusion and exclusion criteria established for this study.

Eligibility Criteria

The inclusion and exclusion criteria in this study were established to maintain consistency, transparency, and validity in the literature selection process so that the synthesis results could be scientifically justified (Christou et al., 2025). The inclusion and exclusion criteria are presented in Table 1.

TABLE 1. *Eligibility criteria*

Aspect	Inclusion criteria	Exclusion criteria
Research focus	Empirical research that explicitly examines the implementation of gamification in mathematics education at the primary school level	Research that does not address mathematics education or does not examine the implementation of gamification.
Definition of gamification	Research that incorporates game elements—such as points, badges, leaderboards, levels, challenges, or game-based feedback—into a non-game mathematics learning context.	Research that solely utilizes games as a teaching method (game-based learning) or employs "serious games" without integrating specific gamification elements into the learning activities
Educational level	Research involving primary school students (typically grades 1–6, or approximately 6–12 years of age).	Research involving only early childhood, secondary, or higher education students.
Special educational needs	Research conducted in regular schools, as well as in settings or classrooms for students with special educational needs or exceptional abilities, provided the context is primary school mathematics education and other criteria are met.	Research unrelated to primary school mathematics education.
Research design	Empirical research utilizing quantitative, qualitative, or mixed-methods designs that report on the implementation or evaluation of gamification.	Systematic literature reviews, scoping reviews, meta-analyses, editorials, opinion pieces, or other non-empirical publications.
Outcomes examined	Research that reports on the outcomes of gamification, such as mathematics learning achievement, conceptual understanding, problem-solving, motivation, engagement, attitudes, or students' social aspects.	Research that does not report outcomes related to mathematics learning or student responses to the implementation of gamification.
Publication type	Research articles published in academic journals or conference proceedings, available in full-text format.	Non-academic publications, duplicate articles, and articles for which the full text is unavailable.
Publication language	Articles published in English.	Articles published in languages other than English.
Publication year range	Articles published during the 2016–2026 period, in accordance with the search timeframe established for the study.	Articles published before 2016 or after the 2026 search cutoff date.

Study Selection

The eligibility assessment of the articles was conducted by two researchers (A.S. and M.S.), who independently reviewed the titles and abstracts based on pre-established inclusion and exclusion criteria. Articles that potentially met the criteria were then subjected to a full-text review to determine their suitability for inclusion in the study. Any discrepancies in the assessments were resolved through consensus, with the involvement of other researchers (R.H., A.B.E.W., and W.).

Data Extraction and Quality Assessment

Data extraction and quality assessment of the articles were conducted independently by three researchers. Information obtained from each study was recorded and compiled into an evidence table to facilitate the organization and analysis of the research findings. Data collection from the primary studies involved all five authors of the article—A.S., M.S., R.H., A.B.E.W., and W. Any discrepancies in the extraction results or assessments were resolved through discussion to reach a consensus among the reviewers.

Data Collection Process

The selection and data collection process in this study is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). This process includes the identification of articles, removal of duplicates, screening of articles, assessment of full-text eligibility, and determination of the studies to be included in the review.

In the identification phase, articles were searched for via Scopus, Web of Science, and national journals accredited by SINTA, following established information sources and search strategies. Any articles identified through reference searching or other methods were recorded separately. All identified records were then examined to detect and remove duplicates before the screening process began.

During the screening phase, the titles and abstracts of the articles were reviewed for their relevance to the research focus: the application of gamification in mathematics education at the primary school level. Irrelevant articles were excluded from the selection process. For the remaining articles, the full texts were retrieved and assessed for eligibility based on predefined inclusion and exclusion criteria—specifically, a focus on mathematics education, the primary school level, the presence of gamification elements, the use of empirical research methods, and the reporting of learning outcomes. Articles that did not meet these criteria were excluded, with the reasons for their exclusion documented.

Articles that met all eligibility criteria were then included in the synthesis. Information from each included article was extracted based on study characteristics, gamification elements, mathematics learning outcomes, and findings relevant to the research questions. The number of records identified, removed, screened, assessed for eligibility, and ultimately included is documented in the PRISMA 2020 flow diagram, as presented in Figure 1.

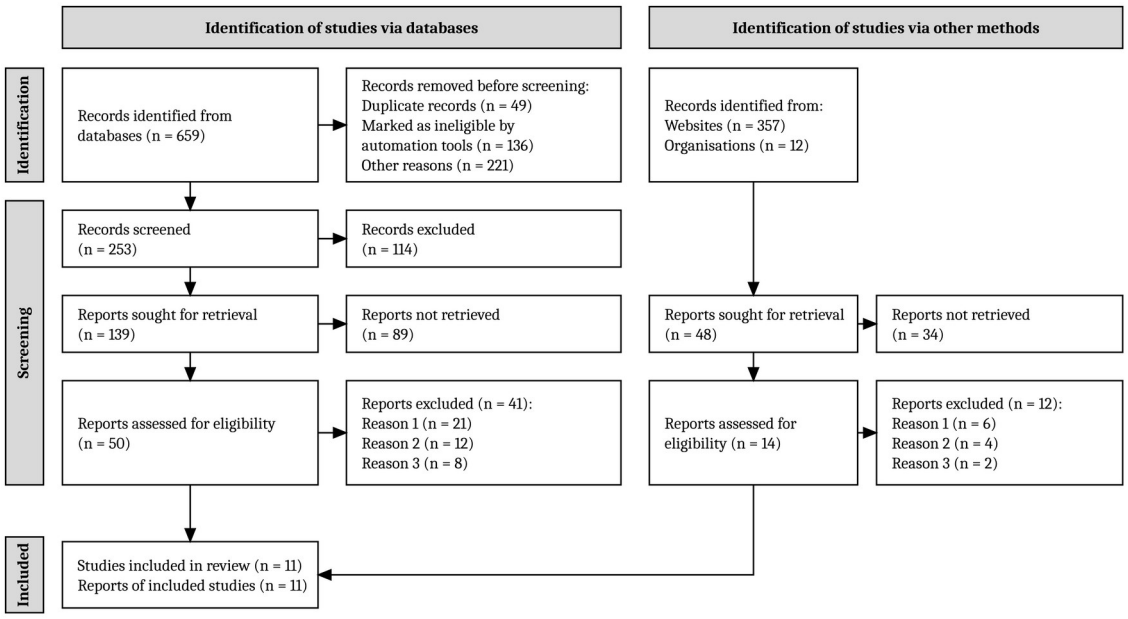


FIGURE 1. *PRISMA 2020 flow diagram of the study selection process*

RESULTS

Based on the review process, 11 articles were identified that discussed the use of gamification in mathematics learning. These articles examined the elements, activities, and impacts of gamification in elementary mathematics education. A summary of the reviewed articles is presented in Table 2.

TABLE 2. *Characteristics and main findings of the included studies*

No.	Study and country	Research design	Participants	Mathematical content	Gamification elements and platform	Duration	Comparison condition	Outcome measures	Main findings
1	Guro & Corpuz (2025) Philippines	Quasi-experimental (non-equivalent control and experimental groups, pretest–posttest)	80 Grade 5 students at Mulondo Central Elementary School (40 control, 40 experimental)	Grade 5 first-quarter mathematics curriculum	**Elements:** points, levels/progress bars, badges, leaderboards, rewards, team challenges **Platform:** game-based activities adapted from DepEd K to 12 Self-Learning Modules and a Minecraft Education Edition context	1 school year (2023–2024)	**Control:** traditional instruction **Experimental:** gamification strategy	40-item mathematics pretest and posttest; student attitude survey questionnaire	**Pretest:** equivalent baseline skills ($p = 0.112$). **Attitude:** strongly positive ($M > 3.50$). **Posttest:** control ($M = 13.68$) outperformed experimental ($M = 12.10$), $p < 0.001$.
2	Phuntsho & Dorji (2025) Bhutan	One-group pretest–posttest design	32 Grade 5 students (18 boys, 14 girls) at Phuensum Primary School, Samtse	Fractions, multiplication, and geometry	**Elements:** points, levels, challenges, small-group dynamics, competitive/interactive tasks **Platform:** digital	7 weeks	No control group; pre- vs. post-intervention comparison	Mathematics Achievement Test (20 multiple-choice and 10-mark extended items); 15-item Student Engagement Scale (behavioral, emotional, cognitive)	**Achievement:** posttest ($M = 62.3$) > pretest ($M = 48.7$), $t(31) = 19.23$, $p < 0.001$, $d = 3.36$. **Engagement:** total score rose from 51.84 to 68.54, with gains in all three domains.
3	Turkmen & Soybas (2019) Turkey	Mixed methods (quasi-experimental pretest–posttest control group with observations and interviews)	50 Grade 5 students in Nigde (28 experimental, 22 control)	Fractions	**Elements:** points, scoring systems, direct feedback, competition, rules, game scenarios **Platform:** Educational Informatics Network (EBA) digital games and applications	14 weeks (28 lesson hours; 2 lessons/week)	**Control:** curriculum instruction without digital games **Experimental:** gamified learning with EBA games	20-item Mathematics Academic Achievement Test; Mathematics Attitude Scale; observations and unstructured interviews	**Achievement:** experimental 10.14 → 13.39; control 10.59 → 13.27; no significant between-group difference ($p = 0.922$). **Attitude:** significant within-group gain in the experimental group (2.91 → 3.08, $p = 0.015$); no significant between-group difference ($p = 0.328$). **Qualitative:** peer collaboration, lower anxiety, more enjoyment and participation.
4	Karamert & Vardar (2021) Turkey	Quasi-experimental	46 Grade 5 students (23 experimental, 23 control)	Fractions (Grade 5 curriculum)	**Elements:** pyramidal design model (avatars, badges, progress map, collections, content unlocking, levels, points, quests, teams) **Platform:** physical, non-digital materials	6 weeks (5 hours/week; 30 hours)	**Control:** non-gamified instruction based on the national curriculum **Experimental:** instruction with physical gamification elements	24-item multiple-choice achievement test on fractions; 21-item 4-point Attitude Scale towards Mathematics	**Achievement:** experimental 27.89 → 60.14; control 27.17 → 47.10; significant difference favoring the experimental group ($U = 143.00$, $p = 0.007$). **Attitude:** no significant between-group difference ($U = 243.50$, $p = 0.644$) or within-group change ($p = 0.843$).
5	Laksana et al. (2024) Indonesia	Quasi-experimental	108 students at a Muhammadiyah elementary school in Ponorogo (55 experimental, 53 control)	Mathematical problem solving	**Elements:** rewards, levels, challenges, open-world/exploratory mechanics, social cooperation **Platform:** application-based digital gamification	During regular mathematics lessons	**Control:** conventional teaching without digital gamification **Experimental:** mathematics learning with digital gamification	Problem-solving test; Metacognitive Awareness Inventory (MAI)	**Gamification effect:** significant, favoring digital gamification ($F = 5.231$, $p = 0.024$). **Metacognition effect:** significant ($F = 47.963$, $p < 0.001$). **Interaction:** significant ($F = 7.649$, $p = 0.001$).

(continued on next page)

TABLE 2. *(Continued)*

No.	Study and country	Research design	Participants	Mathematical content	Gamification elements and platform	Duration	Comparison condition	Outcome measures	Main findings
6	Rahayu et al. (2026) Indonesia	One-group pretest–posttest (quasi-experimental)	28 Grade 2 students in Malang City	Addition and subtraction of whole numbers	**Elements:** scores, levels, interactive quiz challenges, inter-group competition, star-sticker rewards **Platform:** digital media built with Genially and Educaplay	3 stages (pretest, gamified treatment, posttest)	No control group; pre- vs. post-intervention comparison within the Team Games Tournament model	20-item learning interest questionnaire (4-point Likert: enjoyment, involvement, interest, attention)	**Interest:** posttest ($M = 77.46$) > pretest ($M = 56.86$); Wilcoxon $Z = -4.624$, $p < 0.001$; all 28 students improved.
7	Jagust et al. (2018) Croatia	Within-subjects repeated-measures quasi-experiment with focus group interviews	54 students (27 female, 27 male) in two Grade 2 classes and one Grade 3 class	Addition/ subtraction 0–100; multiplication/division by 2, 3, 4, 5; multiplication by 0	**Elements:** leaderboard, points, narrative (computer-virus scenario), time-adaptive algorithm, group score aggregation **Platform:** custom "Math Widget" mobile platform on tablets	4 sessions of 15 minutes (November 2016–April 2017)	Four conditions: non-gamified, competitive, adaptive, collaborative	In-app logs (completion rate, time, correct and incorrect attempts); focus groups (15 students)	**Performance trend:** gamified conditions sustained or increased performance, whereas non-gamified showed a decline ($p = 0.002$). **Adaptive:** highest gain, outperforming non-gamified ($p < 0.05$), but most incorrect attempts (22%, $p = 0.028$).
8	Lee & Lai (2024) Taiwan	Two-stage sequential quasi-experiment (CCA baseline → GCA treatment vs. continuous CCA) with lag sequential analysis and interviews	52 Grade 5 students (26 experimental, 26 control)	Equivalent fractions; addition and subtraction of fractions with unlike denominators	**Elements:** virtual monster roles, real-time points, rubrics for group/personal encouragement, reminders **Platform:** collaborative argumentation platform (ClassDojo module, tablets)	4 weeks (2 weeks/560 min CCA; 2 weeks/560 min GCA)	**Control:** conventional collaborative argumentation (CCA) for 4 weeks **Experimental:** CCA then gamified collaborative argumentation (GCA)	100-point achievement test; intrinsic/extrinsic motivation scale (6 items); tendency to collaborate (5 items); coding of argumentation behaviors; interviews	**Achievement:** GCA > CCA ($F = 5.71$, $p < 0.05$). **Motivation:** intrinsic ($F = 20.55$, $p < 0.001$) and extrinsic ($F = 8.97$, $p = 0.004$) higher. **Collaboration:** higher in GCA ($F = 49.01$, $p < 0.001$).
9	Widodo & Rahayu (2019) Indonesia	Mixed methods (quasi-experimental pretest–posttest control group with interviews and observations)	Grade 3 students in Purwakarta, West Java, across public, private, and religious-based schools	Multiplication, addition, and subtraction	**Elements:** game rules, dice (6-, 8-, 10-, 20-sided), honeycomb map, cards, point-based competition, win conditions, referee/peer roles **Platform:** paper-based board games ("Beemmath" and "Kurtacil")	3 treatment sessions	**Experimental:** instruction with arithmetic games during exercises **Control:** direct instruction without gamified exercises	Multiplication achievement test (max. 15); N-gain; mastery (score ≥ 70%)	**Mastery:** students reaching mastery rose from 28 to 53. **N-gain:** moderate in public (0.51) and private (0.47) classes; low in the religious-based class (0.16) owing to high baseline scores. **Engagement:** positive perceptions; all students reported better understanding.
10	Rahim et al. (2024) Pakistan	Quantitative descriptive survey	27 Grade 5 students in Gorikote, Astore District	Primary school mathematics (general)	**Elements:** points, leaderboards, competition, interactive quizzes, immediate feedback **Platform:** Kahoot (digital)	Not reported (students with prior Kahoot experience)	No control or comparison group	22-item 5-point Likert perception questionnaire (CVI = 1; Cronbach's $\alpha > 0.70$)	96.3% found Kahoot enjoyable and helpful for mathematical skills; 92.6% responded positively to its immediate feedback and interactivity.
11	Sucipto et al. (2026) Indonesia	Quasi-experimental non-equivalent control group with pretest–posttest	93 Grade 5 students (47 gamification, 46 traditional)	Integers, fractions, decimals, measurement, perimeter, and area	**Elements:** points, badges, levels, stories, progress boards, tiered challenges, immediate feedback **Platform:** non-digital/low-tech	4–6 sessions of 70–90 minutes	**Control:** traditional teaching **Experimental:** low-tech gamification	Achievement test; N-gain; Hedges' g; mastery; observation of engagement	**Achievement:** adjusted mean 79.2 vs. 72.7, $F(1, 89) = 11.0$, $p = 0.0012$. **N-gain:** 0.53 vs. 0.37; mastery 83% vs. 63%. **Engagement:** 78.6% vs. 68.1%.

DISCUSSION

Gamification Elements and Platforms in Mathematics Learning in Elementary Schools

A systematic review indicates that the implementation of gamification in mathematics education at the primary school level incorporates a variety of game elements, including points, levels, badges, leaderboards, rewards, challenges, immediate feedback, narratives, and collaborative activities. These elements serve distinct functions—ranging from tracking learning progress and providing reinforcement to presenting challenges and facilitating interaction among students. Jagust et al. (2018), for instance, integrated points, leaderboards, narratives, aggregated group scores, and adaptive algorithms into the "Math Widget" platform. Their research findings demonstrate that an adaptive gamified environment leads to better mathematical performance compared to a non-gamified one. Meanwhile, Lee and Lai (2024) incorporated game roles, points, positive reinforcement, and rubrics into collaborative learning to foster mathematical argumentation in the context of fractions. These findings suggest that gamification elements can be embedded within instructional designs that go beyond mere task completion, creating space for interaction and the development of mathematical thinking.

Theoretically, gamification elements can be understood as design components that shape the learning experience through goals, challenges, feedback, and social interaction. Grabner-Hagen and Kingsley (2023) explain that gamification elements can be leveraged to support intrinsic motivation, social engagement, and students' perceptions of achievement. The effectiveness of gamification highly depends on the harmony between these elements and the learning context. Clear narratives and personalized feedback can help foster cognitive engagement, while the combination of meaningful rewards and social interaction has been shown to increase students' motivation without creating an overly competitive atmosphere (Smiderle et al., 2020).

In addition to the variety of elements, the review indicates that gamification can be implemented through both digital and non-digital platforms. Digital platforms are used to provide interactive quizzes, score tracking, immediate feedback, and monitoring of learning progress. Phuntsho and Dorji (2025) implemented digital gamification through activities involving points, levels, challenges, and group interactions, while Rahayu et al. (2026) utilized Genially and Educaplay to integrate scores, levels, interactive quizzes, competition, and rewards into the learning of addition and subtraction operations. Turkmen and Soybas (2019) also employed digital games and applications for teaching fractions. These research findings suggest that the use of digital platforms incorporating gamification elements contributes to improved scores among elementary school students in mathematics, although some studies indicate that no significant impact has yet been observed. This aligns with literature reviews reporting that gamification—when integrated into e-learning systems through the inclusion of gamification elements—can influence both the learning process and learning outcomes (Saleem et al., 2022).

Conversely, non-digital gamification utilizes physical media and simple materials to construct game-based learning experiences. Karamert and Vardar (2021) employed physical game materials for teaching fractions, while Widodo and Rahayu (2019) developed arithmetic games based on dice, cards, and game boards. Sucipto et al. (2026) also implemented low-tech gamification by combining elements such as points, badges, progress boards, narratives, tiered challenges, and immediate feedback. A synthesis of the findings further indicates an improvement in student scores through the application of non-digital gamification. These results align with previous research, which suggests that non-digital gamification can have a positive impact on the outcomes and performance of elementary school students in mathematics learning (Russo et al., 2024; Setambah et al., 2024).

This variation demonstrates that gamification elements are not dependent on the use of digital applications; rather, they can be implemented through physical media designed with clear rules, objectives, and game mechanics. The primary distinction between the two platforms lies in the means of implementation and the nature of the interactions they facilitate. Digital platforms can automate score tracking and the provision of feedback, whereas non-digital games allow teachers to manage rules, challenges, and interactions directly through tangible

materials. Consequently, both approaches serve as viable alternatives for mathematics instruction, depending on the specific learning objectives, subject matter, and the context in which the instruction takes place.

The Influence of Gamification on the Mathematical Cognitive Ability Dimensions of Elementary School Students

A systematic review indicates that gamification has the potential to support mathematics learning outcomes for elementary school students within the cognitive domain; however, its impact must be examined by taking several components into account. Some studies show significant advantages in learning outcomes, while others report score improvements that do not differ significantly from those of control groups. This pattern suggests that the effectiveness of gamification cannot be assessed solely based on score increases following an intervention; rather, it requires consideration of intergroup comparisons, the characteristics of the instructional design, the nature of the intervention, and the specific type of mathematical ability being measured.

Evidence supporting the effectiveness of gamification can be seen in studies that report significant differences between gamified groups and comparison groups. Karamert and Vardar (2021) found a significant difference in mathematics achievement ($p=0.007$). Lee and Lai (2024) reported superior learning outcomes in gamification-based collaborative learning ($F=5.71$, $p<0.05$), while Laksana et al. (2024) found a significant impact on mathematical problem-solving skills ($F=5.231$, $p=0.024$). A similar pattern was observed by Sucipto et al. (2026), who reported adjusted mean learning outcomes of 79.2 for the gamified group and 72.7 for the traditional learning group ($F(1,89)=11.0$, $p=0.0012$). The N-gain score for the gamified group was also higher than that of the control group, at 0.53 and 0.37, respectively. Overall, these research findings indicate that gamification can support mathematics achievement.

Beyond test results, gamification also has the potential to support the development of mathematical performance throughout the learning process. Jagust et al. (2018) found that gamified activities can maintain or improve mathematical performance over time, whereas non-gamified activities showed a declining trend ($p=0.002$). Adaptive conditions outperformed non-gamified conditions ($p<0.05$). Meanwhile, Widodo and Rahayu (2019) reported an increase in the number of students reaching mastery—from 28 to 53—through the use of dice- and card-based arithmetic games. These findings regarding the effectiveness of gamification align with research by Agustin et al. (2025), which indicates that the implementation of gamification can positively influence mathematical achievement, including by enhancing conceptual understanding and learning outcomes among elementary school students. Furthermore, a study by Pires et al. (2019) also highlights the potential of gamification to improve mathematics learning outcomes through activities that foster reasoning and problem-solving skills. Theoretically, the "Theory of Gamified Learning" posits that gamification can influence learning outcomes by driving changes in behavior and relevant learning processes (Landers, 2014).

However, these positive results are not universal. Turkmen and Soybas (2019) found no significant difference in learning outcomes between the experimental and control groups in the post-test ($p=0.922$), even though both groups showed an increase in scores. Guro and Corpuz (2025) reported that the implementation of gamification did not have a significant effect on mathematics performance ($F = 1.605$, $p = 0.112$). Phuntsho and Dorji (2025) also reported an increase in the mean learning outcome from 48.7 to 62.3 ($t(31)=19.23$, $p<0.001$, $d=3.36$). Nevertheless, that study employed a single-group design without a control group; therefore, the improvement observed following the intervention cannot be definitively attributed solely to gamification. This varied pattern aligns with a systematic review by Tonioka et al. (2025) which reported that 86.7% of the 15 studies examined showed positive results, while 13.3% did not demonstrate effectiveness. These findings reinforce the notion that the potential effectiveness of gamification in mathematics education may depend on various components to achieve academic success.

The effectiveness of gamification in mathematics education can be influenced by game design, the alignment of gamification elements with learning objectives, student characteristics,

the learning environment, the teacher, and the duration of the intervention. Zeng et al. (2024) examined factors such as geographical region, educational level, learning environment, field of study, and game elements in relation to academic achievement. Diaz et al. (2024) also analyzed region, educational level, field of study, learning modality, and the specific gamification application used as moderating variables. Meanwhile, Vazquez-Cano et al. (2023) emphasized the importance of aligning gamification applications with the curriculum, feedback, assessment, and accessibility, as well as maintaining a balance between the level of challenge and students' abilities (Leiss et al., 2025). Furthermore, teachers' perceptions and their capacity to implement gamification can also influence its application and overall success in the classroom. Consequently, the varied outcomes of gamification in mathematics education should be examined by considering both the game design and the context of its implementation, rather than focusing solely on the presence of game elements.

The Influence of Gamification on the Affective Dimension of Mathematics Learning among Elementary School Students

Beyond academic achievement, gamification is used to support engagement, motivation, interest, and attitudes toward learning mathematics. Findings in this area generally indicate that gamification can serve as a means to make learning activities more interactive. Regarding attitudes, Guro and Corpuz (2025) reported that elementary school students held a highly positive attitude toward mathematics, with a score greater than 3.50—falling into the "highly positive" category. Turkmen and Soybas (2019) found a significant improvement in attitudes within an experimental group ($p = 0.015$); however, the difference between the experimental and control groups was not statistically significant ($p = 0.328$). Theoretically, shifts in attitude can be explained by the mechanisms of gamification that shape a student's learning experience. Gamification incorporates various game-design elements that can influence user experience and responses (Robson et al., 2015). In the context of mathematics education, clear goals, immediate feedback, challenges, and reinforcement for success can help students feel more capable and comfortable while learning (Sinay & Nahornick, 2016). Such positive experiences may foster a more favorable attitude toward mathematics. Nevertheless, the results from Turkmen and Soybas (2019) suggest that improvements in attitude within an experimental group do not necessarily translate into a significant difference when compared to a control group. Similarly, Karamert and Vardar (2021) found no significant difference in attitudes between groups ($p = 0.644$). These inconsistencies may stem from variations in students' initial conditions or the specific design of the gamification implementation; however, these factors require further investigation before they can be definitively identified as the underlying causes. In summary, while gamification has the potential to cultivate a positive attitude toward learning mathematics, evidence that it consistently produces better attitudes compared to conventional instruction remains limited.

A positive trend is evident in research measuring student engagement. Phuntsho and Dorji (2025) reported an increase in engagement scores from 51.84 to 68.54 following an intervention. Sucipto et al. (2026) found task engagement to be 78.6% in the gamified group, compared to 68.1% in the traditional learning group, and identified a positive predictive relationship between engagement and post-test results ($p=0.004$). These findings align with research suggesting that gamification can enhance student engagement in learning (Qiao et al., 2023; Solekhah et al., 2023; Taşkın & Çakmak, 2023).

Lee and Lai (2024) also reported significant differences in intrinsic motivation ($F=20.55$, $p<0.001$) and extrinsic motivation ($F=8.97$, $p=0.004$). Taken together, these findings suggest that gamification can support participation and the learning experience, particularly when game-based activities are integrated with mathematical interactions and tasks. These findings align with research indicating that gamification can enhance both the extrinsic and intrinsic motivation of students (Bovermann & Bastiaens, 2020; Buckley & Doyle, 2016; Faiella & Ricciardi, 2015).

Regarding interest and perception, Rahayu et al. (2026) reported an increase in interest in learning mathematics, with the mean score rising from 56.86 to 77.46 ($Z = -4.624$, $p < 0.001$).

Meanwhile, Rahim et al. (2024) found that 96.3% of respondents provided positive feedback concerning the enjoyment and utility of Kahoot, while 92.6% responded positively regarding its feedback mechanisms and interactivity. Theoretically, the concept of "situational interest" posits that engaging characteristics within a learning environment can trigger students' attention and interest toward the activities in which they are participating (Durmus, 2016; Magen-Nagar & Steinberger, 2017).

This synthesis highlights a distinction between the learning experience and academic achievement. While gamification can make activities more engaging, encourage participation, or boost motivation, such responses do not automatically translate into superior learning outcomes (Alt, 2023). Conversely, mathematics achievement may improve without any significant shift in attitudes. Therefore, engagement, motivation, interest, attitudes, perceptions, and learning outcomes should be treated as distinct dimensions. Consequently, evaluating gamification requires measuring these various outcomes separately and examining the relationships between them, if one wishes to explain how the learning experience relates to mathematics achievement.

CONCLUSION

The results of a systematic literature review indicate that gamification has the potential to support mathematics learning among elementary school students, particularly in terms of achieving learning outcomes and developing mathematical cognitive abilities, such as conceptual understanding and problem-solving. Several studies have reported better learning outcomes in groups that implemented gamification compared to comparison groups. However, other studies have found no significant difference between the two groups. Consequently, the available findings are insufficient to conclude that gamification is consistently more effective than other approaches to learning.

Varied research findings indicate that the implementation of gamification requires careful consideration of how game elements align with mathematics learning objectives, student characteristics, the design of the intervention, and the specific context in which it is applied. While elements such as points, badges, levels, challenges, feedback, and collaborative activities can be incorporated into instructional design, their presence alone does not guarantee improved learning outcomes. Furthermore, evidence regarding affective aspects—specifically mathematics anxiety—remains limited; therefore, no definitive conclusion can yet be drawn as to whether gamification is effective in reducing such anxiety.

The findings of this review should be interpreted with consideration for the limitations of the evidence, including the relatively small sample sizes in several studies, the diversity of research designs and interventions, and the absence of a systematic assessment of methodological quality. Furthermore, the limited scope of information sources and the restriction of publications to the English language may mean that not all relevant research has been identified. Consequently, the results of this review are best understood as an overview of the potential and varied applications of gamification in primary school mathematics education, rather than as evidence that gamification invariably yields positive outcomes.

Future research should employ more robust experimental or quasi-experimental designs, utilize adequate sample sizes, and transparently report effect sizes as well as outcomes for comparison groups. Subsequent studies should also broaden their focus to include learning outcomes within the psychomotor domain. Longitudinal research is further required to determine the sustainability of the impact of gamification on learning outcomes. Additionally, studies comparing various gamification elements, platforms, and durations could help identify implementation conditions better suited to the characteristics of students and the objectives of mathematics education in primary schools.

ACKNOWLEDGMENTS

The authors express their gratitude to Universitas Sebelas Maret for its support in this research. The authors also thank colleagues and reviewers who provided constructive feedback throughout the preparation of this manuscript.

DECLARATIONS

Funding

This research was funded by Universitas Sebelas Maret through the Penguatan Kapasitas Grup Riset (PKGR-UNS) scheme under Grant Contract No. 371/UN27.22/PT.01.03/2025.

Conflict of Interest

The authors declare that there are no conflicts of interest related to the preparation and publication of this article.

Ethics Approval and Consent to Participate

This study is a systematic review that does not involve human or animal subjects; therefore, ethical approval was not required. However, the entire research process was conducted with adherence to academic integrity, transparency, and scientific honesty, ensuring that all referenced sources were cited appropriately.

Availability of Data and Materials

All data used in this study were obtained from previously published research articles identified through Scopus, Web of Science, and SINTA-accredited journals, as described in the Methods section. No new data were generated directly in this study.

Author Contributions

All authors contributed equally to the formulation of the research idea, study design, data analysis, interpretation of findings, and manuscript preparation. All authors have read and approved the final version of the article.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation Process

During the preparation of this work, the authors used ChatGPT (OpenAI) to improve the language and readability of the manuscript and to assist in refining the visual quality of figures originally created by the authors. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

REFERENCES

Agustin, L., Widiarti, N., Ellianawati, E., & Avrilianda, D. (2025). Literature review: Innovation in mathematics learning through gamification to improve elementary school students' learning outcomes (2015–2025). *Jurnal Penelitian Pendidikan, 42*(2), 365–371. https://doi.org/10.15294/jpp.v42i2.32952

Akhter, N., & Akhter, N. (2018). Learning in mathematics: Difficulties and perceptions of students. *Journal of Educational Research, 21*(1), 147–163. https://jer.iub.edu.pk/journals/JER-Vol-21.No-1/11.pdf

Al-Mutawa, F., Al-Rasheedi, G., & Al-Maie, D. (2021). Kuwaiti students' achievements in mathematics: Findings from the TIMSS assessments: Reality and reasons. *SAGE Open, 11*(3). https://doi.org/10.1177/21582440211031903

Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *International Journal of Information and Learning Technology, 35*(1), 56–79. https://doi.org/10.1108/IJILT-02-2017-0009

Alt, D. (2023). Assessing the benefits of gamification in mathematics for student gameful experience and gaming motivation. *Computers & Education, 200*, Article 104806. https://doi.org/10.1016/j.compedu.2023.104806

Amanatallah, L., & Safa, N. (2023). Elementary students' perceptions towards mathematics problem solving. *Journal of Education and Practice, 14*(27), 29–39. https://doi.org/10.7176/JEP/14-27-03

Andrijati, N., Mardapi, D., & Retnawati, H. (2020). The profile of elementary school students' ability in mathematical reasoning. *International Journal of Scientific & Technology Research, 9*(1), 1844–1850.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181–185. https://doi.org/10.1111/1467-8721.00196

Barnes, M. A., & Raghubar, K. P. (2014). Mathematics development and difficulties: The role of visual-spatial perception and other cognitive skills. *Pediatric Blood & Cancer, 61*(10), 1729–1733. https://doi.org/10.1002/pbc.24909

Blazer, C. (2011). *Strategies for reducing math anxiety* (Information Capsule, Vol. 1102). Research Services, Miami-Dade County Public Schools. https://eric.ed.gov/?id=ED536509

Bodovski, K., & Youn, M. J. (2011). The long-term effects of early acquired skills and behaviors on young children's achievement in literacy and mathematics. *Journal of Early Childhood Research, 9*(1), 4–19. https://doi.org/10.1177/1476718X10366727

Bovermann, K., & Bastiaens, T. J. (2020). Towards a motivational design? Connecting gamification user types and online learning activities. *Research and Practice in Technology Enhanced Learning, 15*(1), Article 1. https://doi.org/10.1186/s41039-019-0121-4

Buckley, P., & Doyle, E. (2016). Gamification and student motivation. *Interactive Learning Environments, 24*(6), 1162–1175. https://doi.org/10.1080/10494820.2014.964263

Cerezci, B. (2020). The impact of the quality of early mathematics instruction on mathematics achievement outcomes. *Journal of Childhood, Education and Society, 1*(2), 216–228. https://doi.org/10.37291/2717638X.20201248

Chang, D., Hwang, G. J., Chang, S. C., & Wang, S. Y. (2021). Promoting students' cross-disciplinary performance and higher order thinking: A peer assessment-facilitated STEM approach in a mathematics course. *Educational Technology Research and Development, 69*(6), 3281–3306. https://doi.org/10.1007/s11423-021-10062-z

Christou, E., Parmaxi, A., & Zaphiris, P. (2025). A systematic exploration of scoping and mapping literature reviews. *Universal Access in the Information Society, 24*(1), 941–951. https://doi.org/10.1007/s10209-024-01120-3

Dan, N. N., Trung, L. T. B. T., Nga, N. T., & Dung, T. M. (2024). Digital game-based learning in mathematics education at primary school level: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(4), 1–14. https://doi.org/10.29333/ejmste/14377

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification". In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (pp. 9–15). https://doi.org/10.1145/2181037.2181040

Diaz, A. F., & Estoque-Loñez, H. (2024). A meta-analysis on the effectiveness of gamification on student learning achievement. *International Journal of Education in Mathematics, Science, and Technology, 12*(5), 1236–1252. https://doi.org/10.46328/ijemst.4185

Divjak, B., & Tomić, D. (2011). The impact of game-based learning on the achievement of learning goals and motivation for learning mathematics: Literature review. *Journal of Information and Organizational Sciences, 35*(1), 15–30. https://hrcak.srce.hr/69672

Durmus, Y. T. (2016). Effective learning environment characteristics as a requirement of constructivist curricula: Teachers' needs and school principals' views. *International Journal of Instruction, 9*(2), 184–198. https://doi.org/10.12973/iji.2016.9213a

Evans, N. S., Burke, R., Vitiello, V., Zumbrunn, S., & Jirout, J. J. (2023). Curiosity in classrooms: An examination of curiosity promotion and suppression in preschool math and science classrooms. *Thinking Skills and Creativity, 49*, Article 101333. https://doi.org/10.1016/j.tsc.2023.101333

Fadda, D., Pellegrini, M., Vivanet, G., & Zandonella Callegher, C. (2022). Effects of digital games on student motivation in mathematics: A meta-analysis in K-12. *Journal of Computer Assisted Learning, 38*(1), 304–325. https://doi.org/10.1111/jcal.12618

Faiella, F., & Ricciardi, M. (2015). Gamification and learning: A review of issues and research. *Journal of E-Learning and Knowledge Society, 11*(3), 13–21. https://www.je-lks.org/ojs/index.php/Je-LKS_EN/article/view/1072

Figueroa-Flores, J. F. (2016). Gamification and game-based learning: Two strategies for the 21st century learner. *World Journal of Educational Research, 3*(2), 507–522. https://doi.org/10.22158/wjer.v3n2p507

Fletcher, K., Wright, C. A., Pesch, A., Abdurokhmonova, G., & Hirsh-Pasek, K. (2024). Active playful learning as a robust, adaptable, culturally relevant pedagogy to foster children's 21st century skills. *Journal of Children and Media, 18*(3), 309–321. https://doi.org/10.1080/17482798.2024.2356956

Grabner-Hagen, M. M., & Kingsley, T. (2023). From badges to boss challenges: Gamification through need-supporting scaffolded design to instruct and motivate elementary learners. *Computers and Education Open, 4*, Article 100131. https://doi.org/10.1016/j.caeo.2023.100131

Guro, J. D., & Corpuz, G. G. (2025). Gamification learning strategies on learners' performance in mathematics. *European Modern Studies Journal, 9*(2), 1–26. https://doi.org/10.59573/emsj.9(2).2025.1

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? A literature review of empirical studies on gamification. In *Proceedings of the 47th Hawaii International Conference on System Sciences* (pp. 3025–3034). https://doi.org/10.1109/HICSS.2014.377

Howard, L., & Whitaker, M. (2011). Unsuccessful and successful mathematics learning: Developmental students' perceptions. *Journal of Developmental Education, 35*(2).

Hsieh, Y. H., Lin, Y. C., & Hou, H. T. (2015). Exploring elementary-school students' engagement patterns in a game-based learning environment. *Educational Technology & Society, 18*(2), 336–348.

Isdale, K., Reddy, V., Juan, A., & Arends, F. (2017). *TIMSS 2015 grade 5 national report: Understanding mathematics achievement amongst grade 5 learners in South Africa*. HSRC Press.

Jagust, T., Boticki, I., & So, H. J. (2018). Examining competitive, collaborative and adaptive gamification in young learners' math learning. *Computers & Education, 125*, 444–457. https://doi.org/10.1016/j.compedu.2018.06.022

Jutin, N. T., & Maat, S. M. (2024). The effectiveness of gamification in teaching and learning mathematics: A systematic literature review. *International Journal of Academic Research in Progressive Education and Development, 13*(1), 1290–1309. https://doi.org/10.6007/IJARPED/v13-i1/20703

Karamert, O., & Vardar, A. K. (2021). The effect of gamification on young mathematics learners' achievements and attitudes. *Journal of Educational Technology and Online Learning, 4*(2), 96–114. https://doi.org/10.31681/jetol.904704

Kim, S., Chang, M., Deater-Deckard, K., Evans, M. A., Norton, A., & Samur, Y. (2017). Educational games and students' game engagement in elementary school classrooms. *Journal of Computers in Education, 4*(4), 395–418. https://doi.org/10.1007/s40692-017-0095-4

Koivisto, J., & Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management, 45*, 191–210. https://doi.org/10.1016/j.ijinfomgt.2018.10.013

Laksana, S. D., Setyosari, P., Praherdhiono, H., Kuswandi, D., & Jannan, D. (2024). The effect of the use of digital gamification and metacognitive skills on students' mathematics solving ability. *Pegem Journal of Education and Instruction, 14*(3), 117–125. https://doi.org/10.47750/pegegog.14.03.11

Lame, G. (2019). Systematic literature reviews: An introduction. *Proceedings of the Design Society: International Conference on Engineering Design, 1*(1), 1633–1642. https://doi.org/10.1017/dsi.2019.169

Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming, 45*(6), 752–768. https://doi.org/10.1177/1046878114563660

Lee, W. C., & Lai, C. L. (2024). Facilitating mathematical argumentation by gamification: A gamified mobile collaborative learning approach for math courses. *International Journal of Science and Mathematics Education, 22*(Suppl. 1), 11–35. https://doi.org/10.1007/s10763-024-10462-6

Leiss, L., Großschedl, J., Wilde, M., Frankel, S., Becker-Genschow, S., & Großmann, N. (2025). Gamification in education—Teachers' perspectives through the lens of the theory of planned behavior. *Frontiers in Psychology, 16*, 1–17. https://doi.org/10.3389/fpsyg.2025.1571463

Magen-Nagar, N., & Steinberger, P. (2017). Characteristics of an innovative learning environment according to students' perceptions: Actual versus preferred. *Learning Environments Research, 20*(3), 307–323. https://doi.org/10.1007/s10984-017-9232-2

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2015). *TIMSS 2015 international results in mathematics*. TIMSS & PIRLS International Study Center, Boston College. https://timss2015.org/timss2015/mathematics/

Muthivhi, A. E. (2015). Piaget's theory of human development and education. In *International encyclopedia of the social & behavioral sciences* (2nd ed.). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.92013-0

O'Leary, K., Fitzpatrick, C. L., & Hallett, D. (2017). Math anxiety is related to some, but not all, experiences with math. *Frontiers in Psychology, 8*, Article 2067. https://doi.org/10.3389/fpsyg.2017.02067

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Partovi, T., & Razavi, M. R. (2019). The effect of game-based learning on academic achievement motivation of elementary school students. *Learning and Motivation, 68*, Article 101592. https://doi.org/10.1016/j.lmot.2019.101592

Phuntsho, T., & Dorji, C. (2025). The effect of gamification on grade five students' engagement and learning outcomes in mathematics. *International Journal for Multidisciplinary Research, 7*(5). https://doi.org/10.36948/ijfmr.2025.v07i05.58721

Pires, F., Lima, F. M., & Bernardo, J. R. (2019). Gamification and engagement: Development of computational thinking and the implications in mathematical learning. In *2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT)*. https://doi.org/10.1109/ICALT.2019.00112

Qiao, S., Yeung, S. S., Zainuddin, Z., Ng, D. T. K., & Chu, S. K. W. (2023). Examining the effects of mixed and non-digital gamification on students' learning performance, cognitive engagement and course satisfaction. *British Journal of Educational Technology, 54*(1), 394–413. https://doi.org/10.1111/bjet.13249

Rahayu, S., Wulandari, D., Rachman, T., & Putri, S. D. P. (2026). The influence of gamification-based learning media using Genially and Educaplay on elementary school students' interest in learning mathematics. *Indonesian Journal of Primary Education, 10*(1), 93–102. https://ejournal.upi.edu/index.php/IJPE/article/view/100361

Rahim, M., Mohamed, L. A., & Haq, S. ul. (2024). Investigating the perceptions of primary school students on gamification-based learning in mathematics: A descriptive survey study. *Pakistan Journal of Humanities and Social Sciences, 12*(3), 2521–2534. https://doi.org/10.52131/pjhss.2024.v12i3.2454

Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational Psychologist, 53*(3), 145–164. https://doi.org/10.1080/00461520.2018.1447384

Robson, K., Plangger, K., Kietzmann, J. H., McCarthy, I., & Pitt, L. (2015). Is it all a game? Understanding the principles of gamification. *Business Horizons, 58*(4), 411–420. https://doi.org/10.1016/j.bushor.2015.03.006

Russo, J., Kalogeropoulos, P., Bragg, L. A., & Heyeres, M. (2024). Non-digital games that promote mathematical learning in primary years students: A systematic review. *Education Sciences, 14*(2), Article 200. https://doi.org/10.3390/educsci14020200

Ružić, I. M., & Dumančić, M. (2015). Gamification in education. *Informatologia, 48*(3–4), 198–204.

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review, 32*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Saleem, A. N., Noori, N. M., & Ozdamli, F. (2022). Gamification applications in e-learning: A literature review. *Technology, Knowledge and Learning, 27*(1), 139–159. https://doi.org/10.1007/s10758-020-09487-x

Setambah, M. A. B., Adnan, M., Zaini, S. H., Mujiasih, M., Hidayat, R., Ibrahim, M. A., & Hanazono, H. (2024). Impact of "Donkey", "Snap" dan "King" (DSK) non-digital gamification cards on fourth-grade students' math performance in fractions. *Infinity Journal, 13*(1), 175–196. https://doi.org/10.22460/infinity.v13i1.p175-196

Sinay, E., & Nahornick, A. (2016). *Teaching and learning mathematics research series I: Effective instructional strategies*. Toronto District School Board.

Smiderle, R., Rigo, S. J., Marques, L. B., Peçanha de Miranda Coelho, J. A., & Jaques, P. A. (2020). The impact of gamification on students' learning, engagement and behavior based on their personality traits. *Smart Learning Environments, 7*(1), Article 3. https://doi.org/10.1186/s40561-019-0098-x

Smit, L. S. (2016). *A better understanding of 21st century skills in mathematics education and a view of these skills in current practice* [Master's thesis, Utrecht University]. https://studenttheses.uu.nl/handle/20.500.12932/23058

So, W. W. M., Wan, Z. H., & Luo, T. (2023). *Cross-disciplinary STEM learning for Asian primary students: Design, practices, and outcomes*. Routledge. https://doi.org/10.4324/9781003262237

Solekhah, H., Kutni, I. D., & Pamungkas, A. B. (2023). Student's engagement and perception of gamification in mathematics. *International Journal of Theory and Application in Elementary and Secondary School Education, 5*(2), 255–266. https://doi.org/10.33830/ijtaese.v5i2.1430

Sucipto, E., Bafadal, I., & Mas'ula, S. (2026). Gamification versus traditional teaching: Impacts on mathematics learning outcomes and engagement. *Journal of Research in Instructional, 6*(1), 413–425. https://doi.org/10.30862/jri.v6i1.64

Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability, 12*(23), 1–28. https://doi.org/10.3390/su122310113

Taşkın, N., & Çakmak, E. K. (2023). Effects of gamification on behavioral and cognitive engagement of students in the online learning environment. *International Journal of Human–Computer Interaction, 39*(17), 3334–3345. https://doi.org/10.1080/10447318.2022.2096190

Toheri, Winarso, W., & Haqq, A. A. (2019). Three parts of 21st century skills: Creative, critical, and communication mathematics through academic-constructive controversy. *Universal Journal of Educational Research, 7*(11), 2314–2329. https://doi.org/10.13189/ujer.2019.071109

Tonioka, N. H., Sutopo, Y., Ellianawati, E., Avrilianda, D., & Kurniawan, Y. (2025). Systematic literature review: The implementation of gamification in mathematics learning at primary schools. *Journal of Innovation and Research in Primary Education, 4*(4), 2764–2774. https://doi.org/10.56916/jirpe.v4i4.1877

Turkmen, G. P., & Soybas, D. (2019). The effect of gamification methodology on students' achievements and attitudes towards mathematics. *Bartın University Journal of Faculty of Education, 8*(1), 258–297. https://doi.org/10.14686/buefad.424575

Vazquez-Cano, E., Quicios-García, M. P., Fombona, J., & Rodriguez-Arce, J. (2023). Latent factors on the design and adoption of gamified apps in primary education. *Education and Information Technologies, 28*(11), 15093–15123. https://doi.org/10.1007/s10639-023-11797-3

Vrcelj, A., Hoic-Bozic, N., & Dlab, M. H. (2023). Use of gamification in primary and secondary education: A systematic literature review. *International Journal of Educational Methodology, 9*(1), 13–27. https://doi.org/10.12973/ijem.9.1.13

Whitney-Smith, R., Hurrell, D., & Day, L. (2022). The role of mathematics education in developing students' 21st century skills, competencies and STEM capabilities. In N. Fitzallen, C. Murphy, V. Hatisaru, & N. Maher (Eds.), *Mathematical confluences and journeys: Proceedings of the 44th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 554–561). MERGA.

Widodo, S., & Rahayu, P. (2019). Analysis of elementary school students' mastery in math instruction based on arithmetic gamification. *Journal of Physics: Conference Series, 1157*(4), 042112. https://doi.org/10.1088/1742-6596/1157/4/042112

Yadav, A. K., & Yadav, S. S. (2024). The role of gamification in enhancing student motivation and learning experiences in high school mathematics classes. *Educational Metamorphosis, 3*(1), 83–91. https://phnmcollege.ac.in/wp-content/uploads/2024/08/10-EM-V3-N1.pdf

Yan, L. L. L., & Matore, M. E. E. M. (2023). Gamification trend in students' mathematics learning through systematic literature review. *International Journal of Academic Research in Progressive Education and Development, 12*(1), 400–423. https://doi.org/10.6007/IJARPED/v12-i1/15732

Zakaria, E., & Nordin, N. M. (2008). The effects of mathematics anxiety on matriculation students as related to motivation and achievement. *Eurasia Journal of Mathematics, Science and Technology Education, 4*(1), 27–30.

Zeng, J., Sun, D., Looi, C. K., & Fan, A. C. W. (2024). Exploring the impact of gamification on students' academic performance: A comprehensive meta-analysis of studies from the year 2008 to 2023. *British Journal of Educational Technology, 55*(6), 2478–2502. https://doi.org/10.1111/bjet.13471

Zhu, Y., Liu, X., Xiao, Y., & Sindakis, S. (2024). Mathematics anxiety and problem-solving proficiency among high school students: Unraveling the complex interplay in the knowledge economy. *Journal of the Knowledge Economy, 15*(4), 20516–20546. https://doi.org/10.1007/s13132-023-01688-w