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Digital Based Mathematics Learning in Primary Education: Systematic Literature Review

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A B S T R A C T

This study examines the trends and implementation of game-based learning (GBL) in primary school mathematics learning, integrating global perspectives and the Indonesian context. This study aims to: (1) identify post-2021 GBL design trends (digital vs. non-digital), (2) explore the determinants of successful implementation across different geographical contexts, and (3) analyze the synergistic role of teachers and technology in reducing the risk of disruption. A systematic literature review (SLR) following the PRISMA protocol was conducted by analyzing 15 Scopus-indexed international articles (2021-2025). Findings show that developed countries adopt more AI/AR-based digital GBL and adaptive apps, while Indonesia emphasizes hybrid approaches (culture-based board games, physical-digital integration) and affordable technologies. Key success factors include teacher-developer collaboration, technical training and cultural relevance, although challenges such as the digital divide (30% of rural schools without computers) and overly complex designs persist. Teacher-led scaffolding-based learning (pre/post-game guidance, time management) and technology-based tools (instant feedback, adaptive difficulty levels) synergistically reduced distractions, aligning with ZPD and Flow Theory principles. This study confirms the importance of glocalization - integrating global innovations with local contexts to support inclusive, adaptive and sustainable mathematics learning. The implications call for policy reforms to address infrastructure gaps, teacher capacity building and context-sensitive GBL design.

1. Introduction

The development of digital technology has brought significant transformation in the world of education, including at the elementary school level. Mathematics, as a discipline that requires conceptual understanding and logic, is often perceived as challenging by students, triggering academic anxiety (Ersozlu, 2024). Global surveys show that conventional learning methods that focus on memorization and repetitive exercises are increasingly irrelevant to the preferences of the digital

generation who are used to interactive stimulation (Dan et al., 2024). On the other hand, technology also offers opportunities for innovation, one of which is through game-based learning (GBL). This approach not only utilizes entertainment elements but also designs learning experiences that are aligned with pedagogical principles, such as scaffolding and intrinsic motivation (Sun et al., 2021).

Theoretically, GBL is rooted in the concept of constructivism that emphasizes the role of interactive activities in building understanding (Rye et al., 2025). In the context of mathematics, educational games can serve as a medium to simulate real problems, facilitate concept exploration through trial-and-error, and reduce anxiety (Rocha & Dondio, 2021). Recent research by Al-Barakat et al, (2025) confirmed that the integration of digital games improved elementary students' mathematical thinking skills by 30%, especially in problem solving and spatial reasoning.

Similar findings were reported by Sarifah (2022), where Android-based games successfully increased interest in learning mathematics through immersive design and instant feedback. However, the effectiveness of GBL is not free from implementation challenges. A study by Russo (2024) revealed that 58% of primary school teachers prefer non-digital games (such as board games) due to limited technological infrastructure in rural schools. This is in line with Dia's (2024) study that developed a traditional game-based textbook to support computational thinking, suggesting that non-digital approaches remain relevant in the context of limited resources. On the other hand, digital games designed with adaptive scaffolding, such as the AI-based application in Bang's (2023) study, were shown to improve students' mathematics learning outcomes by 22% through content personalization.

Another challenge lies in the balance between entertainment and academic content. Procopio's (2024) study emphasizes the importance of integrating neuroscience principles in game design to ensure optimal cognitive activation. Meanwhile, Xu (2024) proposed a multidisciplinary approach by incorporating student behavioral data analysis to measure the development of creative thinking during GBL use. In Morocco, Bouzid (2021) found that although digital games increased motivation, the increase in academic achievement was only significant when balanced with structured teacher guidance.

The COVID-19 pandemic has accelerated the adoption of GBL, but it has also widened the digital divide. Ramos' research (2024) tested a math learning intervention through game-based physical activity (*Active Mathematics*), which showed increased student participation in hybrid classes. However, a UNESCO report (2023) highlighted that 60% of primary schools in rural areas still lack access to digital devices, so GBL innovations need to consider the local context.

Although many studies have explored GBL, a systematic review by Dan (2024) identified three research gaps: (1) the lack of comparative analysis between digital and non-digital games, (2) the need for long-term studies on the impact of GBL on intrinsic motivation, and (3) the exploration of cultural factors in game design. This article aims to fill these gaps through a systematic literature review of 15 Scopus-

indexed journal articles (2021-2025). The research questions focused on: (1) what are the design trends of GBL (digital vs. non-digital) in primary mathematics learning post-2021, (2) what factors determine successful implementation of GBL across diverse geographic contexts, (3) What is the role of teachers and technology in mitigating the risk of distraction during GBL use. Through this systematic review, the authors hope to provide educators with robust evidence to effectively implement both digital and physical game-based learning, while simultaneously urging policymakers to address critical infrastructure gaps and integrate culturally relevant, innovative approaches into curricula and teacher training programs.

Furthermore, the research aims to fill identified gaps in the literature concerning the digital versus non-digital debate and cultural factors, thereby stimulating future investigations into the long-term impacts of GBL and other under-explored areas. Ultimately, the authors aspire for this work to advance the 'glocalization' of education, fostering an adaptive and inclusive learning environment by thoughtfully merging global innovations with local contexts.

2. Methodology

The academic articles selected for this study were sourced from the Scopus database, chosen due to its extensive size, high quality, and credibility. Scopus is one of the largest curated databases for abstracts and citations, offering extensive global and regional coverage of scientific journals, conference proceedings, and books (Singh et al. 2021). It ensures that only top-quality data are indexed through a strict content selection process and ongoing re-evaluation by an independent Content Selection and Advisory Board (CSAB) Cortegiani et al. (2020).

This guarantees that the database indexes only carefully curated, high-quality content, reinforcing the credibility of Scopus (Baas et al., 2020). This article was prepared using a systematic literature review method of 15 publications related to game-based mathematics learning in elementary schools. Identify articles using the *Publish or Perish* (PoP) application using the keywords *game-based learning* and the title words *primary school, elementary schools*. The search was limited to articles published between 2021 and 2025.

The search results obtained 219 publications indexed by Scopus. The publications were then further identified and 30 articles and proceedings were found. Furthermore, 15 publications were excluded as they did not meet the inclusion criteria or were not relevant to the research questions. The final selection for analysis included 15 articles that were in accordance with the research on game-based mathematics learning in elementary school. The stages of searching for journal articles and proceedings are shown in Figure 1.

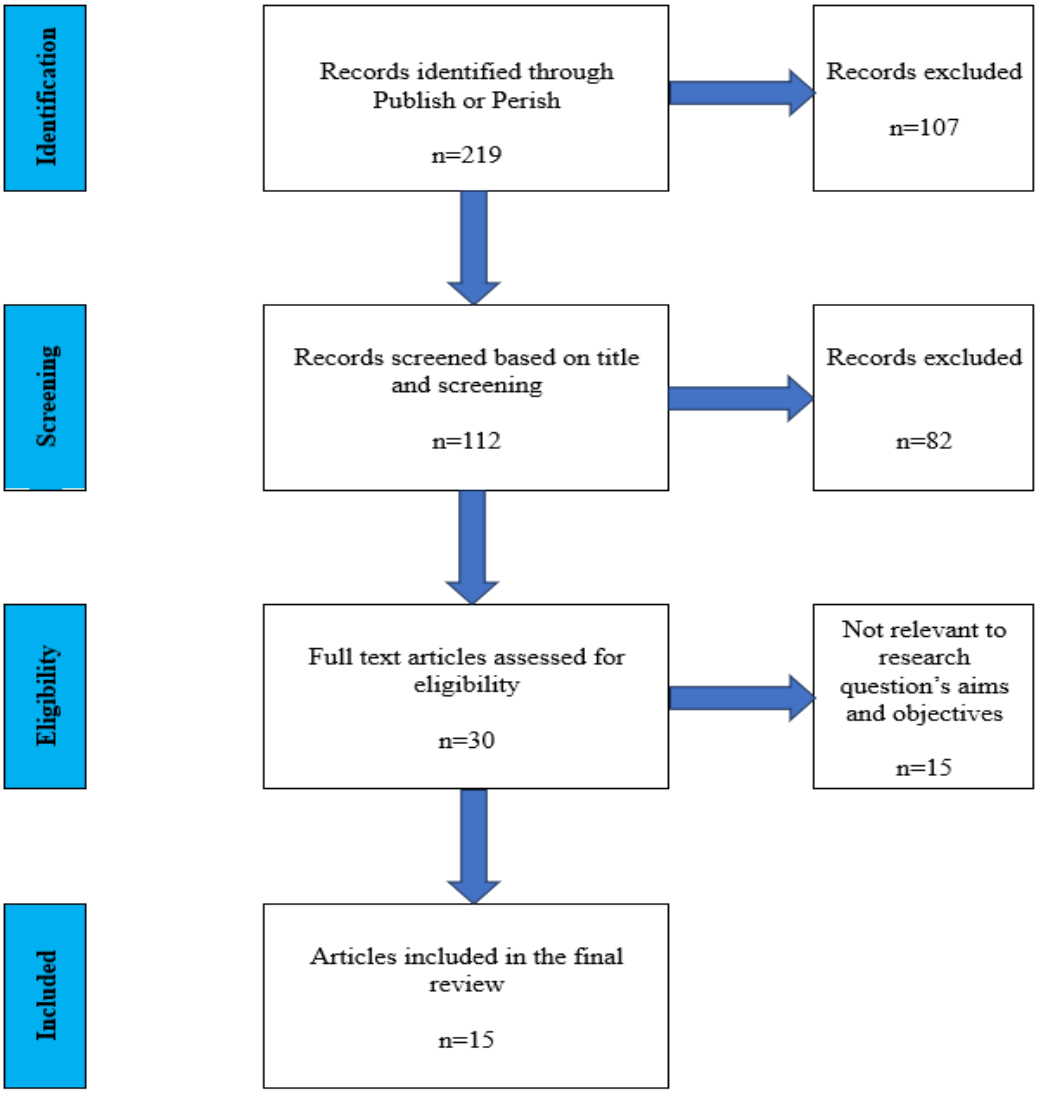

Figure 1. Illustration of Article Search

3. Results and Discussion

This systematic literature review analyzed 15 peer-reviewed articles published between 2021 and 2025. The selected studies investigate various pedagogical models, methods, media, and materials aimed at enhancing learning in primary school settings, with a significant focus on mathematics education, the use of games, and technology integration. The following sections present the synthesized findings.

Learning Models and Methods

The reviewed literature showcases a diverse range of learning models and instructional methods being explored and implemented in primary education. Game-Based Learning (GBL) emerged as the most prevalent model, appearing in

various forms across a majority of the articles. Learning models and methods shown in Table 1.

Table 1. Learning Models and Methods

Authors (Year)	Learning Model	Learning Methods
Al-Barakat et al. (2025)	Digital Game-Based Learning (DGBL) / "digital gamification".	Experimental group taught using digital game applications; control group received traditional methods. Pre-test/post-test analyses. ANCOVA for data analysis.
Bang et al. (2023)	Adaptive Game-Based Learning (GBL); Personalized Learning; Adaptive Instructional System.	Using "My Math Academy" app (personalized content, adaptive embedded assessments, adaptive learning trajectories). Blocked cluster randomized design (treatment vs. control).
Bouzid et al. (2021)	Digital Game-Based Learning (DGBL) of Mathematics; ADDIE model for edutainment game development.	Learning arithmetic via a digital edutainment game. Experimental approach (game-group vs. paper-group; paper-session vs. game-session). MA assessment.
Dan et al. (2024)	Systematic Literature Review of Digital Game-Based Learning (DGBL) in primary math.	(Reviewed methods) Use of digital games; various gameplay modes (individual, collaborative, competitive); utilization of game elements.
Dia et al. (2024)	Game-Based Learning using traditional games to integrate Computational Thinking; ADDIE model for development.	Learning via 4 traditional Indonesian games (Congklak, Setatak, Galah Panjang, Yeye). Integration with 4 computational thinking skills. Students play games and solve related tasks in a supplementary textbook.
Ersozlu (2024)	Systematic Literature Review on technological interventions for math anxiety.	(Reviewed methods) Online distance education, game-based learning, use of various digital tools (interactive software, simulations, AI, AR, BCI), parental involvement.
Larkin & Lowrie (2023)	Systematic Qualitative Literature Review on STEM integration.	(Reviewed methods) Inquiry-based, Project-based, Problem-based, Design-based, Play-based, and Teacher-directed learning approaches in STEM.
Procopio et al. (2024)	Game-Based Learning (GBL) methodological approach, underpinned by neuroscience principles.	Student-teachers designed game-like activities using ICT tools (Scratch, GeoGebra) based on neuroscience. Student-teacher presentations and peer/teacher evaluation using a rubric.
Ramos et al. (2024)	Classroom-based physical active learning.	Experimental group (EG) learned math via physical active math games; Control group (CG) learned traditionally. Pre/post diagnostic & assessment tests.
Ritonga et al. (2022)	Development of PE learning variations with a play approach; R&D (Borg & Gall).	Play approach through games (e.g., obstacle jump, arranging blocks, puzzles) for PE.
Rocha & Dondio (2021)	Game-Based Learning (GBL); Situated learning principles.	Playing "Once Upon a Maths" adventure videogame (history of math narrative, mini-games). Pre/post-testing (math performance & MA). Group interviews.
Russo et al. (2024)	Game-Based Learning (GBL); Investigates preferences for digital vs. non-digital.	Survey (Qualtrics questionnaire) of 111 Australian primary educators on usage and preferences for digital vs. non-digital math games. Thematic analysis of open-ended responses.

Authors (Year)	Learning Model	Learning Methods
Sarifah et al. (2022)	Game-Based Learning using Android educational games; ADDIE model for development.	Using an Android-based educational game "Numbers Game" (summation material; easy, medium, hard levels). Experimental research (posttest-only control group design).
Sun et al. (2021)	Digital game-based learning (DGBL) with teacher scaffolding.	Students learning math by playing the digital game "Wuzzit Trouble". Teachers provided whole-class and one-to-one scaffolding. Qualitative data from classroom observations and student interviews.
Xu et al. (2024)	Game-Based Learning model (proposed) for creative thinking development; Multivariate data integration for analysis.	Proposes a teaching model using games as a carrier. Analyzes influence of games and differentiated assignments on creative thinking. Uses algorithms to identify "creative thinking genes".

This includes Digital Game-Based Learning (DGBL) utilizing custom-built video games, adaptive apps, and Android-based educational games (Rocha & Dondio, 2021;Sarifah et al., 2022;Sun et al, 2021; Bouzid et al, 2021; Bang et al, 2023; Al-Barakat et al, 2025; Dan et al, 2024). Traditional/Physical GBL was also prominent, with studies leveraging culturally relevant games like Bakiak, Congklak, and Setatak (Ritonga et al, 2022; Dia et al. (2024). Active Learning Models were evident, such as classroom-based physical active learning for mathematics Ramos et al. (2024). Technology-Integrated Learning was a cross-cutting theme, exploring the role of various digital tools Ersozlu (2024). Research and Development (R&D) Models like ADDIE were frequently used for the systematic creation and validation of new learning products and models (Sarifah et al, 2022; Dia et al, 2024;Bouzid et al, 2021). Neuroscience-Informed Approaches (Neuroeducation) were explored in the design of educational games by student-teachers Procopio et al. (2024). STEM Integration Models were reviewed, highlighting different levels of integration from disciplinary to transdisciplinary Larkin & Lowrie (2023).

Students actively engaging with digital or physical games was a central learning method. Teacher Scaffolding: Identified as a critical instructional method to support student learning within DGBL environments, applied both to the whole class and individually Sun et al. (2021). Personalized and Adaptive Learning: Technology-enabled methods tailoring content and pace to individual student needs, often through embedded assessments in digital games Bang et al. (2023). Culturally Relevant Pedagogy: The use of traditional games and local contexts was a method to enhance engagement and understanding (Dia et al., 2024). Inquiry-Based, Project-Based, and Problem-Based Learning: These were identified as key teaching approaches, particularly within the context of STEM education Larkin & Lowrie (2023). Differentiated Instruction: The use of differentiated assignments was explored as a method to foster creative thinking Xu et al. (2024).

Experimental Research Designs: Pre-test/post-test control group designs were frequently employed to assess the effectiveness of interventions (Ramos et al., 2024; Bouzid et al., 2021; Bang et al., 2023; Al-Barakat et al, 2025). Qualitative Data Collection: Methods such as classroom observations, student and teacher

interviews, and thematic analysis were widely used to gain in-depth insights into perceptions and experiences (Rocha et al., 2021; Sun et al., 2021; Russo et al., 2024). Systematic Literature Reviews: Several articles adopted this methodology to synthesize existing research and identify trends in specific areas (Russo et al., 2024; Larkin & Lowrie, 2023; Ersozlu, 2024; Dan et al., 2024).

Learning Media

The studies utilized a broad spectrum of learning media, which can be broadly categorized into digital, physical, and occasionally, mixed or unspecified types. Learning media classification shown in Figure 2.

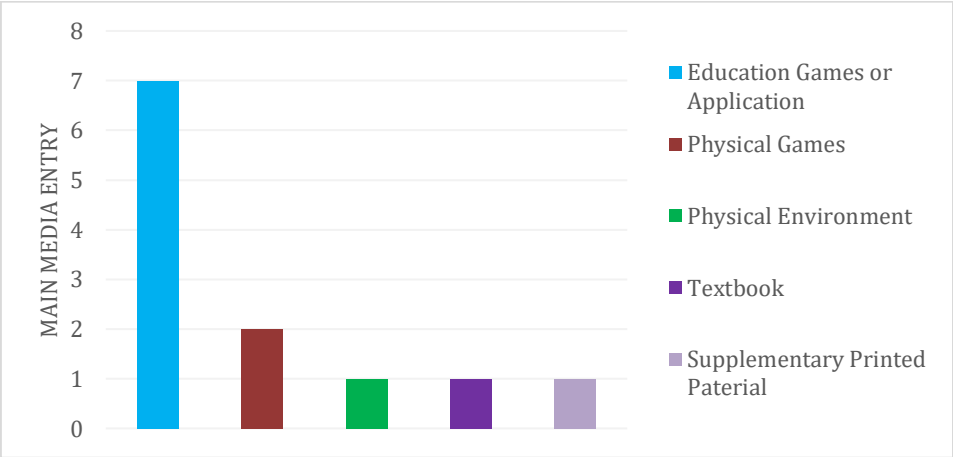

Figure 2. Learning Media Classification

Digital Media: This was a significant focus, encompassing: Educational Games and Applications: Custom-developed video games (e.g., "Once Upon a Maths" by Rocha et al., 2021; "Wuzzit Trouble" in Sun et al., 2021), Android-based games (e.g., "Numbers Game" by Sarifah et al., 2022), adaptive learning apps (e.g., "My Math Academy" by Bang et al., 2023), and games developed with tools like Macromedia Flash (Al-Barakat et al., 2025) and Scratch/GeoGebra (Procopio et al., 2024). Hardware: Tablets, smartphones, computers, interactive whiteboards (smartboards), and pedometers (Ramos et al., 2024). Software and Platforms: GeoGebra for geometry, Moodle for course management, online questionnaire platforms (Qualtrics), and various other digital tools reviewed by Ersozlu (2024) and Dan et al. (2024).

Physical Media: Traditional Games and Equipment: Congklak, Setatak, Galah Panjang, Yeye, and associated physical items like balls, obstacles, and blocks (Ritonga et al., 2022; Dia et al., 2024). Printed Materials: Supplementary textbooks, worksheets, lesson plans, syllabi, printed passports as rewards, and paper-based tests/questionnaires (Rocha et al., 2021; Dia et al., 2024). Manipulatives: Physical manipulatives were highlighted as preferred by teachers in the review by Russo et al. (2024). Physical Learning Environments: Sports fields for active learning (Ramos et al., 2024).

Unspecified/Mixed Media: Xu et al. (2023) referred to "games" generally without specifying the medium. Larkin & Lowrie (2023) reviewed STEM studies where media like robotics could have both physical and digital components. The choice of media was typically aligned with the pedagogical approach, learning objectives, and the context of the study, including cultural relevance and resource availability.

Learning Materials

The primary subject focus across the reviewed articles was Mathematics at the elementary school level. However, some studies also incorporated other dimensions. Learning material classification shown in Figure 3.

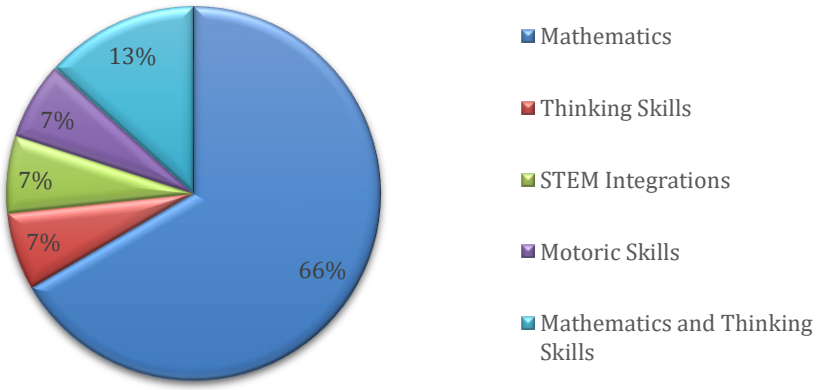

Figure 3. Learning Material Classification

Arithmetic was the most common area, covering number sense, basic operations (addition, subtraction, multiplication, division), whole numbers, integers, rational numbers, fractions, and decimals (Rocha et al., 2021; Sarifah et al., 2022; Sun et al., 2021; Dia et al., 2024; Dan et al., 2024; Bouzid et al., 2021; Bang et al., 2023; Al-Barakat et al., 2025). Geometry, concepts of plane and spatial geometry, shapes (polygons, triangles, circles), measurement (length, weight, area, volume), perimeter, and relationships between lines were frequently addressed (Rocha et al., 2021; Procopio et al., 2024; Dia et al., 2024; Al-Barakat et al., 2025). Recognizing and using patterns, including number patterns and odd/even numbers (Rocha et al., 2021; Dia et al., 2024). Data interpretation mentioned as part of the curriculum covered in "Once Upon a Maths" (Rocha et al., 2021).

Development of skills and competencies like mathematical thinking skills, including induction, deduction, problem-solving, and visual representation (Al-Barakat et al., 2025). Computational thinking, explicitly targeted through decomposition, pattern recognition, abstraction, and algorithms (Dia et al., 2024; Dan et al., 2024). Creative thinking, investigated in relation to games and differentiated assignments (Xu et al., 2023). Basic motor skills, such as jumping, in the context of Physical Education (Ritonga et al., 2022). Character values, cooperation, courage, honesty (Ritonga et al., 2022).

Broader educational themes like history of hathematics, used as a narrative framework for a math video game (Rocha et al., 2021). Neuroscience principles, applied to the design of educational games by student-teachers (Procopio et al., 2024). STEM integration, content from Science, Technology, Engineering, and Mathematics (Larkin & Lowrie, 2023). Cultural context, integration of local culture, particularly through traditional games, was a key feature of materials in several Indonesian studies (Ritonga et al., 2022; Dia et al., 2024). earning materials were often aligned with national curricula or specific educational standards (e.g., Portuguese, Irish, Indonesian, CCSS-M). Many studies involved the development of bespoke learning materials, such as custom digital games or supplementary textbooks.

Key Conclusions

The reviewed articles collectively provide strong evidence for the benefits of innovative pedagogical approaches, particularly GBL and technology integration, in primary education. The key conclusions are as detailed in Table 2.

Table 2. Key Conlusions

Authors (Year)	Key Conclusions
Al-Barakat, A. A., El-Mneizel, A. F., Al-Qatawneh, S. S., AlAli, R. M., Aboud, Y. Z., & Ibrahim, N. A. H. (2025)	Digital game applications significantly enhanced mathematical thinking skills in primary students compared to traditional methods. Statistically significant gender differences were found (males outperformed females), but the impact was limited. No significant interaction between teaching method and gender.
Bang, H. J., Li, L., & Flynn, K. (2023)	"My Math Academy" significantly improved early math skills for K-1st graders, especially for those with lower prior knowledge and on difficult skills, while keeping them engaged. Teachers valued its ease of use and personalization.
Bouzid, T., Kaddari, F., Darhmaoui, H., & Bouzid, E. G. (2021)	DGBL via edutainment games can significantly reduce math anxiety and improve motivation, concentration, and overall math-class experience for Moroccan elementary students.
Dan, N. N., Trung, L. T. B. T., Nga, N. T., & Dung, T. M. (2024)	DGBL research in primary math is growing, mainly focusing on arithmetic and effectiveness. Less focus on geometry, statistics, probability, 21st-century skills, and developing new teaching methods/tools. Mini-games and individual play are dominant.
Dia, I. O., Putra, Z. H., Witri, G., Dahnilsyah, & Aljarrah, A. (2024)	The traditional game-based computational thinking supplementary textbook is highly usable and feasible, receiving positive student feedback due to its cultural and game connection. Experts validated it as "Very Valid".
Ersozlu, Z. (2024)	Online distance education increases math anxiety in primary students; GBL and digital tools show positive results in reducing it. Collaborative efforts are important.
Larkin, K., & Lowrie, T. (2023)	Much work is needed to move from claimed STEM integration to actual practice. Recommends authentic interdisciplinary approaches and methods like problem-based or project-based learning. Engineering was found to be more integrated than initially hypothesized, often paired with science.

Authors (Year)	Key Conclusions
Procopio, M., Fernández-Cézar, R., Fernandes-Procopio, L., & Yánez-Araque, B. (2024)	Integrating neuroscience principles into GBL design by student-teachers can enhance math learning and their understanding of brain learning processes. A divergence exists between teaching reality and student-teachers' preconceptions.
Ramos, L.; Simões, V.; Franco, S. (2024)	"Active Mathematics" significantly increased students' physical activity (PA) without negatively impacting math grades.
Ritonga, D. A., Damanik, S., Damanik, S. A., Suprayitno, & Priyambada, G. (2022)	PE learning variations with a play approach effectively improve students' basic movement skills and character values.
Rocha, M., & Dondio, P. (2021)	"Once Upon a Maths" significantly increased math performance. No overall effect on Math Anxiety (MA), but female students in one class showed increased MA. Students showed high engagement.
Russo, J. A., Roche, A., Russo, T., & Kalogeropoulos, P. (2024)	Australian primary educators use non-digital games more frequently and prefer them over digital games for math, mainly for pedagogical reasons (collaboration, manipulatives, adaptability, easier observation).
Sarifah, I., Rohmaniar, A., Marini, A., Sagita, J., Nuraini, S., Safitri, D., Maksum, A., Suntari, Y., & Sudrajat, A. (2022)	Android-based educational games ("Numbers Game") are proven to increase the interest in learning mathematics for 6th-grade elementary school students.
Sun, L., Ruokamo, H., Siklander, P., Li, B., & Devlin, K. (2021)	Teacher scaffolding (whole-class and one-to-one) in DGBL positively affected students' knowledge learning, arithmetic skills, interest development, and perceptions of math.
Xu, E., Lin, Z., & Wang, X. (2023)	Games promote creative thinking in elementary students; 60% of students' personalities change, and 50% develop new ideas during games. Differentiated assignments also aid creative thinking.

This collection of articles collectively paints a dynamic and diverse picture of efforts to improve education in elementary schools, with a strong emphasis on mathematics and the development of related skills. Several central themes and discussion points emerge from this analysis:

The majority of the research explores or implements GBL in various forms. Both traditional physical games (e.g., Bakiak, Congklak) and digital games (video games, applications) are consistently reported to have a positive impact. The benefits include increased learning interest, motivation, engagement, understanding of mathematical concepts, academic performance, as well as the development of computational and creative thinking skills. The study by Russo et al. (2024) provides an interesting perspective that teachers in Australia tend to prefer non-digital games for pedagogical reasons such as increased collaboration and ease of adaptation.

Digital technology is a powerful tool in GBL and other educational interventions. Adaptive applications like "My Math Academy" demonstrate great potential in personalizing learning and providing significant impact on students with lower prior knowledge. Tools like Scratch and GeoGebra empower prospective teachers

to design their own interactive learning materials. However, the role of technology is not always universally positive. The review by Ersozlu (2024) highlights that online distance learning can actually increase mathematics anxiety, indicating that technology implementation must be done carefully and thoughtfully.

Mathematics anxiety and motivation, several studies specifically target the affective domain. Both Rocha et al. (2021) and Bouzid et al. (2021) found that GBL can reduce mathematics anxiety, although Rocha et al. found mixed results regarding gender. Ersozlu's (2024) review reinforces that GBL and digital tools are generally positive in reducing anxiety, in contrast to distance learning. Almost all studies involving games reported an increase in student interest and motivation. The success of interventions depends not only on the media or materials but also on the pedagogical approach used. The study by Sun et al. (2021) highlights the crucial role of teacher scaffolding in maximizing learning through digital games. Neuroscience principles, as explored by Procopio et al. (2024), offer a foundation for designing learning experiences that are more aligned with how the brain works.

The use of traditional Indonesian games (Ritonga et al., 2022; Dia et al., 2024) and the exploration of DGBL in the Moroccan context (Bouzid et al., 2021) emphasize the importance of cultural relevance in learning materials and media to enhance student engagement and understanding. Development of 21st-Century Skills, in addition to mathematical content knowledge, there is a growing focus on the development of broader skills. The study by Dia et al. (2024) centers on computational thinking, Xu et al. (2023) on creative thinking, and Al-Barakat et al. (2025) on mathematical thinking in general. The review by Dan et al. (2024) notes a need for more DGBL research focused on 21st-century skills.

The review by Larkin & Lowrie (2023) shows that despite much rhetoric about STEM integration, practices in the field are often still siloed or only achieve low levels of integration. More effort is needed to achieve authentic interdisciplinary and transdisciplinary integration. Several articles highlight the importance of teacher preparedness and perspectives. Russo et al. (2024) explore teacher preferences, while Procopio et al. (2024) involve prospective teachers in designing neuroscience-based games, which not only develops their understanding of the material but also of the learning process itself.

Implications and Future Research Directions

Collectively, the findings from these articles have important implications for educational practice and future research. For Educators: There is ample evidence to support the use of GBL (digital and physical) to improve various aspects of student learning. However, the selection and implementation of games must be careful, considering learning objectives, student characteristics, resource availability, and cultural context. The role of the teacher as a facilitator and scaffolder remains crucial, even in technology-based learning environments.

For Curriculum Developers and Policymakers: The integration of innovative approaches such as GBL, culture-based learning, and neuroscience principles into

curricula and teacher training programs needs to be considered. Support for technological infrastructure and continuous professional development for teachers is essential. Efforts for more authentic STEM integration also need to be encouraged.

For Researchers, there are still many areas that require further exploration. The literature reviews we discussed (Dan et al., 2024; Larkin & Lowrie, 2023; Ersozlu, 2024) explicitly mention the need for further research on specific mathematics topics in DGBL (such as statistics and probability), the long-term impact of technological interventions, the role of socioemotional factors, and the exploration of collaborative and competitive gameplay modes. Studies on how teachers can effectively integrate various types of media and approaches are also important. Gender differences in responses to certain interventions, as noted by Rocha et al. (2021) and Al-Barakat et al. (2025), also require further investigation.

4. Conclusion

The dynamics and innovations in elementary school education, particularly in efforts to make learning more engaging, effective, and relevant. Game-based learning, in both physical and digital forms, emerges as a very promising strategy to enhance students' cognitive and affective learning outcomes. The integration of technology offers the potential for personalization and broader reach, but it must be balanced with careful pedagogical considerations, including the role of the teacher, potential anxiety, and equity of access. An in-depth discussion of 15 research articles highlights a significant shift towards innovative learning models in elementary schools, with a primary focus on Game-Based Learning (GBL) in its various forms.

This model consistently shows positive results in increasing engagement, motivation, understanding of mathematical concepts, and even in reducing students' mathematics anxiety. The integration of technology, through adaptive applications and ICT tools like Scratch and GeoGebra, plays an important role in personalizing learning and creating interactive materials. However, the importance of careful pedagogical approaches, such as teacher scaffolding, Problem-Based Learning (PBL), and cultural relevance through traditional games, is also strongly emphasized to maximize effectiveness. The most common learning materials are basic arithmetic and geometry, with a growing focus on developing computational and creative thinking skills.

The main conclusion shows that GBL, both digital and physical, is a promising strategy. Although technology offers many advantages, its implementation must be judicious, considering the potential for increased anxiety in online distance learning. Teacher preferences, as seen in Australia, sometimes lean more towards non-digital games for pedagogical reasons. Collaboration among all stakeholders and further research on specific topics, long-term impacts, and authentic STEM integration remain important areas for the future development of elementary education.

References

Al-Barakat, A. A., El-Mneizel, A. F., Al-Qatawneh, S. S., AlAli, R. M., Aboud, Y. Z., & Ibrahim, N. A. H. (2025). Investigating the Role of Digital Game Applications in Enhancing Mathematical Thinking Skills in Primary School Mathematics Students. *Decision Making: Applications in Management and Engineering*, *8*(1), 132–146. https://doi.org/10.31181/dmame8120251301

Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, *1*(1), 377–386. https://doi.org/10.1162/qss_a_00019

Bang, H. J., Li, L., & Flynn, K. (2023). Efficacy of an Adaptive Game-Based Math Learning App to Support Personalized Learning and Improve Early Elementary School Students' Learning. *Early Childhood Education Journal*, *51*(4), 717–732. https://doi.org/10.1007/s10643-022-01332-3

Bouzid, T., Kaddari, F., Darhmaoui, H., & Bouzid, E. G. (2021). Enhancing math-class experience throughout digital game-based learning, the case of moroccan elementary public schools. *International Journal of Modern Education and Computer Science*, *13*(5). https://doi.org/10.5815/ijmecs.2021.05.01

Cortegiani, A., Ippolito, M., Ingoglia, G., Manca, A., Cugusi, L., Severin, A., Strinzel, M., Panzarella, V., Campisi, G., Manoj, L., Gregoretti, C., Einav, S., Moher, D., & Giarratano, A. (2020). Citations and metrics of journals□discontinued from Scopus for publication concerns: the GhoS(t)copus Project [version 2; peer review: 2 approved, 1 approved with reservations] . *F1000Research*, *9*(415). https://doi.org/10.12688/f1000research.23847.2

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). https://doi.org/10.29333/ejmste/14377

Dia, I., Hainul Putra, Z., Witri, G., & Aljarrah, A. (2024). Development of a Traditional Game-Based Computational Thinking Supplementary Textbook for Elementary School Students. In *Mathematics Teaching Research Journal* (Vol. 185, Issue 2).

Ersozlu, Z. (2024). The role of technology in reducing mathematics anxiety in primary school students. *Contemporary Educational Technology*, *16*(3), ep517. https://doi.org/10.30935/cedtech/14717

Larkin, K., & Lowrie, T. (2023). Teaching Approaches for STEM Integration in Pre- and Primary School: a Systematic Qualitative Literature Review. *International Journal of Science and Mathematics Education*, *21*, 11–39. https://doi.org/10.1007/s10763-023-10362-1

Procopio, M., Fernández-Cézar, R., Fernandes-Procopio, L., & Yánez-Araque, B. (2024). Neuroscience-Based Information and Communication Technologies Development in Elementary School Mathematics through Games: A Case Study Evaluation. *Education Sciences*, *14*(3). https://doi.org/10.3390/educsci14030213

Ramos, L., Simões, V., & Franco, S. (2024). "Active Mathematics"—A Classroom-Based Physical Active Learning Intervention in an Elementary School: An Experimental Pilot Study. *Education Sciences*, *14*(6). https://doi.org/10.3390/educsci14060637

Ritonga, D. A., Damanik, S., Damanik, S. A., Suprayitno, & Priyambada, G. (2022). Development of Learning Variations to Improve Basic Jumping Skills and Play Approaches of Elementary School Students. *International Journal of Education in Mathematics, Science and Technology*, *10*(2), 360–371. https://doi.org/10.46328/ijemst.2246

Rocha, M., & Dondio, P. (2021). Effects of a videogame in math performance and anxiety in primary school. *International Journal of Serious Games*, *8*(3), 45–70. https://doi.org/10.17083/IJSG.V8I3.434

Russo, J. A., Roche, A., Russo, T., & Kalogeropoulos, P. (2024). Examining primary school educators' preferences for using digital versus non-digital games to support mathematics instruction. *International Journal of Mathematical Education in Science and Technology*. https://doi.org/10.1080/0020739X.2024.2361699

Rye, S., Sousa, M., & Sousa, C. (2025). Introduction to Game-Based Learning. In S. Rye, M. Sousa, & C. Sousa (Eds.), *Transformative Learning Through Play: Analogue Games as Vehicles for Educational Innovation* (pp. 29–68). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-78523-8_2

Sarifah, I., Rohmaniar, A., Marini, A., Sagita, J., Nuraini, S., Safitri, D., Maksum, A., Suntari, Y., & Sudrajat, A. (2022). Development of Android Based Educational Games to Enhance Elementary School Student Interests in Learning Mathematics. *International Journal of Interactive Mobile Technologies*, *16*(18), 149–161. https://doi.org/10.3991/ijim.v16i18.32949

Singh, J., Matthees, B., & Odetunde, A. (2021). Leaning online education during COVID-19 pandemic – attitudes and perceptions of non-traditional adult learners. *Quality Assurance in Education*, *29*(4), 408–421. https://doi.org/10.1108/QAE-12-2020-0147

Sun, L., Ruokamo, H., Siklander, P., Li, B., & Devlin, K. (2021). Primary school students' perceptions of scaffolding in digital game-based learning in mathematics. *Learning, Culture and Social Interaction*, *28*. https://doi.org/10.1016/j.lcsi.2020.100457

Xu, E., Lin, Z., & Wang, X. (2024). An innovative study on creative thinking development of elementary school students using multiple data integration. *Applied Mathematics and Nonlinear Sciences*, *9*(1). https://doi.org/10.2478/amns.2023.2.00841

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