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The Effectiveness of Game-Based Learning in Enhancing Elementary Students' Mathematical Conceptual Understanding: A Systematic Literature Review

Efektivitas Game-Based Learning dalam Meningkatkan Pemahaman Konsep Matematika Siswa Sekolah Dasar: Sebuah Systematic Literature Review

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Abstract

Mathematics learning in elementary schools should not only emphasize computational skills but also conceptual understanding, which can be developed through active and interactive learning experiences. This study aims to analyze the effectiveness of Game-Based Learning (GBL) in improving elementary students' mathematical conceptual understanding and to identify the forms of media, implementation patterns, and conditions that support its effectiveness. A Systematic Literature Review (SLR) was conducted using the PRISMA framework on 11 articles published between 2022 and 2026 that met the inclusion criteria. The findings indicate that GBL tends to improve students' mathematical conceptual understanding through concrete games, digital games, Augmented Reality, and AI Edu Tools, although its effectiveness varies across studies. This review contributes by mapping the types of game-based media, the strength of empirical evidence, and key challenges and research gaps, particularly concerning consistency in measuring conceptual understanding, research design variation, learner characteristics, and learning mechanisms within game-based activities.

Keywords: Game-Based Learning; Mathematical Conceptual Understanding; Elementary Students; Educational Game Media; Augmented Reality

Abstrak

Pembelajaran matematika di sekolah dasar tidak hanya menekankan kemampuan berhitung, tetapi juga pemahaman konsep yang dapat dibangun melalui pengalaman belajar yang aktif dan interaktif. Penelitian ini bertujuan menganalisis efektivitas penerapan Game-Based Learning (GBL) dalam meningkatkan pemahaman konsep matematika siswa sekolah dasar serta mengidentifikasi bentuk media, pola penerapan, dan kondisi yang mendukung efektivitasnya. Penelitian menggunakan Systematic Literature Review (SLR) dengan pedoman PRISMA terhadap 11 artikel terbitan 2022–2026 yang memenuhi kriteria inklusi. Hasil kajian menunjukkan bahwa GBL cenderung efektif dalam meningkatkan pemahaman konsep matematika melalui penggunaan permainan konkret, digital, Augmented Reality, dan AI Edu Tools, meskipun tingkat efektivitasnya berbeda antarpelelitian. Kontribusi penelitian ini terletak pada pemetaan bentuk media, kekuatan bukti empiris, serta tantangan dan research gaps, terutama terkait konsistensi pengukuran pemahaman konsep, variasi desain penelitian, karakteristik peserta didik, dan mekanisme pembelajaran dalam permainan.

Kata Kunci: Game-Based Learning; Pemahaman Konsep Matematika; Siswa Sekolah Dasar; Media Permainan Edukatif; Augmented Reality



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INTRODUCTION

Mathematics education at the elementary school level is directed not only toward students' ability to perform calculations but also toward developing conceptual understanding that enables them to explain, connect, and apply mathematical ideas in various situations. Therefore, instruction needs to provide learning experiences that make concepts understandable through meaningful activities. Rahmadani et al. showed that numeracy learning combining interactive activities, gradual practice, and reward systems can increase engagement, confidence, and numeracy skills while encouraging a shift from procedural strategies toward conceptual understanding.¹ Similarly, Asy-Syifa and Khaerudin position the acquisition and internalization of knowledge as a process that extends beyond the transfer of information.² In mathematics education, this need encourages the use of approaches that actively involve students, one of which is *Game-Based Learning* (GBL).

The need for GBL is particularly relevant because mathematical conceptual understanding cannot be developed solely through procedural repetition and the production of correct answers. Students need opportunities to try strategies, discover relationships, receive feedback, and apply concepts in different situations. Brezovszky et al. found that a game-based learning environment can support elementary school students' *adaptive number knowledge*,³ while del Moral Pérez et al. demonstrated improvements in students' logical-mathematical abilities through game-based learning.⁴ In the Indonesian context, Pandanu developed *Journey in Integria*, a web-based educational application specifically designed for conceptual learning of integer operations.⁵ The need for effective instructional approaches must also consider the position of teachers, as changes in teaching practices occur alongside the increasing complexity of pedagogical and administrative responsibilities faced by educators.⁶

GBL operates by embedding learning content within game activities through goals, rules, challenges, interaction, and feedback, allowing students not merely to receive information but to use it throughout the learning process. The meta-analysis by Byun and Joung showed that digital games have been used in K–12 mathematics education and examined in relation to their effects on mathematics achievement.⁷ However, Pan et al. emphasized that the effectiveness of

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- 1 Nadia Rahmadani, Difa'ul Fikri Jayyid, and Abubakar Siddiq Uba, "Beyond Arithmetic Skills: Integrating Interactive Learning, Gradual Practice, and Reward Systems to Foster Children's Numeracy Development," *Eduvista: Journal of Education and Innovation* 1, no. 1 (2026): 1–13, <https://doi.org/10.67964/k98wz439>.
 - 2 Hawwa Asy-Syifa and Khaerudin, "The Model of Knowledge Acquisition in Islam as a Foundation for Reconstructing the Learning Paradigm," *Mishkat: Journal of Theology and Civilization* 1, no. 1 (2026): 77–88, <https://doi.org/10.67964/kndqb313>.
 - 3 Boglárka Brezovszky et al., "Effects of a Mathematics Game-Based Learning Environment on Primary School Students' Adaptive Number Knowledge," *Computers & Education* 128 (2019): 63–74, <https://doi.org/10.1016/j.compedu.2018.09.011>.
 - 4 M Esther del Moral Pérez, Alba P Guzmán Duque, and L Carlota Fernández García, "Game-Based Learning: Increasing the Logical-Mathematical, Naturalistic, and Linguistic Learning Levels of Primary School Students," *Journal of New Approaches in Educational Research* 7, no. 1 (2018): 31–39, <https://doi.org/10.7821/naer.2018.1.248>.
 - 5 Rino Sinus Pandanu, "Developing Journey in Integria: A Web-Based Educational Application for Conceptual Learning of Integer Operations," *Eduvista: Journal of Education and Innovation* 1, no. 1 (2026): 57–68, <https://doi.org/10.67964/yaajt539>.
 - 6 Eva Kumalasari, Nayla Wirdatun Ni'ammah, and Imam Junaris, "Toward the Dehumanization of Islamic Education Teachers: A Conceptual Synthesis of Workload Complexity in the Merdeka Curriculum," *Societa: Journal of Society and Change* 1, no. 1 (2026): 126–42, <https://perfidiajournal.com/index.php/societa/article/view/31>.
 - 7 JaeHwan Byun and Eunmi Joung, "Digital Game-Based Learning for K–12 Mathematics Education: A Meta-Analysis," *School Science and Mathematics* 118, no. 3–4 (2018): 113–26, <https://doi.org/10.1111/ssm.12271>.

GBL depends on how mathematical content is integrated with game mechanisms rather than simply on the use of games.⁸ This is consistent with Rahmadani et al., who highlighted the importance of interaction, gradual practice, and rewards in numeracy learning. Outside the educational context, Alifah and Gamawa also demonstrated that digital game environments such as Roblox can involve users through emotional mechanisms, although these findings cannot be used as evidence of GBL effectiveness in mathematics education.⁹

Research on GBL in mathematics education has been conducted extensively, but the evidence has not been entirely consistent. Byun and Joung identified 33 empirical studies on digital game-based learning in K–12 mathematics education, but only 17 studies provided sufficient statistical data for calculating effect sizes.¹⁰ Tokac et al. subsequently analyzed 24 studies and found that game-based mathematics learning produced a small learning advantage compared with traditional instruction, with effect sizes varying across studies.¹¹ Other research has demonstrated more specific benefits; Brezovszky et al. found improvements in elementary school students' *adaptive number knowledge*.¹² However, Pan et al. based on 43 articles, showed that the relationship between game design, the integration of mathematical content, and learning outcomes requires further explanation.¹³ Thus, the effectiveness of GBL cannot be understood solely from the presence of games in the learning process.

Based on these conditions, a review is needed that specifically focuses on the effectiveness of GBL in improving elementary school students' mathematical conceptual understanding, rather than merely their mathematics achievement or general learning outcomes. The urgency of this review lies in the diversity of games, media, research designs, mathematical topics, and outcome indicators used across existing studies, meaning that positive findings regarding GBL need to be interpreted according to their implementation contexts. Pan et al. emphasized the need for research that explains the relationship between game design, mathematical content, and the learning process, while meta-analytic evidence indicates variation in effects across studies. Therefore, this study aims to analyze the effectiveness of GBL in improving elementary school students' mathematical conceptual understanding and to identify patterns of media, implementation forms, conditions of effectiveness, challenges, and *research gaps* emerging from the reviewed studies.

Method

This study employed a *Systematic Literature Review* (SLR) approach guided by the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA).¹⁴ This approach was used to identify and

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- 8 Yanjun Pan, Fengfeng Ke, and Xinhao Xu, "A Systematic Review of the Role of Learning Games in Fostering Mathematics Education in K-12 Settings," *Educational Research Review* 36 (2022): 100448, <https://doi.org/10.1016/j.edurev.2022.100448>.
 - 9 Helga Tabina Putri Alifah and Bukar Isa Gamawa, "The Effect of Fear of Missing out and Sales Promotion on Virtual Goods Impulse Buying: The Mediating Role of Positive Emotion among Roblox Users," *Novera: Journal of Economics and Business* 1, no. 1 (June 1, 2026): 14–28, <https://doi.org/10.67964/q7m5fw20>.
 - 10 Byun and Joung, "Digital Game-Based Learning for K–12 Mathematics Education: A Meta-Analysis."
 - 11 Umit Tokac, Elena Novak, and Christopher G Thompson, "Effects of Game-Based Learning on Students' Mathematics Achievement: A Meta-Analysis," *Journal of Computer Assisted Learning* 35, no. 3 (2019): 407–20, <https://doi.org/10.1111/jcal.12347>.
 - 12 Brezovszky et al., "Effects of a Mathematics Game-Based Learning Environment on Primary School Students' Adaptive Number Knowledge."
 - 13 Pan, Ke, and Xu, "A Systematic Review of the Role of Learning Games in Fostering Mathematics Education in K-12 Settings."
 - 14 Neal R. Haddaway et al., "PRISMA2020: An R Package and Shiny App for Producing PRISMA 2020-compliant Flow Diagrams, with Interactivity for Optimised Digital Transparency and Open Synthesis," *Campbell Systematic Reviews* 18, no. 2 (June 27, 2022), <https://doi.org/10.1002/cl2.1230>.

analyze studies examining the effectiveness of *Game-Based Learning* (GBL) in improving elementary school students' mathematical conceptual understanding. The literature selection process was conducted based on predetermined inclusion and exclusion criteria. The inclusion criteria consisted of articles published between 2022 and 2026, indexed in SINTA, written in Indonesian, involving elementary/Islamic elementary school students as research subjects, measuring the effectiveness of GBL in improving mathematical conceptual understanding, and available in full and accessible form. Meanwhile, articles that did not meet the criteria for publication year, indexing, language, research subjects, research focus, or accessibility were excluded from the review.

The article selection process was conducted in stages following the PRISMA flow presented in Figure 1. At the *identification* stage, 76 records were obtained from database searches. No duplicate articles were identified or removed, so all 76 records proceeded to the *screening* stage. At this stage, the articles were examined based on their titles and abstracts to determine their initial relevance to the research focus, and 51 articles were excluded because they did not correspond to the focus of the review. Subsequently, 25 articles proceeded to the full-text assessment to evaluate their eligibility. At the *eligibility* stage, the articles were examined more thoroughly based on the predetermined inclusion and exclusion criteria. As a result, 14 articles were excluded because they did not meet the requirements of the study, leaving 11 articles that satisfied the criteria and were included in the review.

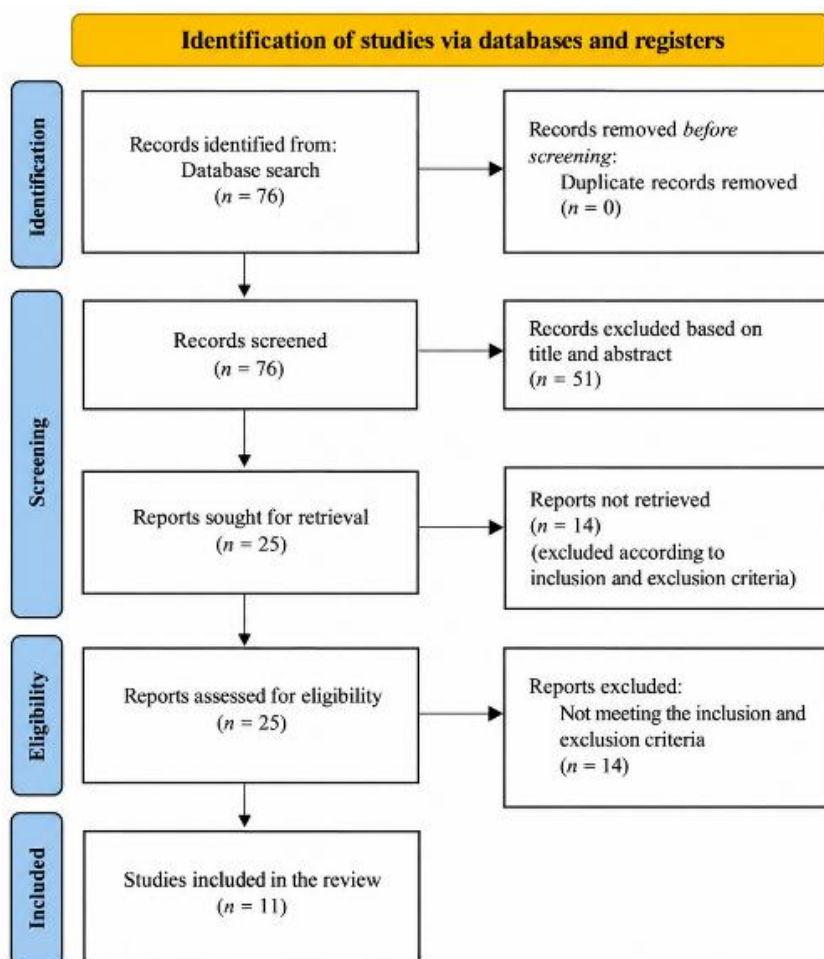


Figure 1. PRISMA-Based Literature Selection Flowchart

Source: Developed by the authors based on the literature selection process.

The 11 articles that met all the criteria were subsequently analyzed to provide an overview of GBL implementation in elementary mathematics education. The analysis considered several aspects, including the authors and publication year, research subjects, research design, type or medium of GBL used, and the main findings related to students' mathematical conceptual understanding. The findings from each article were then compared to identify patterns of effectiveness, variations in the media used, and conditions associated with the successful implementation of GBL. The synthesis results served as the basis for discussing the characteristics of the reviewed studies, patterns of effectiveness and the suitability of GBL media, as well as the challenges and *research gaps* in implementing GBL to improve elementary school students' mathematical conceptual understanding.

RESULTS AND DISCUSSION

Characteristics of Studies on the Implementation of Game-Based Learning for Elementary School Students' Mathematical Conceptual Understanding

The eleven studies included in this systematic literature review were published between 2023 and 2026 and examined the implementation of *Game-Based Learning* (GBL) to support mathematical conceptual understanding among elementary school students. The studies employed diverse research designs, including classroom action research, quasi-experimental studies, pre-experimental studies, and quantitative approaches. The participants were students from Grades II to VI, with different sample sizes and learning contexts. The mathematical topics also varied, ranging from integer operations and fractions to other elementary mathematical concepts. This variation indicates that GBL has been implemented across different grade levels, learning materials, and instructional settings. As summarized in Table 1, the reviewed studies also used various forms of game-based media, including physical learning games, flashcards, puzzles, augmented reality, and AI-based educational tools.

Table 1. Characteristics of Studies on the Implementation of Game-Based Learning for Elementary School Students' Mathematical Conceptual Understanding

No.	Author(s) & Year	Participants and Research Design	Form of GBL	Main Findings
1	Sulthanah et al.	20 Grade II students; classroom action research	<i>Papan Jurang</i>	Conceptual mastery increased from 38.50% to 92.31%.
2	Awalia & Putra	Grade IV students; quantitative experimental study	<i>Smart Snake Ladder</i>	Significant difference between the experimental and control groups (Sig. = 0.000).
3	Gulo & Rizqi	40 Grade II students; quasi-experimental study	<i>PATEM (Papan Tembak)</i>	Mean scores were 90.40 in the experimental group and 75.85 in the control group.
4	Fariqoh et al.	26 Grade VI students; pre-experimental study	<i>Augmented Reality</i>	Scores increased from 49.15 to 85.81 (Sig. = 0.000).
5	Putri et al.	50 Grade IV students; quasi-experimental study	<i>ZepQuiz</i>	N-Gain was 0.57 in the experimental group and 0.40 in the control group; the difference was not statistically significant.

6	Sanjoyo et al.	Grade II students; classroom action research	Puzzle	Mastery increased from 28.58% to 85.71%.
7	Marsita et al.	Grade II students; quasi-experimental study	Flashcards	Posttest scores were 90 in the experimental group and 67.29 in the control group (Sig. = 0.000).
8	Sholikhah & Kusumadewi	25 Grade IV students; pre-experimental study	<i>AI Edu Tools</i>	Scores increased from 56.7 to 81.4 (p = 0.000).
9	Meitriani et al.	21 Grade V students; classroom action research	GBL activities	Mean scores increased from 30.95 to 83.81, with mastery reaching 100%.
10	Ilyas	53 Grade V students; quasi-experimental study	<i>Gurita Berantai</i>	N-Gain was 0.5420 in the experimental group and 0.3278 in the control group (Sig. = 0.011).
11	Afiyah & Sutriyani	Grade III students; quantitative study	Fraction flashcards	Scores increased from 4.14 to 8.24 (p = 0.000).

Source: Compiled from the eleven studies included in the systematic literature review.

The characteristics presented in Table 1 show that the reviewed studies used different methodological approaches to examine the implementation of GBL. Classroom action research was generally used to observe improvements across learning cycles, while quasi-experimental and pre-experimental designs were used to compare or measure changes in students' performance before and after the intervention. The participants were primarily elementary school students in Grades II–VI, indicating that GBL has been applied across various stages of elementary mathematics education. The studies also addressed different mathematical topics and employed different instructional media. Some interventions relied on tangible materials, such as puzzles, flashcards, and game boards, whereas others incorporated digital technologies, such as *augmented reality* and AI-based educational tools. This diversity suggests that GBL is not limited to a single type of classroom activity or learning technology.

In terms of the learning media used, the reviewed studies demonstrate a combination of conventional game materials and technology-supported learning environments. Physical media included *Papan Jurang*, *Smart Snake Ladder*, *PATEM*, puzzles, and flashcards, which enabled students to interact directly with objects while learning mathematical concepts. Meanwhile, technology-based approaches included *augmented reality*, *ZepQuiz*, and *AI Edu Tools*, providing more interactive and digitally mediated learning experiences. The mathematical content also varied according to students' grade levels, including integer operations, fractions, and other elementary mathematical concepts. This variation is important because it shows that GBL can be adapted to different learning materials rather than being restricted to a particular mathematical topic. The studies therefore illustrate a relatively broad application of game-based approaches in elementary mathematics classrooms.

Overall, the findings reported by the eleven studies indicate a predominantly positive pattern in the use of GBL for improving students' mathematical understanding. Several studies reported substantial increases in conceptual mastery or test scores, while quasi-experimental studies generally found higher outcomes in the experimental groups than in the control groups. For example, the studies using *Papan Jurang*, *PATEM*, *augmented reality*, flashcards, and *Gurita Berantai* reported statistically significant improvements or differences. However, the results were not uniformly significant. The study using *ZepQuiz* reported a higher N-Gain in the experimental group than in the control group, but the difference was not statistically significant. This finding

indicates that the effectiveness of GBL should not be understood solely from the use of games. Rather, its outcomes may vary according to the type of game, learning media, instructional design, and characteristics of the students and learning context.

Patterns of Effectiveness and the Suitability of Game-Based Learning Media in Enhancing Students' Mathematical Conceptual Understanding

The synthesis of eleven studies indicates that the implementation of *Game-Based Learning* (GBL) generally demonstrates a positive pattern in enhancing elementary school students' mathematical conceptual understanding. However, this pattern does not appear in the same form or with the same strength across all studies. Sulthanah et al.,¹⁵ Sanjoyo et al.,¹⁶ and Meitriani et al.,¹⁷ for example, employed classroom action research and demonstrated gradual improvements in conceptual understanding across learning cycles. Sulthanah et al. reported an increase in mastery from 38.50% to 92.31%, while Sanjoyo et al. found an increase from 28.58% to 85.71%. Meitriani et al. likewise reported an increase in mean scores from 30.95 to 83.81. A similar pattern was observed by Fariqoh et al.¹⁸ and Sholikhah and Kusumadewi,¹⁹ who found higher scores following the implementation of GBL supported by *Augmented Reality* and *AI Edu Tools*, respectively. The consistency of these findings suggests that GBL can create learning experiences that support the development of conceptual understanding.

This pattern becomes more evident when findings from classroom action research and *one-group pretest-posttest* studies are compared with studies employing experimental and control groups. Awalia and Putra found a significant difference in conceptual understanding between students who used *Smart Snake Ladder* and those in the control group, with a significance value of 0.000.²⁰ Gulo and Rizqi similarly reported a significant difference, with a mean score of 90.40 in the experimental group and 75.85 in the control group after the use of *Papan Tembak (PATEM)*.²¹ Marsita et al. reported a mean *posttest* score of 90 in the experimental group and 67.29 in the

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- 15 Najla Sulthanah et al., "Peningkatan Kemampuan Pemahaman Konsep Matematika Menggunakan Metode Game Based Learning Berbantuan Media Papan Jurang Siswa Sekolah Dasar," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 1 (2026), <https://doi.org/10.23969/jp.v11i01.40326>.
 - 16 T B P Sanjoyo, R P Sriwijayanti, and A Anjarwati, "Penerapan Media Pembelajaran Puzzle Menggunakan Game Based Learning Untuk Meningkatkan Pemahaman Konsep Siswa Pada Konsep 'Penjumlahan Bersusun' Kelas II SDN Mayangan IV," *Innovative: Journal of Social Science Research* 4, no. 2 (2024): 5978–93, <https://doi.org/10.31004/innovative.v4i2.10066>.
 - 17 Ni Nyoman Wahyu Meitriani, I Wayan Dwija, and I Putu Suardika Putra, "Penerapan Game Based Learning Untuk Meningkatkan Pemahaman Konsep Operasi Hitung Bilangan Bulat Siswa Kelas V Sekolah Dasar Negeri 4 Karangasem Tahun Pelajaran 2021/2022," *LAMPUHYANG* 14, no. 1 (2023): 180–94, <https://doi.org/10.47730/jurnallampuhyang.v14i1.338>.
 - 18 Anis Fariqoh, Wulan Sutriyani, and Erna Zumrotun, "Pengaruh Game Based Learning Berbasis Augmented Reality Terhadap Pemahaman Konsep Bangun Ruang SD," *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)* 5, no. 3 (2025): 1243–53, <https://doi.org/10.53299/jppi.v5i3.1745>.
 - 19 Zumrotus Sholikhah and Rida Fironika Kusumadewi, "Pengaruh Model Game Based Learning Berbantuan AI Edu Tools Terhadap Pemahaman Konsep Matematika Bangun Datar Siswa Kelas IV SD," *Buletin Ilmiah Pendidikan* 5, no. 1 (2026): 102–11, <https://doi.org/10.56916/bip.v5i1.4003>.
 - 20 Vira Nur Awalia and Lisa Virdinarti Putra, "Stimulasi Pemahaman Konsep Siswa Melalui Model Pembelajaran Game Based Learning Berbantuan Media Smart Snake Ladder," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 1 (2026): 63–69, <https://doi.org/10.23969/jp.v11i01.42201>.
 - 21 Weli Kusmira Gulo and Hesti Yunitiara Rizqi, "Dampak Penggunaan Model Pembelajaran Game Based Learning Berbantuan PATEM Terhadap Kemampuan Pemahaman Konsep Siswa Sekolah Dasar," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 1 (2026), <https://doi.org/10.23969/jp.v11i01.41479>.

control group,²² while Ilyas found an *N-Gain* of 0.5420 in the experimental group compared with 0.3278 in the control group.²³ Compared with studies that only observed changes within a group before and after an intervention, these findings provide a clearer basis for examining students' achievement relative to a comparison group. Thus, the positive pattern associated with GBL is not limited to within-group improvement but also appears when student outcomes are compared with those receiving different forms of instruction.

Nevertheless, comparisons across the studies indicate that GBL does not consistently produce statistically significant improvements. Putri et al. provides an important finding in this regard.²⁴ Using a quasi-experimental design, the study reported an *N-Gain* of 0.57 for the experimental group and 0.40 for the control group through the use of *ZepQuiz*, but the difference was not statistically significant. This finding differs from those of Awalia and Putra, Gulo and Rizqi, Marsita et al., and Ilyas, all of whom reported significant differences between their experimental and control groups. This variation indicates that the presence of game elements alone is insufficient to explain successful learning outcomes. Even when students using GBL achieve greater gains, the difference may not necessarily be statistically significant. Therefore, the effectiveness of GBL needs to be understood through the quality of the relationship among the game mechanism, learning activities, mathematical content, and the conceptual objectives to be achieved. This finding also cautions against generalizing that all forms of GBL have the same level of effectiveness.

These differences in outcomes can be further understood by examining the characteristics of the game media employed. Sulthanah et al. used *Papan Jurang*, Sanjoyo et al. used *Puzzle*, Marsita et al. used *Flashcard*, Gulo and Rizqi used *Papan Tembak (PATEM)*, and Ilyas used *Gurita Berantai*. Although these games differ in form, they share a common characteristic: students interact directly with the media and follow game rules related to the mathematical content. Sanjoyo et al., for instance, reported increased mastery of the concept of multi-digit addition, while Marsita et al. found a significant difference in achievement between the experimental and control groups. These findings indicate that concrete media serve a function beyond simply creating an engaging learning environment. When manipulation, choice, challenge, and repetition are connected to the concept being learned, the media can act as an intermediary that helps students connect the experience of playing with mathematical understanding.

The same pattern is not limited to concrete media, as several studies demonstrate that GBL can also be developed through digital technologies. Fariqoh et al. used *Augmented Reality* and found an increase in mean conceptual understanding scores from 49.15 to 85.81.²⁵ Sholikhah and Kusumadewi likewise found an increase from 56.7 to 81.4 through GBL supported by *AI Edu Tools*.²⁶ These findings indicate that technology can expand the forms of representation and

22 Endah Nike Marsita, Dwi Rahmawati, and Ade Gunawan, "Efektivitas Game Based Learning Berbantuan Flashcard Terhadap Pemahaman Konsep Matematika," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 2 (2026), <https://doi.org/10.23969/jp.v11i2.55341>.

23 Nur Aisyah Ilyas, "Pengaruh Penerapan Model Game-Based Learning Berbantuan Media Gurita Berantai Terhadap Pemahaman Konsep Bilangan Bulat Pada Siswa Kelas V SD Inpres Perumnas Antang I," *Didaktik: Jurnal Ilmiah PGSD STKIP Subang* 12, no. 2 (2026): 150–63, <https://doi.org/10.36989/didaktik.v12i02.15267>.

24 Lala Sulistia Putri, Maulana, and Cucun Sunaengsih, "Pengaruh Penggunaan ZepQuiz Dalam Model Game-Based Learning Terhadap Pemahaman Materi Pengukuran Sudut Di Sekolah Dasar," *EDUKASI* 13, no. 2 (2025): 540–54, <https://doi.org/10.61672/judek.v13i2.3271>.

25 Fariqoh, Sutriyani, and Zumrotun, "Pengaruh Game Based Learning Berbasis Augmented Reality Terhadap Pemahaman Konsep Bangun Ruang SD."

26 Sholikhah and Kusumadewi, "Pengaruh Model Game Based Learning Berbantuan AI Edu Tools Terhadap Pemahaman Konsep Matematika Bangun Datar Siswa Kelas IV SD."

interaction available during the learning process. Wijianti et al. similarly positioned GBL as a means of constructing conceptual understanding of plane figures through game-based activities.²⁷ However, these findings need to be considered alongside Putri et al., as the use of *ZepQuiz* did not produce a statistically significant difference despite a higher *N-Gain* in the experimental group.²⁸ This comparison demonstrates that technological sophistication is not, by itself, a determinant of GBL effectiveness. Technology becomes meaningful when its features genuinely support students' activities in understanding mathematical concepts.

In addition to media characteristics, the alignment between the game mechanism and mathematical content also emerges as an important pattern across the eleven studies. Meitriani et al. implemented GBL for integer arithmetic and found an increase in mean scores from 30.95 to 83.81.²⁹ Ilyas used *Gurita Berantai* for integer concepts and obtained an *N-Gain* of 0.5420 in the experimental group. For different mathematical topics, Sanjoyo et al. used *Puzzle* for multi-digit addition, Fariqoh et al. used *Augmented Reality* to support understanding of solid figures, and Putri et al. used *ZepQuiz* for angle measurement. Afiah and Sutriyani also found improved learning outcomes through *Flashcard* media for fractions.³⁰ This diversity demonstrates that GBL can be applied across various mathematical topics, but the game format needs to be aligned with the characteristics of the concept being learned. In this context, improvements in outcomes should not be assessed solely through final scores, but also by considering whether the game activities provide students with opportunities to use and apply the concepts targeted by the learning objectives.

The pattern emerging from the eleven primary studies is further supported by several supplementary sources that provide context for the relationship among games, media, and mathematics learning. Rahmadhana and Setiawan examined a *flashcard*-based game to improve elementary students' mathematical conceptual understanding,³¹ while Muna et al. investigated the implementation of the GBL³² method in relation to elementary students' mathematics learning outcomes. Mareta et al. developed mathematics teaching materials oriented toward *games-based learning* to optimize students' conceptual understanding,³³ whereas Dari and Fiantika developed the Android-based digital educational game *MathSpinners* for multiplication and

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- 27 Novia Wahyu Ika Wijianti, Aqidatul Munfariqoh, and Anna Mariyani, "Konstruksi Pemahaman Konsep Bangun Datar Melalui Game-Based Learning Pada Siswa Kelas V SDN 1 Patalan," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 2 (2026), <https://doi.org/10.23969/jp.v11i02.57200>.
 - 28 Putri, Maulana, and Sunaengsih, "Pengaruh Penggunaan ZepQuiz Dalam Model Game-Based Learning Terhadap Pemahaman Materi Pengukuran Sudut Di Sekolah Dasar."
 - 29 Meitriani, Dwija, and Putra, "Penerapan Game Based Learning Untuk Meningkatkan Pemahaman Konsep Operasi Hitung Bilangan Bulat Siswa Kelas V Sekolah Dasar Negeri 4 Karangasem Tahun Pelajaran 2021/2022."
 - 30 Kholifatun Nur Afiah and Wulan Sutriyani, "Efektivitas Metode Game-Based Learning Berbantuan Media Flashcard Pecahan Terhadap Hasil Belajar Matematika Siswa," *LINEAR: Journal of Mathematics Education* 5, no. 2 (2024): 171–80, <https://doi.org/10.32332/xmy86j91>.
 - 31 Zhafirah Fildzah Ramadhana and Bramianto Setiawan, "Implementasi Permainan Jalan-Jalan Berbasis Flashcard Untuk Meningkatkan Pemahaman Konsep Matematika Siswa Kelas I Sekolah Dasar," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 10, no. 3 (2025): 246–58, <https://doi.org/10.23969/jp.v10i03.33215>.
 - 32 Nailil Muna et al., "Pengaruh Metode Game Based Learning Terhadap Hasil Belajar Mata Pelajaran Matematika Kelas V SDI Bahrul Ulum Panjang Jiwo," *Primary Education Journals (Jurnal Ke-SD-An)* 5, no. 1 (2025): 141–44, <https://doi.org/10.36636/primed.v5i1.5154>.
 - 33 R Mareta, Jayanti, and D W Rachmawati, "Pengembangan Bahan Ajar Matematika Berorientasi Games Based Learning Mengoptimalkan Kemampuan Pemahaman Pada Siswa Kelas IV," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 3 (2026), <https://doi.org/10.23969/jp.v11i03.56989>.

division.³⁴ These supporting studies are consistent with the main findings that games become more meaningful when positioned as part of the instructional design rather than as an additional activity. Overall, the synthesis indicates that GBL effectiveness is shaped by the alignment among media, game mechanisms, mathematical content, student characteristics, and learning objectives. At the same time, the presence of statistically nonsignificant findings indicates that such alignment needs to be deliberately designed rather than assumed simply because instruction incorporates games.

Challenges and Research Gaps in the Implementation of GBL

Although the eleven studies reviewed demonstrate an overall positive tendency, the findings are insufficient to conclude that *Game-Based Learning* (GBL) is consistently effective in enhancing elementary school students' mathematical conceptual understanding. Putri et al., for example, reported an *N-Gain* of 0.57 in the experimental group and 0.40 in the control group through the use of *ZepQuiz*, but the difference was not statistically significant.³⁵ This finding provides an important counterpoint to the studies by Awalia and Putra,³⁶ Gulo and Rizqi,³⁷ Marsita et al.,³⁸ and Ilyas,³⁹ which reported significant differences between their experimental and control groups. These differences indicate that the effectiveness of GBL needs to be understood contextually and is not determined solely by the presence of game elements. Even when students using GBL achieve greater score gains, such gains do not necessarily indicate a significant difference compared with the comparison condition. Therefore, research on GBL needs to move beyond asking whether games are effective toward examining the conditions under which particular games effectively support conceptual understanding.

Differences in the strength of the evidence also need to be considered when comparing the findings of the eleven studies. Sulthanah et al., Sanjoyo et al., and Meitriani et al. employed classroom action research and demonstrated improvements in conceptual understanding across several learning stages.⁴⁰ Meanwhile, Fariqoh et al. and Sholikhah and Kusumadewi employed a *one-group pretest-posttest* design, in which changes were observed within the same group before and after the intervention.⁴¹ In contrast, Awalia and Putra, Gulo and Rizqi, Marsita et al., Ilyas, and

34 Tantri Wulan Dari and Feny Rita Fiantika, "Pengembangan Game Edukatif Digital MathSpinners Berbasis Android Untuk Meningkatkan Pemahaman Konsep Perkalian Dan Pembagian Di Sekolah Dasar," *Pendas: Jurnal Ilmiah Pendidikan Dasar* 11, no. 2 (2026): 1–11, <https://doi.org/10.23969/jp.v11i02.51642>.

35 Putri, Maulana, and Sunaengsih, "Pengaruh Penggunaan ZepQuiz Dalam Model Game-Based Learning Terhadap Pemahaman Materi Pengukuran Sudut Di Sekolah Dasar."

36 Awalia and Putra, "Stimulasi Pemahaman Konsep Siswa Melalui Model Pembelajaran Game Based Learning Berbantuan Media Smart Snake Ledder."

37 Gulo and Rizqi, "Dampak Penggunaan Model Pembelajaran Game Based Learning Berbantuan PATEM Terhadap Kemampuan Pemahaman Konsep Siswa Sekolah Dasar."

38 Marsita, Rahmawati, and Gunawan, "Efektivitas Game Based Learning Berbantuan Flashcard Terhadap Pemahaman Konsep Matematika."

39 Ilyas, "Pengaruh Penerapan Model Game-Based Learning Berbantuan Media Gurita Berantai Terhadap Pemahaman Konsep Bilangan Bulat Pada Siswa Kelas V SD Inpres Perumnas Antang I."

40 Sulthanah et al., "Peningkatan Kemampuan Pemahaman Konsep Matematika Menggunakan Metode Game Based Learning Berbantuan Media Papan Jurang Siswa Sekolah Dasar"; Sanjoyo, Sriwijayanti, and Anjarwati, "Penerapan Media Pembelajaran Puzzle Menggunakan Game Based Learning Untuk Meningkatkan Pemahaman Konsep Siswa Pada Konsep 'Penjumlahan Bersusun' Kelas II SDN Mayangan IV"; Sholikhah and Kusumadewi, "Pengaruh Model Game Based Learning Berbantuan AI Edu Tools Terhadap Pemahaman Konsep Matematika Bangun Datar Siswa Kelas IV SD."

41 Fariqoh, Sutriyani, and Zumrotun, "Pengaruh Game Based Learning Berbasis Augmented Reality Terhadap Pemahaman Konsep Bangun Ruang SD"; Sholikhah and Kusumadewi, "Pengaruh Model Game Based Learning Berbantuan AI Edu Tools Terhadap Pemahaman Konsep Matematika Bangun Datar Siswa Kelas IV SD."

Putri et al. employed quasi-experimental designs with comparison groups.⁴² These differences in research design indicate that the findings are based on different forms of comparison. Improvements across cycles or before and after an intervention indicate changes following GBL implementation, whereas designs involving control groups allow such changes to be compared with another instructional condition. Therefore, future research should consider more consistent research designs and adequate comparison conditions to evaluate the effectiveness of GBL more rigorously.

Another issue concerns the consistency of how *mathematical conceptual understanding* is measured. Most of the studies explicitly positioned conceptual understanding as the outcome being examined, including Sulthanah et al., Gulo and Rizqi, Fariqoh et al., and Sholikhah and Kusumadewi. However, Afiah and Sutriyani reported changes in mathematics learning outcomes, rather than specifically in conceptual understanding. Their study found an increase in the mean score from 4.14 to 8.24 following the implementation of GBL supported by *Flashcards*. This finding remains relevant for demonstrating the potential of GBL in mathematics learning, but its outcome is not fully identical to that of studies specifically measuring conceptual understanding. A similar distinction can be seen in Anggi et al., which examined basic arithmetic skills through the *Pokemon TCG* game.⁴³ These differences in focus indicate that the *game-based mathematics* literature encompasses a range of mathematical abilities. Therefore, an important *research gap* concerns the need for more consistent indicators of conceptual understanding so that findings across studies can be compared more precisely.

The contexts and characteristics of the participants also indicate areas for further research. The eleven studies involved elementary and Islamic elementary school students from Grades II to VI, but the number of participants and research settings varied across studies. Sulthanah et al., for example, involved 20 Grade II students, Gulo and Rizqi involved 40 students, Sholikhah and Kusumadewi involved 25 students, and Ilyas involved 53 students. This variation indicates that the evidence on GBL comes from different participant groups and instructional contexts, although some studies were still conducted with relatively small groups of participants. These conditions mean that the findings should be interpreted within the context of each study rather than directly generalized to all elementary school students. Future research could expand the number of participants, involve schools with different characteristics, and examine GBL across more diverse instructional contexts. Such efforts would provide a more comprehensive understanding of GBL effectiveness rather than relying primarily on evidence from individual classes or specific school settings.

The use of technology in GBL also reveals issues that have not yet been fully addressed. Fariqoh et al. and Sholikhah and Kusumadewi reported improvements in conceptual understanding through *Augmented Reality* and *AI Edu Tools*, respectively, whereas Putri et al. found no statistically significant difference through *ZepQuiz*. These differences indicate that the digitization of learning media does not, by itself, determine the success of GBL. Dari and Fiantika developed *MathSpinners*, an Android-based educational game for multiplication and

42 Awalia and Putra, “Stimulasi Pemahaman Konsep Siswa Melalui Model Pembelajaran Game Based Learning Berbantuan Media Smart Snake Ladder”; Gulo and Rizqi, “Dampak Penggunaan Model Pembelajaran Game Based Learning Berbantuan PATEM Terhadap Kemampuan Pemahaman Konsep Siswa Sekolah Dasar”; Marsita, Rahmawati, and Gunawan, “Efektivitas Game Based Learning Berbantuan Flashcard Terhadap Pemahaman Konsep Matematika”; Ilyas, “Pengaruh Penerapan Model Game-Based Learning Berbantuan Media Gurita Berantai Terhadap Pemahaman Konsep Bilangan Bulat Pada Siswa Kelas V SD Inpres Perumnas Antang I”; Putri, Maulana, and Sunaengsih, “Pengaruh Penggunaan ZepQuiz Dalam Model Game-Based Learning Terhadap Pemahaman Materi Pengukuran Sudut Di Sekolah Dasar.”

43 Muhamad Anggi, Wina Dwi Puspitasari, and Ujiati Cahyaningsih, “Pengaruh Model Pembelajaran Game-Base Learning Dengan Media Pokemon TCG Untuk Meningkatkan Kemampuan Berhitung Aritmatika Dasar Di SD,” *Pendas: Jurnal Ilmiah Pendidikan Dasar* 10, no. 4 (2025): 306–17, <https://doi.org/10.23969/jp.v10i04.34749>.

division, while Mareta et al. developed mathematics teaching materials oriented toward *games-based learning*. These studies demonstrate continued development in game-based media design, but they do not directly establish which conditions of technology use produce stronger conceptual understanding. Thus, the *research gap* concerning technology is not simply the need to develop more digital media, but rather the need to identify the features, forms of interaction, and modes of technology use that genuinely support students' conceptual learning processes.

Beyond effectiveness and media, the reviewed studies also leave room for a deeper examination of the learning mechanisms involved in GBL. Several studies primarily reported changes in scores, mastery percentages, or differences between groups, while explanations of the learning processes occurring during gameplay were not the main focus of the reported findings. Yet GBL may involve students in trying strategies, responding to challenges, receiving feedback, repeating actions, and applying concepts to solve problems. Meitriani et al., for example, demonstrated improved understanding of integer operations, while Sanjoyo et al. reported improvement in the concept of multi-digit addition. Ilyas also found a significant difference in students' understanding of integer concepts through *Gurita Berantai*. These findings demonstrate changes in learning outcomes, but they do not specifically explain the contribution of each game activity to the development of conceptual understanding. Future research should therefore pay greater attention to the interaction processes, student activities, and learning mechanisms that occur during gameplay.

Based on the overall findings, the *research gaps* in the implementation of GBL in elementary mathematics education do not primarily concern a lack of evidence that games can be incorporated into instruction. The eleven studies reviewed have demonstrated an overall positive tendency, although not all findings were statistically significant. The gaps are more clearly reflected in four aspects: consistency in measuring conceptual understanding, variation in the strength of research designs, limited diversity in research contexts and participant characteristics, and insufficiently detailed explanations of the learning mechanisms that occur during gameplay. Putri et al. demonstrated that higher score gains do not necessarily result in statistically significant differences, while Afyah and Sutriyani highlighted the distinction between learning outcomes and conceptual understanding as research outcomes. Accordingly, future studies could employ more consistent conceptual indicators, stronger comparative research designs, more diverse participant contexts, and analyses of GBL processes and mechanisms. Such directions would allow research to move beyond simply examining whether GBL improves conceptual understanding toward a deeper understanding of how, when, and under what conditions GBL supports elementary school students' mathematical conceptual understanding.

CONCLUSION

The findings of this *systematic literature review* indicate that *Game-Based Learning* (GBL) tends to be effective in improving elementary school students' mathematical conceptual understanding, although its effectiveness varies according to the type of game, learning media, characteristics of the mathematical content, and instructional design. This effectiveness is reflected in increased mastery and conceptual understanding scores reported in classroom action and *pre-experimental* studies, as well as significant differences found in several *quasi-experimental* studies. GBL can support students' conceptual understanding because learning takes place through more concrete, interactive, repetitive activities that provide opportunities for students to apply mathematical concepts through game rules and challenges. However, the non-significant findings from the use of *ZepQuiz* indicate that the incorporation of game elements or digital technology does not automatically produce better conceptual understanding. Therefore, the effectiveness of GBL depends more on the alignment between the game mechanism, learning

media, characteristics of the mathematical concept, and instructional objectives than merely on the use of games as a variation in teaching.

This review contributes to the literature by mapping patterns of GBL implementation in elementary mathematics education, including variations in concrete and digital media and differences in the strength of evidence across research designs. Nevertheless, this review is limited by the number and diversity of the analyzed articles, variations in research designs, and the lack of consistent measurement of mathematical conceptual understanding across the reviewed studies. Some studies also place greater emphasis on general learning outcomes or mathematical abilities and therefore do not fully represent changes in conceptual understanding. Future research should consequently employ more consistent indicators of conceptual understanding, stronger comparative designs with appropriate control groups, and more diverse student characteristics, grade levels, and school contexts. Future studies should also move beyond determining whether GBL is effective by examining how game mechanisms, forms of interaction, feedback, challenges, and media characteristics contribute to the development of students' mathematical conceptual understanding.

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