TEACHING ALGEBRA THROUGH GAMES: A LITERATURE REVIEW

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ABSTRACT

This systematic literature review investigates the application of game-based learning (GBL) in teaching algebra at the junior and senior secondary levels within the Indonesian education system between 2014 and 2024. The review synthesizes 22 empirical studies written in both English and Indonesian, selected from an initial pool of approximately 3,000, based on strict inclusion criteria such as curriculum alignment, empirical design, and measurable learning outcomes. Findings show that 14 studies utilized digital games, while 8 employed non-digital formats. Of the 22 studies, 18 reported increased student engagement, 17 demonstrated improvements in conceptual understanding, and 10 highlighted enhanced problem-solving skills. Frequently used platforms included Quizizz, DragonBox, and Android-based educational games, while non-digital games ranged from board games to card-based activities. Theoretical underpinnings were often grounded in constructivist and game-based learning frameworks. Despite promising results, gaps remain in exploring advanced algebra topics and long-term effectiveness. This review underscores the potential of game-based strategies to enhance algebra instruction in Indonesia, while calling for broader and more methodologically diverse research in the future.

Keywords: algebra, games, mathematics, game-based learning

1. Introduction

Algebra is a foundational branch of mathematics that plays a central role in developing students' logical reasoning, abstract thinking, and problem-solving skills. As a core topic in the middle and secondary school mathematics curriculum, algebra serves as a gateway to advanced mathematical thinking and application. However, numerous studies have highlighted that many students struggle to understand algebraic concepts, often perceiving them as abstract, difficult, and disconnected from real-life contexts (Cai & Knuth, 2011; Stacey & Chick, 2004). In Indonesia, national assessments and international benchmarking tests such as PISA and TIMSS have consistently revealed low achievement levels in mathematical literacy, especially in algebra-related tasks (OECD, 2019; Mullis et al., 2020). These findings suggest an urgent need

for more engaging and effective pedagogical strategies to improve students' learning outcomes in algebra.

One promising innovation in mathematics education is the use of game-based learning (GBL), which integrates elements of play, challenge, feedback, and storytelling into the learning process. GBL aligns with constructivist learning theory, where students actively construct knowledge through meaningful experiences, often in collaborative and exploratory settings (Vygotsky, 1978; Piaget, 1972). In the context of algebra education, games—whether digital or analog—offer dynamic environments where students can experiment with symbols, manipulate variables, and solve problems through play-based interaction. Several studies have shown that game-based learning can improve students' engagement, conceptual understanding, motivation, and retention in mathematics (Clark et al., 2016; Ke, 2008). Moreover, games provide safe spaces for trial and error, promote intrinsic motivation, and support personalized learning, making them particularly valuable for topics like algebra that require repeated practice and deep conceptualization (Gee, 2003; Papastergiou, 2009).

In Indonesia, the educational landscape has also shifted toward more student-centered approaches with the implementation of Kurikulum 2013 and more recently the Kurikulum Merdeka, which emphasize creativity, higher-order thinking skills, and differentiated instruction. These policy reforms create a conducive framework for integrating innovative pedagogies such as game-based learning. Moreover, Indonesia's rapid digitalization and the increasing accessibility of smartphones and internet among school-aged children have opened new opportunities for incorporating educational games into formal and informal learning contexts (Novrialdy, 2019). Consequently, teachers, researchers, and educational technologists in Indonesia have begun to develop and implement various types of games—ranging from Android-based algebra games and puzzle apps to board games and card games—to support algebra instruction at the secondary level.

Despite growing interest in the application of game-based learning for teaching algebra in Indonesia, the existing research is fragmented, often limited to small-scale studies or one-off development projects. While some studies have demonstrated positive impacts on learning outcomes and student engagement, there has been limited effort to consolidate findings, assess patterns, and evaluate long-term implications. A comprehensive review is needed to synthesize what has been learned over the past decade, identify effective practices, highlight limitations, and inform future research and development.

This study aims to fill a specific research gap in the fragmented and limited body of empirical work on game-based algebra instruction within Indonesia's secondary education context. Although individual studies have explored the use of digital and non-digital games, these efforts are often isolated, small-scale, short-term, and focus narrowly on early algebra topics such as expressions and linear equations. There is a notable lack of comprehensive synthesis regarding the types of games used, their measured impacts on student learning outcomes, the role of theoretical frameworks, and practical implementation challenges. This systematic review addresses that gap by consolidating evidence from 22 empirical studies conducted between 2014 and 2024. Specifically, the review (1) identifies the types of games applied in algebra instruction, (2) evaluates their impact on conceptual understanding, engagement, and

problem-solving skills, (3) maps the theoretical models that guide these interventions, and (4) analyzes limitations and directions for future research. By offering a structured overview of patterns and gaps, this review contributes to the development of evidence-informed educational strategies and encourages more scalable, theory-driven, and contextually relevant innovations in Indonesian mathematics education. It also provides policymakers, educators, and curriculum developers with clearer insights into how game-based learning can be integrated into national reforms such as Kurikulum Merdeka to support 21st-century competencies.

2. Method

This study adopted a systematic literature review (SLR) approach to identify, evaluate, and synthesize research on the use of game-based learning (GBL) in algebra instruction for junior and senior secondary students within the Indonesian context. A systematic review was chosen to provide a structured and comprehensive overview of existing knowledge, patterns, and research gaps, particularly relevant given the increasing integration of educational technology and curriculum reform in Indonesia over the past decade. The review focused on publications from 2014 to 2024, aligning with the post-implementation period of *Kurikulum 2013* and the emergence of *Kurikulum Merdeka*, both of which emphasize student-centered, creative, and differentiated learning.

The literature search was conducted across both international and Indonesian academic databases, including Google Scholar, ERIC, DOAJ, Garuda, Neliti, and institutional repositories. A combination of English and Indonesian search terms was used to identify studies related to algebra instruction and game-based learning. Keywords included "algebra game Indonesia," "game-based learning matematika SMP SMA," "pembelajaran aljabar berbasis permainan," and "media pembelajaran aljabar." Boolean operators and quotation marks were used to refine the results, and additional relevant literature was retrieved through snowballing reference lists.

The initial search yielded approximately 3,000 documents. However, a rigorous screening process based on predefined inclusion and exclusion criteria was applied to ensure focus, relevance, and quality. Studies were included if they met the following conditions: (1) published between 2014 and 2024, (2) written in English or Indonesian, (3) conducted in Indonesia or clearly aligned with the Indonesian national curriculum, (4) focused on teaching algebra at the junior or senior secondary level using game-based methods, and (5) employed empirical approaches with measurable outcomes such as student engagement, conceptual understanding, motivation, or problem-solving. Both digital (e.g., mobile apps) and non-digital (e.g., board games) implementations were considered.

Figure 1: PRISMA Flow Diagram of Study Selection
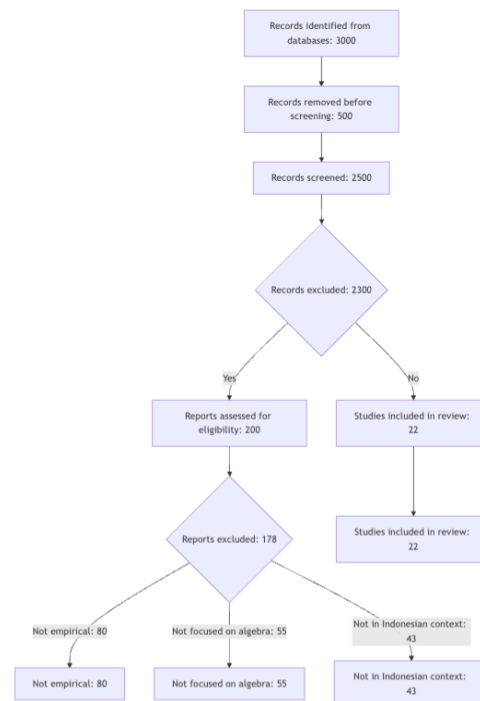
Exclusion criteria included studies focusing on primary or tertiary education levels, general discussions of games without algebra-specific content, lack of empirical data, or failure to meet basic academic quality standards. Duplicates, inaccessible full texts, and theoretical-only papers were also excluded.

Following this multi-stage screening process—including title and abstract screening, full-text evaluation, and quality appraisal—a total of 22 studies were selected for inclusion in the final analysis. This relatively small number, despite a large initial pool, reflects the specificity and rigor of the inclusion criteria rather than a lack of research activity. Many retrieved studies, while thematically adjacent, did not meet the methodological, contextual, or topical thresholds required for this review.

For each of the selected studies, data such as game type, algebra topic, participant profile, research design, outcomes, and theoretical underpinnings were extracted and organized into a summary matrix. The studies were then analyzed thematically to identify patterns in pedagogical strategies, outcome trends, and research gaps. The findings are presented in the following sections, organized by emergent themes and contextualized within broader educational discourses.

3. Result and Discussion

The analysis of the 22 selected studies highlights several key themes in the implementation of game-based learning (GBL) for algebra instruction within Indonesia's secondary education context. Both digital and non-digital games were positioned not merely as supplementary learning tools, but as integral components of instructional strategies designed

to enhance students' conceptual understanding, engagement, and problem-solving abilities in algebra (Sarji, 2021; Wicaksono & Yunianta, 2022). Common algebra topics addressed in these studies included simplifying algebraic expressions, solving linear equations, and interpreting word problems—topics that are often recognized as challenging for students. As such, these areas were frequently selected as focal points for game-based pedagogical interventions (Clark et al., 2016), indicating the potential of games to support learning in conceptually demanding areas of mathematics.

Table.1 Mapping of Studies by Year of Publication

Year	2015	2018	2020	2021	2022	2023	2024
Number of Studies	2	2	4	2	4	6	2

In terms of delivery format, digital games emerged as the dominant medium across the reviewed literature. A number of Android-based applications developed by local university researchers—such as *Petualangan Aljabar*, *Petualangan Alja*, and *Alien Aljabar*—embedded algebraic problem-solving tasks within engaging adventure, puzzle, and action game narratives (Sarji, 2021; Wicaksono & Yunianta, 2022). These games typically required students to complete algebraic challenges to advance through levels, leveraging gameplay mechanics akin to commercial entertainment games to maintain motivation and interest. In addition to locally developed tools, several studies explored the implementation of widely recognized platforms such as *DragonBox* and *Quizizz*. Although not originally designed in Indonesia, these tools were successfully adapted to suit the local classroom context. Notably, *DragonBox* demonstrated effectiveness in enhancing both conceptual understanding and mathematical problem-solving when integrated into a multi-representational learning model, as shown in the quasi-experimental research by Supriadi et al. (2020). Meanwhile, *Quizizz* received positive evaluations for its user-friendly interface, game-like competitiveness, and ability to gamify review sessions—factors that contributed to increased student engagement and focus during algebra learning (Yanuarto & Hastinasyah, 2022).

Table.2 Research Based on Citations

No	Title of Study	Game Type	Level	Focus Topic	Reported Outcome	Author(s)
1	Pengembangan Media Permainan Matematika Big Snake and Ladder Game pada Materi Aljabar	Non-Digital	SMP	Algebraic Expressions	The developed "Big Snake and Ladder Game" was deemed highly feasible and engaging, enhancing students' understanding of algebraic concepts.	Putri, L.M. (2023)
2	Impact the Labirin: The Board Game on the Student's Numeracy Ability	Non-Digital	SMP	Whole Numbers and Fractions	Implementation of the "Labirin" board game improved students' numeracy abilities and facilitated easier learning of mathematics concepts.	Putra, et al. (2024)
3	The Use of Applets to Improve Indonesian Student Performance in Algebra	Digital	SMP	Algebraic Concepts	Utilizing interactive applets enhanced students' performance in algebra, addressing common misconceptions and difficulties.	Jupri, A. (2015)
4	Game-Based Learning: Learn Math While You Play With It	Digital	SMP	Basic Algebra Concepts	Improved student engagement and understanding of algebraic concepts	Antipolo, J. (2021).
5	Development of Games-Based Learning Media 'Eco Quest: Guardian of the Element'	Digital	SMA	Not Algebra (Environmental Science)	Increased environmental awareness, not focused on algebra	Amelia, et al. (2024)
6	Pengembangan media petualangan aljabar berbasis permainan edukasi untuk siswa SMP	Digital	SMP	Algebraic Expressions & Operations	Developed an educational game that increased student engagement and algebra understanding.	Sarji (2021)
7	Concept understanding and mathematic problem solving skills in algebraic materials: The effect of DragonBox game assisted	Digital	SMP	Algebraic Concepts & Problem Solving	DragonBox improved conceptual understanding and problem-solving during remote learning.	Supriadi et al. (2020)

No	Title of Study	Game Type	Level	Focus Topic	Reported Outcome	Author(s)
	DMR of COVID-19					
8	Penerimaan game instruksional DragonBox Algebra 12+ pada pembelajaran aljabar berdasarkan teori Technology Acceptance Model (TAM)	Digital	SMP	Algebra Instructional Acceptance & Use	Found high levels of acceptance and perceived usefulness of DragonBox in algebra learning.	Teofani, Marzal, & Sofyan (2020)
9	Pengembangan game edukasi "Petualangan Alja" untuk melatih conceptual understanding dan procedural fluency siswa SMP materi aljabar	Digital	SMP	Conceptual Understanding & Procedural Fluency	Game improved both conceptual and procedural fluency in algebra among SMP students.	Wicaksono & Yunianta (2022)
10	Pengembangan media bus race algebra pada materi bentuk aljabar untuk siswa kelas VII SMP	Board Game (Bus Race Algebra)	Junior High School (Grade VII)	Algebraic forms	The media was valid and effective in helping students understand algebraic expressions	Prambudi, E. Y., & Yunianta, T. N. H. (2020)
11	Development of PUHA (Pop Up Horses Algebra) educational games for enhancing grade 7 students' algebraic learning	Non-Digital	SMP	Algebraic Expressions	Improved conceptual understanding of algebra	Surur, et al. (2024)
12	Development of algebraic domino games in mathematics learning based on ICT in junior high school	Digital	SMP	Algebraic Expressions and Equations	Increased engagement and problem-solving skills	Umbara, et al. (2021)

No	Title of Study	Game Type	Level	Focus Topic	Reported Outcome	Author(s)
13	Development of Game-Based Mathematics Learning Media to Improve Mathematical Understanding Abilities	Digital	SMP	Algebra (General)	Improved understanding and motivation	Putri et al. (2023)
14	The Development of Borad game 'The Adventure Of Algebra' in The Senior High School Mathematics Learning	Non-Digital	SMA	Algebra (General)	Improved learning interest and understanding	Andini & Yunianta (2018)
15	Gamification: Quizizz in Mathematical Game Learning for Secondary Students	Digital	SMP/ SMA	Algebra (Review and Assessment)	Enhanced engagement and critical thinking	Yanuarto & Hastinasyah (2022)
16	Eksperimentasi Model Pembelajaran Kooperatif Teams Games Tournament, Numbered Head Together Dan Problem Based Learning Dengan Pendekatan Saintifik Pada Materi Operasi Dan Faktorisasi Bentuk Aljabar Ditinjau Dari Aktivitas Belajar Siswa	Teams Games Tournament (TGT), Numbered Head Together (NHT), and Problem-Based Learning with games	Junior High School	Algebra (operations and factorization), Learning Activities	TGT model showed higher effectiveness in increasing student learning activity on algebra material	Buana, A. C., Kusmayadi, T. A., & Sujadi, I. (2015)
17	Pengembangan Game Edukasi Ksatria Aljabar Berbasis Android sebagai Suplemen Pembelajaran pada Materi Aljabar	Digital	SMP	Algebra (conceptual understanding)	The game effectively supplements algebra learning and improves student engagement	Taufiqurrahman, M., Wintarti, A., & Prihartiwi, N. R. (2023)

No	Title of Study	Game Type	Level	Focus Topic	Reported Outcome	Author(s)
18	Penerapan Model Pembelajaran Game Based Learning dengan Quiz Game Baambloze terhadap Kemampuan Berpikir Kritis Matematik Siswa SMP	Digital	SMP	Critical thinking in mathematics	Game-based learning model using Baambloze improved students' mathematical critical thinking	Hartanto, R. T., Hamidah, H., & Kusuma, J. W. (2024)
19	Pengaruh Game Edukasi Berbasis Android "Alien Aljabar" terhadap Kemampuan Pemahaman Matematis Aljabar Siswa	Digital	SMP	Algebra (conceptual understanding)	The game increased students' mathematical understanding in algebra	Zubaidah, S. (2023)
20	The effect of game based learning with math bingo in reducing math anxiety to improve students' mathematics learning outcomes in data presentation materials	Digital	SMP	Math Anxiety (Related to Algebra Topics)	Reduced anxiety, improved outcomes	Ayyasy (2023)
21	Ekspansi Media Permainan Kartu Uno Spin Matematika Untuk Pembelajaran Matematika Materi Bentuk Aljabar Pada Siswa Smp	Non-Digital	SMP	Simplifying Algebraic Expressions	Feasible, improves interest and understanding	Hasanah et al. (2022)
22	PENERAPAN MODEL PEMBELAJARAN KOOPERATIF TIPE TGT	Non-Digital (Cooperative Game Model)	SMP	Addition and Subtraction of Algebraic Forms	Improved learning outcomes in algebra	Sulaiman (2018)

No	Title of Study	Game Type	Level	Focus Topic	Reported Outcome	Author(s)
	UNTUK MENINGKATK AN HASIL BELAJAR SISWA KELAS VIII SMP NEGERI 4 PALU PADA MATERI PENJUMLAHA N DAN PENGURANG AN BENTUK ALJABAR					

3.1   Thematic   Analysis   of   Game-Based   Learning   Outcomes

The findings from the 22 reviewed studies were grouped into thematic categories based on the primary learning outcomes reported. These include: (1) cognitive outcomes (conceptual understanding and problem-solving), (2) affective outcomes (motivation and engagement), and (3) pedagogical factors (teacher roles and implementation conditions).

A. Cognitive Outcomes: Conceptual Understanding and Problem-Solving
Seventeen studies reported improvements in students' conceptual understanding of algebra, particularly in topics such as algebraic expressions, linear equations, and factorization. For example, Supriadi et al. (2020) and Wicaksono & Yunianta (2022) demonstrated that games like DragonBox and Petualangan Alja enhanced procedural fluency and symbolic manipulation. Ten studies also documented gains in problem-solving abilities, often through gameplay scenarios that required students to apply reasoning and strategic thinking (e.g., Sarji, 2021; Setyawan et al., 2021).

### B. Affective Outcomes: Engagement and Motivation
Eighteen studies cited increased engagement and motivation as key outcomes of game-based interventions. Platforms such as Quizizz (Yanuarto & Hastinasyah, 2022) and interactive story-based games (Sarji, 2021) maintained student interest through challenge, competition, and instant feedback. These affective gains were especially significant in contexts where algebra is typically perceived as abstract or intimidating.

C. Pedagogical Factors: Teacher Role and Implementation
Only five studies explicitly discussed the role of the teacher in implementing GBL (e.g., Buana et al., 2015; Hartanto et al., 2024). Findings indicate that the success of GBL interventions often depended on how teachers facilitated gameplay, scaffolded problem-solving, and managed class flow. However, most studies did not detail teacher training or integration strategies, revealing a notable gap in implementation research.

Separetely, although non-digital games (8 studies) appeared less frequently than digital ones (14 studies), they still contributed meaningfully to algebra instruction in the Indonesian context. For example, *Petualangan Aljabar* and *Petualangan Alja*, developed as physical or hybrid formats, were designed to enhance students' procedural fluency and conceptual understanding in algebra through engaging gameplay (Sarji, 2021; Wicaksono & Yunianta, 2022). These games often employed role-play, level progression, or card mechanics to contextualize algebraic problems in interactive settings. Despite their simple design, such games proved especially useful in environments with limited technological access, demonstrating their practicality and accessibility in diverse educational settings.

Figure.2 Learning Outcome Distribution in Studies
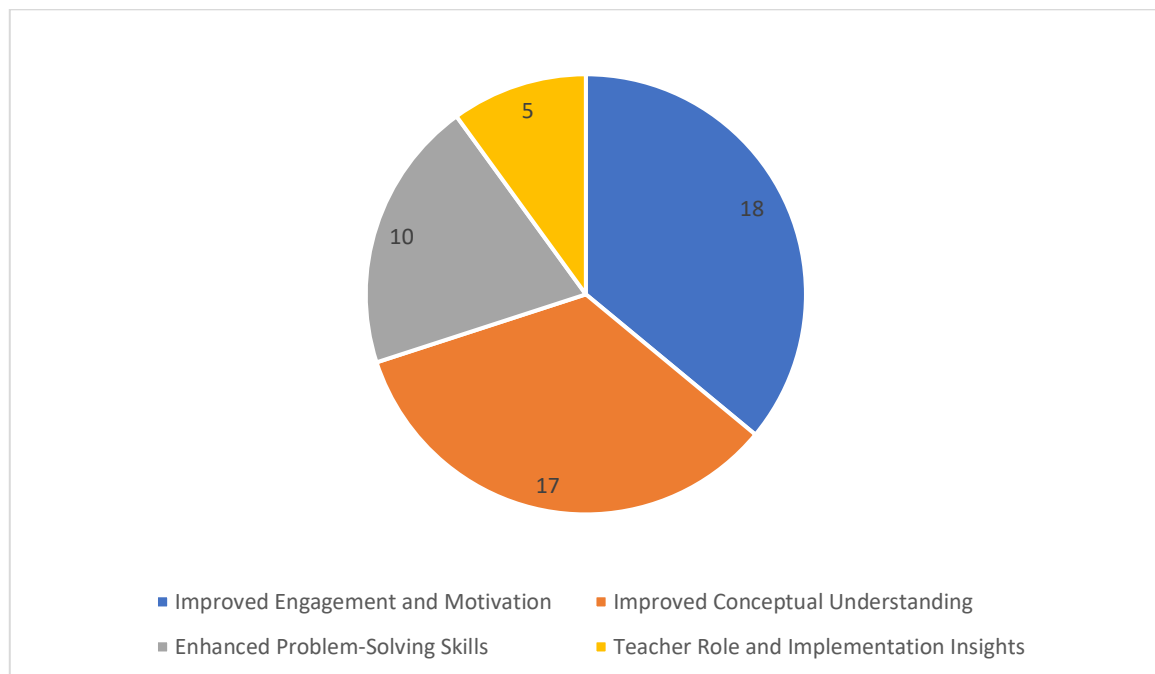
Across both digital and non-digital interventions, one of the most recurring outcomes was improved conceptual understanding. Studies indicated that games help students form meaningful connections through multiple representations—visual, symbolic, and contextual—thereby supporting deeper algebraic reasoning (Clark et al., 2016; Supriadi et al., 2020). For instance, the *DragonBox* app enabled students to internalize the balancing process in equation solving, making abstract algebraic procedures more tangible. Similarly, Wicaksono and Yunianta (2022) demonstrated that students exposed to the *Petualangan Alja* game displayed marked improvements in both procedural fluency and conceptual understanding, underscoring the cognitive benefits of game-based learning (GBL).

In addition to cognitive gains, affective outcomes were prominent in the reviewed studies. Game-based learning significantly enhanced student motivation and engagement—factors critical for sustained learning in algebra, a subject often perceived as abstract and intimidating (Papastergiou, 2009; Novrialdy, 2019). Game elements such as competition, challenge, and storytelling were found to reduce anxiety and foster a more positive attitude toward mathematics (Malone & Lepper, 1987). This aligns with Gee's (2003) assertion that good

games provide "pleasantly frustrating" environments that motivate students to persevere and reflect.

Furthermore, the interactive nature of games fostered increased student participation and on-task behavior. Yanuarto and Hastinasyah (2022) found that using Quizizz in algebra review sessions not only raised student attention but also supported formative assessment through real-time feedback. These findings affirm the broader view that digital games, when embedded thoughtfully into instructional design, can create participatory learning environments that are both engaging and academically rigorous (Clark et al., 2016; Ke, 2008).

A developing yet crucial theme was the potential of games to foster problem-solving skills. Games like *DragonBox* embedded algebraic word problems and dynamic challenges, prompting students to apply reasoning strategies in non-linear, interactive scenarios (Supriadi et al., 2020). This aligns with Vygotsky's (1978) sociocultural theory and Piaget's (1972) constructivist perspective, both of which emphasize the role of interactive, meaningful tasks in developing higher-order thinking.

Nevertheless, the review also revealed certain limitations. Many studies were limited in scale, often implemented in single classrooms or short durations, which hinders the generalizability of findings (Clark et al., 2016). Moreover, while early algebra topics like simplifying expressions and solving linear equations were widely studied, more advanced topics such as quadratic functions or systems of equations remain underexplored (Stacey & Chick, 2004). This suggests an ongoing need for broader, longitudinal research to evaluate the sustained impact and scalability of game-based learning interventions in algebra.

Furthermore, while many interventions were aligned with constructivist and game-based learning theories (Piaget, 1972; Vygotsky, 1978), few studies deeply examined the role of the teacher in facilitating game-based learning (Clark et al., 2016). The effectiveness of GBL not only depends on the design of the game but also on how it is implemented, scaffolded, and integrated into lesson plans (Clark et al., 2016). Teacher attitudes, technological readiness, and professional development opportunities are crucial factors that remain under-researched in the Indonesian context (Yanuarto & Hastinasyah, 2022). Similarly, while student motivation was often discussed (Papastergiou, 2009; Malone & Lepper, 1987), there was little attention given to differentiated learning, equity in access to technology, or gender-related dynamics in game-based engagement.

In light of these findings, several implications emerge. First, game-based learning has strong potential to enhance algebra instruction in Indonesia, especially when aligned with curricular goals and supported by sound pedagogical frameworks (Cai & Knuth, 2011). Second, future research should aim to move beyond proof-of-concept studies and focus on scaling up interventions, assessing long-term impacts, and integrating teacher perspectives (Booth et al., 2012; Clark et al., 2016). Third, there is room for more innovative and context-sensitive game designs that address advanced algebra topics and leverage culturally relevant themes. Lastly, collaboration between educators, researchers, and developers is essential to create sustainable, evidence-based educational games that can be adopted widely across Indonesian schools (Clark et al., 2016; Gee, 2003).

This literature review has examined the role of game-based learning in teaching algebra at the secondary school level in Indonesia over the last decade. While the findings across the 22 reviewed studies were generally positive, several methodological weaknesses were commonly observed. Many studies employed small sample sizes, limited to single classrooms or schools, which restricts the generalizability of their results. Short intervention durations and a lack of follow-up assessments were also typical, making it difficult to evaluate long-term learning effects. In addition, only a few studies used rigorous experimental or quasi-experimental

designs with control groups, and very few included detailed statistical analysis or effect size reporting. The role of the teacher and contextual variables were often underexplored, which limits the understanding of implementation fidelity and practical challenges in classroom settings.

Despite these limitations, the studies also demonstrated important strengths. Most were well-aligned with the Indonesian national curriculum and targeted specific algebra topics that are known to be difficult for students. Many used direct classroom-based implementation, allowing for practical relevance. Several studies introduced innovative, locally developed digital or non-digital games tailored to student needs, and provided clear descriptions of the tools used. Furthermore, the emphasis on student-centered learning and the consistent documentation of affective and cognitive outcomes provide a valuable foundation for future applied research in this area.

The findings also confirm that both digital and non-digital games have been widely explored as innovative instructional tools aimed at improving students' conceptual understanding, engagement, and problem-solving abilities in algebra. Whether in the form of educational apps such as *DragonBox* and *Petualangan Aljabar*, gamified platforms like *Quizizz*, or adapted board and card games, these interventions reflect a growing pedagogical shift toward student-centered, interactive, and motivational approaches in mathematics education. The reviewed studies consistently report that game-based learning enhances student participation, increases motivation, and leads to measurable gains in algebra comprehension (Supriadi et al., 2020; Sarji, 2021; Wicaksono & Yunianta, 2022). These findings are in line with broader international research which highlights the cognitive and affective benefits of games in mathematics classrooms (Clark et al., 2016; Ke, 2008; Gee, 2003).

The effectiveness of these games lies not only in their capacity to engage, but in their alignment with well-established learning theories such as constructivism, which advocates for learning through active experience (Piaget, 1972; Vygotsky, 1978). Games provide environments in which students can visualize algebraic processes, interact with symbolic representations, and apply reasoning skills in problem-solving contexts. Furthermore, the intrinsic motivation elicited by challenge and play reinforces positive attitudes toward mathematics, an outcome that is often difficult to achieve through conventional instruction alone (Papastergiou, 2009; Malone & Lepper, 1987). Despite these promising developments, the current body of research reveals several important limitations. Many studies were conducted on a small scale, with short implementation periods and limited control conditions, which restricts the generalizability of the findings (Clark et al., 2016). There is also a lack of exploration at the senior high school level, where algebra becomes more abstract and cognitively demanding (Stacey & Chick, 2004). Additionally, the role of the teacher in facilitating game-based learning remains under-researched, even though implementation fidelity, scaffolding, and classroom dynamics are known to affect learning outcomes significantly (Clark et al., 2016; Booth et al., 2012). Finally, issues such as digital access, equity, and long-term sustainability of educational game use in Indonesian classrooms deserve greater attention (OECD, 2019; Mullis et al., 2020).

This review suggests several avenues for future research. Longitudinal and large-scale studies are needed to examine the sustained impact of game-based algebra instruction across diverse Indonesian school settings (Clark et al., 2016). Investigations into how teachers integrate games into lesson plans, manage classroom flow, and adapt games to varying student needs would provide crucial insights into practical implementation (Booth et al., 2012). Moreover, the design of games that address more complex algebra topics—aligned with

Indonesia's evolving national curriculum—would expand the potential of game-based learning beyond early algebra (Cai & Knuth, 2011).

4. CONCLUSION

In conclusion, teaching algebra through games in Indonesia shows great promise as an engaging and effective pedagogical strategy. The recurring benefits reported, such as improved understanding, stronger motivation, and better problem-solving, highlight the alignment between game-based learning and 21st-century education goals (Clark et al., 2016; Papastergiou, 2009). As Indonesia continues to reform its curriculum and promote innovative teaching practices, integrating games thoughtfully and strategically can serve as a catalyst for improving algebra learning outcomes.

However, realizing this potential at scale will require more rigorous and targeted future research. Specifically, longitudinal studies are needed to assess the sustained impact of game-based learning over time, beyond the short-term gains currently reported. Future work should also focus on teacher-centered integration models, exploring how educators adopt, adapt, and scaffold GBL tools in real classrooms, and how professional development can support this process. Moreover, experimental and quasi-experimental designs with control groups and statistical analyses are essential to strengthen causal claims. Research should also explore advanced algebra topics, equity in digital access, and student diversity, including gender, socio-economic status, and learning differences. These directions will contribute to building a more robust, scalable, and contextually relevant evidence base for GBL in Indonesian mathematics education.

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