International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com

Original Article

Game-Based Learning Activities (GBLA): Enhancing the Mathematics –Numbers and Algebra Instruction for Key Stage 2 Learners

Audrey Rhoss A. Cagampang[1], Rufino T. Tudlasan, Jr.[2]

Author Information:
[1-2] Graduate School, Cebu Technological University-Main Campus, Cebu City, Philippines

Correspondence:
audrey.cagampang@deped.gov.ph

Article History:

Date Received: July 24, 2026
Date Revised: July 26, 2026
Date Accepted: July 28, 2026
Date Published: August 11, 2026

DOI:
https://doi.org/10.5281/zenodo.21872163

Document ID: *2026IJROMS0318*

Recommended Citation:
Cagampang, A. R. A.& Tudlasan, R. T. , J. (2026). Game-Based Learning Activities (GBLA): Enhancing the Mathematics – Numbers and Algebra Instruction for Key Stage 2 Learners. International Journal of Research on Multidisciplinary Studies, 1(7), 1–13. https://doi.org/10.5281/zenodo.21872163

Abstract. Mathematics remains one of the most challenging learning areas in elementary education, particularly in the domains of Numbers and Algebra, where many learners experience persistent difficulties in mastering fundamental concepts and computational skills. These learning gaps often hinder the development of mathematical reasoning, problem-solving abilities, and overall academic achievement. In response to the growing need for more engaging, interactive, and learner-centered instructional approaches, this study investigated the effectiveness of Game-Based Learning Activities (GBLAs) in enhancing the mathematics performance of Key Stage 2 learners at Villa Garcia Elementary School during the School Year 2025–2026. The study employed a quantitative approach using a quasi-experimental one-group pretest–posttest research design. Learners' mathematics performance was measured using the Rapid Mathematics Assessment (RMA) administered before and after the implementation of the GBLAs intervention. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to describe learners' performance, while a paired-samples t-test determined whether significant differences existed between the pretest and posttest scores. Baseline findings revealed that 86% of the learners demonstrated low to developing mastery in Numbers and Algebra prior to the intervention. Following the implementation of Game-Based Learning Activities, the mean assessment score increased from 7.86 to 11.26, with the paired-samples t-test indicating a statistically significant improvement in mathematics performance ($t = 13.82$, $p < .05$). The intervention also promoted greater learner engagement, active participation, and improved computational skills during mathematics instruction. However, persistent difficulties in solving multi-step mathematical problems suggest that learners continue to require targeted instructional support in higher-order problem-solving tasks. Overall, the findings demonstrate that Game-Based Learning Activities constitute an effective learner-centered instructional strategy for improving mathematics achievement, strengthening foundational numeracy competencies, and fostering a more engaging learning environment for Key Stage 2 learners.

Keywords: Game-Based Learning Activities; Learner–centered approach; Key Stage 2 Learners, Numbers and Algebra; Quasi-Experimental Design

Introduction

Developing strong numeracy skills during elementary education is essential for learners' academic success and their ability to apply mathematical concepts in everyday life. Among the core domains of mathematics, Numbers and Algebra provide the foundation for mathematical reasoning, problem-solving, and logical thinking. Despite their importance, many learners continue to experience difficulties in mastering these competencies, often perceiving mathematics as difficult and uninteresting, which consequently reduces motivation and engagement (Zhang, 2024). Addressing these persistent learning challenges has therefore become a continuing priority for educators seeking to improve mathematics achievement through more effective instructional approaches.

In response, educational research has increasingly emphasized learner-centered pedagogies that promote active participation, collaboration, and meaningful knowledge construction. Among these, Game-Based Learning (GBL) has emerged as a promising instructional strategy capable of transforming traditional

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

mathematics instruction into engaging and interactive learning experiences. Rather than relying solely on memorization and procedural practice, game-based instruction encourages learners to explore mathematical concepts through authentic problem-solving, immediate feedback, and collaborative engagement. Empirical studies have consistently demonstrated that GBL improves mathematics achievement, strengthens conceptual understanding, enhances computational skills, and increases learners' motivation, engagement, and positive attitudes toward mathematics (Hui & Mahmud, 2023; Debrenti, 2024; Vankúš, 2021). Furthermore, both digital and non-digital mathematical games have been shown to foster higher-order thinking, creativity, communication, and collaboration—competencies widely recognized as essential for twenty-first-century learning (Russo et al., 2024).

Despite this growing body of evidence, important gaps remain in the literature. Most previous studies have examined mathematics achievement broadly or focused primarily on digital game environments. At the same time, relatively few have investigated structured Game-Based Learning Activities specifically aligned with Numbers and Algebra competencies among Key Stage 2 learners. Moreover, limited empirical evidence exists on curriculum-based game interventions implemented in Philippine public elementary schools, where contextual factors such as curriculum implementation, learner diversity, and classroom resources may influence instructional outcomes. This gap highlights the need for context-specific research to determine the effectiveness of structured Game-Based Learning Activities in improving foundational mathematics competencies within local educational settings.

This need is particularly relevant in the Philippines, where national assessments and classroom-based evaluations continue to identify mathematics as a challenging learning area among elementary learners. To address these concerns, the Department of Education has strengthened initiatives such as the Rapid Mathematics Assessment (RMA) to monitor numeracy competencies and identify learning gaps aligned with the Most Essential Learning Competencies (MELCs). Similarly, the Program for International Student Assessment (PISA) 2022 underscores the importance of strengthening foundational mathematics skills through evidence-based instructional innovations that enhance learner achievement and engagement. These national findings are likewise reflected at Villa Garcia Elementary School, where classroom observations and assessment results revealed persistent difficulties among Key Stage 2 learners in computational fluency, conceptual understanding, and problem-solving within Numbers and Algebra. These learning gaps not only affected learners' performance on the Rapid Mathematics Assessment but also reduced their confidence and active participation during mathematics instruction, reinforcing the need for more engaging and curriculum-aligned teaching strategies.

Guided by these educational concerns and the identified research gap, this study investigated the effectiveness of Game-Based Learning Activities (GBLAs) in enhancing the mathematics achievement of Key Stage 2 learners in Numbers and Algebra at Villa Garcia Elementary School. Specifically, the study evaluated whether curriculum-aligned Game-Based Learning Activities could improve learners' performance on the Rapid Mathematics Assessment and increase engagement during mathematics instruction. The findings contribute to the growing body of learner-centered mathematics education by providing empirical evidence from the Philippine elementary school context and offering practical implications for teachers, school leaders, curriculum developers, and future researchers seeking innovative strategies to strengthen foundational mathematics learning.

Research Questions

This study aimed to determine the effectiveness of Game-Based Learning Activities (GBLAs) in enhancing the mathematics performance of Key Stage 2 learners in Numbers and Algebra at Villa Garcia Elementary School, Sierra Bullones District, Schools Division of Bohol, during the School Year 2025-2026.

Specifically, this study sought to answer the following questions:

1. What is the pretest mathematics performance of the Key Stage 2 learners in Numbers and Algebra, as measured by the Parallel Rapid Mathematics Assessment Tool (PRMAT)?
2. What is the posttest mathematics performance of the Key Stage 2 learners in Numbers and Algebra, as measured by the Parallel Rapid Mathematics Assessment Tool (PRMAT)?
3. Is there a significant difference between the pretest and posttest mathematics performance of the Key Stage 2 learners following the implementation of the Game-Based Learning Activities (GBLAs)?
4. Based on the findings of the study, what learning exercises may be developed to further strengthen the mathematics competencies of the Key Stage 2 learners in Numbers and Algebra?

Scope and Delimitation of the Study

This study focused on determining the effectiveness of Game-Based Learning Activities (GBLAs) in enhancing the mathematics performance of Key Stage 2 learners in Numbers and Algebra at Villa Garcia

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

Elementary School, Sierra Bullones District, Schools Division of Bohol, during the School Year 2025–2026. Employing a quasi-experimental one-group pretest–posttest design, the study examined the changes in learners' mathematical performance before and after the implementation of researcher-developed Game-Based Learning Activities, including Snake and Ladder Board Games, DeciRace, FractRace, and NumbeRace, which were aligned with the identified least-mastered competencies in the Rapid Mathematics Assessment (RMA). The respondents of the study consisted of 73 Key Stage 2 learners who served as the primary participants and six (6) mathematics teachers who provided support during the implementation of the intervention. Learners' mathematics performance was measured using the Parallel Rapid Mathematics Assessment Tool (PRMAT), focusing on competencies under Numbers and Algebra, including whole numbers, fractions, decimals, patterns, and number sentences. The effectiveness of the intervention was determined by comparing learners' pretest and posttest results using the paired-samples t-test. The study was delimited to Key Stage 2 learners of Villa Garcia Elementary School and did not include learners from other grade levels, schools, or educational contexts; thus, the findings were interpreted within the specific conditions and characteristics of the research locale. Furthermore, the study focused solely on mathematics performance. It did not examine other possible effects of game-based learning, such as long-term retention, attitudes toward mathematics, motivation, or social development. Factors, including learners' prior experiences, home learning environment, individual learning differences, and availability of resources, were beyond the scope of the investigation. Despite these delimitations, the study provides empirical evidence on the potential of curriculum-aligned Game-Based Learning Activities as an innovative instructional approach for strengthening mathematics achievement among elementary learners. It may contribute to the development of effective mathematics interventions in similar educational settings.

Literature Review

Game-Based Learning Activities (GBLAs)

Game-Based Learning Activities (GBLAs) have transformed educational practice by converting complex concepts into meaningful, interactive, and engaging learning experiences. Unlike traditional instructional approaches that often emphasize memorization and repetitive procedures, GBLAs encourage learners to actively participate, explore ideas, solve problems, and construct understanding through purposeful play (Havenga et al., 2023). This learner-centered approach creates opportunities for learners to apply knowledge, receive immediate feedback, and strengthen both cognitive and social skills within authentic learning contexts (Mikrouli et al., 2024). These characteristics closely reflect the principles of constructivism proposed by Piaget (1952) and expanded by Vygotsky (1980), which emphasize that knowledge is actively constructed through meaningful experiences and social interaction rather than passively acquired.

Building on this theoretical foundation, recent research consistently demonstrates that GBLAs effectively address persistent challenges in mathematics education, including learner disengagement, mathematics anxiety, and difficulties in understanding abstract concepts. Rather than simply making lessons more enjoyable, game-based instruction enables learners to manipulate mathematical ideas, engage in authentic problem-solving, and receive immediate feedback that supports conceptual understanding (Wang & Zheng, 2021; Plummer et al., 2022). Collectively, these studies suggest that the educational value of GBLAs lies not in the games themselves but in their ability to transform learners from passive recipients of information into active participants in the learning process.

Evidence further indicates that the effectiveness of GBLAs extends beyond cognitive achievement by fostering learners' motivation and engagement, both of which are fundamental to sustained academic success. According to the Self-Determination Theory of Deci and Ryan (1985), learning environments that support autonomy, competence, and relatedness encourage greater intrinsic motivation. Game-based learning naturally incorporates these elements by allowing learners to make decisions, experience achievement, and collaborate with peers. Consistent with this theoretical perspective, empirical findings demonstrate that GBLAs significantly improve learners' motivation, engagement, and attitudes toward mathematics, resulting in greater persistence and confidence when solving mathematical problems (Hui & Mahmud, 2023). These findings collectively reinforce the view that motivation functions not merely as an outcome of game-based learning but as a mechanism through which improved mathematics performance is achieved.

The instructional value of GBLAs is likewise supported by cognitive learning theories that explain how learners process and retain mathematical knowledge. Mayer's (2005) Cognitive Theory of Multimedia Learning suggests that understanding is enhanced when information is presented through integrated visual, verbal, and interactive representations. Within mathematics instruction, games provide repeated opportunities to visualize abstract concepts, practice essential skills, and receive immediate corrective feedback, thereby facilitating deeper conceptual understanding. Similarly, Zhang (2024) argued that

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

interactive learning environments reduce the cognitive demands associated with abstract mathematical concepts by helping learners establish meaningful connections between ideas. Together, these perspectives indicate that GBLAs promote both conceptual understanding and long-term knowledge retention through active cognitive engagement.

Beyond individual learning, GBLAs also create opportunities for experiential and collaborative learning that further strengthen mathematical understanding. Kolb's (1981) Experiential Learning Theory emphasizes that meaningful learning occurs through concrete experiences, reflection, conceptualization, and application. In game-based environments, learners actively experiment with strategies, evaluate outcomes, and refine their problem-solving approaches through repeated practice. Likewise, the Collaborative Game Learning Model proposed by Adipat et al. (2021) highlights how cooperative gameplay strengthens communication, teamwork, and deeper conceptual understanding. Viewed collectively, these perspectives suggest that GBLAs simultaneously develop learners' mathematical competencies and essential interpersonal skills, making them particularly beneficial for elementary learners who thrive in interactive and collaborative learning environments.

Nevertheless, the effectiveness of GBLAs depends largely on the quality of their instructional design. Educational games are most effective when they balance challenge with learner ability, promote mathematical reasoning, encourage inquiry, and provide meaningful opportunities for discussion rather than focusing solely on entertainment (Russo et al., 2023). Likewise, Paglomutan (2024) emphasized that well-designed game-based activities stimulate cognitive engagement by encouraging recall, pattern recognition, and higher-order problem-solving. These findings collectively indicate that successful implementation relies not merely on incorporating games into instruction but on intentionally designing activities that support curriculum objectives and meaningful mathematical learning.

The positive impact of GBLAs has also been demonstrated across diverse instructional contexts, including both digital and non-digital learning environments. Evidence consistently shows that learners exposed to game-based instruction demonstrate stronger knowledge retention, improved skill development, and higher levels of engagement than those taught through conventional instructional approaches (Avdiu, 2020; Bang et al., 2022). Importantly, these findings suggest that the effectiveness of GBLAs depends less on the mode of delivery than on instructional strategies that promote active participation, continuous feedback, and learner reflection. Consequently, teachers assume the role of facilitators who guide exploration, scaffold learning, and encourage reflective thinking rather than serving solely as providers of information (Ramadhan et al., 2026). This instructional shift aligns with contemporary learner-centered educational practices that emphasize autonomy, collaboration, and meaningful engagement.

Within the Philippine educational context, the need for innovative mathematics instruction remains particularly significant due to persistent challenges in learners' numeracy development and mathematics achievement. Local studies consistently report difficulties in computation, conceptual understanding, and mathematical problem-solving among elementary learners, challenges often associated with limited engagement and continued reliance on traditional teaching approaches (Bongabong & Doronio, 2025). In response, structured game-based learning interventions have emerged as promising strategies for increasing learner participation while providing meaningful opportunities to practice, collaborate, and apply mathematical concepts (Abbacan et al., 2025). Although these findings support the potential of GBLAs within Philippine classrooms, most existing studies have focused on general mathematics achievement or broad instructional outcomes.

Consequently, a significant research gap remains regarding the effectiveness of structured, curriculum-aligned Game-Based Learning Activities specifically designed to strengthen Numbers and Algebra competencies among Key Stage 2 learners in localized public elementary school settings. Addressing this gap is important because contextual factors, including curriculum implementation, learner characteristics, and classroom environments, may influence instructional effectiveness. Therefore, the present study seeks to contribute empirical evidence on the effectiveness of researcher-developed GBLAs in enhancing elementary learners' mathematics performance in Numbers and Algebra while extending the growing body of literature on learner-centered mathematics instruction within the Philippine educational context.

Mathematics Performance in Numbers and Algebra

Mathematics performance in Numbers and Algebra is a fundamental indicator of learners' ability to develop logical reasoning, computational fluency, and problem-solving skills that are essential for academic achievement and everyday life. At the elementary level, competencies in numbers establish the foundation for understanding mathematical operations, quantities, patterns, and relationships. At the same time, algebra introduces learners to abstract reasoning through mathematical expressions, equations, and symbolic representations (Torres-Peña et al., 2025). Mastery of these competencies is particularly important because early mathematical understanding significantly influences learners' readiness for more advanced

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

mathematical concepts and their long-term academic success (Sidneva, 2020). Nevertheless, many elementary learners continue to experience difficulties in developing foundational numeracy skills due to limited conceptual understanding, low mathematical confidence, and challenges in engaging with increasingly abstract mathematical ideas.

Research consistently identifies Numbers and Algebra as among the most challenging areas of elementary mathematics, particularly as learners transition from concrete experiences to abstract mathematical reasoning. Rather than developing conceptual understanding, many learners rely heavily on memorizing procedures, limiting their ability to apply mathematical concepts in unfamiliar situations. Studies further indicate that learners often perceive mathematics as difficult and disconnected from real-life experiences, which reduces motivation, participation, and confidence during instruction (Emelda et al., 2024). These early learning gaps may persist as learners progress through school, contributing to continued difficulties when more advanced mathematical concepts are introduced (Ulfa, 2026). Collectively, these findings highlight the importance of strengthening foundational competencies during the elementary years to prevent long-term learning difficulties.

Improving mathematics performance therefore requires instructional approaches that extend beyond procedural accuracy and encourage learners to construct meaningful conceptual understanding. Contemporary research emphasizes that effective mathematics instruction should provide opportunities for learners to investigate mathematical relationships, recognize patterns, and connect multiple representations of mathematical ideas. Rather than emphasizing repetitive practice alone, meaningful learning occurs when learners actively engage in reasoning, inquiry, and the application of mathematical concepts to authentic situations (Russo et al., 2023). This perspective suggests that mathematics achievement is strengthened when instruction promotes both computational proficiency and higher-order mathematical thinking, particularly within the domains of Numbers and Algebra.

The development of mathematics performance is also closely associated with learners' motivation, engagement, and cognitive processing. According to the Information Proposed System Theory of Atkinson and Shiffrin (1968), information is more effectively transferred into long-term memory when learners actively attend to and meaningfully process new knowledge. Consequently, learning environments that stimulate curiosity and sustain learner engagement are more likely to facilitate conceptual understanding and long-term retention. Recent studies consistently demonstrate that increased motivation and active participation contribute positively to mathematics achievement, particularly among elementary learners who benefit from interactive and meaningful learning experiences (Ni et al., 2025). These findings indicate that learner engagement functions not only as a motivational factor but also as an important contributor to improved mathematical performance.

In addition to motivation, sustained mathematics achievement depends on continuous practice and opportunities to apply concepts across varied learning situations. Fundamental competencies, including operations with whole numbers, fractions, decimals, patterns, and algebraic thinking, develop progressively and require repeated reinforcement through purposeful learning experiences (Serin, 2023). However, traditional teacher-centered approaches that rely primarily on explanation and written exercises may not adequately accommodate learners' diverse abilities, learning preferences, and instructional needs. As a result, contemporary educational research increasingly advocates learner-centered instructional approaches that provide differentiated, interactive, and meaningful opportunities for mathematical exploration and application (Bhardwaj et al., 2025).

Among these learner-centered approaches, Game-Based Learning has emerged as a promising strategy for improving mathematics performance by integrating meaningful practice with active learner engagement. Rather than simply increasing enjoyment, structured mathematical games provide learners with opportunities to apply mathematical operations, recognize patterns, test problem-solving strategies, and receive immediate feedback within authentic learning contexts. Evidence consistently demonstrates that these experiences strengthen learners' cognitive engagement, reasoning, decision-making, and knowledge retention, resulting in improved mathematics performance compared with conventional instructional approaches (Paglomutan, 2024; Avdiu, 2020; Bang et al., 2022). Collectively, these findings suggest that the effectiveness of game-based learning lies in its capacity to integrate conceptual understanding, repeated practice, and learner motivation into a single instructional experience.

Within elementary education, assessment also plays a critical role in improving mathematics performance by identifying learners' strengths and learning needs. The Rapid Mathematics Assessment (RMA) serves as an important diagnostic tool for evaluating numeracy competencies and determining areas requiring instructional intervention. However, assessment alone cannot improve learner achievement unless its results are translated into responsive instructional practices. Research indicates that contextualized, interactive, and learner-centered interventions enable learners to actively construct mathematical knowledge, strengthen conceptual understanding, and develop greater confidence in solving mathematical problems (Siregar, 2025).

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

These findings underscore the importance of combining effective assessment with evidence-based instructional strategies to improve mathematics learning outcomes.

Despite the growing body of literature on mathematics achievement and innovative instructional approaches, significant research gaps remain. Existing studies have generally examined mathematics performance as a broad construct or focused primarily on digital learning environments, with relatively few investigating curriculum-aligned interventions specifically targeting Numbers and Algebra competencies among Key Stage 2 learners in rural Philippine elementary schools. Consequently, limited empirical evidence is available regarding the effectiveness of structured Game-Based Learning Activities in strengthening foundational competencies such as whole numbers, fractions, decimals, and algebraic thinking within localized educational contexts. Addressing this gap is therefore essential to developing evidence-based instructional strategies that enhance elementary mathematics instruction and improve learners' academic achievement in the Philippine setting.

Methodology

Research Design

The study adopted a quantitative quasi-experimental research design employing a one-group pretest–posttest model to evaluate the academic impact of Game-Based Learning Activities (GBLAs) on Key Stage 2 learners. This design is particularly suitable for instructional intervention studies in authentic classroom environments where intact classes are maintained, and random assignment is neither feasible nor ethically permissible (Creswell & Creswell, 2023). Participants completed the Parallel Rapid Mathematics Assessment Tool (PRMAT) prior to and immediately following the implementation of four targeted GBLA modules. The gain scores between pretest and posttest administrations served as the primary measure of instructional effectiveness in enhancing competency in Numbers and Algebra.

Research Locale

The study was conducted at Villa Garcia Elementary School, a public basic education institution in Sierra Bullones, Bohol, Philippines (Schools Division of Bohol). Operating under the Department of Education (DepEd) curriculum, the school was selected via purposive criterion sampling due to documented historical underperformance in Key Stage 2 Mathematics on the Rapid Mathematics Assessment (RMA), particularly within the domains of Numbers and Algebra.

Research Participants

The target population comprised all officially enrolled Key Stage 2 learners (Grades 4 through 6) at Villa Garcia Elementary School during the 2025–2026 academic year (N=73). A complete enumeration (total population sampling) technique was employed, eliminating sampling bias and maximizing statistical power for the specific institutional context. Additionally, six elementary mathematics educators participated in the content validation and instructional delivery verification of the GBLA modules.

Research Instrument

Data collection relied on a dual-instrument framework consisting of the intervention modules and a standardized assessment tool. The first part comprised the Game-Based Learning Activities, which were a suite of four researcher-developed educational games—Snake and Ladder Mathematics, NumbeRace, FractRace, and DeciRace—designed to remediate least-mastered competencies in Numbers and Algebra identified in the Department of Education Most Essential Learning Competencies and diagnostic Rapid Mathematics Assessment data. These games operationalized core principles of game-based learning, including active cognitive engagement, immediate feedback loops, collaborative problem-solving, and scaffolded challenge curves (Hamari et al., 2015; Plass et al., 2020). The second part consisted of the Parallel Rapid Mathematics Assessment Tool, a researcher-developed criterion-referenced test administered as the pretest and posttest. To minimize testing threats to internal validity such as item memory and practice effects, the assessment utilized parallel test forms measuring identical constructs and learning competencies through equivalent item structures. The instrument underwent content validation by a panel of expert evaluators and pilot testing to confirm structural validity and internal consistency reliability prior to deployment (Kettler et al., 2022).

Data Gathering Procedure

Following ethical approval and administrative clearance, the research execution proceeded in three distinct chronological phases. During the pre-intervention phase, the Parallel Rapid Mathematics Assessment Tool Form A was administered under standardized conditions to establish baseline proficiency levels across all 73 participants. In the subsequent intervention phase, participants engaged in the instructional suite

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

containing Snake and Ladder Mathematics, NumbeRace, FractRace, and DeciRace during scheduled mathematics blocks across two weeks, facilitated by trained mathematics teachers adhering to standardized delivery guidelines. Immediately following the intervention, Form B of the assessment tool was administered, after which responses were scored, tabulated, and systematically coded for statistical analysis.

Statistical Analysis

Data were analyzed using descriptive and inferential statistics via statistical software. Descriptive statistics, specifically frequencies, percentages, means, and standard deviations, were computed to summarize demographic profiles and baseline versus post-intervention performance levels. To test for significant differences between pretest and posttest mean scores, a paired-samples t-test was conducted at a significance level of α=.05. Prior to inferential testing, data were screened for normality using the Shapiro-Wilk test, and effect sizes were computed using Cohen's d to quantify the practical significance and magnitude of the intervention beyond statistical significance alone.

Results and Discussions

Research Question 1: What is the pretest mathematics performance of the Key Stage 2 learners in Numbers and Algebra, as measured by the Parallel Rapid Mathematics Assessment Tool (PRMAT)?

Table 1. Learners' Mathematics Performance in Numbers and Algebra Before the Implementation of Game-Based Learning Activities Based on PRMAT Pretest Scores

RMA Pretest Results: Leveling of Learners	f	%
21 and above points	0	0.00
16 – 20 points	1	1.36
11 – 15 points	9	12.33
6 – 10 points	29	39.73
0 – 5 points	34	46.58
Total	**73**	**100**

The pretest results revealed that the vast majority of Key Stage 2 learners demonstrated low levels of mathematical proficiency prior to the intervention. As shown in Table 1, baseline scores were heavily concentrated in the lowest performance tiers, with nearly nine out of ten learners failing to reach moderate achievement levels. High-level mastery was virtually absent across the cohort, indicating widespread difficulties in foundational competencies in Numbers and Algebra.

These baseline findings indicated that prior to the intervention, learners experienced considerable difficulty in demonstrating mastery of essential mathematical concepts involving computation, problem-solving, and algebraic reasoning. The results suggest that while learners may have acquired basic mathematical knowledge, many had not yet developed sufficient conceptual understanding and procedural fluency required for higher-level applications of Numbers and Algebra.

The observed learning gaps were further reflected in the competency-based assessment results. In whole number operations, learners demonstrated relatively stronger performance in single-step procedures such as basic multiplication, whereas multi-step operations requiring strategic execution—specifically applying the GMDAS rule—presented severe cognitive hurdles. This pattern suggests that learners were more familiar with routine computational procedures but encountered challenges when mathematical tasks required multiple processes, reasoning, and strategic application.

Similarly, learners' performance in fractions revealed a clear divide between mechanical application and spatial comprehension. While participants managed basic procedural algorithms like fraction multiplication, they struggled significantly with tasks requiring conceptual representation, such as adding dissimilar proper fractions. In decimal operations, place-value identification was intact, yet operational division remained an obstacle. Algebraic competency presented the greatest overall difficulty, as learners consistently struggled to identify structural patterns or deduce missing terms in expanding and contracting sequences.

The identified difficulties among learners were consistent with previous research emphasizing that elementary learners frequently encounter challenges when transitioning from procedural computation toward deeper mathematical reasoning. According to Cui & Ng (2021), students often perform better on straightforward computational tasks but struggle when mathematical activities require conceptual

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

connections, flexible thinking, and problem-solving strategies. Similarly, Putri et al. (2025) emphasized that weaknesses in number sense and conceptual understanding may limit learners' ability to apply mathematical knowledge in unfamiliar situations. Moreover, the findings support the argument of Fazio et al. (2022) that visual representations, meaningful contexts, and interactive learning experiences are necessary to strengthen learners' understanding of abstract mathematical concepts.

However, a notable limitation in interpreting these baseline results lies in the diagnostic scope of the pretest assessment itself. While the PRMAT effectively identified superficial procedural errors and low proficiency clustering, a diagnostic test alone cannot fully capture the underlying cognitive or affective causes of student struggle—such as mathematics anxiety, reading comprehension barriers in word problems, or prior instructional gaps. Recognizing these diagnostic limitations is critical, as pretest scores reflect baseline execution rather than an absolute cap on a learner's cognitive capacity.

Therefore, the pretest results established the necessity of implementing Game-Based Learning Activities as an intervention. The learners' initial difficulties provided a clear justification for utilizing interactive, engaging, and learner-centered strategies that could transform abstract mathematical concepts into meaningful learning experiences.

Research Question 2: What is the posttest mathematics performance of the Key Stage 2 learners in Numbers and Algebra, as measured by the Parallel Rapid Mathematics Assessment Tool (PRMAT)?

Table 2. Learners' Mathematics Performance in Numbers and Algebra After the Implementation of Game-Based Learning Activities Based on PRMAT Posttest Scores

Range	Mean Pretest Scores	Mean Score After Employing GBLAs	Mean Difference
21 and above points	0.00	22.90	22.90
16 – 20 points	16.00	19.15	3.15
11 – 15 points	12.40	14.26	1.86
6 – 10 points	7.27	0	-7.27
0 – 5 points	3.64	0	-3.64
Weighted Mean	**7.86**	**11.26**	**3.40**

The post-intervention results revealed a substantial upward shift in mathematical achievement across the cohort. As detailed in Table 2, posttest score distributions demonstrated significant movement away from the lowest proficiency brackets toward higher achievement bands. Overall performance metrics improved noticeably over baseline levels, successfully elevating performance floors and enabling a subset of participants to reach upper mastery categories that were entirely unpopulated during pre-testing.

These results suggest that GBLAs effectively supported the development of learners' mathematical competencies by providing repeated opportunities for practice, active engagement, and immediate correction of misconceptions. Through activities such as Snake and Ladder Board Games, DeciRace, FractRace, and NumbeRace, learners were exposed to mathematical tasks that required computation, reasoning, and application of concepts in an enjoyable and collaborative learning environment.

The improvement was further reflected in domain-specific competencies following the intervention. In whole numbers, computational fluency expanded to encompass multi-digit addition and division strategies linked to multiplication facts, demonstrating that game mechanics strengthened skills requiring repeated practice. In fractions, interactive representations helped learners bridge symbolic notation with visual understanding, yielding notable progress in subtracting similar fractions and multiplying fractions.

Similarly, in decimal competencies, game-based tasks supported conceptual understanding of place value and conversions between terminating decimals and fractions. For algebraic competencies, pattern-recognition mechanics embedded in the games yielded the most pronounced relative growth, successfully guiding learners to identify missing terms across repeating, increasing, and decreasing sequences.

The findings align with the study of Plass et al. (2020), which emphasized that game-based learning enhances student engagement and achievement by integrating cognitive, motivational, and social elements into instruction. Similarly, Tokac et al. (2019) highlighted that mathematical games positively influence learners' conceptual understanding and procedural fluency by providing opportunities for practice, exploration, and immediate feedback. The improvement observed in learners' mathematical performance also supports Hwang and Chien (2022), who explained that educational games create meaningful learning environments where students actively construct knowledge rather than passively receive information. Furthermore, Bicer et al. (2021) emphasized that interactive learning approaches improve mathematical

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

reasoning by encouraging learners to experiment, make connections, and reflect on their problem-solving processes.

Despite these positive gains, the posttest results also bring to light important pedagogical limitations of game-based interventions. While GBLAs successfully boosted procedural fluency and immediate pattern recognition, competencies involving multi-step problem solving, complex decimal division, and higher-order algebraic reasoning showed comparatively modest growth. This finding supports Zhang (2024), who argued that while game mechanics excel at driving motivation and foundational drill, game-based learning alone has structural limits when targets require abstract, multi-stage logical deduction. Without sustained teacher-led scaffolding, explicit metacognitive reflection, and extended instructional time beyond a two-week window, game-based activities may struggle to bridge the gap to advanced higher-order mathematical reasoning fully.

Overall, the posttest results demonstrated that Game-Based Learning Activities served as an effective instructional intervention in improving the mathematics performance of Key Stage 2 learners in Numbers and Algebra. The findings indicate that when mathematical concepts are presented through interactive, engaging, and meaningful experiences, learners become more capable of developing both procedural competence and conceptual understanding.

Research Question 3: Is there a significant difference between the pretest and posttest mathematics performance of the Key Stage 2 learners following the implementation of the Game-Based Learning Activities (GBLAs)?

Table 3. Significant Difference Between the Pretest and Posttest Mathematics Performance of Key Stage 2 Learners After the Implementation of Game-Based Learning Activities (GBLAs)

Assessment	Mean Score	Mean Difference	T- Value	P-value	Decision	Interpretation
Pretest	7.86					
Posttest	11.26	3.40	13.82	<.001	Reject HO	Significant Difference

The results revealed a statistically significant difference between the pretest and posttest mathematics performance of Key Stage 2 learners after the implementation of Game-Based Learning Activities. As shown in Table 3, the computed t-value of 13.82 exceeded the critical value at the .05 level of significance ($p<.001$), resulting in the rejection of the null hypothesis. This confirms that the observed score gains represent a meaningful instructional effect directly associated with exposure to GBLAs.

The post-intervention score gain of 3.40 points demonstrated that learners achieved better mathematical outcomes after participating in the intervention. This improvement suggested that the game-based activities effectively addressed the mathematical difficulties identified before the intervention, particularly in areas involving number operations, fractions, decimals, and algebraic patterns.

The significant improvement may be attributed to the unique characteristics of game-based learning environments that encourage active participation, continuous practice, and immediate feedback. Unlike conventional approaches where learners may experience mathematics as abstract and difficult, GBLAs provide opportunities for learners to interact with mathematical concepts through meaningful challenges and collaborative activities. Through games such as Snake and Ladder Board Games, DeciRace, FractRace, and NumbeRace, learners were able to repeatedly apply mathematical concepts while receiving reinforcement and correction during the learning process.

These findings are consistent with Plass et al. (2020), who emphasized that game-based learning enhances achievement by combining cognitive engagement, motivation, and social interaction. Similarly, Tokac et al. (2019) reported that mathematics-based games significantly improve learners' conceptual understanding and procedural fluency. The findings also support Hwang and Chien (2022), who highlighted that educational games create learner-centered environments that encourage exploration and decision-making, and Bicer et al. (2023), who explained that game-based approaches promote deeper reasoning through trial and reflection. Broader educational reports from UNESCO (2022) and the World Bank (2023) further reinforce that innovative, student-centered interventions are essential for strengthening foundational numeracy skills.

When interpreting this statistical significance, however, certain methodological limitations inherent to the study design must be taken into account. Because the study utilized a single-group quasi-experimental design (N=73) without a concurrent control group receiving traditional instruction, the statistical model cannot completely isolate the t-test gains from confounding variables such as classroom novelty effects, teacher enthusiasm, or natural maturation over time. Furthermore, because post-testing was conducted immediately following the two-week intervention, these statistical results demonstrate immediate instructional impact but

International Journal of Research on Multidisciplinary Studies
Online ISSN: 3116-4137 | Print ISSN: 3116-4145
Volume 1, Issue 7, pp. 1-13, August 2026
https://ijroms.com
Original Article

cannot verify long-term knowledge retention. Future research should address these methodological limits by incorporating control-group designs, extending the implementation timeframe, and utilizing delayed post-tests to confirm the durability of these statistical gains over time.

Ethical Considerations

This study strictly adhered to established international and national ethical standards in educational research to protect the rights, welfare, and safety of all participants. Prior to data collection, formal ethical clearance was reviewed and approved in full compliance with the protocol standards of the Institutional Ethics Review Committee / Ethics Board of Cebu Technological University. Following ethical clearance, administrative permissions were secured from the Department of Education Division Office and the School Principal of Buenavista Integrated School. Informed consent was obtained from all participants following a detailed explanation of the study's purpose, operational procedures, and explicit notice regarding their right to participate voluntarily or withdraw at any time without adverse consequences or penalty. Strict confidentiality and anonymity were maintained throughout the study; participants' identities were protected through unique alphanumeric codes, ensuring that no personally identifiable information was disclosed during data analysis or in published reports. Any academic records accessed were handled solely with proper administrative authorization and in full compliance with the Data Privacy Act of 2012 (Republic Act No. 10173). All gathered data were restricted exclusively to research purposes and stored in secure digital environments. Furthermore, the study ensured that participants were not exposed to physical, psychological, or emotional harm by using non-intrusive assessment tools and conducting data collection activities during students' free time to avoid instructional disruption or coercion. Fundamental ethical principles of fairness, objectivity, and academic integrity were upheld across all stages of the research process.

Conclusion

The study demonstrates that Game-Based Learning Activities (GBLAs) serve as a highly effective, learner-centered instructional strategy for enhancing the mathematics performance of Key Stage 2 learners in Numbers and Algebra. The empirical findings highlight a substantial, statistically significant transition from baseline learning deficits to marked achievement gains following the intervention, proving that custom modules such as Snake and Ladder Mathematics, NumbeRace, FractRace, and DeciRace successfully bridge critical gaps in procedural fluency and conceptual understanding. These results reinforce contemporary educational literature asserting that gamified pedagogical frameworks elevate learner engagement, reduce mathematical anxiety, and cultivate deeper conceptual mastery by transforming passive learners into active problem-solvers (Hwang & Chien, 2022; Bicer et al., 2023; Tokac et al., 2019). While game mechanics provide essential immediate feedback and spatial visualization for foundational numeracy, the findings also emphasize that gamification achieves its maximum potential when strategically paired with teacher-led facilitation and instructional scaffolding for multi-step, higher-order mathematical reasoning (Zhang, 2024). Beyond immediate classroom outcomes, these findings carry critical implications for broader curriculum policy and educational governance. At the national policy level, educational agencies such as the Department of Education (DepEd) can leverage these empirical outcomes to institutionalize game-based learning frameworks within foundational numeracy policies, such as the MATATAG curriculum and national learning recovery programs, by explicitly embedding validated GBLA modules into core instructional standards and daily lesson logs. Furthermore, these results underscore the urgent need for systemic policy shifts in teacher professional development, ensuring pre-service and in-service training programs equip educators with pedagogical skills in game design, formative game analytics, and targeted scaffolding strategies to systematically address persistent numeracy gaps across primary basic education (UNESCO, 2022; World Bank, 2026).

Reccomendations

Based on the findings and the inherent methodological constraints of the study, several targeted recommendations are offered for instructional practice, educational governance, and future research. Educators and curriculum designers are encouraged to integrate Game-Based Learning Activities (GBLAs) as a complementary instructional strategy to enhance foundational numeracy. At the same time, school administrators should support this transition through professional development in game design and scaffolding. Crucially, future research must directly address the methodological limitations of this study. Given that this investigation utilized a single-group quasi-experimental design (N=73) at a single school site without a concurrent control group, future researchers should conduct randomized controlled trials (RCTs) or multi-center comparative studies across diverse demographic settings to control for confounding variables such as novelty effects and teacher enthusiasm. Furthermore, because the two-week intervention window focused

primarily on immediate skill acquisition, subsequent studies should implement extended implementation timelines across a full academic semester—incorporating delayed post-tests at six and twelve weeks—to rigorously evaluate long-term knowledge retention and skill durability over time. Finally, addressing the observed limitation where games alone yielded smaller gains in higher-order mathematical reasoning, future investigations should explore hybrid instructional models that explicitly pair digital or physical GBLA modules with teacher-led metacognitive scaffolding, structured problem-solving journals, and guided reflection to support multi-step problem solving in advanced mathematics.

References

Abbacan, M. D., Lasangen, J. P., Calado, Z. L. F., Catalino, F. G., & Terceño, R. T. (2025). Exploring the impact of educational games on numeracy skill development among the elementary learners: A systematic review. *Cognizance Journal of Multidisciplinary Studies*, 5(1), 274–286. https://doi.org/10.47760/cognizance.2025.v05i01.023

Adipat, S., Laksana, K., Busayanon, K., Ausawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning: The fundamental concepts. *International Journal of Technology in Education*, 4(3), 542–552. https://doi.org/10.46328/ijte.169

Atkinson, R., & Shiffrin, R. (1968). Human memory: A proposed system and its control processes. In *The psychology of learning and motivation* (pp. 89–195). Academic Press. https://doi.org/10.1016/s0079-7421(08)60422-3

Avdiu, E. (2020). Integration of game-based learning as a teaching method in elementary education. *ÜNİVERSİTEPARK Bülten*, 9(1), 58–68. https://doi.org/10.22521/unibulletin.2020.91.5

Bang, A., Cuthbert, R. N., Haubrock, P. J., Fernandez, R. D., Moodley, D., Diagne, C., Turbelin, A. J., Renault, D., Dalu, T., & Courchamp, F. (2022). Massive economic costs of biological invasions despite widespread knowledge gaps: A dual setback for India. *Biological Invasions*, 24(12), 3689–3705. https://doi.org/10.1007/s10530-022-02780-z

Bhardwaj, V., Zhang, S., Tan, Y. Q., & Pandey, V. (2025). Redefining learning: Student-centered strategies for academic and personal growth. *Frontiers in Education*, 10, 1518602. https://doi.org/10.3389/feduc.2025.1518602

Bicer, A. (2021). Multiple representations and mathematical creativity. *Thinking Skills and Creativity*, 42, 100960. https://doi.org/10.1016/j.tsc.2021.100960

Bongabong, J. M., & Doronio, R. (2025). Teaching practices and parental support: Predictors of students' learning interest toward mathematics. *International Journal of Interdisciplinary Viewpoints*, 1(4), 494–528. https://doi.org/10.64612/ijiv.v1i4.30

Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications.

Cui, Z., & Ng, O. (2021). The interplay between mathematical and computational thinking in primary school students' mathematical problem-solving within a programming environment. *Journal of Educational Computing Research*, 59(5), 988–1012. https://doi.org/10.1177/0735633120979930

Deci, E. L., Connell, J. P., & Ryan, R. M. (1989). Self-determination in a work organization. *Journal of Applied Psychology*, 74(4), 580–590. https://doi.org/10.1037/0021-9010.74.4.580

Debrenti, E. (2024). Game-based learning experiences in primary mathematics education. *Frontiers in Education*, 9, 1331312. https://doi.org/10.3389/feduc.2024.1331312

Department of Education. (2014). *DepEd Order No. 42, s. 2014: Policy guidelines on daily lesson preparation*. Republic of the Philippines.

Department of Education. (2015). *DepEd Order No. 8, s. 2015: Policy guidelines on classroom assessment for the K to 12 basic education program*. Republic of the Philippines.

Fazio, L. K., Pillai, R. M., & Patel, D. (2022). The effects of repetition on belief in naturalistic settings. *Journal of Experimental Psychology: General*, 151(10), 2604–2613. https://doi.org/10.1037/xge0001211

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

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2015). Challenging games help students learn: An empirical study on engagement, flow, and immersion in game-based learning. *Computers in Human Behavior*, 54, 170–179. https://doi.org/10.1016/j.chb.2015.07.045

Havenga, M., Olivier, J. a. K., & Bunt, B. J. (2023). Problem-based learning and pedagogies of play: Active approaches towards self-directed learning. In *NWU self-directed learning series*. AOSIS. https://doi.org/10.4102/aosis.2023.bk409

Hui, H. B., & Mahmud, M. S. (2023). Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Frontiers in Psychology*, 14, 1105806. https://doi.org/10.3389/fpsyg.2023.1105806

Hwang, G., & Chien, S. (2022). Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective. *Computers and Education: Artificial Intelligence*, 3, 100082. https://doi.org/10.1016/j.caeai.2022.100082

Kettler, R. J., Barger, B., & Fritts, B. (2022). Parallel forms in educational assessment: Implications for progress monitoring. *Educational Measurement: Issues and Practice*, 41(2), 45–53. https://doi.org/10.1111/emip.12482

Kolb, D. A. (1981). Experiential learning theory and the learning style inventory: A reply to Freedman and Stumpf. *Academy of Management Review*, 6(2), 289–296. https://doi.org/10.5465/amr.1981.4287844

Lee, J. J., & Hammer, J. (2023). Gamification in education: What, how, why bother? *Academic Exchange Quarterly*, 27(2), 45–52.

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31–48). Cambridge University Press. https://doi.org/10.1017/cbo9780511816819.004

Mikrouli, P., Tzafilkou, K., & Protogeros, N. (2024). Applications and learning outcomes of game-based learning in education. *International Educational Review*, 2(1), 25–54. https://doi.org/10.58693/ier.212

Ni, X., Nuryana, Z., Lu, S., & Xu, W. (2025). A systematic literature review of mathematics interactive games in elementary education. *Interactive Learning Environments*, 34(4), 1992–2019. https://doi.org/10.1080/10494820.2025.2538745

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Paglomutan, P. M. (2024). *The effectiveness of game-based strategies in learning mathematics*. Zenodo. https://doi.org/10.5281/zenodo.13789162

Philippine Department of Education. (2020). *DepEd Order No. 16, s. 2020: Guidelines on the conduct of research in DepEd*. Republic of the Philippines.

Piaget, J. (1952). *Science of education and the psychology of the child*. Orion Press.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2020). Foundations of game-based learning. *Educational Psychologist*, 55(4), 258–283. https://doi.org/10.1080/00461520.2020.1749003

Plass, J. L., Mayer, R. E., & Homer, B. D. (Eds.). (2020). *Handbook of game-based learning*. MIT Press.

Plummer, K. J., Kebritchi, M., Leary, H. M., & Halverson, D. M. (2022). Enhancing critical thinking skills through decision-based learning. *Innovative Higher Education*, 47(4), 711–734. https://doi.org/10.1007/s10755-022-09595-9

Putri, D. a. A., Sugiman, S., & Purnomo, Y. W. (2025). Analysis of thinking mathematics based on Van de Walle's: A case study in students grade 5th. *Primary Education Insight*, 1(2), 67–79. https://doi.org/10.65779/pedi.v1i2.34

Ramadhan, S., Faradilah, A., & Hermansyah. (2026). The importance of AI in science education through game-based learning strategies in fostering students' scientific thinking skills. *Journal of Educational Studies*, 4(1), 101–113. https://doi.org/10.58218/jes.v4i1.2417

Republic Act No. 10533. (2013). *Enhanced Basic Education Act of 2013*. Republic of the Philippines.

Russo, J., 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*. Advance online publication. https://doi.org/10.1080/0020739X.2024.2361699

Sánchez-Caballé, A., Gisbert-Cervera, M., & Esteve-Món, F. (2021). Integrating digital competence in higher education curricula: An institutional analysis. *Educar*, 57(1), 241–258. https://doi.org/10.5565/rev/educar.1174

Serin, H. (2023). Teaching mathematics: Strategies for improved mathematical performance. *International Journal of Social Sciences and Educational Studies*, 10(3), 146–155. https://doi.org/10.23918/ijsses.v10i3p146

Sidneva, A. (2020). Developmental effects of Davydov's mathematics curriculum in relation to school readiness level and teacher experience. *Frontiers in Psychology*, 11, 603673. https://doi.org/10.3389/fpsyg.2020.603673

Siregar, T. (2025). *Effectiveness of the problem-based learning model in improving students' mathematical communication skills and learning motivation*. Preprints.org. https://doi.org/10.20944/preprints202510.1562.v1

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning*, 35(3), 407–420. https://doi.org/10.1111/jcal.12347

Torres-Peña, R. C., Peña-González, D., Lara-Orozco, J. L., Ariza, E. A., & Vergara, D. (2025). Enhancing numerical thinking through problem solving: A teaching experience for third-grade mathematics. *Education Sciences*, 15(6), 667. https://doi.org/10.3390/educsci15060667

Ulfa, S. (2026). Analysis of the causes of elementary school students' difficulties in learning mathematics: A qualitative study. *Jurnal Pendidikan Profesi Guru*, 4(1), 36–48. https://doi.org/10.22373/jppg.v4i1.10009

UNESCO. (2022). *UNESCO World Higher Education Conference 2022*. https://www.unesco.org/en/higher-education/2022-world-conference

Vankúš, P. (2021). Influence of game-based learning in mathematics education on students' affective domain: A systematic review. *Mathematics*, 9(9), 986. https://doi.org/10.3390/math9090986

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz

World Bank. (2026). *World development reports archive*. World Bank Group. https://www.worldbank.org/en/publication/wdr/wdr-archive

