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Enhancing Grade 2 Learners' Numeracy Skills Through Game-Based Learning

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Abstract: *This study determined the effectiveness of game-based learning in enhancing the numeracy skills of Grade 2 learners. It specifically measured improvements in place value, mental math, and the identity property of addition after classroom-based interventions. The study investigated whether significant differences existed between pretest and posttest scores, thereby establishing the instructional value of game-based strategies in strengthening foundational mathematics competencies. A descriptive-evaluative research design with a one-group pretest–posttest approach was employed. Thirty Grade 2 learners from Butuan Central Elementary School, Central Butuan District 1, participated as an intact section chosen for accessibility and practicality. A validated 30-item multiple-choice numeracy test aligned with the Mathematics MELCs served as the primary instrument. The game-based learning tool was developed and validated by ICT professionals, Master Teachers, Mathematics Coordinators, and a School Head to ensure accuracy and instructional suitability. Data collection followed an Input–Process–Output framework: permission was secured, the pretest was administered, game-based activities were implemented, and the posttest was conducted. Scoring adhered to DepEd's performance classifications, while validators used a four-point scale to assess instructional quality. Data analysis utilized frequency and percentage to describe performance levels, mean and standard deviation to determine score trends, and paired sample t-tests to measure significance. Findings: Results revealed substantial improvement across all numeracy competencies. In place value, 60% of learners reached the Strong level, and 26.7% achieved Advanced proficiency. For mental math, 66.7% attained Strong, and 30% reached Advanced levels, showing reduced reliance on finger counting and increased use of mental strategies. The identity property of addition yielded the most remarkable gains, with all learners performing at Strong or Advanced levels. Paired t-test results confirmed statistically significant differences between pretest and posttest scores (p = .000). Classroom observations supported these gains, highlighting increased confidence, engagement, and enthusiasm. Overall, game-based learning effectively enhanced both cognitive performance and learner motivation in mathematics.*

Keywords: Instructional Strategies, ***Game-Based Learning, Numeracy Skills***

INTRODUCTION

Mathematics plays a vital role in developing young learners' critical thinking and problem-solving abilities, yet many early-grade students continue to struggle with basic numeracy concepts. Teachers and school administrators report persistent difficulties in addition, subtraction, number patterns, and place value skills considered foundational for future learning. Despite the Department of Education's (DepEd) continued efforts to strengthen early-grade instruction through digitized educational tools and large-scale assessments such as the Rapid Mathematics Assessment (RMA), many Grade 2 learners remain below proficiency levels. This ongoing challenge highlights the need for more engaging and developmentally appropriate instructional strategies that respond to the learning preferences of today's digitally oriented students.

Research supports the use of game-based learning as an effective tool for enhancing mathematics achievement. Al-Bogami and Elyas (2020) found that digital games increase learners' motivation and curiosity by providing interactive, enjoyable learning environments. Similarly, Bagacina et al. (2023) reported that game-based learning significantly improved learners' mathematical performance and classroom engagement in Philippine schools. International and local literature consistently emphasizes that game-based activities through visuals, instant feedback, and interactive tasks help simplify complex mathematics concepts and strengthen retention. These studies provide a strong theoretical foundation for integrating digital games into early numeracy instruction.

However, despite growing global evidence, research gaps remain, particularly in the local public-school context. At Butuan Central Elementary School, RMA results show that many Grade 2 learners continue to struggle with computation and problem-solving by the end of the school year. Traditional instruction, often

centered on rote drills and memorization, fails to fully engage learners who are more familiar with digital platforms than textbook-based activities. Moreover, only a few local studies explore the effectiveness of game-based numeracy interventions specifically aligned with the Most Essential Learning Competencies (MELCs) for Grade 2 learners in public elementary schools.

By integrating interactive digital games into classroom instruction and assessing learners' performance before and after the intervention, the study provides empirical evidence on whether game-based learning can improve competencies such as addition, subtraction, number patterns, and place value. In doing so, the study contributes locally relevant insights and supports DepEd's call for innovative, data-driven approaches to improving early-grade mathematics learning

Theoretical framework

This study was anchored on Kiili's Experiential Gaming Model (2005), which emphasizes that learning becomes meaningful when learners actively participate, receive immediate feedback, and reflect on their actions within a game setting. Kiili (2005) explains that games naturally create cycles of experiencing, experimenting, and improving, allowing learners to construct understanding through authentic interactions. In this study, Grade 2 learners engaged with numerical challenges embedded in game-based activities, enabling them to explore place value, mental math, and addition through hands-on experiences. The improvement in their performance moving from lower pretest scores to Strong and Advanced posttest levels demonstrates how Kiili's experiential learning cycle supports deeper comprehension and sustained engagement.

Another foundational theory guiding this research is James Paul Gee's Learning Principles in Video Games (2003). Gee (2003) argues that well-designed games mirror highly effective learning environments because they encourage exploration, problem-solving, and hypothesis-testing within meaningful contexts. By integrating mathematics tasks into an interactive game, the study created opportunities for learners to "learn by doing" manipulating numbers, making decisions, and observing immediate consequences. The increased participation and enthusiasm seen during the intervention affirm Gee's claim that digital games promote situated learning where knowledge becomes more concrete and meaningful for young learners.

The study also draws from Self-Determination Theory by Ryan and Deci (2000), which posits that learners are more motivated when their needs for autonomy, competence, and relatedness are met. The game-based learning intervention supported these needs by providing choices (autonomy), levels and rewards (competence), and shared classroom experiences (relatedness). Learners who initially hesitated became more confident and willing to participate as they experienced success within the game. Their significant improvement from pretest to posttest validates Ryan and Deci's (2000) view that motivation plays a vital role in enhancing learning outcomes.

Similarly, the framework incorporates Malone and Lepper's Taxonomy of Intrinsic Motivation (1987), which identifies challenge, curiosity, control, and fantasy as key elements that make learning enjoyable. The digital game developed for this study included interactive challenges, colorful visuals, choices, and engaging tasks directly mirroring these motivational components. As a result, learners remained focused, excited, and eager to solve numerical problems. Their active participation supports Malone and Lepper's (1987) argument that intrinsically motivating learning environments improve both engagement and mastery.

These theories strengthen the rationale for using game-based learning as an instructional approach for enhancing numeracy skills. They explain why young learners at Butuan Central Elementary School became more engaged, more confident, and more accurate in solving mathematical problems after the intervention. At the same time, the results of this study reinforce the principles proposed by Kiili (2005), Gee (2003), Ryan & Deci (2000), and Malone & Lepper (1987), showing that when learning becomes interactive, motivating, and meaningful, learners not only perform better they also enjoy the process. Thus, this study both draws from and adds evidence to the theoretical foundations that support game-based learning as a powerful tool for mathematics instruction.

Methodology

This study employed a descriptive-evaluative research design to determine the effectiveness of game-based learning in enhancing the numeracy skills of Grade 2 learners. The design involved administering a pre-test and a post-test to measure changes in learners' performance before and after participation in game-based mathematics activities. This approach allowed a direct comparison of learning outcomes and provided evidence of the intervention's impact on key numeracy competencies such as place value, mental math, number patterns, and the identity property of addition.

The research was conducted at Butuan Central Elementary School, Central Butuan District 1, located along A.D. Curato Street in Barangay Diego Silang, Poblacion, Butuan City. The school operates on a shifting schedule for primary grades, ensuring manageable class sizes and accessibility. It was selected as the research site due to the researcher's teaching

assignment, which allowed close monitoring of the intervention and facilitated efficient data collection.

A validated 30-item multiple-choice test aligned with the Most Essential Learning Competencies (MELCs) in Mathematics served as the primary research instrument. The same instrument was administered during the pre-test and post-test to determine learners' progress. Expert validation of the game-based learning tool was conducted by an ICT professional, a School Head, a Master Teacher, and two Mathematics Coordinators, who evaluated the content alignment, instructional quality, interface design, and technical functionality. Revisions were implemented based on their feedback to ensure the tool was educationally sound and appropriate for Grade 2 learners.

Data gathering followed the Input–Process–Output framework. After securing approvals from the District Supervisor and School Principal, the pre-test was administered. The validated game-based learning intervention was then implemented during regular class instruction. Following the intervention period, a post-test was conducted to assess the improvement in learners' numeracy skills. Scoring followed DepEd's standard performance level descriptors, and validator ratings were interpreted using a four-point scale ranging from Poor to Very Satisfactory.

To analyze the data, frequency and percentage were used to describe the distribution of learners across performance levels. Mean and standard deviation were computed to determine overall performance trends. A paired sample t-test was employed to identify significant differences between the pre-test and post-test scores, providing evidence of the effectiveness of the game-based learning intervention.

Sampling technique and Sample

The study employed an intact group sampling technique, wherein the entire Grade 2 Santan section was selected as the participant group. This non-probability sampling method was used because the learners were already organized as a class and were readily accessible to the researcher, ensuring smooth implementation, monitoring, and evaluation of the game-based learning intervention. The sample of the study consisted of 30 Grade 2 learners enrolled in the school year 2025–2026 at Butuan Central Elementary School, Central Butuan District 1. The group included 16 males (53.33%) and 14 females (46.67%), all belonging to the same Grade 2 section (Santan). These learners served as the primary participants for both the pre-test and post-test assessments measuring numeracy skills.

Results and Discussions

The Level of Numeracy Skills of the Learner after Exposure to the Game-Based Learning

Table 1 presents the level of numeracy skills of Grade 2 learners after their exposure to the game-based learning activities. The results showed generally strong to advanced performance across all competencies: place value, mental math strategies, mental math (3-digit + 1), and identity property of addition.

Table 1

Level of Numeracy Skills of Grade 2 Learners in Mathematics after the Exposure of Game-Based Learning

Score Ranges	Place Value		Mental Math (3 digit + 1)		Identity Property (Addition)		Descriptive Level
	f	%	f	%	f	%	
27 – 30	8	26.7	9	30.0	16	53.3	Advanced
21 – 26	18	60.0	20	66.7	14	46.7	Strong
15 – 20	3	10.0	0	0	0	0	Basic
9 – 14	1	3.3	1	3.3	0	0	Approaching
0 - 8	0	0	0	0	0	0	Needs support
Total	30	100	30	100	30	100	

The results in Table 1 showed that after exposure to game-based learning, most Grade 2 learners reached either the Strong or Advanced levels of numeracy. In Place Value, 60% of learners fell under the Strong category while 26.7% reached the Advanced level. During classroom implementation, learners who once struggled to identify hundreds, tens, and ones became more eager to demonstrate their answers using the grid activity in the game. Some even volunteered explanations like, "One is in the hundreds, so it means one hundred." This improvement reflected what Lopez-Pedersen et al. (2023) emphasized: early assessments, when paired with targeted interventions, effectively helped address foundational gaps.

For Mental Math with three-digit plus one-digit numbers, 66.7% of learners were Strong, and 30% achieved the Advanced level. Classroom observations revealed that learners were no longer entirely dependent on counting with their fingers. Instead, they began explaining their thought processes out loud, such as breaking apart numbers or adding tens before ones. The game's interactive format encouraged repeated practice, mirroring Agustin and Amelia's (2025) finding that game-based learning approaches

strengthened arithmetic performance through engaging drills.

The Identity Property of Addition showed the most remarkable outcome, with all learners scoring either Strong (46.7%) or Advanced (53.3%). None remained at the Basic or Approaching levels. In practice, learners quickly recognized that adding zero does not change the number. They delighted in racing to answer these items correctly, and their enthusiasm often sparked laughter and applause from classmates. This supported Garcia and Pasia's (2024) conclusion that game-based learning instruction made abstract ideas clearer and significantly boosted young learners' performance in mathematics. These results indicated that the game-based learning was not only an engaging tool but also an effective intervention for improving numeracy skills. As Velasco (2022) noted, learners achieved better outcomes when activities were interactive and game-based than with traditional methods. The current study's findings confirmed this, showing that learners became more confident, participative, and accurate after consistent exposure to the game.

Test of significant difference in the level of numeracy skills of the learners

Table 2 presents the paired t-test results comparing learners' pretest and posttest scores across the four numeracy competencies. The data reveal a significant improvement in learners' performance after exposure to the game-based learning intervention, indicating that the game-based learning effectively enhanced their numeracy skills.

Table 2

Paired t-test between pretest and posttest scores of the learners

Test		Mean	SD	t-value	p-value	Decision on H_o	Interpretation/Remarks
Place Value	Posttest	24.17	4.026	15.818*	.000	Reject H_o	Significant
	Pretest	11.07	3.107				
Mental Math (3 Digit + 1)	Posttest	24.57	3.319	19.959*	.000	Reject H_o	Significant
	Pretest	11.53	3.037				
Identity Property (Addition)	Posttest	26.80	1.808	33.030*	.000	Reject H_o	Significant
	Pretest	13.77	1.755				

**significant @ p<.01

Table 2 presents the pretest and posttest mean scores for learners across the four identified learning competencies. It can be noted that the pretest scores indicate approaching numeracy skills, well below the mean (score range 9-14). This explained the lower standard deviation of the pretest mean scores, as these scores are more concentrated at lower levels of numeracy. In the posttest, the scores had moved towards higher levels of numeracy skills, with a greater concentration in the score ranges above the mean (21-26 and 27-30), leaving a few in the lower scales.

The result of the paired t-test between the pretest and posttest mean scores of the learners showed significant differences in the four learning competencies: place value (t=15.818; p=.000); mental math (3 digit +1) at (t=19.959; p=.000); and identity property (Addition) at (t=33.030; p=.000). Thus, the null hypothesis is rejected. This means that the learners' numeracy skills, in terms of these competencies, improved after exposure to game-based mathematical activities. This provided proof of the efficacy of these games in improving numeracy skills.

During classroom implementation, these results were reflected not only in numbers but also in learners' behavior and confidence. At the beginning, most learners hesitated to answer, often second-guessing themselves during the pretest. However, as soon as game-based learning was introduced, a noticeable shift occurred: learners leaned forward with excitement, eagerly awaiting their turn to respond. Even those who were usually quiet in traditional lessons became active participants. For instance, when the place-value grids were flashed on screen, learners were quick to identify the correct digit positions, something they had previously found difficult.

The interactive quizzes also made computation less intimidating. In mental addition activities, learners were seen whispering possible answers before finally choosing confidently, a clear sign that they were trying to apply strategies rather than just guessing. The identity property of addition became more straightforward to grasp because repeated exposure to simple quiz items reinforced the idea that adding zero does not change a number's value. More importantly, the immediate feedback built their confidence, wrong answers were corrected right away, and right answers were celebrated, which motivated learners to try harder in the succeeding rounds.

Garcia and Pasia (2024) noted that game-based activities enhanced engagement and understanding by making abstract concepts more concrete, while

Velasco (2022) highlighted that interactive learning tools helped sustain motivation and retention. As observed in class, the learners' improvement was not just about higher scores but about a stronger willingness to learn, greater participation, and a more positive attitude toward mathematics. This reinforced the posttest results, proving that the game-based learning was effective in bridging gaps in numeracy skills and making abstract concepts more concrete and enjoyable.

Conclusions

The findings of the study clearly demonstrate that game-based learning significantly enhanced the numeracy skills of Grade 2 learners across key competencies such as place value, mental math, and the identity property of addition. Most learners progressed to the Strong and Advanced proficiency levels, supported by substantial improvements in posttest scores and positive behavioral changes during classroom implementation. The statistical results confirm that the intervention had a highly significant effect on learners' performance, while classroom observations highlight increased confidence, motivation, and participation. Overall, the study affirms that game-based learning is an effective, engaging, and learner-centered approach that strengthens foundational numeracy skills and promotes a more positive attitude toward mathematics.

Teachers are encouraged to integrate structured game-based activities into daily mathematics instruction to reinforce concepts and sustain learner engagement. Students may be provided with regular opportunities to explore math through interactive games that promote collaboration, creativity, and confidence. School principals may support this approach by providing resources, training, and flexible learning environments that encourage the use of educational technology and game-based tools. Future researchers may to explore the long-term effects of game-based learning, examine its impact on other mathematical competencies, or expand the study to larger and more diverse learner groups to strengthen generalizability.

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