

Original Article

Game-Based Multiplication: Enhancing Fact Mastery in Grade 4 Learners in Philippine Public Elementary Schools

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Abstract. Multiplication fact fluency remains a persistent challenge among intermediate primary learners, particularly in contexts where instruction is predominantly drill-based, teacher-led, and assessment-driven. This quasi-experimental study examined the effectiveness of structured math games as instructional tools in enhancing the multiplication fact mastery of Grade 4 learners across twelve public elementary schools in Bauang North District, La Union, Philippines. A total of 360 learners participated, with 180 exposed to four weeks of game-based multiplication instruction (e.g., Multiplication Bingo, Salute!, Roll and Multiply, Multiplication War) and 180 receiving conventional drill-based instruction (timed worksheets, flashcards, recitation). The intervention systematically integrated games into warm-up, main activity, and reflection phases aligned with the Department of Education's Most Essential Learning Competencies for Grade 4 Mathematics. Statistical analyses revealed significant improvements in the experimental group's multiplication fact mastery scores compared to the control group ($p < .001$), with a moderate-to-large effect size (Cohen's $d = 0.85$). Gains were especially evident in accuracy (percentage correct), with the experimental group shifting from 15.56% Proficient/Advanced at pretest to 48.33% at posttest, while the control group improved only from 16.67% to 28.89%. These findings emphasize the potential of low-tech, play-based, socially interactive pedagogies in primary mathematics education, positioning structured math games as effective scaffolds for developing automaticity and confidence in multiplication facts within the Philippine context.

Keywords: *Fact fluency; Game-based learning; Grade 4 mathematics; Multiplication mastery; Quasi-experimental design.*

Mathematical fluency, especially the ability to recall multiplication facts quickly and accurately, is an important aspect of children's mathematical learning as it allows them to stop counting on their fingers and instead move confidently through multi-digit multiplication, division, fractions, and eventually algebra. However, for many Grade 4 learners, multiplication fact mastery remains a persistent challenge, with a significant proportion of students unable to retrieve basic facts without relying on counting strategies.

This appears to be a global phenomenon. As far as the 2019 Trends in International Mathematics and Science Study (TIMSS) is concerned, many participating countries struggled with foundational skills, and multiplication fact fluency, a skill strongly associated with later success in multi-digit arithmetic, fractions, and algebra (Mullis et al., 2020). Similarly, the 2022 Programme for International Student Assessment (PISA) showed that, across

OECD countries, one in four 15-year-olds are "low performers" in mathematics, meaning they struggle with tasks such as using basic algorithms or interpreting simple texts.

The same can be said about the Philippine situation, where the 2019 TIMSS ranked the Philippines last among 58 participating countries in mathematics, with only 19% reaching the Low International Benchmark, meaning they demonstrated only "some basic mathematical knowledge" (Mullis et al., 2020). The 2022 PISA also reported that Filipino 15-year-olds scored an average of 344 in mathematics, well below the OECD average of 472 (OECD, 2023). The EDCOM II has attributed these to failure in building foundational skills in the early grades, a problem that severely hampers learners as they advance to higher levels.

It is in this sense that emerging perspectives have considered game-based interventions to enhance learners' mathematical competence. This is premised on the fact that foundational skills are not solely cognitive but also affective and social. A systematic review by Hui and Mahmud (2023), for instance, found that game-based learning positively influences both the cognitive domain (knowledge and mathematical skills) and the affective domain (including achievement, attitude, motivation, interest, and engagement). Extending this, a study by Abu Bakar, Shahrill, and Zakariya (2023) demonstrated that digital game-based interventions can also enhance students' collaborative learning and communication skills, thereby fostering the social dimension of learning. More recently, Rosidah et al. (2025) confirmed the effectiveness of game-based approaches in increasing student motivation and confidence, key affective factors that support deeper cognitive engagement and problem-solving.

However, much of the existing literature has focused on digital game-based learning in well-resourced settings or on general mathematics achievement rather than specifically on multiplication fact mastery in the intermediate primary grades. Specifically, no prior studies have isolated fact mastery as the primary outcome variable for Grade 4 learners. This leaves a critical gap in understanding how game-based pedagogies address fluency development at this transitional stage.

This limitation is significant, as Grade 4 represents a critical transition point in numeracy development. At this stage, learners are expected to move from concrete operations to fluent, automatic recall to support higher-level topics such as fractions, decimals, and area calculation. Insofar as the Most Essential Learning Competencies (MELCs) of the Department of Education (DepEd) are concerned, Grade 4 learners are expected to demonstrate "apply multiplication and division of whole numbers including money in mathematical problems and real-life situations." Fact mastery, herein defined as the dual ability to retrieve multiplication facts accurately and automatically, is a tool that enables students to meet these higher-order competencies. As the MELCs documents state, multiplication lessons should "Recall Basic Addition and Multiplication Facts" because automatic recall helps reduce cognitive load, allowing a student to focus mental energy on the more complex task at hand; in this case, the process and procedure of multi-digit multiplication (DepEd, 2020).

This study, therefore, investigates the effectiveness of game-based multiplication activities in enhancing the mastery of multiplication facts among Grade 4 learners in public elementary schools. Using a quasi-experimental pretest-posttest control group design, the study compares learners exposed to math games with those receiving traditional drill-based instruction. The findings contribute to ongoing discussions on strengthening foundational numeracy by offering a pedagogical perspective that integrates cognitive, affective, and social dimensions of learning.

Methodology

Research Design

This study employed a quasi-experimental pretest-posttest control group design. This study built on Miller et al.'s (2020) understanding of quasi-experimental designs as comparative studies without random assignment. This was deliberately chosen to investigate intervention effects under actual classroom sectioning so as not to disrupt normal school routines in ways that make findings difficult to translate into practice. In this study, the experimental group received four weeks of game-based multiplication instruction. The control group continued with conventional drill-based methods: timed worksheets, flashcards, recitation. A pretest established baseline mastery; a posttest measured change. This allowed both within-group and between-group comparisons. To address threats such as maturation and testing effects, the researcher followed standard quasi-experimental procedures (Reichardt et al., 2023) by comparing groups both internally and against each other.

Participants and Sampling Technique

In this study, the participants were Grade 4 learners enrolled in the 2025–2026 school year across twelve public elementary schools in the Bauang North District. The researcher used purposive sampling, which, according to Mulisa (2022), is a non-random technique where participants are deliberately selected based on specific characteristics relevant to the study. In this case, the twelve schools were purposively divided into two groups to enable a meaningful comparison.

Six schools formed the experimental group, i.e., Acao, Baccuit, Ballay, Baratao, Bauang North Central, and Bawanta Elementary Schools. Their learners received game-based multiplication instruction (e.g., Multiplication Bingo, Salute!, Roll and Multiply, Multiplication War). The remaining six schools constituted the control group, i.e., Bigbiga, Paringao, Pugo, San Agustin, Quinavite, and Eulogio Clarence M. De Guzman Jr. Elementary Schools. They continued with their regular mathematics classes without game-based multiplication activities.

There was no random assignment of individual students, consistent with the quasi-experimental design of this study. Instead, each school contributed one intact section (an existing Grade 4 class) of thirty learners. Their class advisers and mathematics teachers identified which section was most in need of support for multiplication fact mastery. At the class level, teachers looked for sections where most students either scored below 60% on basic multiplication facts (up to 10×10) in prior assessments or visibly struggled to retrieve facts without counting strategies. Once a section met this profile, all learners in that section were invited to participate.

The use of purposive sampling and teacher-identified sections, while practical for implementation in intact classrooms, introduces a potential limitation in that selection was not based on objective criteria alone. This may affect the generalizability of the findings, as the identified sections may not be representative of all Grade 4 learners in the district. However, the quasi-experimental design and the establishment of baseline equivalence between-groups (as shown in Table 2) help mitigate this concern by confirming that the two groups were comparable at the outset.

In total, 360 learners participated: 180 in the experimental group, 180 in the control group. From a methodological standpoint, $N = 360$ is defensible for inferential analysis. Standard power analysis conventions for independent-samples t-tests suggest that this size provides sufficient statistical power to detect medium-to-large effects (Cohen's $d \geq 0.5$) at $\alpha = 0.05$. This is consistent with recommendations from G*Power, a tool widely cited in contemporary educational research journals (Kang, 2021). This sample size allowed the researcher to compare the two groups while accommodating the natural variability among learners across different schools and classrooms in the district.

Research Instrument

To evaluate multiplication fact mastery, the researcher developed a 40-item Multiplication Fact Fluency Test aligned with the DepEd's MELCs for Grade 4 Mathematics, specifically focusing on competencies related to multiplication of whole numbers up to 10×10 and the application of multiplication facts in simple word problems. The test measured accuracy (number of correct answers), consistent with the dual components of fact fluency commonly assessed in elementary mathematics research (Gliksman et al., 2022). The instrument was divided into two sections: Section A (30 items) required learners to supply the product of basic multiplication facts (e.g., $7 \times 8 = \underline{\quad}$; $4 \times 6 = \underline{\quad}$) without the aid of manipulatives or counting aids; Section B (10 items) presented simple one-step word problems requiring multiplication fact recall (e.g., "There are 9 baskets with 5 eggs each. How many eggs in total?").

Item construction was guided by established frameworks in mathematics fact fluency assessment, including distinctions between automatic retrieval, strategic decomposition, and counting strategies commonly observed in elementary numeracy research (Bay-Williams & Kling, 2019). Each correct response was assigned one point, with total scores ranging from 0 to 40. For analysis, accuracy scores were converted to percentage correct. Proficiency levels (Beginning, Developing, Approaching Proficiency, Proficient, Advanced) were defined based on percentage ranges to facilitate descriptive and inferential analysis.

Before administration, the test was piloted on a small group of Grade 4 learners outside the study sample ($n = 30$), and a panel of experienced Grade 4 mathematics teachers and district numeracy specialists reviewed the items to

ensure alignment with the MELCs, developmental appropriateness, and sensitivity to the targeted multiplication facts. Reliability analysis using Cronbach's alpha confirmed that the instrument consistently measured multiplication fact mastery across items ($\alpha = 0.91$). Test-retest reliability was also established with a two-week interval on a separate pilot group ($r = 0.86$), indicating temporal stability.

Data Gathering Procedure

Prior to the intervention, all participants took the Multiplication Fact Fluency Test. This gave the researcher a pretest baseline, which showed where learners stood before the intervention. The researcher administered the same pretest to both the experimental and control groups under standardized conditions: quiet classrooms, timed sections, no calculators allowed.

After the pretest, the experimental group received four weeks of game-based multiplication instruction. The control group, meanwhile, continued with classroom as usual: timed drills, flashcards, repetitive worksheets, and teacher-led recitation. Prior to the intervention, the researcher trained the mathematics teachers in both groups on the respective procedures and provided them with detailed session guides and checklists. The researcher monitored attendance and engagement to make sure exposure was reasonably consistent across both conditions.

The experimental group met three times per week, each session lasting about 40 to 50 minutes, integrated into the regular mathematics period. Teachers completed daily checklists, which the researcher collected and reviewed during periodic visits, to keep track of fidelity. Each session followed a simple three-part structure: First, the warm-up (5–10 minutes). A quick review of multiplication facts using a whole class game. "Around the World" with multiplication cards was used. Second, the main game activity (20–25 minutes). Learners worked in pairs or small groups on a structured math game. The facilitator rotated games weekly to keep engagement from fading. The games used were (1) *Multiplication Bingo*, i.e., learners cover products on bingo cards as facts are called; (2) *Salute!* which was a card game where two learners multiply two numbers while a third states the product; *Roll and Multiply*, i.e., a dice game where learners roll two dice, multiply, and claim squares on a grid; and *Multiplication War*, a card game comparing products. Third, reflection and exit slip (5–10 minutes). A brief discussion of strategies used, common errors, and quick individual practice. This was the quiet part of the session — a chance for learners to process what they had learned.

As for the control group, during the same time allocation, they completed teacher-assigned drills: multiplication tables recitation, timed written worksheets, and flashcard drills. No game elements. No peer collaboration beyond what naturally happened. Control group teachers likewise received clear instructions to maintain their regular drill-based routines and to avoid using any game-like activities. The researcher monitored both conditions through periodic classroom observations and by reviewing teacher-completed checklists.

To provide implementation fidelity data, a total of 12 experimental sessions (2 per school) and 6 control sessions (1 per school) were observed unannounced. Inter-rater reliability between two observers was strong (Cohen's $\kappa = 0.88$). In all observed control sessions, no game-like activities were recorded. Attrition was zero; all 360 learners completed the posttest, and attendance was 94% (experimental) and 92% (control) across the 12 sessions. At the end of four weeks, both groups completed the posttest. All data, including pretest and posttest, were collected, coded, and entered for statistical analysis.

Data Analysis Procedure

Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize learners' accuracy scores across proficiency levels. These are standard procedures in educational research and are presented concisely to describe score distributions. Paired-sample t-tests were used to examine within-group differences between pretest and posttest scores, while independent-sample t-tests were used to compare the experimental and control groups on posttest. Effect sizes (Cohen's d) were computed to determine the magnitude of observed differences, interpreted as small (0.20), medium (0.50), or large (0.80) according to Cohen's conventions. Assumptions for parametric testing were verified using Shapiro-Wilk tests for normality and Levene's test for homogeneity of variances. Results indicated that assumptions were met; thus, parametric tests were deemed appropriate. Separate analyses were also conducted for accuracy (percent correct). All analyses were performed using SPSS version 29, with significance set at $p < 0.05$.

Ethical Considerations

The study was conducted in accordance with established ethical principles governing educational research. Prior to data collection, informed consent was secured from parents or guardians, while learner assent was obtained from participating pupils. Participants were likewise informed that their involvement was voluntary and that they could withdraw from the study at any stage without any adverse consequences.

To protect participant privacy, all identifying information was removed from the dataset and replaced with coded identifiers. Findings are presented only in aggregated form to preserve anonymity and prevent the identification of individual participants. Digital records were stored in password-protected files, while hard-copy documents were kept in a secured location accessible only to the researcher. All research data will be retained for a prescribed period of three years before undergoing secure disposal.

Institutional approval was obtained from the respective school heads prior to the implementation of the study. Ethics review and approval were secured from the Polytechnic College of La Union before implementing the study. Throughout the research process, the researcher remained mindful of the dual role as both educator and investigator. To minimize potential bias, standardized procedures were followed in administering assessments and interventions, and care was taken to ensure that no group received preferential treatment. These measures were undertaken to uphold the integrity, fairness, and credibility of the research process.

Results and Discussion

As outlined in the research design, the analysis proceeded across three levels of comparison. First, baseline equivalence was established by comparing the pretest scores of the experimental group (EG) and control group (CG). Second, changes within each group were examined through separate comparisons of pretest and posttest scores to determine the extent of learning gains over the course of the intervention. Third, post-intervention differences between the EG and CG were analyzed to assess the effectiveness of the game-based multiplication activities in improving Grade 4 learners' mastery of multiplication facts. To provide a comprehensive account of the findings, each subsection presents both descriptive and inferential evidence. Descriptive statistics, particularly frequency distribution tables, were used to illustrate patterns in learner performance, while t-test results were employed to determine whether observed differences were statistically significant.

Baseline Data: Pretest Multiplication Fact Mastery of CG and EG

Before the implementation of the intervention, all participating Grade 4 learners (N = 360) completed a researcher-developed 40-item Multiplication Fact Fluency Test to establish their baseline level of multiplication fact mastery. Table 1 presents the distribution of pretest scores for both the control group (CG) and experimental group (EG), organized according to proficiency levels based on the percentage of correct responses. The table provides an initial profile of learner performance and serves as the basis for assessing the comparability of the two groups prior to the intervention.

Table 1. *Pretest Multiplication Fact Mastery Scores of Control and Experimental Groups*

Score Range	Interpretation	Control Group		Experimental Group	
		<i>f</i>	%	<i>f</i>	%
33-40	Advanced (83-100%)	0	0.00%	0	0.00%
25-32	Proficient (63-80%)	30	16.67%	28	15.56%
17-24	Approaching Proficiency (43-60%)	100	55.56%	102	56.67%
9-16	Developing (23-40%)	48	26.67%	48	26.67%
0-8	Beginning (0-20%)	2	1.11%	2	1.11%

As shown in Table 1, the nearly identical distribution of pretest scores across the control and experimental groups suggests that the two groups were comparable at baseline. In both groups, the majority of learners were classified under the Approaching Proficiency category, accounting for roughly 56 percent of participants. This pattern indicates that while many learners possessed some knowledge of multiplication facts, automatic recall had not yet been fully developed. Instead, learners likely continued to rely on counting-based or other effortful strategies to arrive at correct answers.

Equally noteworthy is the small proportion of learners who reached the Proficient level and the absence of learners classified as Advanced. These findings apparently point to a broader challenge in multiplication fact fluency

among Grade 4 pupils and emphasize the need for instructional approaches that can strengthen automatic retrieval of basic multiplication facts.

The observed pattern aligns with existing research on numeracy development. Studies have shown that many learners in the intermediate grades continue to struggle with fluent recall, particularly for multiplication facts involving larger factors. Kling and Bay-Williams (2021), for example, noted that many Grade 4 learners remain dependent on counting or decomposition strategies rather than automatic retrieval, a limitation that can constrain later learning in multiplication and division. Similarly, De Vera & De Vera (2025) found low levels of multiplication fact mastery among Filipino Grade 4 pupils in public schools, with a substantial proportion unable to rapidly recall basic multiplication facts.

To test significance, an independent-samples *t*-test was conducted on the pretest accuracy scores.

Table 2. Independent-Samples *t*-Test for Pretest Multiplication Fact Mastery Scores

Group	Mean	SD	<i>t</i>	<i>df</i>	<i>p</i>	Cohen's <i>d</i>
CG	17.82	5.10	0.19	358	.849	0.02
EG	17.70	5.08				

As shown in Table 2, the difference in pretest scores between the control and experimental groups was not statistically significant, $t(358) = 0.19$, $p = .849$. The corresponding effect size was likewise negligible (Cohen's $d = 0.02$), indicating a virtually identical level of multiplication fact mastery across the two groups at baseline. These findings provide empirical support for the comparability of the control and experimental groups prior to the implementation of the intervention. In other words, there is no evidence that either group possessed an initial advantage in multiplication fact fluency. Establishing such baseline equivalence is important for interpreting subsequent outcomes, as it strengthens the inference that any posttest differences observed between the groups are more likely attributable to the game-based multiplication activities rather than to pre-existing differences.

Within-Group Comparison of Multiplication Fact Mastery Scores

Table 3 presents the distribution of learners' accuracy scores in both the pretest and posttest phases for the control group (CG) and experimental group (EG), providing a comparative view of performance changes over time within and across groups.

Table 3. Within-Group Comparison of Multiplication Fact Mastery Scores (CG and EG)

Score Range	Interpretation	Control Group		Experimental Group	
		Pretest	Posttest	Pretest	Posttest
33–40	Advanced	0 (0.00%)	4 (2.22%)	0 (0.00%)	20 (11.11%)
25–32	Proficient	30 (16.67%)	48 (26.67%)	28 (15.56%)	67 (37.22%)
17–24	Approaching Proficiency	100 (55.56%)	90 (50.00%)	102 (56.67%)	68 (37.78%)
9–16	Developing	48 (26.67%)	36 (20.00%)	48 (26.67%)	23 (12.78%)
0–8	Beginning	2 (1.11%)	2 (1.11%)	2 (1.11%)	2 (1.11%)

As summarized in Table 3, both the control and experimental groups registered gains from pretest to posttest; however, the extent of improvement differed substantially between the two groups. The control group showed a gradual upward shift in performance, with the proportion of learners reaching Proficient or Advanced levels increasing from 16.67% to 28.89%, reflecting a modest gain of 12.22 percentage points.

In contrast, the experimental group demonstrated a more substantial and differentiated improvement. The combined proportion of learners classified as Proficient or Advanced rose sharply from 15.56% to 48.33% (gain of 32.77 percentage points). Notably, 11.11% of learners in the experimental group reached the Advanced level at posttest, compared to none at baseline. To further examine whether these observed differences were statistically significant, paired-samples *t* tests were conducted, as presented in Table 4.

Table 4. Paired-Samples *t*-Test for Within-Group Comparison of Multiplication Fact Mastery

Group	Pretest Mean (SD)	Posttest Mean (SD)	<i>t</i>	<i>df</i>	<i>p</i>	Cohen's <i>d</i>
CG	17.82 (5.10)	20.50 (5.80)	4.65	179	< .001	0.49
EG	17.70 (5.08)	25.40 (5.65)	19.10	179	< .001	1.52

The results indicate that both the control and experimental groups registered statistically significant

improvements from pretest to posttest. However, a clear divergence emerged in the magnitude of these gains. The experimental group yielded a large effect size (Cohen's $d = 1.52$), indicating a strong impact of the game-based intervention, while the control group demonstrated a smaller, though still meaningful, improvement (Cohen's $d = 0.49$), falling within the moderate range. It should be noted that within-group effect sizes tend to be larger than between-group effect sizes, as they control for individual differences and measure change from baseline; the more conservative estimate of the intervention's effectiveness is the between-group effect size ($d = 0.85$) reported in Table 6.

The moderate gain observed in the control group may be partly explained by repeated exposure to multiplication facts through traditional drill activities, as well as the testing effect, wherein retrieval practice through assessment contributes to improved later performance (Ophuis-Cox et al., 2023). By contrast, the between-group effect size ($d = 0.85$) is moderate-to-large and consistent with findings from other game-based multiplication interventions. For example, Busquit (2025) reported a very large effect size for a game-based numeracy intervention, and Al-Barakat et al. (2025) demonstrated statistically significant improvements in multiplication skills through electronic games-based learning. Although both groups experienced the same testing schedule, the experimental group's greater engagement and motivation might have amplified the benefits of retrieval practice.

These findings are consistent with prior research. Al-Barakat et al. (2025) similarly reported that game-based mathematics instruction enhances accuracy in fact retrieval compared with conventional drill approaches. Diaz and Estoque-Loñez (2024) also found that gamification can positively affect student learning achievement and engagement, noting its ability to make learning more engaging and provide immediate feedback. Extending these insights, the present study demonstrates that even low-tech, classroom-implementable games can produce substantial learning gains in the public school context, where access to digital learning tools is often constrained.

Posttest Multiplication Fact Mastery of Control and Experimental Groups

Following the analysis of within-group gains, the study proceeded to examine differences in posttest performance between the control and experimental groups to determine whether the improvements observed under the game-based intervention surpassed those achieved through conventional instruction. Table 5 presents the distribution of posttest accuracy scores across both groups.

Table 5. *Posttest Multiplication Fact Mastery Scores of the Control and Experimental Groups*

Score Range	Interpretation	Control Group		Experimental Group	
		<i>f</i>	%	<i>f</i>	%
33–40	Advanced	4	2.22%	20	11.11%
25–32	Proficient	48	26.67%	67	37.22%
17–24	Approaching Proficiency	90	50.00%	68	37.78%
9–16	Developing	36	20.00%	23	12.78%
0–8	Beginning	2	1.11%	2	1.11%

As shown in Table 5, the control group largely remained concentrated within the Approaching Proficiency level (50%), with only about 29% reaching either the Proficient or Advanced categories. In contrast, the experimental group exhibited a clear upward shift in performance distribution, with 48.33% reaching Proficient or Advanced (11.11% Advanced, 37.22% Proficient). Only a small proportion (1.11%) remained at the Beginning level.

This pattern suggests that while both groups demonstrated improvement, the experimental group achieved a substantially higher level of multiplication fact mastery. To determine whether these observed differences were statistically significant, an independent-samples t test was conducted on the posttest scores, as presented in Table 6.

Table 6. *Independent-Samples t -Test for Posttest Multiplication Fact Mastery Scores*

Group	Mean	SD	<i>t</i>	<i>df</i>	<i>p</i>	Cohen's <i>d</i>
CG	20.50	5.80	9.15	358	< .001	0.85
EG	25.40	5.65				

Statistical analysis revealed a significant difference between the control and experimental groups, $t(358) = 9.15$, $p < .001$, accompanied by a large effect size (Cohen's $d = 0.85$). This indicates that the observed difference is not only statistically significant but also practically meaningful in classroom terms. In concrete terms, learners exposed to game-based multiplication activities outperformed those taught through conventional drill-based instruction,

with the experimental group scoring, on average, 4.9 points higher (out of 40) than the control group.

These findings are consistent with and extend existing literature on game-based learning. Juniarmi (2025) emphasizes that game-based environments enhance student motivation and increase time on task, both of which contribute to improved fluency outcomes. Grounded in Self-Determination Theory (Deci & Ryan, 2000, as cited in Alvi, 2024), such learning environments support learners' needs for autonomy, competence, and relatedness, thereby fostering stronger intrinsic motivation to engage in repeated practice. From a cognitive perspective, Cognitive Load Theory further explains that well-designed games may reduce extraneous load by embedding practice within structured and engaging tasks, allowing working memory to focus more efficiently on retrieval processes (Xiang et al., 2025). Similarly, Busquit (2025) reported large effect sizes ($d > 1.0$) for game-based multiplication interventions compared with traditional worksheet-based instruction.

Taken together, the between-group results reinforce the within-group findings, suggesting that the gains observed in the experimental group are more plausibly attributed to the game-based intervention itself rather than to maturation effects or repeated testing alone.

Conclusion

This study affirms that game-based instruction is an effective approach for improving Grade 4 learners' mastery of multiplication facts. Beyond establishing effectiveness, however, the findings also invite a broader rethinking of how numeracy is constructed and experienced in Philippine classrooms. At a time when national assessments continue to reflect persistent gaps in foundational mathematics, the issue extends beyond improving test performance to reconsidering how learners engage with mathematical ideas in the first place. The results suggest that multiplication fact mastery need not be limited to timed drills, repetitive worksheets, or rote memorization. When games are deliberately integrated as instructional scaffolds rather than treated as rewards or fillers, learners engage with numbers in more meaningful ways, i.e., articulating strategies, learning from errors in low-stakes environments, and developing both fluency and confidence.

In terms of contribution to the literature, this study addresses the limited empirical evidence on game-based multiplication instruction at the Grade 4 level within the Philippine public-school context. Whereas much of the existing research has focused on digital game environments in well-resourced settings or on general mathematics achievement, this study extends the discussion to low-tech, classroom-adaptable games at a critical stage in numeracy development. This stage marks the transition from counting-based strategies to automatic retrieval, which is essential for progression to more complex topics such as fractions, decimals, and multi-step problem solving. The findings indicate that structured and collaborative game-based activities can produce substantial improvements in accuracy, with a large effect size (Cohen's $d = 0.85$) that is educationally significant.

More so, the results suggest that game-based multiplication activities offer a practical, low-cost, and engaging strategy for developing fact fluency. Games such as *Multiplication Bingo*, *Salute!*, *Roll and Multiply*, and *Multiplication War* require minimal materials and can be easily integrated into the mathematics period as warm-up activities, station-based tasks, or small-group interventions. Beyond skill practice, these games promote peer interaction, strategic thinking, and immediate feedback. These are elements often limited in traditional drill-based instruction. The findings also align with efforts to strengthen foundational numeracy under the Matatag Mathematics Curriculum by underscoring the value of play-based and participatory approaches in fluency development. Rather than positioning games as enrichment activities, curriculum design may consider them as complementary instructional strategies for developing automaticity. At the school division level, modest investments in simple instructional materials (e.g., dice, cards, timers) and the development of shared game-based resource banks may further support implementation.

This study does not claim to address the structural challenges underlying numeracy performance, such as large class sizes, limited instructional time, or resource constraints. Instead, it offers a focused pedagogical contribution by demonstrating that simple, classroom-based game interventions can produce meaningful gains in multiplication fact mastery. While systemic reform remains necessary, incremental instructional innovations continue to play a vital role in improving learning outcomes. In this sense, game-based multiplication instruction reinforces the view that effective numeracy teaching can extend beyond traditional drill methods and draw meaningfully from structured, playful, and socially interactive learning experiences.

Contributions of Authors

Not indicated

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This study received no external funding and was conducted entirely through the researcher's personal resources.

Conflict of Interests

The researcher serves as a teacher within the same school district where the study was conducted; however, this potential conflict was mitigated by ensuring the anonymity of all respondents and the confidentiality of their responses. No other conflicts of interest are declared.

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