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Raising Problem-Solving Performance Through Interactive Mathematics: A Pretest–Posttest Mixed-Methods Study of Grade 5 Learners in San Roque Elementary School, District of Candelaria, Schools Division of Zambales

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Abstract
Mathematical problem solving is a core goal of schooling worldwide, but many learners are failing to achieve even basic proficiency. Only 69% of 15-year-old students across OECD countries attained at least Level 2 in mathematics in PISA 2022, and the Philippines scored 355 and only 16% of its students reached that baseline (OECD, 2023). Nationally, Filipino Grade 4 learners ranked lowest among 58 countries in TIMSS 2019 (Mullis *et al*., 2020), and only 17% of Grade 5 learners met the minimum mathematics standard in SEA-PLM 2019 (DepEd, UNICEF, & SEAMEO, 2021), even as the MATATAG Curriculum reached Grade 5 in School Year (SY) 2025–2026. Local Grade 5 learners of San Roque Elementary School in Candelaria, Zambales, struggled most with word problems. This study determined the problem-solving performance and attitudes toward mathematics of these learners before and after interactive mathematics. A one-group pretest–posttest design within an explanatory sequential mixed-methods approach was used from June 2025 to March 2026 with all 33 Grade 5 learners (16 boys and 17 girls). Data came from a 20-item problem-solving test, a 10-item attitude questionnaire, observations, and informal interviews, and were analyzed using mean, Mean Percentage Score (MPS), normalized gain, a paired-samples t-test, and thematic analysis. The mean score rose from 10.00 to 16.39 out of 20, moving the class MPS from 50.00 (Average Mastery) to 81.97 (Moving Towards Mastery), a gain of 31.97 percentage points and a medium normalized gain of 0.64. All 33 learners improved, and the improvement was statistically significant, $t(32) = 13.76$, $p < .001$, $dz = 2.40$. Learners who liked mathematics increased from 11 to 22, and those who liked computer-based mathematics from 10 to 23. Observations showed enthusiasm, self-paced practice, immediate feedback, and growing confidence. Interactive mathematics aligned with classroom lessons was therefore associated with substantial gains in performance and more positive attitudes, although the absence of a comparison group calls for a controlled replication.

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Keywords: interactive mathematics, mathematical problem solving, digital game-based learning, Grade 5 learners, attitudes toward mathematics, MATATAG Curriculum

Introduction

Problem solving is a core competence of 21st-century education and a central aim of mathematics teaching, requiring learners to understand a situation, plan a strategy, carry out the computation, and check whether the answer makes sense (Pólya, 1945/2004) [17]. Global assessments show that many learners have not yet attained this competence; in PISA 2022, the OECD average mathematics score was 472, and 69% of students across OECD countries reached at least Level 2, the baseline at which students can recognize how a simple situation can be represented mathematically without direct instruction (OECD, 2023) [16]. The Philippine picture is more challenging; Filipino 15-year-olds scored 355 in PISA 2022 mathematics, only two points above their 2018 score; only 16% reached Level 2, and almost none reached Level 5 or 6 (OECD, 2023) [16]. The gap appears early; in TIMSS 2019, Filipino Grade 4 learners scored 297 in mathematics, the lowest among 58 participating countries (Mullis *et al*., 2020) [15], and in SEA-PLM 2019 only 17% of Filipino Grade 5 learners met the minimum mathematics standard expected at the end of primary education (DepEd, UNICEF, & SEAMEO, 2021). In response, the Department of Education (DepEd) issued the MATATAG Curriculum through DepEd Order No. 010, s. 2024, emphasizing foundational skills such as numeracy, which is being phased in by grade level: Kindergarten and Grades 1, 4, and 7 in SY 2024–2025, followed by Grades 2, 5, and 8 in SY

2025–2026 (DepEd, 2023, 2024) [7, 8]. Grade 5 learners in SY 2025–2026 were therefore the first Grade 5 cohort to experience the revised curriculum.

At San Roque Elementary School in Candelaria, Zambales, the researcher observed that Grade 5 learners find word problems among the hardest parts of mathematics, with many having difficulty identifying the information they need and the operation to perform, which the researcher attributed to limited background knowledge in mathematics and limited support for learning at home. Such gaps often remain hidden until the upper grades, making Grade 5 a critical point for intervention. The baseline test in this study confirmed the concern; the class obtained a Mean Percentage Score (MPS) of only 50.00 (Average Mastery) before the intervention, and no learner exceeded 75 percent of the items.

The literature explains why word problems are hard, and what may help; Daroczy *et al*. (2015) [5] distinguished three sources of difficulty: the linguistic complexity of the problem text, the numerical complexity of the arithmetic, and the interaction between the two; Fuchs *et al*. (2008) [11] found that preventative tutoring improved the problem solving of third-grade students with math and reading difficulties, and Xin *et al*. (2008) [23] reported that teaching a conceptual model-based approach helped students with learning difficulties represent the structure of word problems. Effective instruction makes problem structure visible, gives repeated practice, and provides timely corrective feedback.

Digital games and interactive programs are one way to deliver such practice, and the evidence is generally favorable, but varies with context; Tokac *et al*. (2019) [20] found a small but statistically significant positive effect of game-based learning on PreK–12 mathematics achievement compared with traditional instruction; Wang *et al*. (2022) [22], synthesizing 33 studies (N = 3,894), reported a moderate overall effect of digital game-based STEM education (ES = 0.667), an effect of 0.629 in mathematics, and larger benefits for primary-school learners (ES = 0.835); Mayer (2019) [14] cautioned that the learning value of computer games depends on how well they are designed and aligned with instructional goals, supporting using them to complement classroom teaching; part of their appeal lies in adaptive practice with feedback; in a review of 50 controlled evaluations, Kulik and Fletcher (2016) [13] found that intelligent tutoring systems raised test performance by a median of 0.66 standard deviations over conventional instruction; interactive programs may also improve attitudes, which shape persistence in difficult tasks; Fadda *et al*. (2022) [10] reported promising effects of digital games on student motivation in mathematics in a K–12 meta-analysis; evidence from public elementary schools under the MATATAG Curriculum is still emerging, and this study adds school-level evidence from one such school.

Three ideas anchor the study; Vygotsky's (1978) [21] zone of proximal development holds that learners progress when tasks are pitched just beyond what they can do alone, with support; this is the logic of placing each learner at the skill with the greatest need; Pólya's (1945/2004) four steps of understanding the problem, devising a plan, carrying it out, and looking back frame what problem solving means in the test and in teacher–learner conferences; Bandura's (1997) [1] concept of self-efficacy explains why repeated success and quick feedback may improve attitudes toward mathematics.

This study therefore sought to determine the effect of interactive mathematics on the problem-solving performance and attitudes of Grade 5 learners of San Roque Elementary School in SY 2025–2026. It asked how learners performed before and after the intervention, overall and by sex; how large the gain was; whether the difference between pretest and posttest scores was statistically significant, with the null hypothesis that there is no significant difference at the .05 level; how learners' attitudes toward mathematics and computers changed; and what experiences emerged from observations and informal interviews.

Methodology

Research Design

The study used a one-group pretest–posttest, pre-experimental design (Shadish *et al*., 2002) [19] within an explanatory sequential mixed-methods approach (Creswell & Plano Clark, 2018) [4]. Quantitative data were gathered first, and observations and informal interviews were then used to verify and explain them. The pretest was given after the learners had been taught using the regular lecture method, and the posttest was given after the interactive mathematics sessions.

Respondents and Location

The study was conducted at San Roque Elementary School, Candelaria District, Schools Division of Zambales, from June 2025 to March 2026. Total enumeration was used: all 33 Grade 5 learners enrolled in SY 2025–2026 participated, as shown in Table 1.

Table 1: Frequency and Percentage Distribution of Grade 5 Learner-Participants by Sex

Sex	f	%
Male	16	48.48
Female	17	51.52
Total	33	100.00

Intervention

Interactive mathematics was delivered in the classroom for 45 minutes per day over 40 weeks, alongside the regular Mathematics class, which continued to follow the normal pacing guide. Based on the pretest, each learner was assigned to the skill area in which he or she scored lowest. In each session the program presented 9–10 problems per skill, scored the learner's work, saved the record, and let the learner review mistakes, and learners could redo a skill after discussing their errors with the teacher. The teacher circulated during sessions, observed learners at work, and aligned the skills practiced with the lessons taught in class.

Instruments

Three instruments were used. The first was a 20-item Mathematics Problem-Solving Test, scored one point per correct answer (range 0–20) and covering the Grade 5 competencies taught during the period; Rapid Mathematics Assessment was used for the pretest and posttest. The second was a 10-item Learner Attitude Questionnaire on liking mathematics, self-rated competence, liking computers, liking computer-based mathematics, and computer ownership, given at the beginning and at the end of the study. The third was an observation and informal interview guide for

recording learners' behavior, remarks, and experiences. The instruments were pilot-tested with Grade 5 Magsaysay in San Roque Elementary School, content validity was reviewed by a Math teacher, and the internal consistency of the test was KR-20 = .70.

Data Collection

Permission to conduct the study was secured from the school head, and parents or guardians gave written consent while learners gave their assent. Participation was voluntary, identities were kept confidential, and records were coded and used only for this study, in accordance with the Data Privacy Act of 2012 (Republic Act No. 10173) and the DepEd Child Protection Policy (DepEd Order No. 40, s. 2012) [6]. The researcher personally administered and retrieved the instruments, with 100% retrieval. The attitude questionnaire and pretest were given before the interactive sessions, and the posttest and second attitude questionnaire at the end. Observations and informal interviews were conducted throughout, and doubtful questionnaire answers were verified through them.

Data Analysis

Frequency, percentage, and mean described the participants, scores, and attitudes. Performance was also expressed as the Mean Percentage Score (MPS), computed as the mean score divided by the number of items and multiplied by 100, and interpreted using the DepEd mastery levels: 96–100 Mastered, 86–95 Closely Approximating Mastery, 66–85 Moving Towards Mastery, 35–65 Average Mastery, 15–34 Low Mastery, 5–14 Very Low Mastery, and 0–4 Absolutely No Mastery. Gain was expressed as the mean gain and as the normalized gain of Hake (1998) [12], the posttest MPS minus the pretest MPS divided by 100 minus the pretest MPS, interpreted as high (0.70 and above), medium (0.30 to 0.69), or low (below 0.30). Because scores are whole numbers, group means were recomputed from the group score totals. The difference between the pretest and posttest scores of the same learners was tested using a paired-samples t-test at $\alpha = .05$, with Cohen's (1988) [3] d for paired data as the effect size. Observation notes and interview responses were analyzed using thematic analysis (Braun & Clarke, 2006) [2].

Results and Discussion

Table 2 shows that before the intervention the class obtained a mean score of 10.00 out of 20 (MPS = 50.00), which is Average Mastery. Boys obtained a mean of 10.50 (MPS = 52.50) and girls 9.53 (MPS = 47.65), a difference of 0.97 items, and both groups were at the Average Mastery level. The highest score in the class was 15 of 20 (75%) and the lowest was 3, so no learner reached 80% of the items, and only 4 of the 33 learners (12.12%) reached Moving Towards Mastery (MPS 66 and above). The baseline confirmed the need for a more engaging and individualized approach to problem solving.

After the intervention, the class mean rose to 16.39 out of 20 (MPS = 81.97), which is Moving Towards Mastery (Table 3). Boys reached a mean of 16.50 (MPS = 82.50) and girls 16.29 (MPS = 81.47), both Moving Towards Mastery and just below the Closely Approximating Mastery level (MPS 86). The highest posttest score was a perfect 20 and the lowest was 10. The number of learners at or above Moving Towards Mastery rose from 4 (12.12%) to 27 (81.82%), and 15 learners (45.45%) reached Closely Approximating Mastery (MPS 86 and above). Every learner improved, with individual gains ranging from 2 to 12 items, indicating that the gains were spread across the class and were not driven by a few learners.

Table 2: Pretest Results in Mathematics Problem Solving (Lecture Method)

Group	N	No. of Items	HSO	LSO	Mean	MPS	Mastery Level
Male	16	20	15	3	10.50	52.50	Average Mastery
Female	17	20	15	4	9.53	47.65	Average Mastery
Total	33	20	15	3	10.00	50.00	Average Mastery

Note. HSO = highest score obtained; LSO = lowest score obtained.

Table 4 summarizes the gains. The class improved by 6.39 items, or 31.97 percentage points, with a normalized gain of 0.64, a medium gain. Boys gained 6.00 items (g = 0.63) and girls 6.76 items (g = 0.65); both gains were medium, and the small difference between sexes is reported descriptively only. Girls gained slightly more here, which is in line with Filipino girls outperforming boys in mathematics in PISA 2022 (OECD, 2023) [16], but the sex pattern was not tested and should be examined in larger samples.

Table 3: Posttest Results in Mathematics Problem Solving (After Interactive Mathematics)

Group	N	No. of Items	HSO	LSO	Mean	MPS	Mastery Level
Male	16	20	20	10	16.50	82.50	Moving Towards Mastery
Female	17	20	20	10	16.29	81.47	Moving Towards Mastery
Total	33	20	20	10	16.39	81.97	Moving Towards Mastery

Note. HSO = highest score obtained; LSO = lowest score obtained.

The paired-samples t-test (Table 5) was used to test the null hypothesis. The gain was statistically significant, $t(32) = 13.76$, $p < .001$, with a very large effect, $dz = 2.40$, and the 95% confidence interval of the mean gain was 5.45 to 7.34 items. The computed t exceeds the critical value of 2.037 (df = 32, $\alpha = .05$, two-tailed), so the null hypothesis was rejected.

Table 4: Gain in Mathematics Problem-Solving Performance

Group	Pretest Mean	Posttest Mean	Mean Gain (items)	MPS Gain (points)	Normalized Gain (g)	Interpretation
Male	10.50	16.50	6.00	30.00	0.63	Medium
Female	9.53	16.29	6.76	33.82	0.65	Medium
Total	10.00	16.39	6.39	31.97	0.64	Medium

The standardized effect (N=3,8942_) is far larger than the typical effects reported in meta-analyses of digital games in mathematics (Tokac *et al*., 2019; Wang *et al*., 2022) [20, 22], although a within-group effect size is not directly comparable with the between-group effects in those reviews, and the result therefore calls for caution. Without a comparison group, part of the gain may be due to regular classroom instruction, maturation, familiarity with the test, or the researcher's expectations. The result is best read as strong evidence of improvement during a period in which interactive mathematics was used, not as proof that the program alone caused it.

Table 5: Paired-Samples t-Test of Pretest and Posttest Scores (N = 33)

Comparison	Mean Diff.	SD of Differences	t (df = 32)	p	Cohen's dz	Decision
Posttest − Pretest	6.39	2.67	13.76	< .001	2.40	Reject H0 (significant)

Note. Critical N = 3, 8940_ (α = .05, two-tailed, N = 3, 8941_).

Attitudes also shifted clearly (Table 6). The number of learners who liked mathematics doubled from 11 (33.33%) to 22 (66.67%), and those who liked computer-based mathematics rose from 10 (30.30%) to 23 (69.70%). Learners who considered themselves good in mathematics also doubled, which is consistent with the role of mastery experiences in building self-efficacy (Bandura, 1997) [1] and with the motivational effects reported by Fadda *et al*. (2022) [10]. Liking computers in general changed little (48.48% to 51.52%), and only 9 learners (27.27%) owned a computer at both points, suggesting that the shift was linked to the mathematics activities rather than to access at home, showing that most learners depend on the school for computer access. Thematic analysis of the observation notes and informal interviews produced four themes helping explain why scores and attitudes moved together. Learners were enthusiastic: they were excited and happy to do mathematics on the computer, asked, "Is it computer time yet?", and eagerly asked for any vacant computer time. Practice was self-paced, because learners were placed at their assessed level instead of simply by grade level, so none had to feel inferior to peers. Feedback was immediate: the program scored the work, saved it, and let learners see their mistakes, and they redid skills after discussing errors with the teacher, which also made conferences easier because each learner was busy with an activity. Confidence grew, as learners who began with limited ability to use a computer became confident in navigating it, alongside confidence in mathematics.

Table 6: Learners' Attitudes Before and After Interactive Mathematics (N = 3,8943_)

Item	Before f (%)	After f (%)	Change
Like mathematics	11 (33.33)	22 (66.67)	+11 learners
Consider self good in mathematics	11 (33.33)	22 (66.67)	+11 learners
Like computer-based mathematics	10 (30.30)	23 (69.70)	+13 learners
Like using computers	16 (48.48)	17 (51.52)	+1 learner
Own a computer	9 (27.27)	9 (27.27)	No change

These themes match the features that the literature associates with effective problem-solving instruction, namely visible structure, repeated practice, and timely feedback (Daroczy *et al*., 2015; Fuchs *et al*., 2008; Kulik & Fletcher, 2016) [5, 11, 13]. Placing learners at their lowest-scoring skill is consistent with Vygotsky's (1978) [21] zone of proximal development, while the discussion of errors with the teacher kept the "look back" step of Pólya's (1945/2004) model in view.

Conclusion and Recommendations

Before the intervention, Grade 5 learners of San Roque Elementary School were at Average Mastery in problem solving (MPS = 50.00), and no learner exceeded 75% of the items. After interactive mathematics, performance climbed to Moving towards Mastery (MPS = 81.97), an increase of 6.39 items or 31.97 percentage points, a medium normalized gain of 0.64, and all learners (boys and girls) improved; the difference between pretest and posttest scores was statistically significant, $t(32) = 13.76$, $p < .001$, with a very large effect ($dz = 2.40$), so the null hypothesis was rejected; learners' attitudes improved: the number liking mathematics and computer-based mathematics doubled or more; and observation revealed enthusiasm, self-paced practice, immediate feedback, and growing confidence. Because the study was a single group with a small sample in one school, the results document improvement during the intervention, but cannot isolate interactive mathematics as the cause.

The school head and teachers are encouraged to institutionalize weekly, scheduled interactive mathematics sessions of Grade 5 learners that are aligned to the MATATAG lessons of the week, place learners according to need, ascertained by baseline tests, and combine computer time with explicit strategies for word-problem understanding, planning, solving, and looking back, including a review of errors before learners retry, and to encourage the Schools Division and DepEd to prioritize providing school-based computers and connectivity and high-quality offline-capable programs for the upper elementary grades since only 27.27% of learners had their own computer, and to adopt measurable targets, such as the percentage reaching or exceeding Closely Approximating Mastery (MPS 86 and higher), which was 15 of 33 (45.45%) after the program, and track it every quarter. Future researchers should replicate the study with a comparison group, a larger sample, a delayed posttest to ascertain retention, and an instrument with more reliable and item-analysis evidence, and explore sex differences and word-problem types separately.

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