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DigiMath Laro: Effects of Digital Game-Based Instruction on Grade 9 Students' Mathematics Achievement, Problem-Solving Skills, and Attitudes

Bernadette N. Canceran*, Januard D. Dagdag
Isabela State University – Roxas Campus, Philippines
*e-mail: natividadcanceran@gmail.com

Abstract
Persistent difficulties in mathematics learning highlight the need for more engaging and effective instructional approaches. This study examined the effects of DigiMath Laro, a teacher-facilitated digital game-based instructional approach, on Grade 9 students' mathematics achievement, problem-solving skills, and attitudes toward mathematics. A quantitative-dominant mixed-methods, quasi-experimental pretest–posttest design was employed involving 40 students from two intact classes. Twenty-two students received Digital Game-Based Instruction, while 18 received Regular Classroom Teaching for four weeks. Data were gathered using mathematics achievement and problem-solving tests, attitude scales, and student interviews. Results showed that the digital game-based instruction group significantly improved in mathematics achievement, problem-solving skills, and attitudes toward mathematics, with large effect sizes. Although the regular instruction group also improved in mathematics achievement, no significant gains were observed in problem-solving skills or attitudes. After controlling for pretest scores, the digital game-based instruction group achieved significantly higher posttest scores across all outcomes. Student interviews revealed increased engagement and enjoyment, improved understanding and retention, interactive learning experiences, and preference for digital game-based instruction. The findings suggest that DigiMath Laro can enhance cognitive and affective mathematics outcomes when aligned with curriculum competencies and supported by purposeful teacher facilitation.

Keywords: Digital game-based instruction, mathematics achievement, problem-solving skills, mathematics attitude, Grade 9 students

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INTRODUCTION

Technological advancements have significantly transformed teaching and learning by creating new opportunities for interactive, learner-centered, and technology-supported instruction. Students today have grown up in a digitally connected environment and require learning experiences that develop the knowledge and skills needed in the 21st century. In this context, digital game-based instruction has emerged as an innovative pedagogical approach that combines academic content with interactive gaming experiences. Through this approach, learning can become more engaging, participatory, and meaningful, as students take an active role in their learning experiences.

Mathematics teaching and learning involve the continuous development of students' conceptual understanding, procedural knowledge, problem-solving skills, and ability to apply mathematical ideas across different situations. Effective mathematics instruction requires teachers to assess students' existing knowledge, identify their learning needs, and provide appropriate levels of challenge and support to achieve desirable learning outcomes (NCTM, 2000; Handrianto & Nengsih, 2025). However, many students continue to experience difficulty in mathematics, which may negatively affect not only their academic achievement and problem-solving performance but also their attitudes toward the subject.

This concern is particularly relevant in the Philippine educational context. The results of the Programme for International Student Assessment 2022 showed that Filipino learners remained among the lowest-performing students in mathematics, reading, and science among the participating countries (OECD, 2023; Hiltrimartin et al.,2024). The absence of substantial improvement in mathematics performance underscores the need for purposeful instructional interventions that can strengthen students' mathematical knowledge, skills, engagement, and attitudes.

The Department of Education has likewise emphasized the importance of active learner participation and the use of appropriate instructional practices. Under the MATATAG: Bansang Makabata, Batang Makabansa agenda, the Department of Education recognizes the need to strengthen instructional support and improve learners' academic performance, particularly in response to the results of national achievement tests and international large-scale assessments. Consistent with this direction, the Philippine Professional Standards for Teachers emphasize the responsibility of teachers to use appropriate instructional strategies and create learning environments that promote active participation, critical thinking, creativity, higher-order thinking skills, deep understanding, and meaningful connections to real-life situations (Department of Education [DepEd], 2017).

In mathematics education, achievement and problem-solving skills may also be influenced by students' attitudes toward the subject. Attitude encompasses students' likes or dislikes toward mathematics, their willingness to participate in or avoid mathematical activities, their perceptions of their mathematical abilities, and their beliefs regarding the usefulness and practical application of mathematics (Kibrislioglu, 2015; Jusoh et al., 2023). Students who perceive mathematics as difficult, stressful, or irrelevant may be less willing to engage in mathematical tasks. Therefore, instructional approaches that provide enjoyable, supportive, and meaningful learning experiences may help improve both students' cognitive outcomes and their attitudes toward mathematics.

One instructional approach with the potential to address these concerns is digital game-based instruction. Digital game-based instruction integrates academic content with interactive digital games while considering students' cognitive abilities and learning needs. Instruction becomes more effective when learning materials and activities are appropriate to the learners' level of understanding. When instructional materials are excessively difficult or complicated, students' cognitive load may increase and interfere with learning. Digital games may help present mathematical concepts and tasks in a more accessible, interactive, and manageable manner.

The integration of interactive digital platforms may also provide learning opportunities that are not always available through conventional instructional materials. Compared with traditional tools, interactive platforms can support more dynamic learning experiences and improve the quality of teaching and learning (Kalogiannakis et al., 2021; Arwin et al., 2024; Biru et al., 2025). Through digital game-based instruction, students may receive immediate feedback, positive reinforcement, repeated practice, and opportunities to progress at an appropriate pace. These features can encourage students to participate actively, learn from their mistakes, and assume greater responsibility for their learning.

Digital game-based instruction is also consistent with experiential learning. John Dewey's (1938) work emphasizes that meaningful learning occurs when learners actively engage with content and connect learning with practical experiences. From this perspective, problem-solving, experimentation, and active participation are essential components of the learning process. Digital games can provide students with opportunities to learn by doing, respond to challenges, test possible solutions, and receive immediate information about their performance. When appropriately integrated into instruction, these experiences may help make mathematics learning more enjoyable while developing students' achievement and problem-solving skills.

Despite the recognized potential of digital game-based instruction, its effectiveness may vary according to the learners, instructional context, game design, and manner of implementation. There remains a need for classroom-based evidence regarding whether digital game-based instruction can simultaneously improve students' mathematics achievement, problem-solving skills, and attitudes toward mathematics. It is also important to examine how students perceive and experience this instructional approach, particularly in actual secondary-school mathematics classes.

Accordingly, this study implemented DigiMath Laro, a digital game-based instructional intervention designed to provide Grade 9 students with interactive and engaging mathematics learning experiences. The study examined its effects on students' mathematics achievement, problem-solving skills, and attitudes toward mathematics. It also investigated students' attitudes and perceptions regarding digital game-based instruction. By comparing students exposed to DigiMath Laro with those taught through regular classroom instruction, the study sought to provide evidence on the potential of digital game-based instruction as an enhancement strategy for mathematics teaching and learning.

Research Purpose

This study aimed to determine the impact of the integration of Digital game-based Instruction as an innovative teaching tool on students' academic performance, Problem-solving skills, and mathematics attitude. Specifically, this study sought to provide answers to the following research questions:

1. What is the students' level of Mathematics Achievement, Problem Solving skills, and Mathematics attitude before and after exposure to:
   a. Regular Classroom Teaching
   b. Digital Game-based Instruction
2. Is there a significant difference in the Mathematics Achievement, Problem Solving Skills, and Mathematics Attitude between the Digital Game-based Instruction students and the Regular Classroom Teaching students?
3. What is the attitude and perception of the students toward Digital Game-based Instruction?
4. What are the changes in students' Mathematics performance and attitude toward Mathematics as a result of the implementation of Digital Game-based Instruction?

METHODS

The study employed a quantitative-dominant mixed-methods design. The quantitative component used a quasi-experimental, non-equivalent control-group pretest–posttest design to determine the effects of Digital Game-Based Instruction (DGBI) on students' mathematics achievement, problem-solving skills, and attitudes toward mathematics. Two existing Grade 9 classes participated in the study; one class received DGBI, while the other received Regular Classroom Teaching (RCT). Because the students belonged to intact sections, they were not randomly assigned to the two instructional conditions.

A qualitative component was included to provide a deeper understanding of the students' experiences with DGBI. After the intervention, selected students from the DGBI group were interviewed about their engagement, understanding, participation, and perceptions of the instructional approach. The qualitative findings were used to complement and explain the quantitative results. Intentional integration is essential in mixed-methods research because the qualitative and quantitative components should contribute to a more complete interpretation than either component could provide independently (Fetters et al., 2013; Zainil et al., 2024).

Research Setting and Participants

The study was conducted at Lanting Region National High School and involved 40 Grade 9 students from two intact class sections. The Gemini section served as the DGBI group and consisted of 22 students, including 11 males and 11 females. The Libra section served as the RCT group and consisted of 18 students, including eight males and 10 females.

The assignment of the two sections to the instructional conditions was based on their existing classroom organization. The use of intact classes made the design quasi-experimental because the researchers did not randomly assign individual students to the experimental and comparison groups. Consequently, pretest scores were considered in the analysis to account for possible initial differences between the groups.

Instructional Intervention

The intervention used in the experimental group was called DigiMath Laro, an instructional strategy that integrated adopted and modified digital mathematics games into selected Grade 9 lessons. The activities were designed to strengthen students' mathematics achievement and problem-solving skills while promoting more positive attitudes toward mathematics.

Digital game-based activities were incorporated into the lessons covered during the intervention. Students participated in interactive mathematical tasks, quizzes, challenges, and problem-solving activities. The teacher introduced the rules and procedures of each activity, facilitated student participation, clarified mathematical ideas, and guided students who encountered difficulty. Thus, the digital games were used as structured instructional activities rather than as stand-alone entertainment.

ClassPoint, an interactive PowerPoint add-in, was used to deliver several of the activities. Its features included interactive quizzes, fill-in-the-blank exercises, draggable objects, slide annotations, timers, embedded multimedia, reward stars, levels, and leaderboards. These features provided opportunities for active participation, immediate feedback, and reinforcement during mathematics lessons.

The comparison group studied the same Grade 9 mathematics competencies through Regular Classroom Teaching. Separate lesson plans and instructional presentations were prepared for the two groups. Both sets of materials were aligned with the Grade 9 Mathematics Most Essential Learning Competencies to ensure that the groups covered comparable mathematical content while receiving different instructional approaches. The intervention lasted approximately four weeks, from April 1 to May 1, 2024.

Research Instruments

Mathematics Achievement Test

A researcher-prepared test was used to measure students' mathematics achievement before and after the intervention. The test contained 20 objective items based on the Grade 9 Mathematics Most Essential Learning Competencies covered during the study. Each correct answer was awarded one point. The pretest and posttest were designed to measure equivalent content and skills. Mathematics teachers reviewed the items to determine their relevance, appropriateness for Grade 9 students, and alignment with the prescribed competencies. Students were given 60 minutes to complete the achievement and problem-solving assessment.

Mathematical Problem-Solving Test

The assessment also included three constructed-response problems designed to measure students' mathematical problem-solving skills. Each problem was assigned a maximum of five points, giving a total possible problem-solving score of 15 points. The items were based on the same Grade 9 competencies taught to both groups and were reviewed by mathematics teachers for content appropriateness and curricular alignment. Students' written solutions were scored according to the correctness and completeness of their responses. The same scoring criteria were applied to the pretest and posttest answers of both groups.

Attitude Toward Mathematics Inventory
Students' attitudes toward mathematics were measured using the Attitude Toward Mathematics Inventory developed by Tapia (1996). The version used in the study contained 25 statements covering four dimensions: security, value, motivation, and enjoyment. Students responded using a five-point scale ranging from 1, strongly disagree, to 5, strongly agree. Higher scores indicated more positive attitudes toward mathematics. The original instrument was reported to have a coefficient alpha of .97, indicating high internal consistency.

Attitude Toward Digital Game-Based Instruction Scale
A researcher-developed scale was used to measure students' attitudes and perceptions toward DGBI. It consisted of 25 statements rated on a five-point scale ranging from 1, strongly disagree, to 5, strongly agree. Higher scores represented more favorable attitudes toward the instructional approach. The scale was reviewed by seven instructors or expert teachers. Their evaluations were used to determine whether the statements were relevant, clear, and appropriate for measuring students' attitudes toward DGBI. The instrument was administered only to the students in the experimental group before and after the intervention.

Interview Guide
A researcher-prepared interview guide was used to gather qualitative information from selected students in the DGBI group after the intervention. The questions explored the students' experiences with DigiMath Laro, including its perceived effects on their understanding of mathematics, participation in classroom activities, problem-solving, enjoyment, and preference for a particular instructional approach. The interviews were used to supplement the quantitative findings by allowing students to describe their experiences in their own words.

Data-Collection Procedure
Before the study was conducted, the researcher secured permission from the school principal and the cooperating mathematics teacher of Lanting Region National High School. The purpose and procedures of the study were explained to the participants. They were also informed that participation was voluntary and that the information they provided would be treated confidentially. Before the intervention, both groups completed the mathematics achievement test, mathematical problem-solving test, and Attitude Toward Mathematics Inventory. These assessments established the students' initial levels before they received their respective instructional conditions. Students in the DGBI group also completed the Attitude Toward Digital Game-Based Instruction Scale.

The intervention was implemented for approximately four weeks. During this period, the experimental group received mathematics instruction through DigiMath Laro, while the comparison group received Regular Classroom Teaching. Both groups studied competencies aligned with the Grade 9 Mathematics Most Essential Learning Competencies. After the intervention, the two groups completed equivalent posttests in mathematics achievement and problem-solving skills and responded again to the Attitude Toward Mathematics Inventory. The experimental group also completed the post-intervention Attitude Toward Digital Game-Based Instruction Scale. Selected students from the DGBI group were subsequently interviewed. Their responses were used to clarify and enrich the interpretation of the quantitative findings.

Ethical Considerations
The researcher obtained permission from the appropriate school authorities before collecting data. The participants were informed of the objectives, procedures, possible benefits, and potential risks of the study. Participation was voluntary, and the students were informed that they could decline or withdraw without academic penalty. Because the participants were minors, informed consent was obtained from their parents or legal guardians, while assent was obtained from the students.

Participant names were not included in the dataset, interview transcripts, tables, or research report. Codes were used in place of names to protect their identities, and the information collected was used solely for research purposes.

Data Analysis

The quantitative data were analyzed using IBM SPSS Statistics. Frequencies and percentages were used to summarize the sex distribution of the participants. Means, standard deviations, medians, and descriptive classifications were used to describe students' mathematics achievement, problem-solving skills, attitudes toward mathematics, and attitudes toward DGBI.

Before the main analyses, the data were examined for the assumptions required by the selected statistical tests. These analyses included normality, homogeneity of variance, independence of observations, linearity, and homogeneity of regression slopes for the analysis of covariance. Independent-samples *t* tests were initially used to compare the pretest scores of the DGBI and RCT groups. These comparisons were conducted to determine whether the two intact classes differed in mathematics achievement, problem-solving skills, and attitudes toward mathematics before the intervention.

Wilcoxon signed-rank tests were used to determine whether the pretest and posttest scores within each group differed significantly. This analysis examined changes in mathematics achievement, problem-solving skills, and attitudes toward mathematics. For the experimental group, the test was also used to examine changes in attitudes toward DGBI. The effect size for the Wilcoxon signed-rank test was expressed as *r*. Values of approximately .10, .30, and .50 were interpreted as small, medium, and large effects, respectively (Cohen, 1988).

Separate analyses of covariance were used to compare the posttest scores of the DGBI and RCT groups in mathematics achievement, problem-solving skills, and attitudes toward mathematics while controlling for their corresponding pretest scores. In a pretest–posttest design, ANCOVA estimates group differences in posttest scores after accounting for baseline performance. However, because the groups in this study were not randomly formed, the adjusted differences should be interpreted as evidence of an intervention effect within the limits of a quasi-experimental design rather than as definitive proof of causality (van Breukelen, 2013).

Adjusted means, standard errors, *F* statistics, exact *p* values, and partial eta squared values were reported. Partial eta squared values of approximately .01, .06, and .14 were interpreted as small, medium, and large effects, respectively. Statistical significance was evaluated at the .05 level. Exact *p* values were reported to three decimal places, except when the value was below .001.

The interview responses were analyzed using thematic analysis. The researcher reviewed the responses repeatedly, identified statements relevant to the students' experiences, assigned initial codes, grouped related codes, and developed themes representing recurring patterns in the data. The themes were reviewed against the participants' responses and were supported by representative quotations. The qualitative results were then related to the quantitative findings to determine how the students' experiences helped explain the observed changes in achievement, problem-solving skills, and attitudes.

RESULTS AND DISCUSSION

Baseline Characteristics of the Two Groups

Table 1 presents the pre-intervention mathematics achievement, problem-solving skills, and attitudes toward mathematics of students in the Regular Classroom Teaching (RCT) and Digital Game-Based Instruction (DGBI) groups.

Table 1. Pretest Scores of RCT Students and DGBI Students

Trait	Method	Test	*n*	*M*	*SD*	*t (38)*	*p*	η^2	*95%CI*
Math Achievement	RCT	Pretest	18	10.33	3.24	1.631	.111	0.07	[-.42, 3.91]
	DGBI		22	8.59	3.46				
	RCT	Pretest	18	2.83	.92	1.970	.056	0.09	

Problem Solving Skills	DGBI		22	2.14	1.26				[-.02, 1.41]
Mathematics Attitude	RCT	Pretest	18	3.34	.37	5.395**	<.001	0.43	[.43, .95]
	DGBI		22	2.64	.43				

The RCT group obtained a higher mean pretest score in mathematics achievement (M = 10.33, SD = 3.24) than the DGBI group (M = 8.59, SD = 3.46). However, the difference was not statistically significant, $t(38) = 1.63$, $p = .111$, $\eta^2 = .07$. Thus, the two groups did not differ significantly in mathematics achievement before the intervention. A similar pattern was observed in problem-solving skills. The RCT group obtained a mean pretest score of 2.83 (SD = 0.92) was not significantly different from the DGBI group's mean score of 2.14 (SD = 1.26), $t(38) = 1.97$, $p = .056$, suggesting that the initial difference in problem-solving skills was not statistically significant at the .05 level.

In contrast, the groups differed significantly in their initial attitudes toward mathematics. The RCT group reported a more favorable attitude (M = 3.34, SD = 0.37) than the DGBI group (M = 2.64, SD = 0.43), $t(38) = 5.40$, $p < .001$, $\eta^2 = .43$. The effect was large, indicating a meaningful baseline difference between the groups. Therefore, the post-intervention attitude results should not be interpreted solely from raw posttest scores. Controlling for the corresponding pretest scores through analysis of covariance was necessary to obtain a more defensible comparison between the two intact classes.

Overall, the baseline results suggest that the groups were reasonably comparable in mathematics achievement and problem-solving skills but not in their attitudes toward mathematics. This imbalance is important because the study used existing classes rather than randomly assigning students to the two instructional conditions. Consequently, the findings provide evidence of differences associated with DGBI within a quasi-experimental setting, but they should not be interpreted as definitive proof of causality.

Changes in the RCT Group

As shown in Table 2, the mathematics-achievement scores of the RCT group increased significantly from a pretest median of 10 to a posttest median of 17, $Z = -3.63$, $p < .001$, $r = .85$. This large improvement indicates that students also learned under regular classroom instruction. The result is expected because the RCT group received instruction on the same Grade 9 mathematics competencies during the four-week study period.

This finding is important because it shows that the comparison condition was not an absence-of-treatment condition. Regular instruction contributed to students' learning, particularly in mathematics achievement. Therefore, the relevant question is not whether students can learn through regular classroom teaching but whether DGBI provides additional benefits beyond those obtained through regular instruction.

The RCT group's problem-solving score increased only slightly, from a median of 3 to 4. This change was not statistically significant, $Z = -1.84$, $p = .066$, although the reported effect size was moderate, $r = .43$. Thus, the evidence was insufficient to conclude that regular classroom instruction produced a reliable improvement in problem-solving skills during the intervention period. The apparent discrepancy between the nonsignificant probability value and the moderate effect size may be partly explained by the small sample of 18 students. Statistical significance is influenced by sample size, whereas an effect-size estimate reflects the magnitude of the observed change. Nevertheless, because p exceeded .05, the result should be reported as nonsignificant rather than as a significant gain.

The RCT group also showed no significant change in attitude toward mathematics. Its median score increased slightly from 3.18 to 3.32, but the change was negligible, $Z = -0.12$, $p = .906$, $r = .03$. Regular instruction therefore appeared sufficient to improve students' achievement but did not produce a corresponding improvement in their problem-solving skills or attitudes during the study period.

These findings suggest that exposure to mathematical content alone may improve test performance without necessarily changing how students feel about mathematics. Attitude is a multidimensional construct involving enjoyment, confidence, perceived value, and willingness to participate in mathematics; it may therefore require learning experiences that are explicitly engaging, supportive, and emotionally meaningful rather than ordinary exposure to lessons alone.

Changes in the DGBI Group

Students exposed to DigiMath Laro demonstrated significant improvements across all measured outcomes. Their mathematics-achievement scores increased from a pretest median of 8 to a posttest median of 21.50, $Z = -4.11$, $p < .001$, $r = .88$. The magnitude of the improvement was large, indicating that the students performed substantially better after participating in the DGBI lessons.

This result is consistent with meta-analytic evidence showing that game-based learning can improve mathematics achievement. Tokac et al. (2019) found an overall advantage of game-based learning over conventional mathematics instruction, while Byun and Joung (2018) similarly reported positive effects of digital games in K–12 mathematics education. These syntheses do not imply that every digital game is effective; rather, they indicate that well-aligned game-based activities can support mathematics learning when instructional content, gameplay, feedback, and teacher guidance work together.

The finding also agrees with Bai et al. (2012), who found that a three-dimensional mathematics game improved eighth-grade students' algebra learning while maintaining their motivation. That study is particularly relevant because it involved middle-school students and used a pretest–posttest comparison design similar to the present research. The problem-solving skills of the DGBI group likewise improved significantly. The median score increased from 2 at pretest to 10.50 at posttest, $Z = -4.02$, $p < .001$, $r = .86$. This large improvement suggests that DigiMath Laro supported not only the recall or application of mathematical knowledge but also students' ability to work through constructed mathematical problems.

A recent three-level meta-analysis by Cai et al. (2025) found that digital game-based learning had a positive overall effect on students' problem-solving ability. Importantly, the effect was stronger when digital games were combined with relevant teaching strategies than when games were used alone. This finding supports the design of DigiMath Laro, in which the teacher facilitated the activities, explained the procedures, clarified concepts, and connected the game-based tasks to the intended mathematics competencies.

Digital games may support problem-solving by giving students repeated opportunities to interpret challenges, make decisions, test solutions, receive immediate feedback, and revise unsuccessful strategies. However, the learning benefit does not arise merely from playing. Plass et al. (2015) explained that effective game-based learning involves the coordinated operation of cognitive, motivational, affective, and sociocultural processes. Games are therefore most educationally useful when their challenges and feedback are deliberately aligned with the intended learning outcomes.

Students' attitudes toward mathematics also improved substantially. The median attitude score increased from 2.48, interpreted as neutral, to 4.26, interpreted as positive, $Z = -4.11$, $p < .001$, $r = .88$. This result is especially noteworthy because the DGBI group began with significantly less favorable attitudes than the RCT group. The large within-group change indicates that students became more positive toward mathematics after experiencing DigiMath Laro. The DGBI group's attitude toward digital game-based instruction similarly increased from a median of 2.48 to 4.26, $Z = -4.11$, $p < .001$, $r = .88$. Students therefore developed a more favorable view of the intervention after directly experiencing it.

The improvement in attitude is consistent with the theoretical foundation of game-based learning. Well-designed digital games can create clear goals, appropriately challenging tasks, rapid feedback, visible progress, and opportunities to recover from mistakes. These features may reduce the threat associated with difficult mathematics tasks and make participation feel more manageable and rewarding. Nevertheless, the positive attitude should not be attributed simply to entertainment. The educational value of DGBI depends on whether enjoyment and game mechanics remain connected to meaningful mathematical activity.

Table 2. Pretest and Posttest Scores of the RCT Students and DGBI Students

Method	Mathematics traits	Test	n	Md	Description	Z	p	r
RCT	Mathematics Achievement	Pretest	18	10	Poor	-3.627**	<.001	0.85
		Posttest	18	17	Fair			
	Problem Solving Skills	Pretest	18	3	Poor	-1.842	.066	0.43
		Posttest	18	4	Poor			
	Mathematics Attitude	Pre-questionnaire	18	3.18	Neutral	-.118	.906	0.03
		Post-questionnaire	18	3.32	Neutral			
DGBI	Mathematics Achievement	Pretest	22	8	Poor	-4.109**	<.001	0.88
		Posttest	22	21.5	Average			
	Problem Solving Skills	Pretest	22	2	Poor	-4.021**	<.001	0.86
		Posttest	22	10.5	Average			
	Mathematics Attitude	Pre-questionnaire	22	2.48	Neutral	-4.109**	<.001	0.88
		Post-questionnaire	22	4.26	Positive			
	Digital Game-based Attitude	Pre-questionnaire	22	2.48	Negative	-4.109**	<.001	0.88
		Post-questionnaire	22	4.26	Positive			

Post-Intervention Differences Between the Groups

Because the study involved non-equivalent groups, separate analyses of covariance were conducted to compare posttest scores while controlling for the corresponding pretest scores (refer to Table 3). The adjusted comparisons provide the strongest quantitative evidence regarding the relative performance of the two instructional groups.

Mathematics Achievement

After controlling for pretest achievement, the DGBI group obtained a higher adjusted posttest mean (M = 22.35, SE = 1.25) than the RCT group (M = 17.02, SE = 1.39). The adjusted difference was statistically significant, $F(1, 37) = 7.85$, $p = .008$, partial $\eta^2 = .175$.

The effect size indicates that approximately 17.5% of the adjusted variance in posttest mathematics-achievement scores was associated with instructional condition. Using conventional guidelines, this represents a large effect. Thus, although both groups improved in mathematics achievement, the students who experienced DigiMath Laro achieved higher post-intervention scores after their initial achievement levels were statistically controlled.

The finding strengthens the conclusion derived from the within-group analysis. The DGBI group did not merely improve relative to its own pretest; it also outperformed the RCT group after baseline achievement was taken into account. This result is consistent with the meta-analysis of Tokac et al. (2019), which found that game-based learning generally produced stronger mathematics achievement than traditional instruction.

The result may be explained by the combination of repeated mathematical practice, active responding, immediate feedback, and visible progress embedded in the intervention. Unlike passive presentation, DigiMath Laro required students to respond to mathematical challenges and receive information about their performance during the lesson. Such features can provide more opportunities to detect errors and refine understanding.

Nevertheless, the adjusted difference should be interpreted carefully. ANCOVA statistically adjusts for observed baseline scores, but it cannot eliminate all possible differences between intact classes, such as prior learning experiences, classroom dynamics, motivation, attendance, or teacher expectations. The result therefore indicates a strong advantage associated with DGBI in the present classes rather than an effect that can automatically be generalized to all Grade 9 learners.

Mathematical Problem-Solving Skills

After controlling for pretest problem-solving scores, the DGBI group obtained a substantially higher adjusted posttest mean (M = 9.36, SE = 0.88) than the RCT group (M = 4.73, SE = 0.97). The difference was statistically significant, $F(1, 37) = 11.99$, $p = .001$, partial $\eta^2 = .245$.

Approximately 24.5% of the adjusted variance in posttest problem-solving scores was associated with instructional condition, representing a large effect. Among the two cognitive outcomes, the relative advantage of DGBI was stronger for problem-solving skills than for overall mathematics achievement.

The result suggests that DigiMath Laro may have created more frequent or more meaningful opportunities for students to engage actively with mathematical problems. Game-based tasks typically require players to understand a goal, assess available information, select an action, observe its consequences, and modify their approach. When these processes are appropriately connected to mathematical content, they can resemble the iterative reasoning involved in mathematical problem-solving.

The finding closely corresponds with Cai et al.'s (2025) meta-analysis, which found a moderate positive overall effect of digital game-based learning on problem-solving ability and a stronger effect when games were paired with instructional strategies. It is also compatible with research showing that digital environments can improve mathematical problem-solving when they provide structured representations, feedback, and opportunities to revise strategies. However, the present finding should be attributed to the full instructional arrangement (game-based activities combined with teacher facilitation) not to the digital platform alone.

Attitude Toward Mathematics

After controlling for initial attitudes, the adjusted posttest attitude of the DGBI group (M = 4.32, SE = 0.07) was substantially higher than that of the RCT group (M = 3.19, SE = 0.08). The difference was statistically significant, $F(1, 37) = 83.57$, $p < .001$, partial $\eta^2 = .693$. The effect was exceptionally large: approximately 69.3% of the adjusted variance in post-intervention attitude scores was associated with instructional condition. This was the strongest effect observed in the study.

The result indicates that DigiMath Laro was associated not only with improved performance but also with a marked change in how students experienced mathematics. The interactive format, immediate feedback, reward mechanisms, and opportunity to participate through digital activities may have made mathematics appear less threatening and more enjoyable. The qualitative findings discussed below provide further support for this interpretation.

Game-based learning can support positive affect by combining challenge, curiosity, feedback, perceived control, and visible accomplishment. Plass et al. (2015), however, emphasized that motivation and learning emerge from the interaction of game design and instructional conditions; game elements alone do not guarantee either engagement or achievement. Indeed, Philippine evidence has also shown that gamified mathematics activities do not invariably improve performance, reinforcing the need to align games carefully with mathematical objectives and instructional support rather than treating enjoyment as evidence of learning (Lim, 2021; Matt et al., 2022).

Table 3. Posttest Scores of RCT Students and DGBI Students (while Pretest Scores are Statistically Controlled)

Teaching Method	Mathematics traits	n	Unadjusted		Adjusted		F	p	η^2
			M	SD	M	SE			
RCT	Mathematics Achievement	18	17.94	6.35	17.02	1.39	7.85**	.008	.175
DGBI		22	21.59	6.75	22.35	1.25			
RCT	Problem Solving Skills	18	4.89	3.91	4.73	.97	11.99**	<.001	.245
DGBI		22	9.23	4.05	9.36	.88			
RCT	Mathematics Attitude	18	3.30	.29	3.19	.08	83.57**	<.001	.693
DGBI		22	4.23	.32	4.32	.07			

Students' Experiences with DigiMath Laro

The interviews with students in the DGBI group generated four related themes: engagement and enjoyment, improved understanding and retention, interactive learning, and preference for DGBI. These themes help explain why the intervention was associated with substantial changes in achievement, problem-solving skills, and attitudes.

Engagement and Enjoyment

Students consistently described DigiMath Laro as enjoyable. They reported that the activities made mathematics lessons more pleasant and helped reduce the stress they commonly associated with the subject. One participant explained that learning became "more enjoyable," while another stated that playing during the lesson helped relieve stress. These responses suggest that the intervention changed the emotional climate of the mathematics classroom. Instead of experiencing mathematics only as a sequence of explanations and written exercises, students encountered it through activities involving challenge, interaction, feedback, and visible progress. Enjoyment may have encouraged them to remain attentive and persist with tasks that they might otherwise have avoided.

Similar experiences were reported by Deng et al. (2020), whose classroom case study found that digital games enhanced students' engagement and interest in mathematics. That study also emphasized the importance of teacher support in helping students connect gameplay to underlying mathematical principles. The convergence between the present interview responses and previous classroom research indicates that the motivational value of digital games is most meaningful when enjoyment leads students back to the academic task.

Improved Understanding and Retention

Students perceived that they understood the lessons more easily and remembered the content better through DigiMath Laro. Several participants directly connected their perceived understanding with improvements in their test scores. They explained that the digital activities made the lessons easier to follow and allowed them to see whether their answers were correct. This perception is consistent with the quantitative gains in mathematics achievement. The immediate feedback provided during game-based activities may have helped students recognize errors before incorrect procedures became firmly established. Repeated interaction with related problems may also have supported practice and retention.

The finding does not establish that students' self-reported understanding was objectively accurate in every instance. Nevertheless, the consistency between their accounts and the significant achievement gains strengthens the interpretation that the intervention supported learning rather than merely producing enjoyment. Bai et al. (2012) similarly found that a digital mathematics game improved middle-school students' acquisition of algebra knowledge. More broadly, meta-analytic evidence indicates that well-designed digital games can improve mathematics achievement, although effects vary according to design and implementation.

Interactive Learning Experience

Students also emphasized that DigiMath Laro made them more active during lessons. They described increased participation, easier access to instructions, and more direct involvement in solving activities through their devices. One participant explained that students became active in class, while another observed that the digital activities helped learners who initially found mathematics difficult. This theme reflects a shift from predominantly receiving information to responding, deciding, and obtaining feedback. Interactivity can make students' thinking more visible because they are required to produce answers rather than merely listen to explanations. It can also allow the teacher to identify misconceptions and respond immediately.

The students' accounts are consistent with the design of DigiMath Laro, which used interactive quizzes, draggable objects, rewards, levels, and leaderboards through ClassPoint. However, these features should not be interpreted as effective by themselves. Their value lies in how they prompted students to engage with mathematical content and how the teacher used their responses to guide instruction. Plass et al. (2015) explained that game-based learning can involve active cognitive processing, motivation, affect, and social interaction. The students' reports illustrate these processes: they were not simply entertained but were actively answering, receiving feedback, discussing, and continuing through mathematical challenges.

Preference for Digital Game-Based Instruction

The participants generally preferred DGBI to regular classroom teaching. They associated their preference with greater enjoyment, clearer understanding, active participation, and improved performance. Their preference therefore appeared to arise from both the emotional and academic features of the intervention. Preference alone is not sufficient evidence that one method is educationally superior. Students may favor activities that are enjoyable even when those activities produce limited learning. In the present study, however, the preference for DGBI was accompanied by significant improvements in achievement, problem-solving skills, and attitudes. The qualitative and quantitative evidence therefore converged.

The findings do not suggest that digital game-based instruction should completely replace direct explanation, written work, discussion, or other established mathematics-teaching practices. Rather, students' responses support its integration as a structured component of instruction. Teacher explanation and facilitation remain necessary to ensure that students attend to the mathematics embedded in the game rather than concentrating only on points, rewards, or competition.

Table 4. Qualitative Responses of the DGBI Students

Themes	Responses
Theme 1: Engagement and Enjoyment	P1: "Masaya po sa Digital game-based Instruction." P2: "Ito ay napakasayang gamitin kaysa sa original na pagtuturo ng Math." P3: "Kung idedescribe ko yung experience ko siguro mas masaya at enjoyable ang pag-aaral." P4: "Ang experiences ko with digital game-based instructions sa aking pag-aaral ay masaya sapagkat naiibsan yung stress sa pamamagitan ng paglalaro." P5: "My experiences with the digital game-based instruction is positive and it made my learning enjoyable in math."
Theme 2: Improved Understanding and Retention (Achievement)	P1: "Nag improve po ang aking pagiintindi tumaas po scores ko." P2: "Oo ma'am, mas nakakaintindi ako." P3: "Mas prefer ko po mas naiintindihan ko yung digital kaysa sa regular." P4: "Yes I noticed any differences in your understanding or retention of course material when it's delivered through digital game-based instruction at makikita sa aking scores ma'am na tumaas talaga siya."

	P5: "Yes, it made me easier to understand the lesson and I got a high score."
Theme 3: Interactive Learning Experience	P1: "Nagiging active kami sa klase." P2: "Maganda po ito kasi nakakatulong ito na makaturo sa studyante na hindi gaano alam mag solves ng math." P3: "Siguro yung mga benefits nito mapapadali niya yung pag-aaral mo tapos mas madali mong maintindihan yung lesson ng hindi ka nahihirapan dahil hawak hawak mo mismo yung cellphone mo nakikita mo dito yung mga instructions." P4: "Yes, because it enhances my engagement in learning." P5: "The benefits for me is students participate and enjoy."
Theme 4: Preference for Digital Game-Based Instruction	P1: "Mas maganda po sa digital game-based instruction masaya kami habang natututo nagugustuhan ko ang Math." P2: "Mas lalo kong naiintindihan ang Mathematics." P3: "Mas prefer ko po yung digital game-based instruction kaysa sa regular classroom teaching kasi mas naiintindihan ko po yung lesson at mas napapadali po para sa akin." P4: "Yes, digital game-based instruction is better than regular classroom teaching." P5: "Yes, because it enhances my engagement in learning.”

The quantitative and qualitative findings indicate that DigiMath Laro was associated with higher mathematics achievement, stronger problem-solving skills, and more positive attitudes toward mathematics than Regular Classroom Teaching during the four-week intervention. Although both groups improved in mathematics achievement, only the DGBI group demonstrated significant gains across all measured outcomes. After controlling for pretest scores, the DGBI group also obtained significantly higher posttest scores in mathematics achievement, problem-solving skills, and attitudes toward mathematics. The qualitative findings supported these results, as students described DigiMath Laro as enjoyable, interactive, understandable, and motivating. They also reported greater participation, immediate feedback, and a preference for digitally supported mathematics activities. These findings suggest that DigiMath Laro is a promising enhancement to Grade 9 mathematics instruction when digital activities are aligned with curriculum competencies and supported by purposeful teacher facilitation.

The findings should nevertheless be interpreted within the study’s limitations. The study involved only 40 students from two intact classes in one school, and the participants were not randomly assigned to the instructional conditions. The groups also differed significantly in their initial attitudes toward mathematics. Moreover, the four-week intervention did not establish whether the observed improvements would be sustained over time or whether they resulted specifically from the digital games, novelty, competition, teacher support, immediate feedback, or a combination of these factors.

CONCLUSION AND RECOMMENDATIONS

The study demonstrated that DigiMath Laro, a teacher-facilitated digital game-based instructional approach, was associated with meaningful improvements in Grade 9 students’ mathematics achievement, problem-solving skills, and attitudes toward mathematics. Although students in both instructional groups improved in mathematics achievement, those exposed to DigiMath Laro achieved significantly higher adjusted posttest scores than those taught through regular classroom instruction. The intervention showed particularly strong effects on mathematical problem-solving and students’ attitudes toward mathematics. The students’ accounts further indicated that the digital activities made mathematics more enjoyable, interactive, understandable, and engaging. These findings suggest that digital game-based instruction can strengthen both cognitive and affective learning outcomes when its activities are aligned with curriculum competencies and supported by purposeful teacher guidance. However, the findings should be interpreted within the limitations of the small sample, intact-group design, short intervention period, and single-school setting.

Mathematics teachers are encouraged to integrate appropriately designed digital games into classroom instruction as a complement, rather than a replacement, for explanation, discussion, written exercises, and guided problem-solving. Digital activities should be aligned with specific learning outcomes, provide meaningful feedback, and require students to apply mathematical reasoning rather than merely pursue points or rewards. Schools should also provide teachers with training, technological resources, and instructional support for the effective use of digital game-based approaches. Future studies should involve larger and more diverse samples, longer intervention periods, and stronger experimental controls. Researchers should also examine the retention of learning, the effects of specific game features, students' engagement and motivation, and the conditions under which digital game-based instruction is most effective for different learners and mathematical topics.

Conflict of Interest

The authors declare that they have no known financial, professional, or personal conflicts of interest that could have influenced the conduct or reporting of this study.

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Declaration on the Use of Generative Artificial Intelligence

Generative artificial intelligence tools were used only to assist in language editing, grammatical refinement, and improvement of the manuscript's clarity and organization. The authors independently verified all substantive content, statistical results, interpretations, citations, and references and assume full responsibility for the accuracy and integrity of the manuscript. No artificial intelligence tool was used to generate, alter, or fabricate the study data or findings.

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