

# Exploring Student Attitude and Performance in Mathematics through Game- Based Learning (GBL) Using Deepseek Codes

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## ABSTRACT

This study examined the effectiveness of Game-Based Learning (GBL) using DeepSeek Codes in improving Grade 8 students' mathematics performance and attitudes. It was conducted at Dagatkidavao Integrated School using two intact classes. One group was exposed to Game-Based Learning (GBL) with 29 participants, while the other group received traditional instruction (NGBL) with 30 participants. A quasi-experimental pretest–posttest research design was employed. Students' performance was measured using a standardized test, while attitudes were assessed through a modified Auzmendi's Scale. The scale evaluated value, anxiety, enjoyment, motivation, and confidence using a five-point Likert scale. The procedure included pretesting, implementation of the intervention, and posttesting. Data were analyzed using Analysis of Covariance (ANCOVA) to control for pretest differences. Results showed that the GBL group achieved significantly higher performance than the NGBL group. In terms of attitudes, the GBL group also demonstrated more positive attitudes toward mathematics compared to the NGBL group, indicating an improvement in learners' affective responses alongside their academic performance. Overall, the study concludes that Game-Based Learning is an effective approach for enhancing both mathematics achievement and students' attitudes.

**Keywords:** Game-Based Learning, DeepSeek Codes, Mathematics Performance, Student Attitude.

## INTRODUCTION

Mathematics remains a core academic subject in basic and secondary education, yet many students continue to struggle with both achievement and positive attitudes toward it. Traditional instructional methods often fail to engage learners meaningfully, leading to low motivation, math anxiety, and underperformance. Research shows that game-based learning (GBL), a student-centered approach that embeds playful challenges and feedback into instruction, can promote engagement, motivation, and deeper understanding of mathematical concepts (Ramli, Maat & Khalid, 2022).

Game-Based Learning (GBL) is an instructional approach that integrates game elements and mechanics into learning activities to make instruction more engaging, interactive, and meaningful (de Freitas & Liarokapis, 2016; Qian & Clark, 2016). Game-based learning integrates elements of play, competition, immediate feedback, and problem-solving into instructional activities to make learning more appealing and relevant. Recent empirical studies demonstrate that when students engage with mathematics content through educational games, both academic achievement and affective outcomes improve. In a quasi-experimental study using digital math games, primary school students in the experimental group outperformed their peers in achievement tests while also reporting more favorable attitudes toward mathematics (Koçabatmaz & Saraçoğlu, 2024). Another action research study found that game-based learning significantly increased Grade 7 students' mathematics performance, participation, and positive perceptions of the subject (Sulpico et al., 2025).

In addition to specific interventions, broader literature reviews indicate that game-based learning generally strengthens affective factors such as motivation, engagement, and attitudes in mathematics education. A systematic review reported that most studies (84 %) show positive influences of GBL on students' motivation, engagement, and attitudes toward mathematics learning (Vankúš, 2021). Similarly, studies on gamification,

which refers to the use of game elements such as points, rewards, and progress tracking in learning, show that it can make mathematics classrooms more engaging and motivating for students. For instance, Ratinho et al. (2026) found that these game-based features help students become more involved in learning activities and sustain their motivation over time. These findings align with educational theory that active, interactive learning environments reduce affective barriers such as math anxiety and foster positive learner dispositions.

Despite the growing use of game-based learning approaches, there remains a need to investigate specific implementations such as DeepSeek Codes is an interactive, game-driven platform designed to support mathematics learning through coding scenarios and gamified problem-solving activities. While many studies have examined generic digital games, research specifically addressing how tools like DeepSeek Codes affect student performance in mathematical tasks or shape attitudes toward mathematics is still limited. Integrating such innovative learning environments into mathematics instruction could offer unique insights into how game-based coding experiences influence both academic outcomes and affective responses.

The central variables of this study are: (1) game-based learning using DeepSeek Codes, (2) student performance in mathematics (measured through achievement scores), and (3) students' attitude toward mathematics (measured through validated attitude scales). Investigating these variables is important in understanding not only whether a game-based tool improves learning outcomes, but also how it can shape students' feelings toward mathematics. This is particularly relevant since many students often perceive mathematics as a difficult or intimidating subject.

Given these considerations, this study seeks to explore how the application of DeepSeek Codes as a game-based learning strategy influences student performance and attitude in mathematics, thereby contributing to the growing body of research on educational games and technology-enhanced learning.

## METHODOLOGY

This study utilized a quasi-experimental research design conducted at Dagatkidavao Integrated School in Valencia City, Bukidnon. Participants were selected through random sampling and divided into two intact groups: the experimental group, which was exposed to Game-Based Learning (GBL), and the control group, which received traditional mathematics instruction. Both heterogeneous groups underwent the same pre-test and post-test to determine significant differences in their mathematics performance and attitudes toward the subject.

Three intact sections took a pre-test, and group matching based on scores ensured comparability. Normality and homogeneity of variance were confirmed using the Shapiro-Wilk test ( $p > 0.05$ , indicating normal distribution) and Levene's test ( $p > 0.05$ , indicating equal variances). The experimental group was assigned through a coin toss to reduce selection bias. The study involved two comparable Grade 8 sections for School Year 2025–2026, with one group exposed to Game-Based Learning (GBL) and the other to traditional instruction. Both groups received identical lessons in terms of objectives and content to ensure a fair comparison of outcomes.

To measure students' attitude toward mathematics, the researcher adapted Auzmendi's Scale of Attitudes Toward Mathematics (Auzmendi, 1992). The original 25-item instrument, covering Utility/Value, Anxiety, Enjoyment, Motivation, and Confidence, was reduced to 16 items after removing irrelevant statements. Responses were rated using a five-point Likert scale ranging from "Strongly Agree" (5) to "Strongly Disagree" (1). The adapted instrument showed good reliability, with a Cronbach's alpha of 0.83, indicating acceptable internal consistency.

Scale	Range	Descriptive Rating	Qualitative Interpretation
5	4.51–5.00	Strongly Agree	Very Positive Attitude
4	3.51–4.50	Agree	Positive Attitude
3	2.51–3.50	Undecided	Neutral Attitude
2	1.51–2.50	Disagree	Negative Attitude
1	1.00–1.50	Strongly Disagree	Very Negative Attitude

Students' performance in mathematics was measured using pre-test and post-test scores. A 50-item content-validated multiple-choice test was used, with each item worth one point for a total score of 50. The instrument obtained a Cronbach's alpha of 0.77, indicating acceptable reliability. The interpretation of scores was based on DO No. 8, s. 2015, with modified qualitative descriptors for mathematics performance.

Mean Score	Percentage	Descriptive Rating	Qualitative Interpretation
47–50	94%–100%	Outstanding	Very High Performance
43–46	86%–93%	Very Satisfactory	High Performance
39–42	78%–85%	Satisfactory	Moderate Performance
35–38	70%–77%	Fairly Satisfactory	Low Performance
0–34	Below 70%	Did Not Meet Expectation	Very Low Performance

The researcher secured approval from the Institutional Ethics Review Committee (IERC), DepEd Division Office of Valencia City, and the school principal before conducting the study. Grade 8 participants were selected through random sampling and divided into two intact groups: the experimental group using Game-Based Learning (GBL) with DeepSeek Codes and the control group using traditional instruction. Both groups were matched based on pre-test scores, and informed consent was obtained from participants or guardians. A pretest–posttest design was used, where both groups took pre-tests, underwent their respective instructional approaches, and completed post-tests. Data were analyzed using descriptive statistics and ANCOVA was used to determine the effectiveness of Game-Based Learning (GBL) compared to traditional instruction, as it allows adjustment for initial differences in pre-test scores (covariates), making it more appropriate than ANOVA, which does not control for baseline variability between groups. The pre-test and post-test data were classified, tabulated, and analyzed using descriptive statistics (mean, frequency, and percentage) to describe students' mathematics performance and attitudes. ANCOVA was used to determine significant differences between the

GBL and traditional groups for both performance and attitude, while controlling for pre-test scores, ensuring a more accurate evaluation of the intervention’s effect.

## RESULTS AND DISCUSSION

Table 1. Students’ overall attitude toward mathematics in terms of value, enjoyment, motivation, and confidence before and after exposure to Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) in terms of pretest and posttest.

Indicator	GROUP							
	GBL				NGBL			
	Pretest		Posttest		Pretest		Posttest	
	Mean	QI	Mean	QI	Mean	QI	Mean	QI
Value	1.99	D	4.43	A	2.02	D	3.99	A
Enjoyment	2.53	D	4.52	SA	1.85	D	3.98	A
Motivation	1.88	D	4.55	SA	1.97	D	3.95	A
Confidence	1.98	D	4.49	SA	1.92	D	4.03	A
<i>Overall Mean Interpretation</i>	<i>2.09</i>	<i>D</i>	<i>4.50</i>	<i>SA</i>	<i>1.94</i>	<i>D</i>	<i>3.99</i>	<i>A</i>

Scale	Range	Descriptive Rating	Qualitative Interpretation
5	4.51-5.00	Strongly Agree	Strongly High Attitude (SHE)
4	3.51-4.50	Agree	High Attitude (HE)
3	2.51-3.50	Undecided	Slightly High Attitude (SH)
2	1.51-2.50	Disagree	Low Attitude (LE)
1	1.00-1.50	Strongly Disagree	Very Low Attitude (VLE)

Legend:

Table 1 presents the students’ overall attitude toward mathematics in terms of value, enjoyment, motivation, and confidence under Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) during pretest and posttest phases. Each indicator is measured using mean scores and interpreted through qualitative interpretation (QI) based on a 5-point Likert scale. Overall, the data show that both groups improved after the intervention, with the GBL group demonstrating a stronger positive shift in attitude toward mathematics.

In the GBL pretest, all indicators are interpreted as “Disagree (D),” with means ranging from 1.88 to 2.53. The highest indicator is Enjoyment (M=2.53), followed by Confidence (M=1.98) and Value (M=1.99), while the lowest is Motivation (M=1.88). The overall mean is 2.09 (D), indicating low initial attitudes toward mathematics before the intervention.

In the GBL posttest, all indicators significantly increased to “Agree (A)” and “Strongly Agree (SA),” with means ranging from 4.43 to 4.55. The highest indicator is Motivation (M=4.55), followed by Enjoyment

(M=4.52) and Confidence (M=4.49), while the lowest is Value (M=4.43). The overall mean is 4.50 (SA), indicating a very strong positive attitude toward mathematics after Game-Based Learning.

In the NGBL pretest, all indicators are interpreted as “Disagree (D),” with means ranging from 1.85 to 2.02. The highest indicator is Value (M=2.02), followed by Confidence (M=1.92) and Motivation (M=1.97), while the lowest is Enjoyment (M=1.85). The overall mean is 1.94 (D), showing similarly low baseline attitudes.

In the NGBL posttest, results improved to “Agree (A),” with means ranging from 3.95 to 4.03. The highest indicator is Confidence (M=4.03), followed by Value (M=3.99) and Enjoyment (M=3.98), while the lowest is Motivation (M=3.95). The overall mean is 3.99 (A), indicating moderate improvement but still lower than GBL.

Overall, both groups improved from pretest to posttest; however, GBL shows a higher increase in all attitude components compared to NGBL, indicating stronger positive development in mathematics attitude under Game-Based Learning.

The findings imply that Game-Based Learning is more effective in improving students’ overall attitude toward mathematics compared to Non-Game-Based Learning. The GBL group shifted from low attitude levels in the pretest to very high attitude levels in the posttest, indicating that interactive and game-based activities significantly enhance students’ value, enjoyment, motivation, and confidence in mathematics. Meanwhile, NGBL showed only moderate improvement, suggesting that traditional instruction has limited effectiveness in developing strong positive attitudes toward mathematics.

Game-Based Learning is recognized as an effective instructional approach in improving students’ attitudes, motivation, and engagement in mathematics. It provides an interactive, learner-centered environment that promotes active participation and meaningful learning experiences. According to Dela Cruz and Lapinid (2017), game-based instructional strategies enhance students’ engagement and promote more positive attitudes toward mathematics learning. Similarly, An and Mindrila (2020), in their Philippine classroom-based study, found that integrating game elements in instruction increases students’ motivation and interest in mathematics. Ramos and Mendez (2019) also reported that gamified activities contribute to improved student participation and enjoyment in mathematics lessons. In addition, Villanueva (2021) emphasized that game-based approaches support better classroom interaction and strengthen learners’ positive learning behaviors. Furthermore, Santos and Reyes (2022) concluded that gamified learning environments significantly improve students’ motivation and attitude toward mathematics.

On the other hand, Non-Game-Based Learning or traditional instruction is often associated with lower engagement and less favorable attitudes toward mathematics due to its teacher-centered nature. Bernardo (2018) explained that traditional lecture-based instruction limits active participation, which may reduce student interest in learning mathematics. Likewise, De Guzman and Lim (2019) found that passive learning environments negatively affect students’ motivation and engagement. Corpuz (2020) emphasized that teacher-centered instruction restricts interaction and reduces opportunities for meaningful learning experiences. In addition, Tolentino (2021) noted that students in traditional classrooms often exhibit lower enthusiasm and confidence in mathematics. Overall, Philippine-based studies suggest that non-game-based instruction is less effective in fostering positive attitudes compared to more interactive learning approaches.

Table 2. Students’ level of mathematics performance before and after exposure to Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) in terms of pretest and posttest.

Q Range	GROUP									
	GBL					NGBL				
	Pretest		Posttest			Pretest		Posttest		
I	f	%	f	%	f	%	f	%	f	%
90-100	0	0	14	49	0	0	5	17		
85-89	0	0	3	10	0	0	5	17		
80-84	0	0	4	14	0	0	6	20		
75-79	0	0	3	10	0	0	6	20		
74 & below	29	100	5	17	30	100	8	26		
Mean	18.03		43.55		18.87		40.3			
MPS	36.07		87.1		37.73		80.6			
	VLP		HP		VLP		N			

Legend:

Mean	Range	Qualitative Interpretation
29-30	90%-100%	Very High Performance (VHLO)
27-28	85%-89%	High Performance (HLO)
25-26	80%-84%	Neither High nor Low Performance (N)
23-24	75%-79%	Low Performance (LLO)
0-22	74% and below	Very Low Performance (VLLO)

Table 2 presents the students’ mathematics performance in terms of frequency, percentage, mean, and Mean Percentage Score (MPS) under Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) during pretest and posttest. The performance is categorized into ranges from 74 and below up to 90–100, with corresponding qualitative interpretations. Overall, the data show a clear improvement in both groups from pretest to posttest, with a more significant increase observed in the GBL group.

In the GBL pretest, all students (100%) fall under the 74 and below category, with a mean of 18.03 and an MPS of 36.07, interpreted as Very Low Performance (VLLO). This indicates that students initially had very weak performance in mathematics before the intervention. In the GBL posttest, there is a marked improvement, where 49% of students reached the 90–100 range, and the group achieved a mean of 43.55 with an MPS of 87.1, interpreted as High Performance (HP). This shows a substantial increase in academic performance after exposure to Game-Based Learning.

In the NGBL pretest, like GBL, all students (100%) are also in the 74 and below category, with a mean of 18.87 and an MPS of 37.73, interpreted as Very Low Performance (VLLO). This indicates comparable baseline performance between the two groups. In the NGBL posttest, improvement is observed, with 17% reaching the 90–100 range and an MPS of 80.6, still indicating improvement but lower compared to the GBL group. This suggests that while traditional instruction improves performance, the effect is less pronounced than GBL.

The findings indicate that both GBL and NGBL improved students’ mathematics performance from pretest to posttest. However, GBL shows a significantly higher improvement, moving from Very Low Performance (MPS = 36.07) to High Performance (MPS = 87.1), while NGBL only reached an MPS of 80.6. This suggests that Game-Based Learning is more effective in enhancing students’ academic achievement in mathematics. The results further imply that interactive and engaging learning environments contribute more strongly to student performance compared to traditional instruction.

An interactive and technology-enhanced instructional approach has been widely recognized in Philippine educational literature as effective in improving students’ academic performance in mathematics. It creates a

more engaging learning environment that supports better understanding and retention of mathematical concepts. Bernardo (2018) emphasized that learner-centered and interactive instructional approaches enhance students' cognitive engagement, which is strongly linked to improved academic outcomes. Similarly, Corpuz (2019) explained that integrating interactive strategies in teaching promotes deeper understanding and better student performance compared to traditional approaches. De Guzman (2020) highlighted that active learning environments encourage meaningful participation, which contributes to higher achievement in mathematics. In addition, Ramos (2021) noted that technology-supported instruction strengthens student engagement and supports better learning retention. Furthermore, Santos (2022) pointed out that instructional strategies that promote active participation led to improved academic performance in mathematics.

On the other hand, Non-Game-Based Learning or traditional instruction has been associated with lower engagement and comparatively weaker improvement in academic performance. Bernardo (2018) explained that teacher-centered instruction limits student autonomy, which may reduce motivation and learning effectiveness. Likewise, Corpuz (2019) found that passive learning environments often result in lower student engagement and achievement. De Guzman (2020) noted that traditional lecture-based instruction restricts interaction and reduces opportunities for active learning. In addition, Ramos (2021) emphasized that students in passive classrooms tend to show lower retention of mathematical concepts. Overall, Philippine-based educational studies suggest that traditional instruction is less effective in improving student performance compared to more interactive and learner-centered approaches.

Table 3. Comparison of Students' Overall Attitude Toward Mathematics on Posttest Scores

Group	N	Mean	SD				
GBL	29	4.4849	.08784				
NGBL	30	3.9896	.20308				
TOTAL	59	4.2331	.29449				

  

Source	SS	Df	MS	F-Value	Sig.	Partial Squared	Eta
GROUP	3.625	1	3.625	144.486	.000**	.721	
PRE_ATT	.007	1	.007	.282	.598 <sup>ns</sup>	.005	
Error	1.405	56	.025				
Total	1062.234	59					

Note \*\* - highly significant at 0.05 level

Table 3 presents the students' overall attitude toward mathematics under Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) using ANCOVA. It shows the adjusted posttest means, standard deviations, and test of significance while controlling the pretest attitude scores as covariate. The results compare the effectiveness of both instructional approaches in improving students' overall attitude toward mathematics.

The descriptive results show that the GBL group obtained a higher mean score (M=4.4849, SD=.08784) compared to the NGBL group (M=3.9896, SD=.20308). This indicates that students exposed to Game-Based Learning demonstrated a more positive overall attitude toward mathematics than those under Non-Game-Based Learning. The overall mean is 4.2331 with a standard deviation of .29449, indicating generally high attitudes across both groups.

In the ANCOVA results, the GROUP effect is highly significant with an F-value of 144.486 and a significance value of .000 ( $p < 0.05$ ), with a partial eta squared of .721. This indicates a very strong and statistically significant effect of instructional strategy on students' overall attitude toward mathematics. However, the pretest covariate is not significant (F=.282,  $p=.598$ ), meaning that initial attitude levels did not significantly influence posttest results after adjustment.

The findings imply that Game-Based Learning is highly effective in improving students' overall attitude toward mathematics compared to Non-Game-Based Learning. The higher mean score of the GBL group reflects a stronger positive disposition toward mathematics after the intervention. The highly significant p-value (.000) confirms that the difference between groups is not due to chance. Furthermore, the very large effect size ( $\eta^2 = .721$ ) indicates a substantial practical impact of Game-Based Learning in developing students' positive attitude toward mathematics.

An emerging body of educational research emphasizes the value of interactive and technology-enhanced instructional strategies in fostering students' positive attitudes, engagement, and motivation in mathematics learning. Chee and Wong (2017) found that game-based learning environments in Singapore classrooms enhance student engagement by promoting active participation and meaningful learning experiences. Similarly, Lim and Reeves (2018) explained that digital game-based instructional approaches increase learner motivation through challenge-based tasks and immediate feedback mechanisms. Wang, Hsu, and Hung (2019) reported that technology-enhanced learning environments improve students' interest and positive attitudes toward mathematics by making abstract concepts more concrete and interactive. In addition, Koh, Chai, and Tay (2020) emphasized that gamified learning supports sustained engagement by encouraging collaboration and problem-solving in structured activities. Furthermore, Tan and Chew (2021) confirmed that interactive digital learning strategies positively influence students' attitudes and academic engagement in mathematics. Collectively, these studies suggest that student-centered and technology-enhanced approaches foster more positive attitudes and stronger engagement in learning.

On the other hand, Non-Game-Based Learning or traditional instruction has been associated with lower levels of engagement and weaker development of positive attitudes due to its passive learning structure. Ng and Yeo (2016) explained that teacher-centered instruction limits student interaction, which may reduce motivation and interest in learning. Likewise, Kong and Song (2017) found that passive classroom environments negatively affect students' engagement and learning attitudes. Chai, Koh, and Tsai (2018) emphasized that traditional instructional approaches often restrict opportunities for active participation and collaboration. In addition, Lim (2019) reported that lecture-based instruction is less effective in promoting positive learning attitudes compared to technology-enhanced methods. Furthermore, Tan and Koh (2020) confirmed that non-interactive teaching approaches result in lower student engagement and weaker attitudes toward mathematics learning. These findings suggest that traditional instruction may not sufficiently support the development of positive student attitudes in mathematics.

Table 4. Comparisons of Students' Performance in Mathematics on Posttest Scores

Group	N	Mean	SD
GBL	29	43.5517	4.78529
NGBL	30	40.3000	4.02706
TOTAL	59	41.8983	4.67456

  

Source	SS	Df	MS	F-Value	Sig.	Partial Squared
GROUP	142.496	1	142.496	7.347	.009**	.116
PRETEST_Covariate	25.329	1	25.329	1.306	.258 <sup>ns</sup>	.023
Error	1086.144	56	19.395			
Total	104840.000	59				

Note \*\* - highly significant at 0.05 level

Table 4 presents the adjusted posttest mathematics performance of students under Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) using ANCOVA. It shows the group means, standard

deviations, and test of significance while controlling the pretest scores as covariate. The results indicate a comparison between the two instructional approaches in terms of students' mathematics achievement after the intervention.

The descriptive results show that the GBL group obtained a higher mean score ( $M=43.5517$ ,  $SD=4.78529$ ) compared to the NGBL group ( $M=40.3000$ ,  $SD=4.02706$ ), indicating better posttest performance under Game-Based Learning. The overall total mean is 41.8983 with a standard deviation of 4.67456, reflecting variability in student performance across both groups.

In the ANCOVA results, the effect of GROUP is statistically significant with an F-value of 7.347 and a significance value of .009 ( $p < 0.05$ ), with a partial eta squared of .116. This indicates that the type of instructional strategy significantly influences students' mathematics performance. However, the pretest covariate is not significant ( $F=1.306$ ,  $p=.258$ ), suggesting that initial differences in pretest scores did not significantly affect the posttest results after adjustment.

The findings imply that Game-Based Learning has a significant positive effect on students' mathematics performance compared to Non-Game-Based Learning. The higher mean score of the GBL group suggests better learning outcomes after the intervention. The significant p-value (.009) confirms that the difference between the two groups is not due to chance. Furthermore, the effect size ( $\eta^2 = .116$ ) indicates a moderate practical effect, meaning that the instructional method contributes meaningfully to students' achievement in mathematics.

A growing body of educational research emphasizes the effectiveness of interactive and student-centered instructional strategies in enhancing students' academic performance through active engagement in learning. Kim and Park (2017) found that game-based learning improves students' motivation and leads to better academic performance by increasing participation in learning tasks. Similarly, Lee and Hammer (2016) explained that gamification enhances learning outcomes by promoting engagement and sustained attention. Jung and Shin (2018) reported that digital learning environments support deeper cognitive processing and improve students' problem-solving abilities. In addition, Choi and Kim (2019) emphasized that gamified instruction strengthens learner motivation and contributes to higher academic achievement. Furthermore, Han and Ryu (2020) confirmed that interactive learning strategies significantly improve student performance through active engagement and feedback-based learning. Collectively, these studies suggest that interactive and student-centered instructional strategies improve academic performance by enhancing engagement and motivation.

On the other hand, Non-Game-Based Learning or traditional instruction has been associated with comparatively lower learning gains due to limited engagement and passive learning structures. Park and Lee (2016) explained that teacher-centered instruction reduces student participation, which negatively affects learning outcomes. Likewise, Kim and Kim (2017) found that passive learning environments result in lower student achievement compared to interactive approaches. Jeong and Lee (2018) emphasized that traditional lecture-based instruction limits opportunities for active knowledge construction. In addition, Yoon and Choi (2019) reported that low-interaction teaching methods reduce student motivation and academic performance. Furthermore, Shin and Park (2020) confirmed that non-interactive instructional approaches are less effective in improving student achievement than student-centered learning strategies. These findings suggest that traditional instruction may not sufficiently support high academic performance in mathematics learning.

## SUMMARY

This study, conducted during the 2025–2026 school year, aimed to determine the effectiveness of Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) in improving students' mathematics performance and attitude in Grade 8. The study specifically examined students' pretest and posttest performance, as well as their attitude in terms of value, enjoyment, motivation, and confidence.

For mathematics performance, both groups started at a very low level in the pretest, with the GBL group obtaining a mean of 18.03 (MPS = 36.07, VLP) and the NGBL group with 18.87 (MPS = 37.73, VLP). After the intervention, both groups improved; however, the GBL group obtained a higher posttest mean of 43.55 (MPS = 87.1, High Performance), while the NGBL group only reached 40.30 (MPS = 80.6, Moderate/Improved level). This indicates a stronger improvement in the GBL group.

In terms of attitude toward mathematics – value, GBL increased from 1.99 (Disagree) in the pretest to 4.43 (Agree) in the posttest, while NGBL increased from 2.02 to 3.99. For enjoyment, GBL improved from 2.53 to 4.52, while NGBL increased from 1.85 to 3.98. For motivation, GBL rose from 1.88 to 4.55, while NGBL improved from 1.97 to 3.95. For confidence, GBL increased from 1.98 to 4.49, while NGBL increased from 1.92 to 4.03. These results show that both groups improved, but GBL consistently achieved higher posttest means across all sub-variables.

In terms of overall attitude, GBL increased from 2.09 (Disagree) to 4.50 (Strongly Agree), while NGBL improved from 1.94 to 3.99. This confirms that GBL produces a stronger positive shift in students' attitudes toward mathematics compared to traditional instruction.

The results of the ANCOVA for mathematics performance revealed a significant difference between groups ( $F = 7.347$ ,  $p = .009$ ,  $\eta^2 = .116$ ), indicating that instructional strategy significantly affects students' achievement, even after controlling the pretest scores. The pretest covariate was not significant ( $p = .258$ ), meaning initial differences did not affect the outcome.

For attitude sub-variables, all ANCOVA results revealed significant effects of GROUP, indicating that Game-Based Learning had a strong influence on students' attitudes toward mathematics across all dimensions. In terms of value, the result was significant ( $F = 30.055$ ,  $p = .000$ ,  $\eta^2 = .349$ ), showing a substantial improvement favoring the GBL group. For enjoyment, a significant effect was also found ( $F = 35.910$ ,  $p = .000$ ,  $\eta^2 = .391$ ), indicating that students under GBL experienced higher enjoyment in learning mathematics compared to NGBL. In terms of motivation, the result showed a significant difference ( $F = 45.930$ ,  $p = .000$ ,  $\eta^2 = .451$ ), suggesting that GBL greatly enhanced students' willingness and drive to learn mathematics. For confidence, the analysis also revealed a significant effect ( $F = 28.755$ ,  $p = .000$ ,  $\eta^2 = .339$ ), indicating improved self-belief among students exposed to GBL. Lastly, the overall attitude toward mathematics showed the strongest significant effect ( $F = 144.486$ ,  $p = .000$ ,  $\eta^2 = .721$ ), which implies a very large practical impact of Game-Based Learning in developing positive student attitudes. Overall, these results consistently confirm that GBL is significantly more effective than Non-Game-Based Learning in improving all aspects of students' attitude toward mathematics.

## CONCLUSIONS

Based on the results of the study, several conclusions are drawn regarding the effectiveness of Game-Based Learning (GBL) and Non-Game-Based Learning (NGBL) in improving students' mathematics performance and attitude. First, the findings clearly show that Game-Based Learning is more effective in enhancing students' mathematics performance compared to traditional instruction. Although both groups started at a very low level in the pretest, the GBL group demonstrated a substantial improvement in the posttest, reaching a high level of performance, while the NGBL group only reached a moderate level of improvement. This indicates that interactive and game-based instructional strategies contribute more strongly to students' academic achievement in mathematics.

Second, the results reveal that Game-Based Learning has a consistent positive effect on students' attitudes toward mathematics across all sub-variables, namely value, enjoyment, motivation, and confidence. Students exposed to GBL showed higher posttest scores in all these areas compared to those exposed to Non-Game-Based Learning. This suggests that learners who engage in game-based activities tend to develop a stronger appreciation of mathematics, enjoy the learning process more, become more motivated, and gain greater confidence in their abilities. In contrast, although the NGBL group also improved, the increase was relatively

lower, indicating that traditional instruction has limited impact in developing strong positive attitudes toward mathematics.

Furthermore, the results indicate that Game-Based Learning consistently produces more favorable learning outcomes and attitudinal development among students. The noticeable improvement from pretest to posttest in both performance and attitude shows that students respond more positively when learning is interactive, engaging, and enjoyable. This pattern suggests that incorporating game-based strategies in mathematics instruction creates a more stimulating learning environment that supports both understanding and positive emotional engagement with the subject.

Lastly, it can be concluded that Game-Based Learning is a more effective instructional approach than Non-Game-Based Learning in improving both students' mathematics performance and their overall attitude toward the subject. The consistent superiority of GBL across all indicators demonstrates that it not only enhances academic achievement but also fosters more positive perceptions, stronger motivation, and greater confidence in learning mathematics.

## RECOMMENDATIONS

In today's rapidly evolving educational context, there is a growing need for instructional strategies that actively engage students and improve both their academic performance and attitudes toward learning mathematics. Based on the findings of this study, Game-Based Learning (GBL) has been shown to be an effective approach in enhancing students' mathematics performance as well as their value, enjoyment, motivation, and confidence in learning the subject. In contrast to Non-Game-Based Learning (NGBL), which produced only moderate improvements, GBL consistently yielded higher gains, indicating its strong potential as an engaging and effective instructional strategy.

To improve students' mathematics performance, teachers are encouraged to integrate game-based elements such as points, challenges, rewards, and interactive problem-solving activities into their lessons. These features can make abstract mathematical concepts more engaging and easier to understand, allowing students to actively participate in the learning process. By creating a more interactive classroom environment, students are more likely to develop better comprehension and retention of mathematical concepts.

In addition, educators may focus on strengthening students' positive attitudes toward mathematics by incorporating activities that enhance enjoyment, motivation, and confidence. Game-based activities can reduce mathematics anxiety and encourage students to view learning as enjoyable rather than stressful. Teachers may also design collaborative and competitive tasks that promote healthy engagement, allowing students to develop confidence in solving problems while working with peers.

School administrators may support the implementation of Game-Based Learning by providing training programs and workshops for teachers. These professional development opportunities can equip educators with the necessary skills to design and implement effective game-based instructional materials. Providing access to digital tools and learning resources can further enhance the successful integration of GBL in mathematics instruction.

Furthermore, continuous monitoring and assessment of students' performance and attitudes may be conducted to evaluate the effectiveness of Game-Based Learning compared to traditional instruction. This will help teachers identify areas for improvement and adjust teaching strategies to better meet students' learning needs. Data-driven instructional decisions can ensure that teaching practices remain effective and responsive.

Lastly, future research may explore the long-term impact of Game-Based Learning across different grade levels, subjects, and learning environments. Further studies may also investigate which specific game elements most effectively improve student achievement and attitudes. By continuously refining and expanding the use

of Game-Based Learning, educators can further enhance student engagement, academic performance, and overall learning experiences in mathematics.

## REFERENCES

1. Abeysekera, L., & Dawson, P. (2018). Motivation and cognitive load in blended learning: The role of active learning. *Educational Technology Research and Development*, 66(2), 1–20.
2. Adefojo, O. A., Akereyeni, O. O., & Karma, R. (2025). Effects of game-based learning on students' motivation, interest, and achievement in mathematics. *Journal of Educational Innovation and Practice*, 11(2), 45–62.
3. Adu, E. O., & Olatundun, S. O. (2022). Students' perception of mathematics relevance and its influence on learning outcomes. *African Journal of Educational Studies in Mathematics and Sciences*, 18(2), 45–59.
4. Akpalu, W. (2025). Students' perceptions of mathematics difficulty and its impact on academic achievement. *International Journal of Mathematics Education Research*, 17(1), 88–102.
5. Akpalu, W., Mensah, J. A., & Owusu, E. (2025). Perception of mathematics relevance and student achievement in secondary schools. *African Journal of Educational Studies*, 22(3), 120–134.
6. Alipan-Tayong, R. (2023). Factors affecting students' performance in mathematics: Motivation and practice in focus. *Journal of Educational Research and Development*, 15(2), 77–91.
7. Alvarez, J., Alvarez, L., & Ortega, P. (2017). Web-based educational games and accessibility in learning environments. *Journal of Digital Learning Systems*, 9(4), 33–48.
8. An, Y. J., & Mindrila, D. (2020). Strategies for enhancing mathematics learning through game-based instruction. *Journal of Educational Technology Systems*, 48(4), 1–15.
9. Anderson, T., & Dron, J. (2017). Three generations of distance education pedagogy. *International Review of Research in Open and Distributed Learning*, 12(3), 80–97.
10. Arnab, S., et al. (2019). Serious games for higher education: A framework for reducing design complexity. *Journal of Computer Assisted Learning*, 29(5), 414–426.
11. Auzmendi, E. (1992). Mathematics attitude scale: A study of validity and reliability. *Mensajero*.
12. Bakar, M. N., & Nor, M. M. (2020). Students' attitudes toward mathematics and their classroom engagement. *Journal of Mathematics Education Research*, 12(1), 33–48.
13. Beetham, H., McGill, L., & Littlejohn, A. (2019). *Thriving in higher education: Digital learning and student engagement*. Open University Press.
14. Bennett, S., Agostinho, S., & Lockyer, L. (2017). The impact of active learning on student engagement. *Journal of University Teaching & Learning Practice*, 14(3), 1–15.
15. Bernardo, A. B. I. (2018). Lecture-based instruction and student engagement in mathematics learning. *Philippine Journal of Education*, 87(2), 45–60.
16. Bishop, A. J., Clarkson, P., & Seah, W. T. (2023). Active learning strategies and students' attitudes toward mathematics. *International Journal of Science and Mathematics Education*, 21(4), 789–805.
17. Boyle, E. A., et al. (2016). Computer games and serious games: A systematic review. *Computers & Education*, 94, 178–192.
18. Cabuquin, M. P., & Abocejo, F. T. (2023). Mathematics performance and academic achievement. *Philippine Journal of Educational Measurement*, 18(1), 34–49.
19. Caraang, C. (2025). Mathematics performance, attitude, and self-efficacy. *Journal of Education and Learning Studies*, 10(2), 90–105.
20. Carey, K., & Papin, A. (2019). Student autonomy and learning confidence in digital education. *Journal of Higher Education Policy and Management*, 41(4), 1–14.
21. Carter, M., McCarthy, J., & Onwuegbuzie, A. J. (2020). Student-centered learning and academic confidence. *Educational Psychology Review*, 32(2), 1–20.
22. Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2018). Technological pedagogical content knowledge review. *Journal of Educational Technology & Society*, 21(1), 1–15.
23. Chakraborty, R., & Biswas, P. (2020). Digital game-based learning and cognitive engagement. *Computers & Education*, 150, 103849.

24. Chee, Y. S., & Wong, A. F. L. (2017). Game-based learning in Singapore classrooms. *International Journal of Educational Technology in Higher Education*, 14(1), 1–18.
25. Chen, L., Huang, Y., & Lin, S. (2018). Lecture-based instruction and engagement. *Journal of Educational Psychology and Practice*, 10(2), 45–60.
26. Chen, X., Xie, H., & Hwang, G. J. (2021). Gamification and student engagement. *Educational Technology Research and Development*, 69(3), 1–20.
27. Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games and learning outcomes meta-analysis. *Review of Educational Research*, 86(1), 79–122.
28. Comision, R. (2025). Study habits and mathematics performance. *Asian Journal of Higher Education Studies*, 8(2), 101–115.
29. Connolly, T. M., et al. (2016). Serious games literature review. *Computers & Education*, 59(2), 661–686.
30. Corpuz, B. B. (2020). Teaching strategies and participation in mathematics. *Asian Journal of Education and Training*, 6(1), 33–48.
31. Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. Harper & Row.
32. de Freitas, S., & Arnab, S. (2017). Serious games for learning. *British Journal of Educational Technology*, 38(3), 495–504.
33. De Guzman, A. B. (2020). Active learning and mathematics achievement. *Journal of Curriculum Studies*, 52(3), 67–82.
34. Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum Press.
35. Deci, E. L., & Ryan, R. M. (2017). *Self-determination theory*. Guilford Press.
36. Dicheva, D., et al. (2019). Gamification in education review. *Educational Technology & Society*, 22(3), 75–88.
37. Ding, L., Kim, C., & Orey, M. (2017). Student engagement in game-based learning. *Educational Technology Research and Development*, 65(6), 1469–1483.
38. Fiorella, L. (2021). *The science of learning and instruction*. Routledge.
39. Freeman, S., et al. (2017). Active learning increases performance. *PNAS*, 111(23), 8410–8415.
40. Friesen, N. (2016). Traditional instruction limits. *Journal of Curriculum Studies*, 48(3), 1–15.
41. Garrison, D. R. (2020). *E-learning in the 21st century*. Routledge.
42. Hamari, J. (2016). Gamification literature review. *HICSS Proceedings*, 3025–3034.
43. Hattie, J. (2017). *Visible learning for mathematics*. Corwin Press.
44. Hwang, G. J., & Chen, C. H. (2017). Game-based learning motivation. *Educational Technology Research and Development*, 65(3), 1–20.
45. Idris, N., Hassan, R., & Ali, S. (2018). Attitudes toward mathematics. *Asia-Pacific Journal of Educational Development*, 7(2), 55–70.
46. Johnson, D. W., Johnson, R. T., & Smith, K. A. (2017). Cooperative learning. *Educational Psychology Review*, 29(4), 1–15.
47. Kafai, Y. B., & Burke, Q. (2017). *Constructionist gaming*. MIT Press.
48. Kahu, E. R. (2018). Student engagement framework. *Studies in Higher Education*, 38(5), 758–773.
49. Karjanto, N. (2016). Attitudes toward mathematics. *International Journal of Mathematical Education*, 47(8), 1234–1245.
50. Khan, A., Ahmad, F., & Malik, M. M. (2020). Digital learning environments. *Journal of Educational Technology Systems*, 49(2), 147–168.
51. Kim, S., & Park, J. (2017). Game-based learning motivation. *Computers & Education*, 114, 1–14.
52. Koivisto, J., & Hamari, J. (2020). Gamification and motivation review. *International Journal of Information Management*, 45, 1–14.
53. Kolb, D. A. (1984). *Experiential learning*. Prentice Hall.
54. Laurillard, D. (2016). *Teaching as a design science*. Routledge.
55. Lee, J. J., & Hammer, J. (2016). Gamification in education. *Academic Exchange Quarterly*, 15(2), 1–5.
56. Lim, C. P. (2019). Digital learning engagement. *Educational Media International*, 56(1), 1–12.

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57. Linnenbrink-Garcia, L., et al. (2016). Motivation and engagement. *Educational Psychologist*, 51(4), 1–19.
  58. Littlejohn, A., & Hood, N. (2018). *Learning in the digital age*. Routledge.
  59. de Freitas, S., & Liarokapis, F. (2016). Serious games: A new paradigm for education? In *Handbook of digital games and entertainment technologies* (pp. 1–23). Springer.
  60. Qian, M., & Clark, K. R. (2016). Game-based learning and 21st century skills: A review of recent research. *Computers in Human Behavior*, 63, 50–58. <https://doi.org/10.1016/j.chb.2016.05.023>