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Darting Towards Numerical Confidence: Assessing Integer Skill Development of Grade 8 Learners Through a Game-Based Approach

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Abstract

Mastering integers is essential in mathematics; however, many students in the Philippines struggle with basic operations, as evidenced by their poor performance on international assessments such as PISA. The study investigates the effectiveness of a modified dart game in improving Grade 8 students' proficiency in adding and subtracting integers. To tackle the difficulties students encounter, the study employed a game-based learning strategy using the modified dart game. Thirty-two Grade 8 students were purposely selected and divided into two groups through pair-matching randomization: 16 students formed a control group that continued traditional learning methods, while the other 16, in the experimental group, participated in 15-minute daily dart-focused sessions over four weeks. Both groups were given pre-tests and post-tests to measure their progress. Results showed improvements in the experimental group, achieving a higher mean score of 24.25, as compared to the control group, which scored 18.44 in post-tests. A t-test analysis computed a p-value of 0.0072, which validated that there is a statistically significant difference in favor of the experimental group, indicating that the intervention had a positive effect on students' proficiency in integer operations. These findings suggest that integrating a modified dart game can effectively enhance students' arithmetic skills.

Introduction

Mastering basic mathematical skills, particularly integer operations, is fundamentally important and a prerequisite for success in more advanced mathematics such as algebra and calculus (Loveless, 2003). Despite this, numerous studies reveal persistent difficulties among students in understanding and performing integer operations, with common misconceptions hindering their mathematical progress (Harun et al., 2023; Fuadiah et al., 2016; Khalid & Embong, 2019). Empirical data from a sample of Grade 7 students in Basilan demonstrated an average mastery level of only 50.56%, with significant errors, especially in subtraction and handling negative integers, reflecting systemic educational challenges without notable gender disparities (Harun et al., 2023).

Contextualizing these findings within the Philippine educational landscape, the country

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consistently ranks near the bottom in international assessments such as Programme for International Student Assessment (PISA), where only 16% of students reached minimum proficiency in mathematics in 2022, indicating a substantial gap relative to global standards (PISA, 2022; Chi, 2023). Although localized assessments, such as the Division Achievement Test in Benguet, show slight improvements in mathematics scores, proficiency remains below desired benchmarks (School Division of Benguet, 2024).

In response to these challenges, innovative pedagogical approaches integrating game-based learning have been explored. The DaMath board game, developed to enhance engagement and comprehension of integer operations, demonstrated significant improvements in student performance, with mean test scores increasing from 5.21 to 7.10 post-intervention, indicating progress from developing to approaching proficiency levels (Martus et al., 2024). This aligns with broader research supporting the efficacy of interactive, feedback-rich learning environments in improving cognitive and strategic skills (Byun & Loh, 2015).

Additionally, incorporating recreational activities such as darts has been investigated as a means to reinforce arithmetic skills through skill-based practice. Studies report that playing darts enhances cognitive abilities related to mathematical operations, psychomotor skills, and problem-solving, offering a low-intensity, accessible method to support numeracy development (Ndhulula & Vurayai, n.d.; Ostmanadmin, 2024; Padmin, 2016).

Building upon these foundations, darts is introduced as a more holistic recreational method. Unlike stationary board games, darts requires accuracy, focus, and hand-eye coordination, which facilitates the development of psychomotor skills alongside mental arithmetic (Padmin, 2016; Ndhulula & Vurayai, n.d.). As a low-intensity sport, it allows individuals of all ages to master basic operations, including addition and subtraction, in an accessible setting (Ostmanadmin, 2024).

Crucially, selection of darts is driven by its high popularity within the locale, as evidenced by its rapid integration into institutional and legislative frameworks across Benguet and the Cordillera region (Department of Education Cordillera Administrative Region, 2022; Baguio City Council, 2026). This existing cultural familiarity makes it a strategic choice for engagement, as it aligns with current trends toward active, skill-based games (Ndhulula & Vurayai, n.d.). By leveraging a game that is already a staple in the local community, the learning experience becomes more relatable and effective, bridging the gap between recreation and academic mastery.

Building on these insights, recent research aims to evaluate the effectiveness of modified darts games in improving Grade 8 students' proficiency in integer operations within a secondary laboratory school setting in La Trinidad, Benguet, by comparing pre- and post-intervention test results over four weeks. This approach reflects an ongoing effort to integrate active, game-based learning strategies to address foundational mathematical skill deficits and enhance student engagement and achievement.

Numerous pedagogical frameworks support the integration of games to facilitate conceptual acquisition across various disciplines, particularly mathematics. Game-based learning integrates gaming principles such as competition, rewards, and feedback into educational contexts to enhance motivation and engagement (Trybus, 2015; Falciani, 2020). Empirical evidence supports the efficacy of GBL in improving mathematical abilities, fostering social interaction, and reducing anxiety (Andayani & Hasanah, 2022; Dondio et al., 2023).

Kinesthetic learning emphasizes physical movement and environmental interaction as primary tools for effective education (Syofan & Siwi, 2018). A practical application of this is seen in the game of darts, where the physical act of throwing pins and visualizing board segments allows players to kinesthetically calculate and solve mathematical scores in real-time (Ryan, 2017).

Additionally, embodied cognition suggests that internal mental processes are deeply rooted in the body's interactions with the world, meaning that abstract concepts like integers are best understood when linked to physical sensations and movements (Shapiro, 2019). This "learning by doing" approach offloads the mental burden of arithmetic onto the physical environment, leveraging the local popularity of the sport to bridge the gap between physical play and academic mastery (Ndhulula & Vurayai, n.d.; Gupta, 2024).

Lastly, distributed practice, or spaced learning, is a strategy that improves long-term retention by spacing learning sessions over time (Denomme, 2023; Wiseheart et al., 2019). The study's intervention 15-minute daily darts sessions over four weeks applies this principle to reinforce arithmetic skills.

For this paper, it uses level of proficiency as primary variable examined is the students' proficiency in basic operations on integers (addition and subtraction of positive and negative numbers). Proficiency is assessed using standardized pre- and post-tests, in accordance with the Department of Education's grading system (DepEd, 2015; González-Sanmamed et al., 2014).

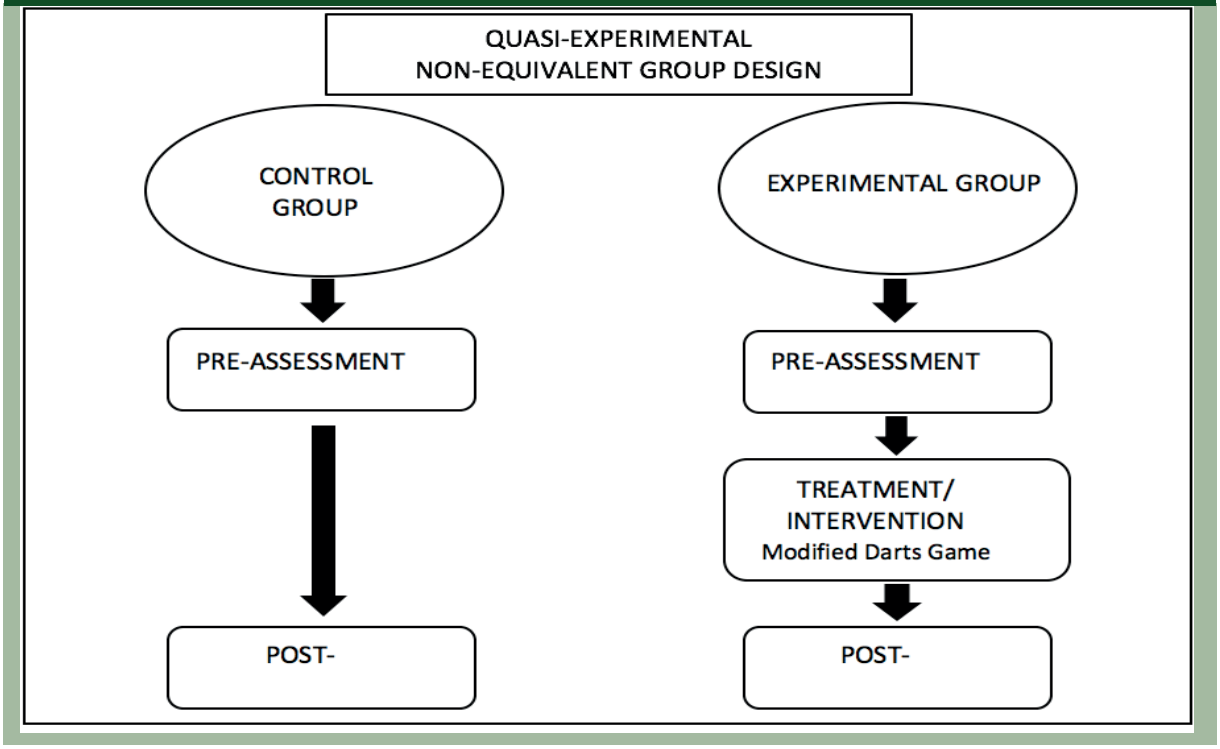
The study employs a quasi-experimental, non-equivalent group design (Figure 1). Thirty two (32) Grade 8 students were purposively sampled and pair-matched into experimental and control groups. The experimental group participated in the modified darts intervention for four weeks, while the control group received no intervention. Pre- and post-assessments measured changes in proficiency, allowing for the evaluation of the intervention's effectiveness.

This research integrates kinesthetic, brain-based, and game-based learning theories, utilizing distributed practice through a modified darts game to enhance students' proficiency in basic integer operations. The study's design enables a systematic comparison of learning outcomes between intervention and control groups, contributing to the evidence base for innovative, active learning strategies in mathematics education.

Specifically, this study aims to investigate the effect of modified darts on the computational skills of grade 8 students, particularly focusing on addition and subtraction of integers. The research is guided by several specific questions. Initially, the study seeks to assess the initial level of proficiency in addition and subtraction of integers for both the control group and the experimental group. Following this, it will examine the post-assessment

Figure 1

Paradigm of the Study



levels of proficiency in these operations for each group. A critical aspect of the analysis involves determining whether there are significant differences in proficiency levels, specifically comparing the pre-assessment and post-assessment results of the control group, as well as those of the experimental group, and subsequently contrasting the post-assessment outcomes between the two groups. Furthermore, the study aims to identify which basic arithmetic skills exhibited the greatest and least improvement in proficiency within the experimental group. By addressing these questions, the research seeks to contribute to a deeper understanding of the effectiveness of modified darts in enhancing computational skills in the context of integer operations among grade 8 students.

This study investigated the effectiveness of using a modified darts game as an innovative instructional strategy to improve Grade 8 students' skills in performing basic integer operations. Recognizing the common difficulties students face with integer concepts and operations, the research transformed the familiar game of darts into an interactive learning tool that physically engages students, thereby enhancing motivation and interest. The approach aimed to develop students' understanding of integer addition and subtraction through a fun, strategic, and enriching activity that integrates cognitive and psychomotor skills.

This method contrasts with traditional teaching approaches by promoting active engagement and sustained interest, which are critical for conceptual understanding and skill retention. The study recommends that educators consider incorporating such game-based learning strategies to enhance student engagement and achievement in foundational mathematics.

Furthermore, this research provides a basis for future studies to explore similar game-based interventions, encouraging the development of creative and interactive tools for teaching fundamental mathematical concepts. By leveraging familiar recreational activities like darts, educators and researchers can design innovative methods that address learning challenges and support deeper mathematical comprehension among students.

Methodology

Research Design

The researchers employed a quantitative research approach to evaluate the effectiveness of a modified darts-based intervention on Grade 8 students' proficiency in integer arithmetic. This approach enabled statistical analysis of pre- and post-assessment scores, allowing for objective measurement of changes in student performance (Bhandari, 2023a; Lagmay et al., 2024). A quasi-experimental design, specifically a non-equivalent group design, was utilized to establish causal relationships between the intervention – modified darts activity and the outcome – integer arithmetic skills (Chiang et al., 2015; Thomas, 2024). Pre-existing groups of students with low proficiency in integer operations were identified through an initial assessment. These were the students who are under the beginning to developing levels. Participants were then pair-matched – the researchers paired participants based on same or similar scores. Then, they randomly assigned one individual from each pair to the experimental group and the other to the control group. The experimental group engaged in four weeks of modified darts activities, and the control group did not receive the intervention. This methodological framework ensured reliable and valid data collection, effectively addressing the research objective of determining the impact of physical, game-based learning on students' mathematical performance.

Population and Locale of the Study

The study was conducted at a Secondary Laboratory School in La Trinidad, Benguet, chosen for its controlled environment, which is suitable for both intervention and assessment activities. Grade 8 students were selected as participants due to the relevance of integer operations in their mathematics curriculum and their identified low proficiency in these skills. The participants were from the two non-agricultural science sections of the selected locale, with the majority of them having low performance during the pre-test. A study by Singh (2023) recommended that a minimum sample size of 30 individuals is advised to have adequate statistical power for quantitative research. Based on this study, a total of 32

students were purposively sampled and divided into two groups (experimental and control) using pair-matching randomization to ensure group equivalence. Sixteen students in the experimental group participated in the modified darts-based intervention, while the remaining sixteen served as controls. The sample size was determined based on recommendations for quantitative research. This design allowed a precise evaluation of the intervention's effect on students' computational skills with integers.

Data Gathering Tool

The primary data collection instrument in this study was a set of cognitive tests designed to assess the Grade 8 students' arithmetic abilities, specifically focusing on integer addition and subtraction (Astuti et al., 2022). The tests consisted of closed-ended, structured questions aligned with the Grade 8 arithmetic curriculum, ensuring standardized assessment across participants and enabling direct comparison between experimental and control groups.

To measure students' proficiency, the researchers developed a 32-item constructed-response test, administered both as pre- and post-assessments, with a 20-minute completion time (Nurnberger-Haag et al., 2022). A table of specifications guided the construction of test items, and content validity was established through expert review by three experienced mathematics educators from various institutions in Benguet. Additionally, a mathematics major evaluated the face validity, confirming the instrument's appropriateness and clarity (Bhandari, 2023b; Cohen et al., 2018).

Before full implementation, pilot testing was conducted at a Regional Science High School to ensure item clarity and practicality, following formal approval from the school administration. Reliability of the instrument was determined using Cronbach's alpha, yielding coefficients of 0.80 and 0.78 for the pre- and post-tests, respectively, indicating high internal consistency (Taber, 2018).

To minimize bias, identical testing conditions were maintained for both assessments. Each correct answer was awarded one point, and total scores were used to evaluate changes in arithmetic proficiency. Descriptive statistics, including means and percentages, summarized the results, which were presented in tables and graphs. This rigorous process ensured that the data collection instrument was valid, reliable, and suitable for accurately measuring the intended arithmetic skills.

Data Gathering Procedure

The researchers initiated the study by submitting their research proposal for review and approval to the assigned adviser and panel members. Upon approval, the cognitive assessment instruments (pre- and post-tests) underwent content and face validation, as well as pilot testing, to ensure validity and reliability.

Subsequently, formal permission to conduct the study was sought from the school principal of the locale of the study. Parental consent and student assent were obtained, with both parties being thoroughly informed about the study's objectives, procedures, risks, and benefits, thereby upholding ethical standards for research involving minors.

Following the acquisition of consent and assent, all participating students completed a pre-assessment on integer addition and subtraction to establish baseline proficiency and facilitate equitable group assignment. The resulting scores were used to ensure normality and homogeneity in the groupings, after which participants were assigned to either the experimental or control group using pair-matching randomization.

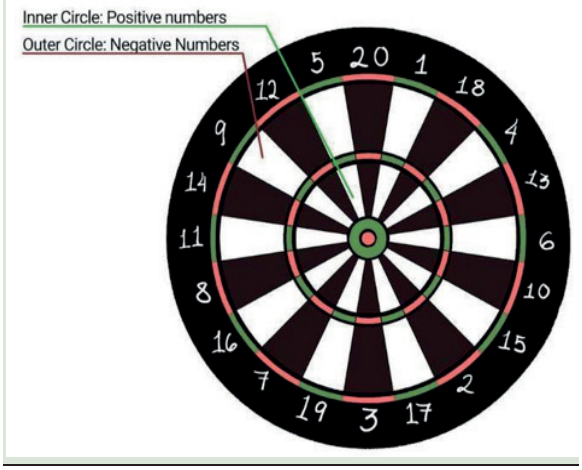
The experimental group then participated in modified dart game sessions for four weeks, with each session lasting 15 minutes and being conducted during lunch breaks or after school. The researchers modified the traditional game of darts to create a kinesthetic learning tool specifically designed to strengthen students' proficiency in integer operations, specifically addition and subtraction. Starting with a base score of 101, the objective is to achieve the lowest score within a 15-minute limit. The primary innovation involves a reconfiguration of the dartboard's scoring zones: while the bull's-eye remains constant, the positive and negative values and the traditional triple and double rings are replaced with positive and negative single rings to emphasize the movement between integers. By requiring players to physically interact with the board to calculate their totals, the game transforms abstract mathematical concepts into a tactile, interactive experience that enhances both cognitive understanding and arithmetic accuracy.

The modified darts game (Figure 2) serves as the kinesthetic and game-based intervention. The game incorporates integer concepts by assigning negative values to certain board segments and adapting scoring rules to require both addition and subtraction. The objective is to physically and cognitively engage students in practicing integer operations within a competitive, time-bound setting.

After the intervention period, both groups completed a parallel post-assessment. All assessment scores were collected, organized, and subjected to statistical analysis to evaluate the effectiveness of the intervention.

Figure 2

Modified Darts Board – Inner and Outer Single Rings



Treatment of Data

In order to identify the proficiency of the Grade 8 students in solving addition and subtraction of integers, the frequency and percentage were calculated using data from the control and experimental groups' pre-assessment and post-assessment scores. This enabled a comparison between the performance of the two groups before and after the intervention, allowing for an evaluation of the effectiveness of the approach in enhancing the students' mastery of integer operations. The level of proficiency was interpreted based on the following scale:

Level of Proficiency	Percentage (%)
Advanced	90 and above
Proficient	85-90
Approaching Proficiency	80-84
Developing	75-79
Beginning	74 and below

To evaluate the effectiveness of interventions aimed at improving students' proficiency in integer operations, a series of statistical analyses was conducted. A paired t-test was employed to compare the pre-assessment and post-assessment scores of participants within both the control and experimental groups. This test determined whether there was a statistically significant difference in students' proficiency before and after the intervention by assessing whether the mean difference between the two sets of related scores was zero.

In addition, an independent t-test was utilized to compare the mean scores between the control and experimental groups, both before and after the intervention. This analysis established whether there were significant differences in performance between the two independent groups, thereby providing evidence of the intervention's impact.

Finally, an item analysis was performed to identify specific areas where the experimental group showed the most and least improvement. The analysis used percentage calculations to determine the proficiency gains for each item, offering a detailed understanding of the intervention's effectiveness across different aspects of integer operations.

Declaration of AI Use and AI Tools Used

The researchers declare that the use of Artificial Intelligence (AI) tools in their study was strictly confined to the enhancement of the scholarly writing process. Notably, they employed Perplexity AI as their primary AI tool, which provided conversational answers to queries related to various aspects of their research. This tool also offered a list of academic and scholarly references, enabling the researchers to further verify the information and contributing significantly to the academic rigor of the study.

In addition to Perplexity AI, the researchers utilized Quillbot for grammar checking and paraphrasing, ensuring that the text was refined for clarity and coherence. Furthermore, they

turned to Grammarly to assist with grammar checking, as well as to improve the brevity, coherence, and cohesion of their paper. This use of Grammarly was particularly crucial when repackaging their work from a comprehensive research manuscript to fit the journal's article format.

The AI tools were employed solely to assist the researchers in locating relevant literature, establishing the academic integrity of their paper, and corroborating the results of the study. The results generated by the AI were meticulously double-checked, and all citations provided were verified to ensure the validity of the resources used. The AI tools were not used for generating data, creating fraudulent citations, or developing the study itself. The researchers remain committed to upholding the highest standards of research integrity throughout their work.

Results and Discussion

Pre-Assessment Level of Proficiency of the Control and Experimental Groups in Addition and Subtraction of Integers

Table 1 presents the pre-assessment performance of control and experimental groups on the addition and subtraction of integers. The data displays and compares the proficiency levels of both groups, and before the experimental group received a modified darts game. Pre-assessment scores provided a baseline measure of students' existing mathematical understanding, allowing researchers to determine the effectiveness of the modified darts game intervention by comparing pre- and post-intervention results.

The pre-assessment data for the control group revealed a marked disparity in proficiency levels regarding integer operations. The majority of students (14 out of 16, or 87.50%) were classified at the Beginning level, indicating a significant deficiency in foundational skills. Only one student (6.25%) achieved the Advanced level, and another student (6.25%) was categorized as Proficient or Approaching Proficiency. Notably, there were no students in the Developing or Proficient intermediate categories, suggesting a bimodal distribution with most students clustered at the lowest proficiency and a single outlier at the highest level.

Table 1

Level of Proficiency of the Control Group in Their Pre-Assessment

Level of Proficiency	Frequency	Percentage (%)
Advanced	1	6.25
Proficient	0	0
Approaching Proficiency	1	6.25
Developing	0	0
Beginning	14	87.50
Mean Percentage Score		20.25 (Beginning)

This distribution underscores a pronounced gap in foundational knowledge and skills related to the addition and subtraction of integers within the control group. The absence of students in the intermediate proficiency levels is particularly significant, highlighting a lack of gradual skill progression and suggesting that targeted interventions are necessary to address these foundational gaps.

Table 2 presents the pre-assessment proficiency levels of the experimental group, revealing that 62.50% of students were at the Beginning level, indicating substantial foundational skill gaps. Notably, 18.75% of students were categorized as Advanced and another 18.75% as Developing, while no students were classified as Proficient or Approaching Proficiency. This distribution underscores the need for targeted interventions to address foundational deficiencies. Although the experimental group included students at higher proficiency levels compared to the control group, homogeneity and normality tests indicated no statistically significant difference in the distribution of proficiency levels between the two groups. Levene's Test was conducted, which resulted in a p-value of 0.1063; the Shapiro-Wilk Test was conducted and gave a p-value of 0.3581 and 0.0920 for the control and experimental groups, respectively. This suggests that both groups were both normal and were relatively homogeneous in terms of pre-existing mathematical skills.

Table 3 presents an analysis of the difference in proficiency levels between the control and experimental groups in their pre-assessment scores.

Table 2

Level of Proficiency of the Experimental Group in Their Pre-Assessment

Level of Proficiency	Frequency	Percentage (%)
Advanced	3	18.75
Proficient	0	0
Approaching Proficiency	0	0
Developing	3	18.75
Beginning	10	62.50
Mean Percentage Score		20.25 (Beginning)

The control group achieved a mean score of 20.25, slightly higher than the experimental group, which scored 20.00. However, the t-value of 0.1119 and the p-value of 0.9118 indicate that this difference is not statistically significant. This suggests that both groups were relatively similar in their baseline proficiency levels before any interventions were applied.

The lack of a significant difference in pre-assessment scores is an important finding that lays the groundwork for evaluating the effectiveness of any subsequent instructional methods or treatments implemented for the experimental group. It implies that any observed changes in proficiency after the intervention can be more confidently attributed to the intervention itself, rather than pre-existing disparities between groups.

The baseline equivalence of low proficiency levels and computational difficulties in integer operations across both the experimental and control groups is heavily corroborated by prior research. This regional deficit is underscored by the Schools Division of Benguet, where baseline data established integer deficiency as a primary barrier to foundational mathematical literacy among Grade 8 learners (Alunes et al., 2019). This localized vulnerability is further validated by national metrics indicating that an overwhelming 73.97% of junior high school students perform strictly within the "Beginning" mastery tier when executing basic integer arithmetic (Abdon, 2025).

Post-Assessment Level of Proficiency of Control and Experimental Groups in Addition and Subtraction of Integers

This section discusses the level of proficiency of the control and experimental groups in their post-assessment on addition and subtraction of integers. The data presents the difference in performance after the implementation of the modified darts game as a learning tool for the experimental group, while the control group continued with their usual lifestyle activities. The proficiency levels were determined based on the students' post-assessment scores.

Table 4 shows the level of proficiency of the control group after the post-assessment on addition and subtraction of integers. The results indicate that the majority of the students, 87.50%, remained at the Beginning level. Only one student managed to reach the Proficient level, as with the Advanced level. None of the students were categorized under the Approaching Proficiency or Developing levels. These findings illustrate limited improvement in the control group's performance. Most students did not pass beyond the Beginning level despite undergoing the same lesson duration as the experimental group. Only a small number of students reached higher proficiency levels, which shows that traditional teaching alone may not be enough to enhance

Table 3

Difference in the Level of Proficiency of the Control and Experimental Group in Their Pre-Assessment

	MEAN SCORE			
	Control Group	Experimental Group	t-value	p-value
Pre-assessment	20.25	20.00	0.1119^{ns}	0.9118

Note *Legend*
ns *no significant difference*
* *with significant difference*
** *with high significant difference*

student understanding of integer operations. This lack of improvement explains the need for more effective instructional strategies to help learners understand the basic arithmetic concepts.

Table 4

Level of Proficiency of the Control Group in Their Post-Assessment

Level of Proficiency	Frequency	Percentage (%)
Advanced	1	6.25
Proficient	1	6.25
Approaching Proficiency	0	0
Developing	0	0
Beginning	14	87.50
Mean Percentage Score		18.44 (Beginning)

The figures in Table 5 present the level of proficiency of the experimental group in their post-assessment. The result shows an improvement compared to the control group, with 31.25% of the students under the Advanced level and 12.50% achieving Proficient. Additionally, 6.25% were classified at Approaching Proficiency, 12.50% at Developing, and 37.50% at the Beginning level. This suggests that the modified darts game served as an effective strategy in enhancing the students' arithmetic skills, as a higher percentage of students achieved beyond the Beginning level compared to the control group.

These results align with the findings of Calimodag (2018), where a notable increase in student performance was also observed after exposure to game-based interventions. Similarly,

Table 5

Level of Proficiency of the Experimental Group in Their Post-Assessment

Level of Proficiency	Frequency	Percentage (%)
Advanced	5	31.25
Proficient	2	12.50
Approaching Proficiency	1	6.25
Developing	2	12.50
Beginning	6	37.50
Mean Percentage Score		24.25 (Developing)

her work showed that structured strategies and reinforced practice can lead to significant academic growth, confirming that student performance improves when learning is paired with proper assessment.

Differences Between the Level of Proficiencies in Addition and Subtraction of Integers

This section discusses the differences between the levels of proficiency of the control and experimental groups in their pre-assessment and post-assessment, together with the difference between the levels of proficiency of the control and experimental groups in their post-assessment. The level of proficiency was based solely on their score before and after the implementation of the modified darts game.

Table 6 indicates that the control group's proficiency in basic arithmetic showed a marginal, statistically insignificant decline from a mean pre-test score of 20.25 to a post-test mean of 18.44

Table 6

Difference in the Level of Proficiency of the Control and Experimental Groups in Their Pre-Assessment and Post-Assessment

	MEAN SCORE			
	Pre-assessment	Post-assessment	t-value	p-value
Control Group	20.25	18.44	1.7012^{ns}	0.1095
Experimental Group	20.00	24.25	4.4289^{**}	0.0005

Note *Legend*
ns *no significant difference*
* *with significant difference*
** *with high significant difference*

(t=1.7012, p=0.1095). This suggests that, in the absence of intervention, students' performance remained relatively stable, with observed changes likely attributable to random fluctuation rather than any systematic effect.

These findings are consistent with the Law of Practice, a principle in cognitive psychology and skill acquisition, which posits that repeated, deliberate practice leads to improved performance through mechanisms such as neural strengthening, cognitive chunking, and optimized practice schedules (Newell & Rosenbloom, 1993; Roediger & Karpicke, 2006). Specifically, consistent and structured practice in arithmetic enhances memory retention and fluency, facilitating more automatic and efficient recall of mathematical facts. Spaced repetition and adaptive, game-based learning environments further support long-term retention and motivation (Kaufmann & Aster, 2012; Chacko et al., 2013).

Thus, the Law of Practice provides a robust framework for understanding the mechanisms underlying skill acquisition and retention in mathematics, highlighting the importance of repeated, deliberate practice for foundational arithmetic proficiency.

Furthermore, the results demonstrate a statistically significant improvement in the proficiency levels of the experimental group, as evidenced by a paired t-test analysis of pre- and post-assessment scores. The mean score increased from 20 to 24.25 following the intervention, and a lower p-value (0.0005) indicates that this gain is unlikely to be due to chance. These findings support the hypothesis that the implementation of the modified darts game had a positive and significant effect on students' proficiency in basic integer operations.

The study thus affirms the studies of Andayani and Hasanah (2022) and Dondio et al. (2023) highlighting the effectiveness of game-based learning approaches. The modified darts game was able to enhance the skills of grade 8 learners in adding and subtracting integers within just a short timeframe. The robust results suggest potential for broader application of similar gamified interventions in other educational contexts. Furthermore, the findings encourage future research to investigate long-term impacts and possible refinements to maximize educational benefits. Overall, the evidence supports the integration of gamification strategies as engaging and effective tools for skill development in educational settings. However, replication of this study with a larger sample size and varied locations can further validate its results.

The study investigated the effectiveness of a modified darts game as an intervention to enhance proficiency in integer operations among Grade 8 students. Post-assessment results revealed that the experimental group (Table 7), which participated in the game-based intervention, achieved a significantly higher mean score (24.25) compared to the control group (18.44). Statistical analysis using an independent t-test confirmed the significance of this difference (p=0.0072), validating the hypothesis that the intervention led to improved mathematical proficiency.

These findings are in contrast to Calimodag (2018), whose research showed no significant difference in math performance between groups exposed to traditional lecture methods and those exposed to lectures infused with games. However, the current results align with Martus et al. (2024), who demonstrated that integrating DaMath, a game-based learning strategy, significantly improved students' performance in integer-related activities. Similarly, Wiseheart et al. (2019) found

Table 7

Difference in the Level of Proficiency of the Control and Experimental Group in Their Post-Assessment

	MEAN SCORE			
	Control Group	Experimental Group	t-value	p-value
Pre-assessment	18.44	24.25	2.8839**	0.0072

Note *Legend*
ns *no significant difference*
* *with significant difference*
** *with high significant difference*

that spaced, repeated practice through game-based interventions led to superior outcomes in mathematical skills.

The present study's use of a modified darts game, combined with spaced repetition, supports the growing body of evidence that interactive and structured game-based activities foster engagement and mastery of mathematical concepts. The intervention not only improved proficiency but also highlighted the potential of such strategies for broader educational applications. The results underscore the importance of incorporating engaging, hands-on learning experiences to address persistent challenges in mathematics education and suggest that further research could optimize and expand the use of such interventions across different contexts and populations.

Basic Arithmetic Skills Improvement of the Experimental Group in the Addition and Subtraction of Integers

This section discusses which basic arithmetic skills in the experimental group improved the most and improved the least. It showcases the basic arithmetic skill, whether the operation used was addition or subtraction, and the number of digits (single or double) indicated in each item. The data gathered as presented was based on the conducted pre-assessment and post-assessment, showing the number of respondents with correct responses as well as their percentage in order to figure the percentage increase and ranking.

Table 8 presents a comparative analysis of Grade 8 respondents' performance in basic arithmetic operations, specifically addition and subtraction, before and after a targeted intervention. The table details the number and percentage of correct responses for each arithmetic skill, the difference between pre- and post-assessment results, the percentage increase in correct responses, and the corresponding rank, where rank 1 indicates the greatest improvement and rank 32 the least.

Analysis of the data revealed that the most significant improvement occurred in the skill of subtracting a negative single-digit integer from a positive single-digit integer. Initially, only 6 out of 16 respondents answered this item correctly in the pre-assessment. The struggle of high school students with subtracting a negative single-digit integer from a positive number can be attributed to significant cognitive confusion. This issue arises because the operation requires them to navigate multiple meanings of the minus sign, which contradicts their long-held belief that subtraction always results in a smaller number (Bofferding, 2010; Khalid & Embong, 2019; Makonye & Fakude, 2016; Vlassis, 2004). Following the intervention, all 16 respondents answered correctly, reflecting a 62.50% increase and ranking this skill as the most improved (rank 1). Observational data suggest that the intervention effectively reinforced the rule that subtracting a negative integer from a positive integer is equivalent to addition, a concept frequently practiced during the intervention activities.

Conversely, the skill with the least improvement was subtracting a positive double-digit integer from a positive single-digit integer. Thirteen (13) respondents answered this item correctly in the pre-assessment, but only 10 did so post-intervention, indicating a decrease of 18.75% and ranking this skill lowest (rank 32). The decline in performance was attributed to the infrequent application of this specific operation during the intervention and common errors, such as omitting the negative sign in the answer.

These findings suggest that the intervention was most effective for arithmetic skills that were directly and frequently practiced during the activities, while skills less emphasized saw little to no improvement or even regression. The results underscore the importance of targeted and comprehensive practice in developing proficiency across all basic arithmetic operations.

Table 9 highlights the effect sizes in the increase of correct responses for basic arithmetic skills in addition and subtraction. The results indicate a notable contrast between the two operations.

In addition, the mean score rose significantly from 11.25 to 13.69, achieving a t-value of -5.4540 and a p-value of 0.000 07, resulting in a Cohen's effect size of 1.36, classified as a large effect. This suggests that students made considerable gains in their addition skills, exhibiting a consistent improvement across all items assessed. Showing that the modified darts game is very effective in improving the proficiency of students.

Table 8

Percentage Increase of the Number of Respondents with Correct Responses in the Basic Arithmetic Skills in Addition and Subtraction of Integers

Basic Arithmetic Skill	No. of Respondents with Correct Responses		Difference of Pre- and Post-Assessment	Percentage Increase (%)	Rank
	Pre-Assessment	Post-Assessment			
ADDITION					
1. Positive Single Digit to a Positive Single Digit	14	16	2	12.50	19
2. Positive Single Digit to a Positive Double Digit	15	16	1	6.25	22.5
3. Positive Double Digit to a Positive Single Digit	15	16	1	6.25	22.5
4. Positive Double Digit to a Positive Double Digit	15	16	1	6.25	22.5
5. Positive Single Digit to a Negative Single Digit	10	15	5	31.25	8
6. Positive Single Digit to a Negative Double Digit	9	13	4	25.00	11.5
7. Positive Double Digit to a Negative Single Digit	11	13	2	12.50	19
8. Positive Double Digit to a Negative Double Digit	8	11	3	18.75	15
9. Negative Single Digit to a Positive Single Digit	12	15	3	18.75	15
10. Negative Single Digit to a Positive Double Digit	11	14	3	18.75	15
11. Negative Double Digit to a Positive Single Digit	13	13	0	0	26.5
12. Negative Double Digit to a Positive Double Digit	12	11	-1	-6.25	30
13. Negative Single Digit to a Negative Single Digit	10	12	2	12.50	19
14. Negative Single Digit to a Negative Double Digit	8	13	5	31.25	8
15. Negative Double Digit to a Negative Single Digit	8	13	5	31.25	8
16. Negative Double Digit to a Negative Double Digit	9	12	3	18.75	15
SUBTRACTION					
1. Positive Single Digit from a Positive Single Digit	14	13	-1	-6.25	30
2. Positive Double Digit from a Positive Single Digit	13	10	-3	-18.75	32

Table 8 *Continuation...*

Basic Arithmetic Skill	No. of Respondents with Correct Responses		Difference of Pre- and Post-Assessment	Percentage Increase (%)	Rank
	Pre-Assessment	Post-Assessment			
SUBTRACTION					
3. Positive Single Digit from a Positive Double Digit	14	14	0	0	26.5
4. Positive Double Digit from a Positive Double Digit	13	13	0	0	26.5
5. Negative Single Digit from a Positive Single Digit	6	16	10	62.50	1
6. Negative Double Digit from a Positive Single Digit	9	16	7	43.75	2.5
7. Negative Single Digit from a Positive Double Digit	8	14	6	37.50	4.5
8. Negative Double Digit from a Positive Double Digit	8	14	6	37.50	4.5
9. Positive Single Digit from a Negative Single Digit	6	9	3	18.75	15
10. Positive Double Digit from a Negative Single Digit	3	8	5	31.25	8
11. Positive Single Digit from a Negative Double Digit	5	9	4	25.00	11.5
12. Positive Double Digit from a Negative Double Digit	5	5	0	0	26.5
13. Negative Single Digit from a Negative Single Digit	4	9	5	31.25	8
14. Negative Double Digit from a Negative Single Digit	5	4	-1	-6.25	30
15. Negative Single Digit from a Negative Double Digit	4	11	7	43.75	2.5
16. Negative Double Digit from a Negative Double Digit	4	5	1	6.25	22.5

Table 9

Effect Size in the Increase of the Number of Respondents with Correct Responses in the Basic Arithmetic Skills in Addition and Subtraction of Integers

	MEAN SCORE				
	Pre-assessment	Post-assessment	t-value	p-value	Cohen's Effect Size
Addition	11.25	13.69	-5.4540	0.000 07	1.36
Subtraction	7.56	10.63	-3.2981	0.004 87	0.82

Range of Values	*Interpretation*
0.00 – 0.19	*trivial effect*
0.20 – 0.49	*small effect*
0.50 – 0.79	*medium effect*
0.80 and above	*large effect*

Conversely, under subtraction, the mean score increased from 7.56 to 10.63, with a t-value of -3.2981 and a p-value of 0.004 87, leading to a Cohen's effect size of 0.82, categorized as a large effect. While there was some improvement in subtraction, the effects were less consistent. As presented in Table 9, some items did not show an increase, and there was a troubling trend where the number of students providing correct answers decreased for certain subtraction problems in the post-test.

The implications of these findings suggest that while the modified darts game was very effective for addition, it may have translated less effectively for subtraction. The mixed results in subtraction underscore the need for more targeted strategies to address specific weaknesses in this area, especially since individual item performance varied significantly. This inconsistency can indicate gaps in understanding or application that require further attention. Thus, enhancing instruction in subtraction is essential to ensure comparable levels of mastery across both arithmetic operations.

Conclusions

The study established that both the control and experimental groups of Grade 8 students exhibited low proficiency in basic arithmetic, particularly in integer operations, at the outset, as indicated by pre-assessment results. This baseline assessment highlighted widespread deficiencies, which informed targeted instructional planning. Following the intervention, findings demonstrated that the modified darts game significantly enhanced arithmetic skills among students in the experimental group. Post-assessment scores revealed greater improvement and higher proficiency levels in the experimental group compared to the control group, supporting the effectiveness of game-based learning in fostering mathematical understanding, especially with integers.

Statistical analysis confirmed that the intervention led to significant gains in addition and subtraction proficiency for the experimental group, with a notable difference between their pre- and post-assessment scores. In contrast, the control group showed no significant change, suggesting that without structured and engaging practice, arithmetic skills may stagnate or decline. The post-assessment comparison further affirmed the intervention's positive impact, validating the hypothesis of a significant difference in proficiency between the groups.

Furthermore, the comparative analysis of the performance of Grade 8 respondents in basic arithmetic operations underscores the effectiveness of the modified darts game, particularly in the areas of addition and subtraction. The data indicate a greater improvement in addition skills, supported by a significant effect size. While there was also considerable advancement in subtraction abilities, culminating in complete mastery of subtracting negative single-digit integers, shortcomings were noted in other areas. Specifically, there was a decline in performance when subtracting positive double-digit integers. These results highlight the need for focused instructional strategies that reinforce fundamental concepts in subtraction. It is essential to adopt a comprehensive approach to teaching arithmetic skills to ensure that students achieve balanced proficiency across all operations.

Recommendations

In line with the conclusions of this study, several recommendations are provided for students, teachers, and future researchers. The study identified significant deficiencies in students' foundational arithmetic skills, particularly in integer operations, as shown by pre-assessment results from both groups. This highlights the need for a targeted instructional and/or intervention strategies and regular diagnostic assessments to personalize teaching and ensure timely interventions.

Post-test findings indicated that the modified darts game, led to substantial improvements in the experimental group's proficiency with integer operations. In contrast, the control group showed minimal progress, demonstrating the effectiveness of interactive, game-based learning approaches. It is highly recommended that the modified darts game be implemented more broadly, including in tutorial sessions, and replicated across different grade levels and larger sample sizes to validate its effectiveness. Further, continuous performance tracking through assessments is suggested to monitor the lasting impact of such interventions.

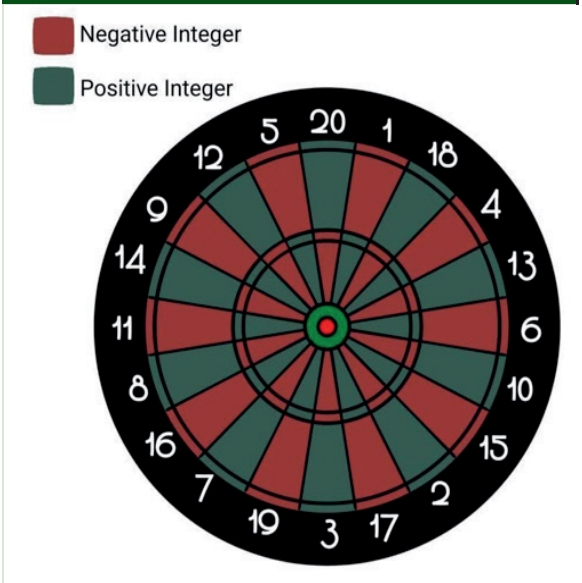
Analysis of specific skills showed the greatest improvement in subtracting a negative number from a positive number, indicating that continued practice in this area is beneficial. For skills with less improvement, the study recommends devising alternative strategies, such as rearranging number positions and applying negative signs after calculation, to aid in skill development.

To further optimize the intervention, the researchers propose additional modifications to the darts game (Figure 3), such as alternating positive and negative tiles on the board and introducing random variables (e.g., drawing cards for positive or negative signs) to ensure balanced skill development across all integer operations. The creation of a dedicated board and the use of these enhancements are recommended to maintain student engagement and focus on computational skills.

Overall, the findings advocate for the integration of innovative, game-based interventions like the modified darts game into mathematics instruction to address foundational gaps in arithmetic skills and support sustained proficiency in integer operations.

Figure 3

Recommended Modified Dart Board



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