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Board Games as Tools in Developing Student's Cognitive Engagement and Performance in Mastering Integers

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Index Terms:

gamification strategies, manipulative learning materials, number operations, learner participation, academic achievement, interactive instruction, learner-centered pedagogy, secondary mathematics education

Abstract. Mathematics plays a vital role in developing learners' critical thinking and problem-solving abilities. However, many students experience difficulties in mastering integer concepts using conventional instructional approaches. This study examined the effectiveness of gamified board game activities in improving learners' academic performance and cognitive engagement in mathematics, particularly in the topic of integers. A quantitative approach employing a quasi-experimental two-group pretest-posttest design was utilized. The participants were Grade 7 learners from Infanta National High School during the School Year 2025–2026. Data were collected using validated assessment and engagement instruments, while weighted mean and t-test analyses were used to evaluate the validity of the activities and determine differences between groups. Results showed that the developed gamified board game activities were rated valid in terms of clarity of instructions, alignment with learning competencies, lesson relevance, learner diversity, and activity variety. Pretest findings revealed no significant difference between the control and experimental groups, indicating comparable prior knowledge. Following the intervention, the experimental group obtained significantly higher posttest scores and demonstrated greater cognitive engagement in self-regulation, learning behavior, class participation, peer collaboration, and learning management. The findings indicate that gamified board game activities are effective instructional tools for enhancing mathematics achievement and learner engagement. These activities provide an interactive and learner-centered approach that promotes active participation and meaningful learning, making them a valuable strategy for mathematics instruction in secondary education.

Introduction

Mathematics plays a critical role in developing learners' problem-solving, reasoning, and decision-making skills that are essential for academic success and everyday life. However, mathematics achievement remains a persistent concern in the Philippines. Results from the 2018 Programme for International Student Assessment revealed that Filipino learners performed below the international average in mathematics, with only a small proportion demonstrating minimum proficiency in mathematical literacy. Similarly, National Achievement Test results have consistently indicated performance levels below the desired mastery standard. These findings underscore the need for innovative instructional approaches that can improve both learner achievement and engagement in mathematics.

In response to these challenges, the Department of Education implemented the Revised K to 10 Curriculum under the MATATAG Agenda, emphasizing the delivery of lessons that are meaningful, engaging, and responsive to learners' needs. Consequently, educators are encouraged to explore learner-centered instructional strategies that promote active participation and deeper understanding of mathematical concepts.

One instructional approach that has gained increasing attention is gamification, which integrates game elements into learning activities to enhance motivation, engagement, and academic performance. Previous studies have reported that gamified learning environments encourage active participation and improve learning outcomes. Educational board games, in particular, have been found to promote collaboration, critical thinking, and concept mastery while creating enjoyable learning experiences. Gasteiger and Moeller (2021), for example, reported improvements in learners' numerical skills

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following participation in board-game-based interventions. Similarly, other studies have highlighted the potential of board games to foster cooperative learning and increase classroom engagement.

Despite these promising findings, existing research has primarily focused on general mathematics achievement or early numeracy skills. Limited evidence exists regarding the effectiveness of teacher-developed gamified board-game activities for teaching integers among Grade 7 learners within the Philippine secondary school context. Moreover, few studies have simultaneously examined learners' academic performance and cognitive engagement, including self-regulation, learning behavior, class participation, peer collaboration, and learning management. This gap limits the understanding of how gamified board games influence both learning outcomes and engagement processes.

Addressing this gap is important because improving mathematics achievement requires not only effective instructional materials but also strategies that sustain learner engagement. Guided by Self-Determination Theory, which emphasizes the roles of autonomy, competence, and relatedness in fostering motivation and learning, this study investigates how gamified board-game activities can support meaningful mathematics learning. The findings may provide educators with evidence-based instructional practices that align with the goals of the MATATAG Curriculum and contribute to improving mathematics education.

Specifically, this study sought to determine the validity of developed gamified board-game activities, compare the academic performance of learners exposed to gamified and traditional instruction, and examine the cognitive engagement of learners who participated in gamified board-game activities. The study addressed the following questions: (1) Are the developed board-game activities valid and suitable for classroom use? (2) Do learners exposed to gamified board-game activities demonstrate higher achievement in integers than those taught through traditional methods? (3) What level of cognitive engagement is exhibited by learners during participation in the gamified activities?

The remainder of this paper is organized as follows: the Methods section describes the research design, participants, instruments, and procedures; the Results section presents the findings; and the Discussion section interprets the results and their implications for mathematics instruction.

Methodology

Research Design

This study employed a quantitative research approach using a quasi-experimental two-group pretest–posttest design. This design was chosen because it is appropriate for determining the effect of an instructional intervention in a natural classroom setting where random assignment is not possible. According to Baker (2017), quasi-experimental research involves manipulation of an independent variable without random assignment, which makes it suitable for educational studies using intact classes. Peters (2022) further explained that a two-group pretest–posttest design allows comparison of the effects of an intervention by measuring participants before and after treatment in both an experimental and a control group.

In this study, the experimental group was exposed to gamified board game activities, while the control group was taught using the traditional instructional method. Both groups were given a pretest before the intervention and a posttest after the intervention to determine learning gains in Mathematics, specifically in integers.

Participants and Sampling Technique

The participants of the study were Grade 7 learners and teachers of Infanta National High School for the School Year 2025–2026. A total of 84 Grade 7 students participated in the study, with 42 students assigned to the experimental group and 42 students assigned to the control group. In addition, 16 teachers participated in the validation of the research instruments. The study used purposive sampling since intact classes were used and random assignment was not feasible. Participants were selected based on specific inclusion criteria, which included being officially enrolled Grade 7 students taking Mathematics (Integers) and having parental consent to participate in the study. Students who were frequently absent during the intervention period were excluded from the final analysis to ensure the reliability of the results.

Research Instruments

This study utilized three main research instruments to gather the necessary data. The first instrument was a researcher-made 40-item multiple-choice test on integers, which served as the pretest and posttest. A Table of Specifications was developed to ensure that the test covered different cognitive levels and that the content was properly distributed according to the learning competencies.

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The second instrument was a Likert-scale questionnaire used to determine the validity of the gamified board game activities. It assessed aspects such as clarity of instructions, alignment with learning competencies, relevance to lessons, learner diversity, and variety of activities.

The third instrument was another Likert-scale questionnaire designed to measure the learners' cognitive engagement during the use of board game activities in learning integers. All questionnaires used a 5-point rating scale.

All instruments were reviewed and validated by the researcher's adviser, panel members, and subject matter experts, particularly Master Teachers. A pilot testing was also conducted in a Grade 7 section that was not part of the actual study to determine reliability. The reliability of the achievement test was measured using KR-20, while McDonald's Omega was used for the Likert-scale instruments. Based on the pilot test results and expert feedback, revisions were made before final implementation.

Data Gathering Procedure

Before the actual data collection, the researcher secured permission from the Schools Division Superintendent and the school principal of Infanta National High School. After approval, parental consent forms were distributed to ensure voluntary participation of learners. The researcher also coordinated with class advisers to facilitate proper scheduling of the study.

The pretest was first administered to both the experimental and control groups. After the pretest, the experimental group was exposed to the gamified board game intervention for a specified period, while the control group was taught using the traditional instructional method. After the intervention, a posttest was administered to both groups to measure learning gains.

Following the posttest, Likert-scale questionnaires were distributed to assess the validity of the board game activities and the cognitive engagement of learners. All collected data were checked, recorded, and encoded before being submitted for statistical analysis.

Data Analysis

The data collected in this study were analyzed using IBM SPSS Statistics version 27. Descriptive statistics such as mean, weighted mean, standard deviation, and mean percentage score were used to describe the level of performance, validity, and cognitive engagement of the respondents. Inferential statistics, specifically the independent samples t-test, were used to determine whether there was a significant difference between the performance of the experimental and control groups. The level of significance was set at 0.05 alpha level ($p < 0.05$), which means that results with a probability value less than 0.05 were considered statistically significant.

Ethical Considerations

Ethical standards were strictly observed throughout the conduct of the study. Approval was obtained from the appropriate school authorities prior to data collection. Informed consent from parents and assent from learners were secured to ensure voluntary participation. The confidentiality of the respondents' data was maintained, and all information gathered was used solely for research purposes. The study ensured that no harm or disadvantage was caused to the participants during the intervention.

Results and Discussion

Validity of the developed Gamified Board Game Activities

Indicators	Teacher			Students			Average		
	WM	VI	Rank	WM	VI	Rank	WM	VI	Rank
1. Clarity of instruction	4.59	Highly Valid	4	4.43	Valid	4	4.51	Highly Valid	4
2. Alignment to the curriculum	4.80	Highly Valid	1	4.47	Valid	2	4.64	Highly Valid	1
3. Relevance to lesson	4.73	Highly Valid	2	4.41	Valid	5	4.57	Highly Valid	2

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4.	Diversity of learners	4.21	Valid	5	4.46	Valid	3	4.34	Valid	5
5.	Variety of Activities	4.63	Highly Valid	3	4.49	Valid	1	4.56	Highly Valid	3
	Average	4.59	Highly Valid		4.45	Valid		4.52	Highly Valid	

Table 1. Level of validity of the developed gamified activities through board games as assessed by teachers and learners.

The developed gamified board game activities obtained an overall validity rating of 4.52, interpreted as Highly Valid. Among the indicators, Alignment with the Curriculum obtained the highest mean (WM = 4.64), followed by Relevance to the Lesson (WM = 4.57), Variety of Activities (WM = 4.56), Clarity of Instruction (WM = 4.51), and Diversity of Learners (WM = 4.34). These findings indicate that the developed board games were generally perceived as appropriate, relevant, and aligned with the intended learning competencies in mathematics. The highest rating for curriculum alignment suggests that the activities successfully supported the competencies and learning outcomes prescribed in the Grade 7 Mathematics curriculum. Likewise, the high ratings for relevance and variety indicate that the board games provided meaningful and engaging learning experiences for learners.

The findings support Horn et al. (2017), who emphasized that board games can serve as effective learning environments when their mechanics and objectives are aligned with instructional goals. Similarly, Fraser and Ling (2015) and Lee and McWilliam (2018) highlighted the importance of clear rules and instructional structure in ensuring meaningful learning experiences during gameplay. The positive ratings also reinforce the assertion of Bayeck (2020) that board games can function as effective instructional tools across different subject areas, including mathematics.

However, Diversity of Learners received the lowest rating among the indicators. This suggests that while the developed activities were generally effective, additional modifications may be necessary to accommodate learners with varying abilities, learning styles, and educational backgrounds. These results support the need for differentiated and inclusive game designs that can address the diverse needs of learners in contemporary classrooms.

Comparison of the Pretest of Experimental and Control Group before the Utilization of Gamified Activities using Board Games

Competency	**Control**			**Experimental**		
	Mean	**Std. Deviation**	**VI**	**Mean**	**Std. Deviation**	**VI**
1. Add integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	2.095	1.303	Fairly Satisfactory	1.762	0.958	Fairly Satisfactory
2. Subtract integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	2.476	1.215	Satisfactory	2.357	1.078	Fairly Satisfactory
3. Multiply integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	2.833	1.447	Fairly Satisfactory	2.571	1.346	Fairly Satisfactory
4. Divide integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	3.000	1.577	Fairly Satisfactory	2.619	1.306	Fairly Satisfactory

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5.	Simplify numerical expressions involving integers using number properties and the order of operations (GEMDAS).	4.476	1.612	Fairly Satisfactory	3.929	1.351	Fairly Satisfactory
Overall		**14.881**	**4.895**	**Fairly Satisfactory**	**13.238**	**3.267**	**Fairly Satisfactory**

Table 2. Pretest scores of the experimental and control groups before the utilization of gamified activities through board games

Prior to the implementation of the gamified board game activities, the control group obtained a mean score of 14.88 ± 4.90, while the experimental group recorded a mean score of 13.24 ± 3.27. Both groups were interpreted as Fairly Satisfactory. These results suggest that learners from both groups possessed comparable levels of prior knowledge regarding integer operations before the intervention. The relatively low scores indicate that learners experienced difficulties in competencies involving addition, subtraction, multiplication, division of integers, and simplification of numerical expressions using GEMDAS. Such findings highlight the need for innovative instructional approaches that can improve conceptual understanding and mastery of mathematical skills. The findings are consistent with Berry (2019), Sung (2015), and Reyes (2016), who emphasized that pretests provide important baseline information regarding learners' prior knowledge and help establish equivalence between comparison groups before the implementation of an intervention.

Comparison of the Posttest of Experimental and Control Group after the Utilization of Gamified Activities using Board Games

Competency	**Control**			**Experimental**		
	Mean	**Std. Deviation**	**VI**	**Mean**	**Std. Deviation**	**VI**
1. Add integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	2.929	1.386	Satisfactory	4.429	1.467	Very Satisfactory
2. subtract integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	3.381	1.248	Satisfactory	3.167	1.738	Satisfactory
3. Multiply integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	3.929	1.659	Satisfactory	5.214	1.661	Satisfactory
4. Divide integers; using concrete models (e.g., counters, integer chips, board games), and with integers written as numerals.	3.667	1.692	Satisfactory	5.595	1.849	Very Satisfactory
5. Simplify numerical expressions involving integers using number properties and the order of operations (GEMDAS).	5.714	2.052	Satisfactory	8.429	2.481	Very Satisfactory
Overall	**19.619**	**6.152**	**Satisfactory**	**26.833**	**6.266**	**Very Satisfactory**

Table 3. Posttest scores of the experimental and control groups after the intervention.

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Following the intervention, the control group obtained a mean score of 19.62 ± 6.15, interpreted as Satisfactory, while the experimental group achieved a mean score of 26.83 ± 6.27, interpreted as Very Satisfactory.

These results suggest that both groups improved after instruction; however, learners exposed to the gamified board game activities demonstrated substantially higher achievement than those who received traditional instruction. The greatest gains were observed in competencies involving division of integers and simplification of numerical expressions using GEMDAS, indicating that the board games effectively supported learners' understanding of more complex mathematical procedures.

The findings support previous studies demonstrating the positive effects of gamification and board-game-based learning on academic achievement. Chen and Wang (2021) reported that board games improved learners' motivation and mathematics performance, while Smith (2018) found that board-game activities enhanced mathematical thinking and problem-solving skills. Similarly, Bartolucci et al. (2019) concluded that board games can strengthen analytical thinking and cognitive development.

From the perspective of Self-Determination Theory, the findings suggest that the board games may have increased learners' sense of competence, autonomy, and relatedness, thereby promoting greater motivation and academic performance.

Significant Difference on the Pretest Scores of Experimental and Control Group

Test	Group	N	Mean	Std. Deviation	SE	t-value	p-value	Decision	Interpretation
Pretest	Control	42.000	14.881	4.895	0.755	1.809	0.075	Failed to Reject Ho	Not Significant
	Experimental	42.000	13.238	3.267	0.504				

Table 4. Significant difference on the pretest scores of experimental and control groups

The independent samples t-test revealed no significant difference between the pretest scores of the experimental and control groups ($t = 1.809$, $p = .075$).
The absence of a significant difference indicates that both groups were statistically comparable prior to the intervention. This finding strengthens the internal validity of the study because it suggests that any differences observed during the posttest phase were unlikely to be caused by pre-existing differences in achievement.
The result agrees with Sanchez et al. (2025), who likewise reported comparable pretest performances between learners exposed to gamified instruction and those receiving traditional instruction.

Significant Difference on the Posttest Scores of Experimental and Control Group

Test	Group	N	Mean	Std. Deviation	SE	t-value	p-value	Decision	Interpretation
Posttest	Control	42.000	19.619	6.152	0.949	5.295	<0.001	Reject Ho	Significant
	Experimental	42.000	26.810	6.291	0.971				

Table 5. Significant difference on the posttest scores of experimental and control groups

Results revealed a statistically significant difference between the posttest scores of the experimental and control groups ($t = 5.295$, $p < .001$). The experimental group outperformed the control group by approximately seven points.
These findings suggest that the gamified board game activities significantly improved learners' mathematics achievement. The board games provided opportunities for active participation, collaborative learning, immediate feedback, and repeated practice, which may have contributed to improved learning outcomes.

The findings corroborate those of Viray (2016), who found significantly higher academic performance among learners exposed to board-game-based instruction. They also support the conclusions of Hilario et al. (2025) and Erşen and Ergül (2022), who reported that game-based learning enhances motivation, engagement, and understanding of mathematical concepts.

The results provide empirical support for integrating gamified instructional materials into mathematics classrooms to address persistent difficulties in learning fundamental mathematical skills.

Level of Engagement of Learners using Gamified Activities through Board Games

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Indicators	Weighted Mean	Verbal Interpretation	Rank
Self-regulation	3.98	Engaged	5
Learning Behavior	4.17	Engaged	2.5
Class Participation	4.19	Engaged	1
Peer Collaboration	4.05	Engaged	4
Learning Management	4.17	Engaged	2.5
Average	**4.11**	**Engaged**	

Table 6. Level of engagement of learners using gamified activities through board games

The overall level of learner engagement was 4.11, interpreted as Engaged. Among the indicators, Class Participation obtained the highest rating (WM = 4.19), followed by Learning Behavior (WM = 4.17), Learning Management (WM = 4.17), Peer Collaboration (WM = 4.05), and Self-Regulation (WM = 3.98).

These findings suggest that the board game activities successfully encouraged learners to actively participate in classroom learning. The high ratings for class participation and learning behavior indicate that learners were actively involved in discussions, problem-solving activities, and collaborative interactions while using the board games.

The findings support Fredricks (2019), who identified engagement as a multidimensional construct involving behavioral, cognitive, and emotional participation. Likewise, Greene (2018) emphasized that active cognitive engagement contributes directly to academic achievement. The positive ratings for peer collaboration further support the findings of Rogerson et al. (2018), who noted that board games promote cooperation, communication, and social interaction among learners.

The results demonstrate that gamified board games can serve not only as tools for improving academic performance but also as mechanisms for fostering meaningful learner engagement in mathematics classrooms.

Conclusion and Implications

Conclusion

This study investigated the effectiveness of gamified board game activities in enhancing students' academic performance and cognitive engagement in Mathematics, specifically in learning integers. Findings indicate that the developed board game activities were rated as highly valid by both teachers and learners in terms of clarity, alignment with learning competencies, relevance, diversity, and variety, suggesting strong instructional suitability for classroom implementation.
Baseline results showed that the experimental and control groups had comparable levels of performance prior to the intervention, indicating similar initial understanding. However, post-intervention results revealed that the experimental group significantly outperformed the control group, demonstrating higher learning gains following exposure to gamified instruction. Although both groups exhibited improvement, the magnitude of progress was greater in the experimental group, indicating that gamified board game activities were more effective than traditional instruction in improving mathematics achievement.

In addition, learners exposed to gamified instruction demonstrated higher cognitive engagement, reflected in increased participation, collaboration, self-regulation, and active learning behavior. These findings collectively suggest that structured gamified learning environments contribute to improved cognitive and behavioral learning outcomes in mathematics education.

Theoretical Implications

The findings of this study are consistent with Self-Determination Theory (SDT) proposed by Deci and Ryan (1985), which emphasizes the importance of autonomy, competence, and relatedness in fostering intrinsic motivation and effective learning. The improved academic performance and heightened cognitive engagement observed among students exposed to gamified board game activities suggest that these instructional strategies effectively satisfy the three basic psychological needs outlined in SDT.

Specifically, the interactive nature of board game activities promotes autonomy by allowing learners to make decisions and actively participate in their learning process. The structured challenges embedded within the games enhance learners' sense of competence as they receive immediate feedback and experience progressive mastery of mathematical concepts.

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Furthermore, the collaborative and competitive elements of the board games foster relatedness by encouraging peer interaction, cooperation, and social engagement within the classroom.

These findings extend SDT by providing empirical support for its application in non-digital gamified learning environments, particularly in mathematics education. The results suggest that board game-based instruction can serve as a practical pedagogical approach for operationalizing SDT principles in classroom settings. This contributes to existing literature by demonstrating that motivational enhancement through SDT can be achieved not only through digital gamification but also through structured analog game-based strategies.

Practical Implications

The findings have direct implications for classroom practice, school leadership, and curriculum implementation. For teachers, the integration of gamified board game activities offers a practical and effective strategy to enhance student engagement and improve achievement in challenging mathematical topics such as integers.

For school administrators, the results underscore the importance of supporting innovative pedagogical approaches through professional development, instructional resource provision, and collaborative platforms such as Learning Action Cell (LAC) sessions to encourage wider adoption of gamified strategies.

For curriculum designers and policymakers, the findings suggest that structured gamified activities may be incorporated into instructional frameworks to promote active learning, learner-centered instruction, and improved student motivation in mathematics education.

Limitations

The study is limited by its focus on Grade 7 learners from a single institution and its restriction to the topic of integers, which limits generalizability across grade levels and subject areas. Additionally, the use of intact classes and purposive sampling constrains external validity. The cognitive engagement measure was administered only after the intervention, limiting the ability to assess changes over time.

These limitations highlight opportunities for methodological refinement in future research, particularly in strengthening longitudinal measurement designs and expanding sampling frameworks.

Future Research Directions

Future studies may examine the long-term effects of gamified board game activities on conceptual understanding, retention, and transfer of mathematical knowledge beyond integers. Comparative research across multiple grade levels and subject domains is also recommended to assess the scalability of gamified instruction.

Additionally, future investigations may explore hybrid instructional models that integrate physical board games with digital gamification tools to determine relative effectiveness. Further research may also examine the relationship between gamified learning and affective variables such as mathematical anxiety, intrinsic motivation, and problem-solving proficiency using validated quantitative measures.

Large-scale multi-school studies are further recommended to enhance generalizability and validate the effectiveness of gamified instructional approaches across diverse educational contexts.

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Competing Interests Statement

The researchers disclosed a possible conflict of interest, as the study took place in the same school where they were students. To mitigate this, they carried out data collection, analysis, and interpretation impartially, free from personal bias or undue influence. Respondents' responses were kept confidential and used exclusively for academic research. Additionally, to maintain ethical integrity, the researchers sought ongoing guidance from their research adviser and strictly adhered to all institutional ethical guidelines.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Data are not publicly available to protect the confidentiality and privacy of the participants.

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Appendices

No appendices are attached to this study.

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