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Investigating the Effects of Mobada Game-Based Learning on Student Activeness in Elementary Mathematics: A Constructivist Perspective

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Abstract

This study investigates the effect of Mobada (Monopoly of Plane Figures) as a game-based learning medium on students' learning activeness in elementary mathematics classrooms. A quantitative pre-experimental approach with a one-group pretest–posttest design was employed, involving 38 fifth-grade students. Data were collected using a validated questionnaire that measured multiple dimensions of learning activity, including participation, attention, and collaboration. Statistical analysis using a paired-samples t-test revealed a significant improvement in students' activity after the intervention ($p < 0.05$). The findings were further strengthened by an extremely large effect size ($d = 2.74$), indicating substantial practical impact. These results suggest that integrating game-based learning creates an interactive, student-centered environment that effectively promotes behavioral engagement. However, the absence of a control group limits causal inference. This study contributes to the literature by positioning learning activeness as a primary outcome and highlighting the role of game-based instructional media in enhancing engagement in mathematics education.

INTRODUCTION

Mathematics learning at the elementary level continues to face persistent challenges, including low student engagement and limited participation during instructional activities. Empirical evidence indicates that classroom practices remain largely dominated by teacher-centered approaches, which limit students' opportunities to actively construct knowledge and engage in meaningful learning (Rehman et al., 2024; Sun & Xiao, 2023). As a result, students frequently demonstrate passive behaviors, minimal initiative, and limited interaction during mathematics lessons. This condition is particularly concerning because student engagement has been identified as a critical factor influencing both conceptual understanding and the development of higher-order thinking skills (Kong et al., 2003; Bray & Tangney, 2016). When students are not actively involved in questioning, discussing, and problem-solving, their ability to internalize mathematical concepts becomes limited. Consequently, low learning activeness not only reflects ineffective instructional practices but also indicates a broader misalignment between current classroom implementation and the demands of 21st-century education, which emphasize active participation and collaborative learning environments.

In response to these challenges, recent developments in instructional design have increasingly emphasized integrating interactive, student-centered approaches, particularly game-based learning (GBL). GBL has been widely recognized as an innovative pedagogical strategy that enhances student engagement by incorporating elements such as challenge, feedback, and social interaction (Erşen & Ergül, 2022; Deng et al., 2020). Studies have shown that game-based learning environments can foster active participation and improve learning engagement, especially when aligned with 21st-century learning principles (Untari, 2022; Ucus, 2015). Furthermore, integrating game mechanics with instructional strategies, such as flipped classrooms and experiential learning, has been shown to increase student interaction and engagement significantly (Tao et al., 2016; Eybers & Hattingh, 2018). These findings suggest that learning is more effective when students are actively involved in meaningful activities that combine cognitive, behavioral, and social dimensions. From a theoretical perspective, such approaches align with constructivist learning principles, which emphasize knowledge construction through interaction and experience (Guangbao & Timothy, 2021).

Despite the growing body of literature supporting game-based learning, a critical limitation remains in how its effectiveness is conceptualized and measured. Most existing studies predominantly focus on cognitive outcomes, such as academic achievement and conceptual understanding, while engagement-related constructs are often treated as secondary variables (Kriswandani & Kusuma, 2025). This tendency limits a deeper understanding of how instructional innovations influence the learning process itself, particularly regarding students' behavioral engagement and active participation. Moreover, although board game-based learning has demonstrated potential to enhance learning experiences, research specifically examining its impact on learning activity in elementary mathematics remains limited (Puspita & Amelia, 2025; Istikha et al., 2025). Existing studies tend to emphasize motivation, reasoning, or achievement rather than positioning learning activeness as a central construct (Almeida et al., 2019). Consequently, there is insufficient empirical evidence explaining how structured game-based interventions can systematically enhance students' active involvement in mathematics learning. This gap highlights the need for research that shifts the focus from outcome-oriented measures toward process-oriented dimensions of learning.

To address this gap, the present study introduces Mobada (Monopoly of Plane Figures) as a game-based learning medium designed to facilitate active participation in elementary mathematics classrooms. The use of board game media has been shown to create interactive learning environments that encourage collaboration, discussion, and problem-solving (Agustiya et al., 2017; Lew & Saville, 2021). In mathematics education, board games have also been found to support conceptual understanding by transforming abstract concepts into tangible learning experiences (Tsai & Chin, 2022; Jhang et al., 2025). Within this framework, Mobada integrates mathematical content into structured gameplay that promotes experiential and socially mediated learning processes. This approach aligns with constructivist and constructionist perspectives, which emphasize that meaningful learning occurs through active engagement and interaction (Rob & Rob, 2018). Unlike previous studies that primarily focus on learning outcomes, this research repositions learning activeness as a central indicator of instructional effectiveness, thereby offering both practical and conceptual contributions to the field of mathematics education.

Based on the identified problem and research gap, this study aims to examine the effect of Mobada, a game-based learning medium, on students' learning activity in elementary mathematics classrooms. Specifically, the study seeks to determine whether implementing Mobada leads to measurable improvements in students' participation, interaction, and engagement during the learning process. The research adopts a pre-experimental design, which is commonly used to assess changes before and after instructional interventions in educational contexts (Marsden & Torgerson, 2012; Widiastuti, 2024; Amro et al., 2026). The findings of this study are expected to provide empirical evidence regarding the role of game-based instructional media in fostering active learning environments and enhancing student engagement. In addition, this research is anticipated to contribute to the development of innovative, student-centered instructional strategies that align with contemporary educational demands, particularly to improve the quality of mathematics learning at the elementary level.

METHODS

This study employed a quantitative approach using a pre-experimental design to examine the effect of Mobada (Monopoly of Plane Figures) as a game-based learning medium on students' learning activeness. Specifically, a one-group pretest–posttest design was adopted to measure changes in students' activeness before and after the intervention. This design is widely used in educational research to evaluate intervention effects in natural classroom settings where randomization is not feasible (Ma et al., 2019; Purnomo et al., 2024). Although this design does not include a control group, it allows identification of within-subject changes and provides initial empirical evidence of the intervention's effectiveness. However, it is acknowledged that such designs are susceptible to internal validity threats, including regression toward the mean, and that these must be carefully considered when interpreting the results (Mee & Chua, 1991).

The participants consisted of 38 fifth-grade students from an elementary school, selected using a saturated sampling technique in which all members of the population were included as research subjects. This approach ensures that the sample accurately represents the classroom context and reduces sampling bias in small-scale educational studies. The independent variable in this study was the implementation of Mobada as a game-based instructional medium, while the dependent variable was students' learning activeness. The intervention design was grounded in prior studies demonstrating that game-based learning can enhance engagement, motivation, and learning outcomes in educational settings (Dabbous et al., 2023; Chang et al., 2024; Pranata, 2024).

Learning activeness was operationalized as a multidimensional construct encompassing behavioral and participatory aspects of student engagement. Data were collected using a structured Likert-scale questionnaire designed to measure four key indicators: participation in learning activities, verbal participation, attention and concentration, and collaboration in group work. The development of the instrument was informed by established frameworks for measuring student engagement, which emphasize the importance of capturing observable and behavioral dimensions of engagement (Gunuc & Kuzu, 2015; Lane & Harris, 2015). In addition, recent integrative reviews highlight that reliable measurement of engagement requires multidimensional instruments with clear construct definitions (Bijkerk et al., 2023). Therefore, the instrument in this study was designed to reflect these dimensions coherently and in a measurable manner.

To ensure measurement quality, the instrument underwent validity and reliability testing prior to implementation. Content validity was established through expert judgment, while construct validity was aligned with established theoretical frameworks of engagement measurement. Internal consistency reliability was assessed using Cronbach's alpha, a widely recognized indicator for evaluating the reliability of Likert-scale instruments (Louangrath & Sutanapong, 2018). These procedures ensured that the instrument met acceptable psychometric standards and was suitable for use in empirical research.

The data collection process involved multiple techniques, including questionnaires, classroom observations, and documentation, to enhance data triangulation and strengthen the credibility of findings. The research procedure consisted of three stages: preparation, implementation, and evaluation. During the preparation stage, research instruments were validated and administrative permissions were obtained. In the implementation stage, a pretest was administered to measure baseline learning activeness, followed by the application of Mobada in mathematics instruction through structured and interactive learning activities. Finally, a posttest was conducted to assess changes in students' learning activeness after the intervention.

Data analysis was conducted using both descriptive and inferential statistical techniques. Descriptive statistics were used to summarize the distribution of scores, and an inferential analysis was performed using a paired-samples t-test to determine whether there was a statistically significant difference between pretest and posttest results. The paired sample t-test is appropriate for analyzing dependent samples and evaluating changes within the same group over time (Mee & Chua, 1991). Prior to hypothesis testing, the normality assumption was examined to ensure the suitability of parametric analysis. In addition to statistical significance, effect size analysis was used to evaluate the practical impact of the intervention, as recent studies emphasize that effect size offers a more meaningful interpretation of educational interventions than p-values alone (Kraft, 2023).

Ethical considerations were strictly observed throughout the study. Participants' confidentiality and anonymity were maintained, and all data were used solely for academic purposes. Informed consent was obtained from relevant stakeholders, including school authorities and participants. These procedures ensured that the study adhered to ethical standards in educational research and respected the rights of all participants involved.

RESULT

Descriptive Statistics

This study involved 38 fifth-grade students, and the data analyzed comprised students' learning activity scores before (pretest) and after (posttest) the implementation of Mobada as a game-based learning medium. Descriptive statistics were employed to provide an initial overview of the data distribution and to identify patterns of change following the intervention.

Table 1. Paired Samples Statistics

Variable	Mean	N	Std. Deviation	Std. Error Mean
Pretest	55.2632	38	7.87979	1.27827
Posttest	78.1842	38	5.44682	0.88359

As shown in Table 1, the mean score for students' learning activeness increased markedly from 55.26 on the pretest to 78.18 on the posttest, indicating a substantial improvement following the intervention. The mean gain of 22.92 points reflects a significant shift in students' behavioral engagement during the learning process. Furthermore, the reduction in standard deviation from 7.88 to 5.45 indicates that students' scores became more homogeneous after the intervention, suggesting that the improvement was not limited to specific individuals but occurred consistently across participants. This pattern implies that Mobada contributed not only to increasing overall activity but also to reducing disparities in student participation, thereby promoting a more equitable learning environment.

Assumption Testing

Prior to conducting inferential analysis, a normality test was performed to ensure that the data met the assumptions required for parametric statistical testing. The Shapiro–Wilk test was employed because it is suitable for small sample sizes.

Table 2. Tests of Normality

Data	Kolmogorov-Smirnov Sig.	Shapiro-Wilk Sig.
Pretest	0.030	0.072
Posttest	0.037	0.080

As shown in Table 2. the Shapiro–Wilk significance values for the pretest (0.072) and posttest (0.080) exceed the 0.05 threshold, indicating that the data are normally distributed. Although the Kolmogorov–Smirnov values are below 0.05, the Shapiro–Wilk test is considered more robust for small samples and therefore serves as the primary basis for decision-making. The fulfillment of the normality assumption confirms that parametric analysis, specifically the paired sample t-test, is appropriate. This ensures that subsequent inferential results are statistically valid and reliable.

Hypothesis Testing

To determine whether the observed differences between pretest and posttest scores were statistically significant, a paired sample t-test was conducted.

Table 4.4 Paired Samples Test

Variable	Mean Difference	Std. Deviation	t	df	Sig. (2-tailed)
Pretest – Posttest	-22.92105	8.37106	-16.879	37	0.000

The results indicate a statistically significant difference between pretest and posttest scores ($p < 0.05$). The negative mean difference (-22.92) confirms that posttest scores were substantially higher than pretest scores. The large t-value (-16.879) indicates a strong statistical effect, suggesting that the increase in learning activeness was consistent across participants and unlikely to have occurred by chance.

Effect Size Analysis

To complement the inferential findings, an effect size analysis was conducted using Cohen's d to evaluate the practical significance of the intervention. Based on the mean difference (22.92) and the standard deviation of the difference scores (8.37), the calculated effect size was:

$$d = \frac{22.92105}{8.37106} \approx 2.74$$

The resulting value ($d = 2.74$) indicates an extremely large effect size, far exceeding the conventional threshold for a large effect ($d = 0.80$). This suggests that the implementation of Mobada had a substantial and meaningful impact on students' learning activity. The magnitude of this effect implies that the observed improvement is not only statistically significant but also highly relevant in practical educational contexts. In other words, the intervention was highly effective in promoting active participation and engagement among students.

Analytical Interpretation

Overall, the findings demonstrate that the implementation of Mobada as a game-based learning medium resulted in a significant and meaningful improvement in students' learning activeness. The convergence of evidence—including increased mean scores, reduced variability, statistically significant t-test results, and an exceptionally large effect size—provides strong empirical support for the intervention's effectiveness. Importantly, the large effect size indicates that the improvement extends beyond statistical significance and reflects a substantial transformation in students' engagement behavior. However, the magnitude of the effect should be interpreted with caution due to the use of a pre-experimental design without a control group, which may inflate the observed effect. Despite this limitation, the consistency of the results suggests that Mobada serves as a highly effective instructional medium for fostering active learning environments in elementary mathematics classrooms.

Visual Evidence Integration

The visual documentation presented in Figure 1 provides contextual support for the quantitative findings by illustrating how the Mobada intervention was enacted in the classroom setting. As depicted, students were actively involved in structured gameplay activities that required turn-taking, discussion, negotiation, and collaborative problem-solving. These observable interaction patterns reflect key indicators of behavioral engagement, including sustained attention, verbal participation, and peer collaboration. The alignment between these observed behaviors and the measured increase in learning activeness strengthens the validity of the findings by demonstrating that the statistical improvements are grounded in authentic classroom practices. In this sense, the visual evidence serves not merely as an illustration but as complementary empirical support, indicating that the increase in students' activity stemmed from meaningful participation in an interactive learning environment facilitated by the Mobada medium.

Figure 1. Visual design of the Mobada board, integrating plane geometry concepts into gameplay

Figure 2. Example of "Chance" card used in the Mobada game to facilitate interactive learning tasks

Figure 3. Sample question card used in Mobada to assess students' understanding of mathematical concepts

DISCUSSION

The findings of this study demonstrate that implementing Mobada as a game-based learning medium significantly improved students' learning activity in elementary mathematics classrooms. This conclusion is supported by multiple lines of evidence, including a substantial increase in mean scores, a statistically significant result from a paired-samples t-test, and an extremely large effect size ($d = 2.74$). The magnitude of this effect indicates that the intervention produced a meaningful transformation in students' behavioral engagement rather than a marginal improvement. In line with contemporary interpretations of educational effect sizes, such a large magnitude suggests strong practical significance, although it must be interpreted cautiously in non-controlled designs (Kraft, 2020; Pogrow, 2019). Similar patterns of substantial improvement have been reported in pre-experimental educational interventions, where changes observed within the same group reflect meaningful instructional impact despite design limitations.

From a theoretical perspective, these findings can be explained through constructivist learning theory, which emphasizes that knowledge is actively constructed through interaction, experience, and social negotiation. The Mobada intervention created an interactive environment where students engaged in gameplay, discussion, and collaborative problem-solving. Such conditions align with research indicating that constructivist learning environments significantly enhance student engagement and self-regulation (Banihashem et al., 2022). Furthermore, student engagement is not a single construct but a multidimensional phenomenon comprising cognitive, emotional, and behavioral components, influenced by classroom interaction dynamics (Yang et al., 2021). The observed increase in learning activeness in this study reflects the activation of these dimensions, suggesting that game-based learning environments can effectively integrate multiple aspects of engagement into the learning process.

The reduction in score variability observed in the posttest further indicates that the intervention contributed to more equitable participation among students. This finding is consistent with research showing that structured classroom practices and interactive learning strategies can sustain students' attention and promote consistent behavioral engagement across diverse learners (Lan et al., 2009). Active learning strategies, particularly those involving participation and dialogue, have been shown to significantly enhance student involvement and critical thinking (Oros, 2007; Precourt & Gainor, 2019). Therefore, the effectiveness of Mobada extends beyond improving average engagement levels and includes fostering a more inclusive learning environment in which a wider range of students actively participate.

The present findings are also consistent with a growing body of research demonstrating the effectiveness of game-based learning in enhancing student engagement and motivation. Studies have shown that both digital and non-digital game-based learning approaches can significantly improve student participation, interaction, and motivation in educational settings (Nadeem et al., 2023; Raharjo et al., 2024). Similarly, gamification strategies and game-based instructional designs have been found to positively influence academic engagement and learning performance (Khan et al., 2017; Ng & Lo, 2022). More recent studies also indicate that game-based environments enhance students' perceptions of participation and satisfaction, further reinforcing their engagement in learning activities (Cordero Valera et al., 2026). However, this study extends previous research by explicitly positioning learning activeness as the primary outcome, rather than treating engagement as a secondary effect of improved achievement.

Despite these contributions, several limitations must be acknowledged. First, the use of a pre-experimental design without a control group limits the ability to establish causal relationships, as external variables such as teacher influence or classroom dynamics may have contributed to the observed improvements. Second, the extremely large effect size, while indicative of strong impact, may be influenced by the design structure and sample characteristics, potentially inflating the observed magnitude. Third, the relatively small and context-specific sample limits the generalizability of the findings. These limitations are consistent with methodological concerns raised in prior pre-experimental studies, which highlight the need for cautious interpretation of results in the absence of controlled comparisons (Murta et al., 2021).

Future research should address these limitations by employing more rigorous research designs, such as quasi-experimental or randomized controlled trials, to strengthen causal inference. Additionally, further studies may explore the long-term sustainability of engagement improvements and examine the effects of game-based learning on other variables, such as motivation, conceptual understanding, and critical thinking skills. Integrating qualitative approaches, including classroom observations and interviews, may also provide deeper insights into the mechanisms through which game-based learning influences student engagement. Moreover, investigating the roles of teacher support and the quality of classroom interaction may further clarify how engagement is sustained across different instructional contexts (Alrajeh & Shindel, 2020; Machumu & Zhu, 2017).

Overall, this study provides strong empirical evidence that Mobada is an effective instructional medium for enhancing students' learning activeness in elementary mathematics. The combination of statistical significance, substantial practical impact, and theoretical alignment reinforces the importance of interactive, student-centered learning environments. More broadly, this study contributes to the literature by emphasizing that student engagement—particularly behavioral activeness—is a critical indicator of instructional effectiveness, thereby offering a more process-oriented perspective on learning outcomes in mathematics education.

CONCLUSIONS

This study provides robust evidence that implementing Mobada as a game-based learning medium substantially enhances students' learning activeness in elementary mathematics. The consistent improvement in scores, supported by statistically significant results and an exceptionally large effect size, indicates that the intervention yields not only statistical significance but also strong practical impact on students' behavioral engagement. Conceptually, the findings advance the literature by positioning learning activeness as a central outcome of instructional effectiveness, rather than a secondary consequence of achievement. The results underscore the value of interactive, game-based environments in fostering active, equitable, and participatory learning processes aligned with contemporary student-centered pedagogy. Nevertheless, the findings should be interpreted with caution due to the pre-experimental design and limited sample scope. Future research employing more rigorous experimental frameworks and broader populations is necessary to strengthen causal claims and generalizability. Overall, this study contributes to a process-oriented understanding of mathematics learning by demonstrating that well-designed game-based interventions can meaningfully transform student engagement in classroom contexts.

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