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Effects of Scratch Gamification with MDA on Students' Engagement and Learning Outcomes

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A B S T R A C T

This study aims to examine the effect of Scratch-based gamification using the MDA (Mechanics–Dynamics–Aesthetics) model on students' engagement and learning outcomes in primary education. A quasi-experimental method with a pretest–posttest design was applied to 115 students. Data were collected through tests and questionnaires and analyzed using paired sample t-tests and descriptive analysis. The results showed a significant improvement in learning outcomes, with a mean pretest score of 56.84 and posttest score of 71.03 ($t = -26.57$; $p < 0.001$). In addition, students' engagement was categorized as high (mean = 3.73). These findings indicate that Scratch-based gamification integrated with the MDA model is effective in improving learning quality.

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INTRODUCTION

The development of digital technology has brought significant changes to the field of education, particularly in creating more interactive and adaptive learning environments for primary school students. As part of the digital generation, learners today tend to be more interested in technology-based learning that is interactive and visual (Ahmed Dahri et al., 2025). However, in practice, learning in primary schools is still dominated by conventional and passive methods, resulting in low levels of student engagement in the learning process.

Student engagement is a crucial factor influencing learning success. Low levels of engagement are often caused by the lack of varied and engaging instructional methods that do not align with the characteristics of learners in the digital era (Balalle, 2024; Koutsikou & Antonopoulos, 2024). Furthermore, traditional learning approaches have not yet been able to provide interactive and personalized learning experiences, which are essential for 21st-century students (Blyznyuk et al., 2025).

As a solution, gamification has been widely applied to enhance students' motivation and engagement through the integration of game elements such as points, badges, and leaderboards. Research indicates that gamification can improve student participation, motivation, and learning outcomes (Ivanković et al., 2025). Moreover, meta-analytic studies have demonstrated that gamification has a positive impact on learning motivation across primary to secondary education levels (Kurnaz & Koçtürk, 2025).

In the context of programming education, the use of platforms such as Scratch combined with gamification has been proven effective in enhancing students' computational thinking, problem-solving skills, and conceptual understanding (Chen et al., 2024). Furthermore, the application of gamification in Scratch-based learning has been shown to yield better learning outcomes compared to conventional teaching methods (Prykhodchenko et al., 2020).

To ensure the effectiveness of gamification design, a systematic conceptual framework is required, one of which is the MDA (Mechanics–Dynamics–Aesthetics) model. This model divides game design into three main components: mechanics (rules and systems), dynamics (user interactions), and aesthetics (users' emotional experiences), all of which play a crucial role in enhancing student engagement and learning experiences (Ahmed Dahri et al., 2025).

Although research on gamification has developed rapidly, there is still a lack of studies that specifically integrate the MDA model into the development of Scratch-based learning applications at the primary school level. In addition, there is limited empirical research examining the combined effects of gamification elements such as scoring systems, levels, badges, and leaderboards on students' engagement and learning outcomes.

Therefore, this study aims to develop a Scratch-based quiz application using a gamification approach grounded in the MDA model and to examine its effects on students' engagement and learning outcomes in primary education. The research questions addressed in this study are as follows:

a. How does Scratch-based gamification affect students' engagement?
b. How does gamification affect students' learning outcomes?
c. How is the MDA model implemented in a Scratch-based gamification application?

LITERATURE REVIEW

The advancement of technology in education has led to the emergence of various instructional innovations aimed at enhancing student engagement and learning outcomes. One widely adopted approach is gamification, which involves the application of game elements in non-game contexts to increase user motivation and participation. Gamification operates by utilizing mechanisms such as points, badges, leaderboards, challenges, and feedback to create more engaging and interactive learning experiences. Theoretically, gamification provides clear goal orientation, immediate feedback, and reinforces positive learning behaviors among students (Krath et al., 2021).

In the educational context, numerous studies have demonstrated that gamification has a positive impact on students' motivation, engagement, and learning outcomes. Previous research employing similar methods, particularly within a metaverse-based learning context, has shown that the application of gamification can enhance digital literacy and student engagement (Sembiring, 2025). (Ivanković et al., 2025) explain that the integration of gamification elements in learning systems can increase active student participation and facilitate the understanding of complex material. This is further supported by longitudinal studies indicating that gamified learning leads to significant improvements in academic performance compared to traditional and online learning approaches (Lampropoulos & Sidiropoulos, 2024). Additionally, a meta-analysis by (Kurnaz & Koçtürk, 2025) reveals that gamification has a positive effect on learning motivation across various educational levels, including primary education.

Student engagement is a key factor in the success of the learning process. It encompasses cognitive, emotional, and behavioral aspects of students' participation in learning activities. Students with high levels of engagement tend to be more focused, active, and achieve better learning outcomes. However, maintaining student engagement in technology-based learning environments remains a challenge. (Balalle, 2024) emphasizes that student engagement is strongly influenced by the instructional methods used, particularly in digital settings. Therefore, approaches that foster active interaction and enjoyable learning experiences are essential. In this context, gamification has proven to be effective in enhancing engagement by incorporating elements of competition, challenge, and rewards that encourage continuous student participation (Lee & Su, 2023; Ruiz et al., 2024).

Furthermore, in the context of primary education, the use of technology-based learning media such as Scratch has become highly relevant. Scratch is a block-based visual programming platform designed to help students understand logical and programming concepts in a simple and interactive manner. Research indicates that the use of Scratch in learning can enhance computational thinking skills, including logical thinking, problem-solving, and creativity (Chen et al., 2024). The integration of gamification into Scratch-based learning further strengthens its effectiveness, as students not only learn concepts but also engage in enjoyable and challenging learning experiences. Studies by (Pérez-Jorge & Martínez-Murciano, 2022; Prykhodchenko et al., 2020) show that students who learn using gamified approaches in Scratch achieve higher learning outcomes compared to conventional methods.

Gamification approaches have also evolved by integrating elements of collaboration and project-based learning. A study by (Žufić et al., 2025) demonstrates that game-based learning activities such as "Classroom Escape" can enhance student engagement and problem-solving skills through team interaction and progressive task exploration. This indicates that gamification not only increases individual motivation but also supports collaborative learning.

In designing an effective gamification system, a systematic conceptual framework is required. One of the widely used models is the MDA (Mechanics–Dynamics–Aesthetics) model, which divides game design into three main components: mechanics (rules and systems), dynamics (user interactions), and aesthetics (emotional experiences). This model provides a comprehensive approach to designing gamified learning experiences that focus not only on features but also on user interaction and emotional engagement (Ahmed Dahri et al., 2025). In this study, mechanics are implemented through scoring systems, levels, badges, and leaderboards; dynamics through students' interactions with the system; and aesthetics through the enjoyable experiences perceived by students during gameplay.

Although numerous studies have demonstrated the effectiveness of gamification in enhancing student engagement and learning outcomes, there remains a lack of research that specifically integrates Scratch-based gamification with a systematic design approach such as the MDA model at the primary education level. Furthermore, there is still a need for empirical studies that examine how the combination of multiple gamification elements within a single learning application simultaneously influences students' engagement and learning outcomes.

Based on the above review, it can be concluded that Scratch-based gamification designed using the MDA model has the potential to enhance students' engagement and learning outcomes. Therefore, the hypotheses proposed in this study are as follows: (H1) Scratch-based gamification has a positive effect on students' learning outcomes, and (H2) Scratch-based gamification has a positive effect on students' engagement.

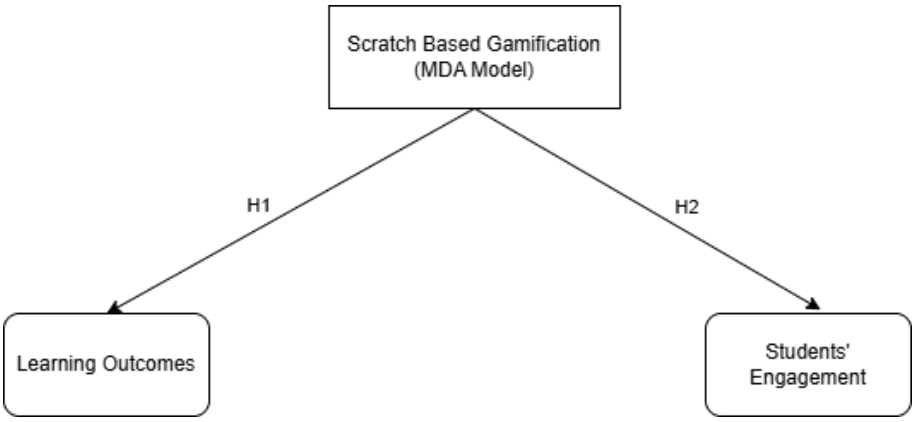

Figure 1. Conceptual Framework

METHODOLOGY

This study employs a quantitative approach with a quasi-experimental design supported by descriptive analysis to examine the effect of Scratch-based gamification on students' learning outcomes and engagement, as well as to describe the implementation of the MDA model in the developed application. The research design used is a pretest–posttest approach, which allows the measurement of students' initial and final abilities after the intervention (Chen et al., 2024).

The population of this study consists of all fifth-grade students at a private primary school, totaling 115 participants, all of whom were included as the research sample using a total sampling technique. This approach was employed to obtain a more comprehensive understanding of the implementation of gamification in a real learning context (Žufić et al., 2025).

The learning media used in this study is a Scratch-based quiz application developed by integrating gamification elements, such as a scoring system (+4 for correct answers and −1 for incorrect answers), levels, badges awarded every five levels, dynamic background changes, audio feedback, and a leaderboard. These elements represent commonly used components of gamification and have been proven effective in enhancing students' motivation and engagement (Khaldi et al., 2023).

The development of the application is based on the MDA (Mechanics–Dynamics–Aesthetics) model, where mechanics are implemented through scoring systems, levels, badges, and leaderboards; dynamics through students' interactions in answering questions and progressing through levels; and aesthetics through enjoyable and motivating learning experiences. This model is used to ensure that the gamification system not only functions technically but also provides meaningful learning experiences (Ahmed Dahri et al., 2025).

Data were collected using three instruments: pretest and posttest to measure students' learning outcomes, a Likert-scale questionnaire to assess students' engagement, and descriptive analysis to examine the implementation of the MDA model within the application. The use of questionnaires to measure engagement is supported by previous studies emphasizing the importance of cognitive, emotional, and behavioral aspects in student engagement (Balalle, 2024; Ruiz et al., 2024). The engagement questionnaire consisted of 15 items measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The instrument was designed to assess three dimensions of student engagement: cognitive, emotional, and behavioral engagement. Prior to data collection, the questionnaire was reviewed by two educational technology experts to ensure content validity. Furthermore, the reliability of the instrument was tested using Cronbach's Alpha, resulting in a coefficient of 0.87, indicating a high level of internal consistency.

The research procedure began with administering a pretest to the students, followed by the implementation of the Scratch-based gamification application in the learning process. After the intervention, students were given a posttest and asked to complete an engagement questionnaire. This procedure is consistent with previous experimental studies in gamification-based learning (Prykhodchenko et al., 2020).

Data analysis was conducted using Google Colab to process quantitative data. Pretest and posttest results were analyzed using a paired sample t-test to determine differences in learning outcomes before and after the intervention. Meanwhile, questionnaire data were analyzed descriptively to assess the level of student engagement. The implementation of the MDA model was also analyzed descriptively by mapping gamification elements into the components of mechanics, dynamics, and aesthetics.

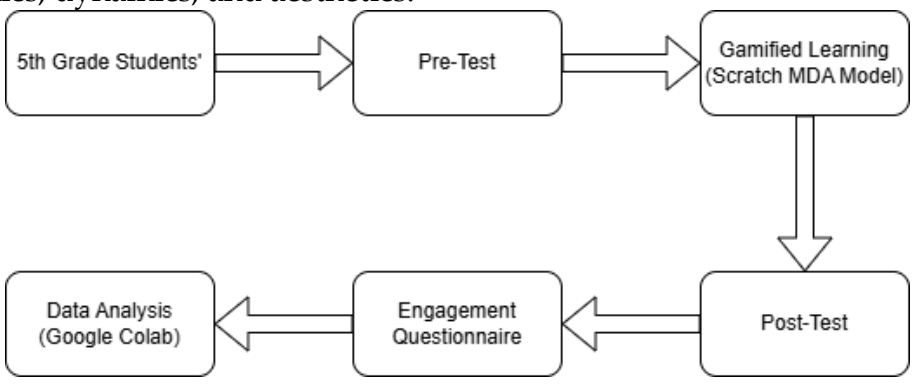

Figure 2. Methodology Flowchart

RESEARCH RESULT

The analysis of students' learning outcomes was conducted using descriptive and inferential statistics with the assistance of Google Colab.

Table 1. Results of the Paired Sample t-test for Pretest and Posttest

Variable	Mean Pre	Mean Post	Gain	t-value	p-value	Conclusion
Learning Outcomes	56.84	71.03	14.19	-26.57	<0.001	Significant

The results show that the mean pretest score was 56.84, while the mean posttest score increased to 71.03, indicating an improvement in students' performance after the implementation of Scratch-based gamification. The average gain score was 14.19, reflecting a positive increase in learning outcomes.

Prior to hypothesis testing, a normality test was conducted using the Shapiro–Wilk method. The results indicated that the pretest ($p = 0.00004$) and posttest ($p = 0.03885$) data were not normally distributed ($p < 0.05$). Although the results of the normality test indicated that the data were not normally distributed ($p < 0.05$), the paired sample t-test was still employed. This decision is justified by the relatively large sample size ($n = 115$), as the t-test is considered robust to violations of normality under the Central Limit Theorem. Therefore, the use of parametric testing in this study remains statistically appropriate. The results of the paired sample t-test revealed a significant difference between pretest and posttest scores ($t = -26.57$, $p < 0.001$). This indicates that the use of Scratch-based gamification has a significant effect on students' learning outcomes. Therefore, hypothesis H1 is accepted, meaning that gamification has a positive effect on students' learning outcomes.

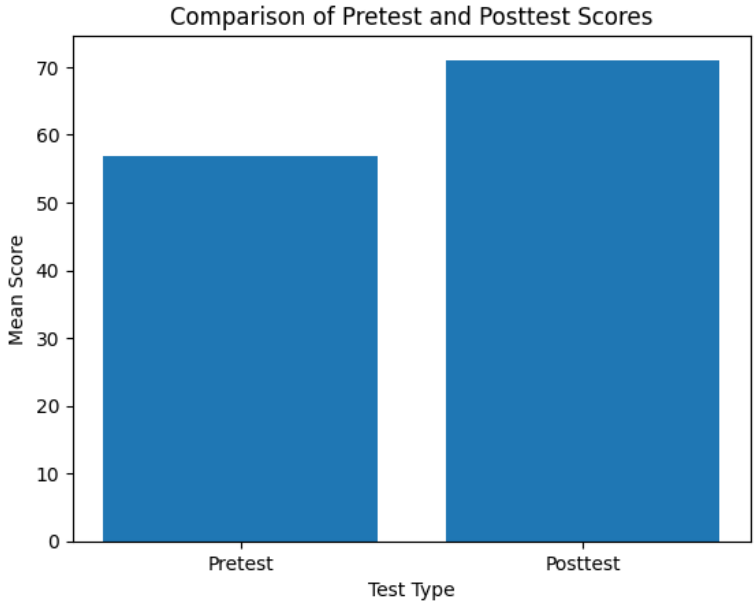

Figure 3. Comparison of Pretest and Posttest Scores

Figure 3 shows that the mean posttest score is higher than the pretest score, indicating an improvement in students' learning outcomes after the implementation of Scratch-based gamification.

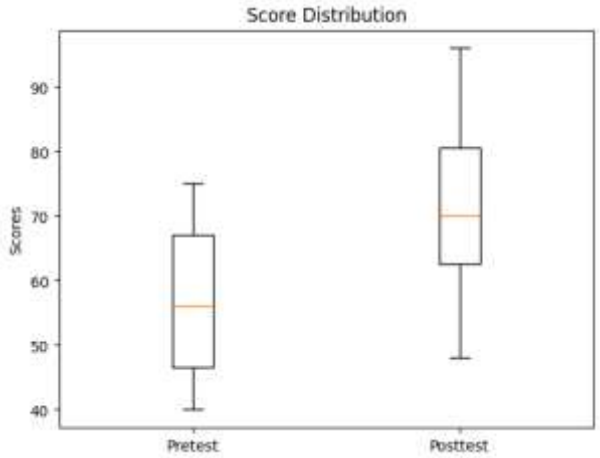

Figure 4. Distribution of Students' Pretest and Posttest Scores

Figure 4 illustrates that the distribution of posttest scores is higher than that of the pretest, with an increased median, indicating an overall improvement in students' performance.

The results of the student engagement analysis show a mean score of 3.73, which falls into the high category. This indicates that the use of Scratch-based gamification is effective in enhancing student engagement in the learning process across cognitive, emotional, and behavioral aspects.

Table 2. Results of Student Engagement Analysis

Variable	Mean	Category
Students' Engagement	3.73	High

These results indicate that gamification elements such as scores, badges, and leaderboards are capable of enhancing students' motivation and participation in the learning process.

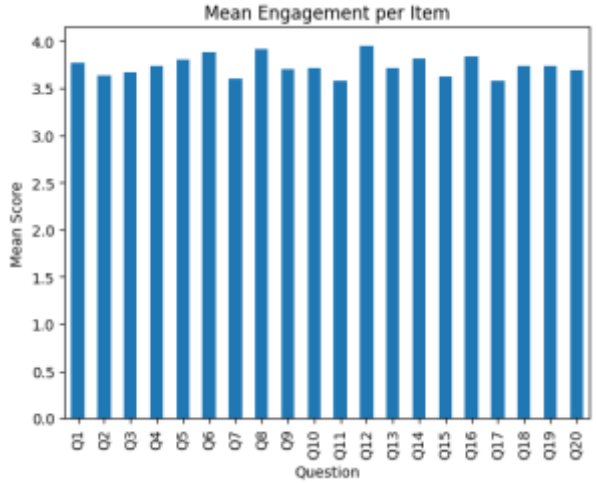

Figure 5. Mean Student Engagement per Item

Figure 5 shows that all questionnaire items have relatively high mean scores, indicating that student engagement across all aspects falls within the high category. This suggests that Scratch-based gamification consistently enhances student engagement across various dimensions of learning.

The results of the analysis also indicate that the MDA (Mechanics–Dynamics–Aesthetics) model was successfully implemented in the developed Scratch-based gamification application. In terms of mechanics, the scoring system (+4 for correct answers and −1 for incorrect answers), levels, badges, and leaderboard provide clear structure and rules in the learning process. From the dynamics perspective, student interactions with the system, such as answering questions, progressing through levels, and engaging in competition via the leaderboard, promote active participation. Meanwhile, in terms of aesthetics, students demonstrated positive emotional responses, such as enjoyment, challenge, and satisfaction while using the application. These findings indicate that the implementation of the MDA model is capable of creating an interactive and enjoyable learning experience, thereby supporting improvements in student engagement and learning outcomes.

DISCUSSION

The results of this study indicate that the implementation of Scratch-based gamification has a positive impact on both students' learning outcomes and engagement. The observed improvement in learning outcomes after the use of gamified learning media suggests that this approach effectively helps students understand the material more comprehensively. This is attributed to the interactive elements of gamification, which enable students to learn through direct experience, making the learning process more meaningful compared to conventional methods.

In terms of student engagement, the findings show that students fall into a high engagement category. This indicates that gamification is effective in enhancing students' motivation, attention, and active participation in the learning process. Elements such as scores, badges, and leaderboards have been shown to encourage students to be more active and enthusiastic in completing each level of the game. These findings are consistent with theories suggesting that gamification enhances student engagement through continuous challenges and feedback (Ivanković et al., 2025; Kurnaz & Koçtürk, 2025).

When viewed through the lens of the MDA (Mechanics–Dynamics–Aesthetics) model, the findings of this study indicate that all three components play a significant role in creating an effective learning experience. In terms of mechanics, the scoring system, levels, and badges provide a clear structure for the learning process. From the dynamics perspective, students' interactions with the system, such as answering questions and achieving specific targets, promote active engagement. Meanwhile, in terms of aesthetics, emotional experiences such as enjoyment and satisfaction when completing challenges have a positive impact on students' learning motivation. These findings are consistent with (Ahmed Dahri et al., 2025) who state that the MDA model enhances user experience in gamification systems.

Furthermore, the use of Scratch as a learning medium also contributes to improving the effectiveness of instruction. Scratch enables students to learn in a visual and interactive manner, making it easier to understand the concepts being taught. When combined with gamification, Scratch not only functions as a learning tool but also as a medium that enhances both student engagement and learning outcomes simultaneously. These findings are supported by previous studies indicating that Scratch-based learning can improve students' thinking skills and conceptual understanding.

Overall, the results of this study demonstrate that the integration of Scratch-based gamification with the MDA approach is an effective strategy for improving the quality of learning in primary education. Gamification not only influences learning outcomes but also creates a more engaging, interactive, and motivating learning experience for students.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this study, it can be concluded that the implementation of Scratch-based gamification has a positive effect on both learning outcomes and student engagement in primary education. The improvement in learning outcomes indicates that gamification helps students understand the material more effectively through an interactive and enjoyable approach. In addition, the high level of student engagement demonstrates that gamification elements such as scores, badges, and leaderboards can enhance students' motivation, participation, and interest in learning.

The implementation of the MDA (Mechanics–Dynamics–Aesthetics) model in the developed application has also been proven to create more meaningful learning experiences. The mechanics aspect provides a clear learning structure, dynamics encourage active student interaction, and aesthetics enhance positive emotional experiences during the learning process. Therefore, the integration of Scratch-based gamification with the MDA approach can be considered an effective strategy for improving the quality of learning in primary education.

Based on these findings, several recommendations can be proposed. First, teachers are encouraged to integrate gamification into the learning process as an alternative method to enhance student engagement and learning outcomes. Second, the development of Scratch-based learning media can be further improved by incorporating more diverse features and levels of difficulty to create a more challenging and adaptive learning environment. Third, future research is recommended to employ more complex experimental designs, such as the inclusion of control groups or advanced statistical analyses, to obtain more comprehensive results. Additionally, future studies may explore the impact of gamification on other aspects such as creativity, collaboration, and students' critical thinking skills.

ADVANCED RESEARCH

Future research is recommended to develop more comprehensive experimental designs by incorporating control groups and more diverse sample sizes to enhance the generalizability of the findings. In addition, future studies may integrate advanced statistical analyses such as regression or structural equation modeling (SEM) to examine relationships among variables more deeply, including the role of student engagement in influencing learning outcomes. The development of the application can also be extended by incorporating adaptive features, artificial intelligence, or collaborative elements to enhance students' learning experiences. Furthermore, future research may explore the impact of gamification on other aspects such as creativity, critical thinking skills, and student collaboration within technology-based learning environments.

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