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WORDWALL-ASSISTED GAME-BASED LEARNING TO IMPROVE STUDENTS' MATHEMATICS LEARNING OUTCOMES: A PRETEST-POSTTEST STUDY IN THE MERDEKA CURRICULUM

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Abstract

This study investigated the improvement of students' mathematics learning outcomes after the implementation of Wordwall-assisted Game-Based Learning (GBL) in a Merdeka Curriculum classroom. The study used a quantitative quasi-experimental method with a one-group pretest-posttest design involving 36 eighth-grade students from a private junior high school in the Sukarame area, Indonesia. The participants were selected purposively because the class showed low initial mathematics achievement and represented the learning context targeted by the intervention. Data were collected using a mathematics learning outcomes test consisting of four essay items aligned with the competency indicators of the Merdeka Curriculum. The instrument was validated prior to the main study and showed acceptable item validity ($p < 0.05$) and very high internal consistency (Cronbach's alpha = 0.878). Data analysis involved descriptive statistics, the Shapiro-Wilk normality test, a paired-samples t-test, learning mastery analysis, and normalized gain (N-Gain). The results showed that the mean score increased from 34.7 in the pretest to 83.3 in the posttest, with an N-Gain of 0.74, categorized as high. Learning mastery also increased from 0% to 94.4%. The paired-samples t-test indicated a statistically significant difference between pretest and posttest scores ($p < 0.001$). These findings suggest that Wordwall-assisted GBL was associated with a significant improvement in students' mathematics learning outcomes. However, because this study did not include a control group, the findings should be interpreted as evidence of within-group improvement rather than as definitive comparative causal evidence.

Keywords: Game-Based Learning; mathematics learning outcomes; Merdeka Curriculum; pretest-posttest; Wordwall

INTRODUCTION

Mathematics is one of the subjects that plays a strategic role in developing logical, critical, and structured thinking skills (Aini Asyhara et al., 2025; Lestari et al., 2026). However, the reality on the ground shows that mathematics is still often considered a difficult and less appealing subject for the majority of students. This situation contributes to low learning motivation and suboptimal learning achievement. These findings are in line with the Programme for International Student Assessment (PISA) 2022 report, which ranked Indonesia 68th out of 79 countries in mathematical literacy, with an average score of 366, well below the OECD average of 472. One of the factors causing low mathematics achievement is the dominance of conventional teaching methods that are still teacher-centered and do not actively involve students (Noprisa & Suryatul, 2025; Nugroho et al., 2024).

Learning that lacks interaction and does not accommodate the learning needs of the digital era tends to make students unmotivated and passive (A. Fredricks et al., 2004; Ninee et al., 2024). Furthermore, the lack of technology utilization in the learning process constitutes a distinct obstacle, particularly in the implementation of the Merdeka curriculum, which demands learning that is more student-centered, innovative, and adaptive to technological developments (Putri et al., 2022).

Previous studies have shown that digital technology and game-based learning can improve students' engagement and learning outcomes in mathematics. (Mayer, 2019) stated that digital games support learning through interactive and meaningful experiences, while Plass et al. (2015) emphasized that game-based learning involves cognitive, motivational, affective, and sociocultural dimensions. Hamari et al. (2016) also found that challenging games can enhance students' engagement, flow, and immersion. In line with Deci and Ryan's Self-Determination Theory, game elements such as autonomy, competence, feedback, and challenge can strengthen students' intrinsic motivation. Moreover, (Wouters, van Nimwegen, et al., 2013) and (Sailer & Homner, 2020) confirmed that game-based learning and gamification have positive effects on students' cognitive outcomes, engagement, and academic performance.

However, several gaps remain. First, many studies discuss digital games in general and do not specifically examine Wordwall as an interactive platform for mathematics learning at the SMP/MTs level. Second, research in the context of the Merdeka Curriculum is still limited, particularly in classes with low initial mathematics achievement. Third, empirical evidence using pretest-posttest data and learning mastery indicators in local Indonesian school contexts is still needed. Therefore, this study focuses on the use of Wordwall-assisted Game-Based Learning (GBL) to provide measurable evidence of improvement in students' mathematics learning outcomes.

One promising innovative approach is Game-Based Learning (GBL). GBL is a learning approach that integrates game elements into the learning process, thereby creating a more engaging and meaningful learning experience (Hamari et al., 2016; Mayer, 2019; Plass et al., 2015). This approach has been shown to enhance students' intrinsic motivation through the fulfillment of basic psychological needs, as explained in Self-Determination Theory (Hamari et al., 2016; Deci & Ryan, 2009; Ryan & Deci, 2020). Various meta-analyses have confirmed that the use of digital games in learning has a positive impact on learning outcomes and conceptual understanding, particularly in mathematics subjects (Huda et al., 2019; Lestari et al., 2021; Wouters, Nimwegen, et al., 2013).

Along with technological advancements, various digital learning platforms continue to develop, one of which is Wordwall. This platform allows teachers to design interactive, game-based learning activities that can be customized according to needs and distributed online. The use of Wordwall in learning has been proven to create an enjoyable learning atmosphere and improve student learning outcomes (Nur et al., 2025). The novelty of this research lies in the structured integration of GBL assisted by Wordwall within the Merdeka curriculum framework, which has not been widely studied empirically in Indonesia.

Based on the description above, this study aims to evaluate whether the implementation of Game-Based Learning assisted by the Wordwall application is associated with a significant improvement in the mathematics learning outcomes of eighth-grade students. The research question posed is: is there a significant difference between students' mathematics learning outcomes before and after the implementation of Wordwall-assisted GBL? The hypothesis tested in this study is as follows: H0: there is no significant difference between students' pretest and posttest mathematics learning outcomes after the implementation of Wordwall-assisted GBL. Ha: there is a significant difference between students' pretest and posttest mathematics learning outcomes after the implementation of Wordwall-assisted GBL. The results are expected to provide empirical and practical contributions to the development of innovative mathematics learning in the era of the Merdeka Curriculum.

METHOD

This study used a quantitative approach with a quasi-experimental method and a one-group pretest-posttest design. This design was used to examine changes in students' mathematics learning outcomes before and after the implementation of

Wordwall-assisted Game-Based Learning (GBL). The one-group pretest-posttest design was considered appropriate because the effectiveness of the intervention was measured by comparing students' pretest and posttest scores within the same group. Since this study did not involve a control group, the effectiveness of Wordwall-assisted GBL was interpreted based on statistically significant improvement between pretest and posttest scores, supported by learning mastery and N-Gain results. Methodologically, experimental and quasi-experimental designs are commonly used to examine the effect of an instructional intervention on measurable learning outcomes (Creswell & Creswell, 2018); (Sugiyono, 2019).

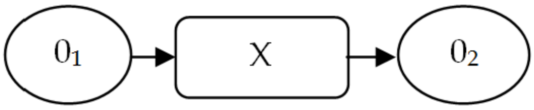

Figure 1. One Group Pre-test-Post-test
(Sumber: Sugiyono, 2019)

Description:
0_1 = Pre-test score before the implementation of GBL with the help of the Wordwall application
X = Implementation of GBL with the help of the Wordwall application
0_2 = Post-test score after the implementation of GBL with the help of the Wordwall application

The research participants were 36 eighth-grade students from a private junior high school in the Sukarame area during the 2023/2024 academic year. The participants were selected using purposive sampling. The class was selected because it had low initial mathematics achievement, regular access to the learning activities prepared by the teacher, and learning characteristics that were relevant to the objective of the intervention. These characteristics made the class suitable for examining changes in students' mathematics learning outcomes after the implementation of Wordwall-assisted GBL.

The intervention was implemented through mathematics learning activities that combined GBL principles with Wordwall-based tasks. The learning activities included problem orientation, guided exploration, game-based practice through Wordwall, immediate feedback, class discussion, reinforcement, and reflection. Wordwall was used as a digital medium to present practice questions, interactive challenges, scoring, and feedback so that students could participate actively and monitor their own understanding during learning.

The research instrument was a mathematics learning outcomes test consisting of four essay questions. The test items were developed based on the competency indicators of the Merdeka Curriculum and were designed to measure students' ability to understand mathematical concepts, apply procedures, solve contextual problems, and communicate mathematical reasoning. Each item was scored using a rubric that considered the accuracy of mathematical concepts, the appropriateness of procedures, the completeness of the solution, and the clarity of written reasoning. Before being used in the main study, the instrument was tested on a different group of students to examine its validity and reliability. The item validity test showed that all items were valid ($p < 0.05$), and the reliability analysis produced a Cronbach's alpha coefficient of 0.878, indicating very high internal consistency.

The research procedure consisted of three stages. The first stage was preparation, which included designing the lesson plan, preparing Wordwall-based learning activities, developing test items, and validating the instrument. The second stage was implementation, which included administering the pretest, implementing Wordwall-assisted GBL during mathematics learning, and administering the posttest after the intervention. The third stage was evaluation and data analysis, in which the pretest and posttest scores were analyzed to determine the significance and magnitude of improvement in students' mathematics learning outcomes.

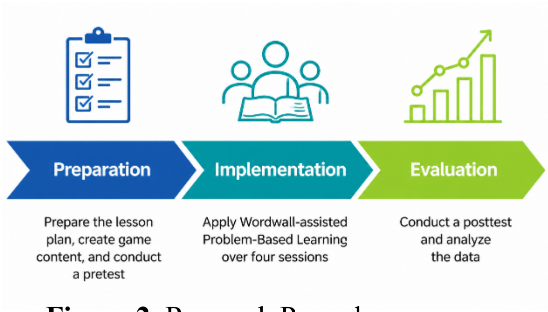

Figure 2. Research Procedure

Data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to summarize the minimum score, maximum score, mean, standard deviation, and learning mastery percentage. The Shapiro-Wilk test was used to examine data normality because it is commonly recommended for small samples and has good power for detecting departures from normality (Razali & Wah, 2011). After the normality assumption was met, a paired-samples t-test was used to test whether there was a significant difference between pretest and posttest scores. Furthermore, N-Gain analysis was used to determine the magnitude of improvement in students' learning outcomes based on normalized gain interpretation (Wahab et al., 2021). The N-Gain criteria are presented in Table 1.

Table 1. N-Gain Categories

No	N-Gain Value Range	Improvement Category
1	N-Gain > 0,7	High
2	0,3 ≤ N-Gain ≤ 0,7	Medium
3	N-Gain < 0,3	Low

RESULTS AND DISCUSSION

This section presents the descriptive statistics, learning mastery, normality test, paired-samples t-test, N-Gain analysis, and interpretation of the findings. The results are discussed in relation to the role of Wordwall-assisted GBL in supporting students' mathematics learning outcomes.

Table 2. Descriptive statistics of students' mathematics learning outcomes

Statistics	Pretest	Posttest
Number of students	36	36
Minimum score	20	70
Maximum score	60	95
Mean	34.7	83.3
Standard deviation	9.84	6.52

Table 2 shows a substantial increase in students' mathematics learning outcomes after the intervention. The mean score increased from 34.7 in the pretest to 83.3 in the posttest. This increase indicates that students performed better after participating in Wordwall-assisted GBL activities. The minimum score also increased from 20 to 70, suggesting that students with the lowest initial performance experienced meaningful improvement. In addition, the standard deviation decreased from 9.84 to 6.52, indicating that students' posttest scores became more homogeneous after the intervention. This pattern suggests that the intervention did not only increase the average score but also helped reduce variation in student performance.

Table 3. Student learning mastery

Category	Pretest	Posttest
Complete	0 students (0%)	34 students (94.4%)
Incomplete	36 students (100%)	2 students (5.6%)

Table 3 shows that learning mastery increased from 0% before the intervention to 94.4% after the intervention. This finding indicates that most students reached the expected learning standard after experiencing Wordwall-assisted GBL. The increase in mastery is pedagogically important because it shows that the intervention supported not only score improvement but also the achievement of minimum learning criteria. Interactive practice, immediate feedback, and game-based challenges may have helped students identify errors, revise their understanding, and strengthen mathematical procedures during learning.

Table 4. Normality test using Shapiro-Wilk

Variable	Shapiro-Wilk Statistic	Sig. (p-value)	Description
Pretest	0.957	0.173	Normal
Posttest	0.964	0.268	Normal

The normality test results in Table 4 show that both pretest and posttest data were normally distributed because the significance values were greater than 0.05. Therefore, the assumption for using a paired-samples t-test was met. This step was important to ensure that the inferential analysis was appropriate for examining score differences within the same group.

Table 5. Paired-samples t-test results

Variable	Mean Difference	t	df	Sig. (2-tailed)
Pretest - Posttest	-48.6	-18.25	35	0.000

Table 5 indicates a statistically significant difference between students' pretest and posttest scores ($p < 0.001$). The negative mean difference occurred because the pretest score was subtracted from the posttest score, showing that the posttest mean was higher than the pretest mean. This result supports the alternative hypothesis that students' mathematics learning outcomes differed significantly after the implementation of Wordwall-assisted GBL. However, because the design did not include a control group, the result should be interpreted as significant within-group improvement rather than as a definitive comparison with another instructional model.

Table 6. N-Gain calculation

Pretest Mean	Posttest Mean	N-Gain	Category
34.7	83.3	0.74	High

Table 6 shows that the N-Gain value was 0.74, which falls into the high category. This result indicates that the improvement in students' mathematics learning outcomes was not only statistically significant but also educationally meaningful. The high N-Gain suggests that students gained a substantial proportion of the possible improvement between their initial performance and the maximum score. This finding strengthens the evidence that Wordwall-assisted GBL was associated with meaningful improvement in the observed class.

The findings can be interpreted through several theoretical perspectives. First, from the perspective of game-based learning, Wordwall provided structured practice, challenges, and feedback that encouraged students to participate actively in mathematics learning. These features are consistent with the argument that game-based learning can support engagement, flow, and immersion when students are challenged at an appropriate level (Hamari et al. (2016); (Plass et al., 2015)). The result is also aligned with broader research showing that digital game-based learning and gamified environments can improve participation, motivation, and achievement when used as part of purposeful instructional design (Gwo-Jen & Po-Han, 2012; Sailer & Homner, 2020; Wouters, van Nimwegen, et al., 2013). Second, from the perspective of Self-Determination Theory, Wordwall-assisted GBL may support students' sense of competence through immediate feedback, autonomy through active participation, and relatedness through classroom interaction ((Deci & Ryan, 2000); (Ryan & Deci, 2020)).

The improvement in learning outcomes also aligns with cognitive and multimedia learning principles. Wordwall activities allow mathematical questions to be presented in a more interactive form, enabling students to connect text, visual cues, response options, and feedback. Such interaction may reduce passivity and help students process mathematical ideas more actively. In this study, the increase in the minimum score and the decrease in standard deviation suggest that the intervention may have helped lower-performing students improve their understanding through repeated practice and immediate correction.

Nevertheless, the findings should be interpreted carefully. The one-group pretest-posttest design is useful for identifying changes before and after an intervention, but it cannot fully control external factors such as maturation, teacher influence, repeated testing effects, or other learning experiences. Therefore, the results provide evidence that Wordwall-assisted GBL was associated with significant improvement in the observed class, but they do not establish strong comparative causal claims against conventional learning. Future studies should use a control group, random assignment where possible, a larger sample, and longer intervention periods to examine the robustness and generalizability of the findings.

Practically, this study suggests that Wordwall-assisted GBL can be used as an alternative strategy to support mathematics learning in the Merdeka Curriculum. Teachers can integrate Wordwall as a formative practice tool, a feedback medium, and an interactive learning activity that encourages student participation. When designed with clear learning objectives, appropriate mathematical tasks, and reflective discussion, Wordwall-assisted GBL has the potential to make mathematics learning more active, enjoyable, and measurable.

CONCLUSION

This study found that students' mathematics learning outcomes improved significantly after the implementation of Wordwall-assisted Game-Based Learning in a Merdeka Curriculum classroom. The mean score increased from 34.7 to 83.3, learning mastery increased from 0% to 94.4%, and the N-Gain value reached 0.74, which is categorized as high. The paired-samples t-test also showed a significant difference between pretest and posttest scores ($p < 0.001$). These results indicate that Wordwall-assisted GBL was associated with significant and meaningful improvement in students' mathematics learning outcomes.

The findings contribute empirical evidence on the use of Wordwall-assisted GBL in junior high school mathematics learning, particularly in a local Indonesian context implementing the Merdeka Curriculum. However, the absence of a control group, the limited sample size, and the relatively short intervention period limit the generalizability and causal strength of the findings. Future research is recommended to employ a stronger experimental design, involve more diverse participants, and examine the impact of Wordwall-assisted GBL on higher-order mathematical abilities such as reasoning, problem-solving, and mathematical communication.

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