Journal of Mathematics Education
Website: http://usnsj.id/index.php/JME
Email: pengelolajme@gmail.com
p-ISSN 2528-2468; e–ISSN 2528-2026

DOI: https://doi.org/10.31327/jme.v11i1.2717

THE EFFECTIVENESS OF MATH GAMES LEARNING MEDIA ON MATHEMATICS LEARNING OUTCOMES OF FOURTH GRADE STUDENTS AT SD LABSCHOOL UNNES

Sabrina Erlita*[1], Elok Fariha Sari[2]
[1,2] Universitas Negeri Semarang

Article Info

Article history:

Received Feb 10, 2026
Revised Feb 16, 2026
Accepted Feb 18, 2026

Keywords:

Math Games
Learning Media
Learning Outcomes
Elementary School

ABSTRACT

The use of digital-based learning media in elementary mathematics instruction has not been optimally implemented, which contributes to low student engagement and learning outcomes. This study aimed to examine the effectiveness of Math Games learning media in improving the mathematics learning outcomes of fourth-grade students at SD Labschool UNNES. The study employed a quantitative approach using a quasi-experimental design with a nonequivalent control group. The research subjects consisted of 38 fourth-grade students, with 19 students in the experimental group and 19 students in the control group. The experimental group received instruction using Math Games, while the control group was taught using conventional learning media. Data were collected through pretest and posttest instruments and analyzed using nonparametric statistical tests. The results indicated that students in the experimental group demonstrated a greater improvement in mathematics learning outcomes compared to those in the control group. Statistical analysis revealed a significant difference in learning outcomes between the two groups. These findings suggest that the implementation of Math Games learning media is effective in enhancing elementary students' mathematics learning outcomes and can serve as an innovative alternative for mathematics instruction in elementary schools.

Corresponding Author:

Sabrina Erlita,
Departement of Primary School Teacher Education,
Universitas Negeri Semarang, Indonesia
Email: erlitasabrina@students.unnes.ac.id

How to Cite:

Erlita, Sabrina., Fariha Sari, Elok. (2026). The Effectiveness of Math Games Learning Media On Mathematics Learning Outcomes of Fourth Grade Students At Sd Labschool Unnes. *JME:Journal of Mathematics Education*, *11*(1), 67-77.

1. INTRODUCTION

Education plays a crucial role in developing human resources capable of responding to the demands of the 21st century. In the context of basic education, mathematics learning is expected not only to develop students' computational skills but also to foster logical

thinking, problem-solving abilities, and positive learning attitudes. However, mathematics is often perceived by elementary school students as a difficult and less engaging subject, which can negatively affect their motivation and learning outcomes. Therefore, innovative learning strategies that integrate technology are increasingly needed to create meaningful and engaging mathematics learning experiences.

The integration of digital technology in learning has been widely recognized as an effective approach to improving the quality of instruction and student engagement. Interactive digital media can help transform abstract mathematical concepts into more concrete and comprehensible forms, particularly for elementary school students. Despite the availability of technological facilities in many schools, teachers often face challenges in optimally utilizing digital learning media. As a result, learning processes frequently remain teacher-centered, relying heavily on conventional methods such as lectures and routine question-and-answer sessions, which may limit students' active participation and understanding.

Student learning outcomes are a key indicator of instructional effectiveness and educational quality. Improving learning outcomes requires not only well-designed instructional content but also appropriate learning media that align with students' characteristics and learning needs. In mathematics learning, the use of engaging digital media is particularly important, as it can help sustain students' attention and motivation while supporting conceptual understanding. One form of technology integration that has gained increasing attention is game-based learning media

Game-based learning media, such as Math Games, offer interactive environments that combine learning objectives with game elements to create enjoyable and motivating learning experiences. Math Games are designed to facilitate mathematics instruction through interactive activities that encourage students to actively engage with learning content. By incorporating elements such as challenges, feedback, and rewards, game-based media have the potential to enhance students' focus, motivation, and participation in mathematics learning. These characteristics make Math Games particularly suitable for elementary school students, who tend to learn more effectively through play-oriented and experiential activities.

Field observations conducted at SD Labschool UNNES revealed several challenges in mathematics learning. Although learning facilities were relatively complete, digital-based learning media were not optimally utilized in classroom instruction. Many students demonstrated low focus during mathematics lessons, and some students' mathematics learning outcomes were still below the minimum competency standard. In addition, students experienced difficulties in performing combined arithmetic operations, indicating gaps in conceptual understanding. Teachers predominantly employed conventional instructional methods, which limited opportunities for interactive and student-centered learning. These conditions highlight the need for alternative instructional strategies that can actively engage students and support improved learning outcomes.

Numerous empirical studies have demonstrated the effectiveness of game-based learning media in mathematics education. (Herawati et al., 2022) found that the use of Math Games significantly improved students' calculation skills and learning motivation. Similarly, (Litau et al., 2023) and (Arrosyad et al., 2023) reported that Math Games effectively increased students' interest, motivation, activity, and involvement in mathematics learning. Studies employing quantitative and experimental research designs also support these findings. (Atiaturrahmaniah and Fajri, 2020), as well as (Wachdani and Anas Thohir, 2022), found that mathematical games and game-based learning models significantly improved students' mathematics learning outcomes compared to conventional instructional approaches.

Further studies have examined specific aspects of game-based learning media, including design, motivation, and learner characteristics. (Andriani et al., 2021) and (Marlianda et al., 2024) showed that students who learned using Math Games achieved better learning outcomes than those who learned through conventional media. In addition, (Haidir et al., 2024) and (Qudsiyah et al., 2024) concluded that educational games increased students' interest and motivation to learn and were particularly suitable for students who were familiar with digital technology. A meta-analysis conducted by (Benavides-Varela et al., 2020) further confirmed that digital-based interventions generally have a positive effect on students' mathematics achievement, although the effectiveness of game-based learning media depends on the learning context and student characteristics.

Despite the growing body of research on game-based learning in mathematics education, several gaps remain. Most previous studies have focused on general effectiveness across different educational levels, with limited attention to specific elementary school contexts and controlled comparisons with conventional learning approaches. In particular, empirical evidence regarding the implementation of Math Games in laboratory school settings at the elementary level remains scarce. Furthermore, few studies have specifically examined the effectiveness of Math Games in improving the mathematics learning outcomes of fourth-grade students within the Indonesian educational context.

Therefore, this study aims to examine the effectiveness of Math Games learning media in improving the mathematics learning outcomes of fourth-grade students at SD Labschool UNNES. By comparing the implementation of Math Games with conventional learning methods, this study seeks to provide empirical evidence on the potential benefits of game-based learning media in elementary mathematics instruction. The findings of this study are expected to contribute to the development of innovative instructional practices and provide practical insights for teachers in integrating digital game-based media into mathematics learning.

2. METHOD

This study employed a quantitative approach using a quasi-experimental design to examine the effect of Math Games learning media on students' mathematics learning outcomes. Specifically, a nonequivalent control group design was used because the research subjects could not be randomly assigned to groups (Kusuma Wardani and Fariha Sari, 2025). This design allowed for a comparison of learning outcomes between an experimental group receiving the treatment and a control group receiving conventional instruction.

The research was conducted at SD Labschool UNNES. The research subjects consisted of fourth-grade students from two intact classes, namely class IVA and class IVB. One class was assigned as the experimental group and the other as the control group using intact group sampling. Each class consisted of 19 students. The independent variable in this study was the use of Math Games learning media, while the dependent variable was students' mathematics learning outcomes. The experimental class was taught using Math Games, whereas the control class received conventional instruction using multiplication boards as learning media. Both classes were taught the same mathematics topic, namely multiplication of whole numbers up to 100, to ensure instructional equivalence.

The research instrument used in this study was a mathematics achievement test administered in the form of a pretest and a posttest. The test was developed based on relevant learning indicators and Bloom's cognitive taxonomy to measure students' understanding and problem-solving abilities in mathematics. The instrument consisted of multiple-choice items, fill-in-the-blank questions, and essay questions. Prior to its implementation, the instrument underwent content validity testing by expert judgment and empirical validity

testing. Reliability testing was conducted to ensure the consistency of the instrument, and only valid and reliable items were used in the data collection process.

The research procedure consisted of three main stages: pretest, treatment, and posttest. At the pretest stage, both the experimental and control classes were given the same test to determine their initial mathematics learning outcomes. The treatment stage was conducted over four learning meetings. During this stage, the experimental class was taught using Math Games learning media, while the control class was taught using conventional learning media. At the final stage, a posttest was administered to both classes to measure students' learning outcomes after the implementation of the learning treatments.

The collected data were analyzed using descriptive and inferential statistical techniques. Descriptive analysis was conducted to describe students' learning outcomes based on mean scores and improvements in learning achievement. Prior to inferential analysis, prerequisite tests were conducted, including the Shapiro–Wilk normality test and homogeneity test. The results indicated that the data were not normally distributed; therefore, nonparametric statistical tests were applied. The Wilcoxon signed-rank test was used to examine differences between pretest and posttest scores within each class. Furthermore, the Mann–Whitney U test was used to compare posttest scores between the experimental and control classes to determine the significance of differences in learning outcomes. In addition, N-gain analysis was conducted to determine the level of improvement in students' mathematics learning outcomes after the learning treatments. The N-gain values were interpreted based on the following criteria: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$).

3. RESULTS AND DISCUSSION

3.1. Results

This study compared students' learning outcomes in the control and experimental classes using pretest and posttest scores.

Figure 1. Student activities when using Math Games media

The results of the data analysis are presented and discussed in the following section.

1. Descriptive Statistics of Student Learning Outcomes

The results of the analysis of the pretest and posttest scores of students in the control class and experimental class are presented in Table 1.

Table 1. Average Pre-test dan Post-test Scores

Class	Average Pretest Score	Average Posttest Score
Control	67	70
Experimental	60	79

Based on the table 1, it is known that the average pretest score for the experimental class was 60, while average posttest score increased to 79. Meanwhile, the control class had an average pretest score of 67, which increased to 70 on the posttest. Both classes experienced an increase in learning outcomes, but the increase in the experimental class was greater than that in the control class.

2. Normality Test

The normality test was conducted as a perquisite test to determine the type of statistical test to be used. The normality test in this study used the Shapiro-Wilk test because the number of subjects was less than 50 students in each class. The results of the normality test for this study's data are presented in table 2.

Table 2. Normality Test Result

Class	Stage	df	Statistic	Sig.
Control	Pretest	19	0.940	0.263
Control	Posttest	19	0.899	0.047
Experiment	Pretest	19	0.967	0.707
Experiment	Posttest	19	0.820	0.002

Based on the normality test results in table 2, the significance value for the control class pretst was 0.263 and for the control class posttest was 0.047. in the experimental class, the significance value for the pretest was 0.707 and for the posttest was 0.002. the decision-making criteria state that the data is normally distributed if the significance value is > 0.05. the test results show that only the control class and experimental class pretest data are normally distributed, while the other data are not normally distributed. Based on these results, non-parametric tests were applied.

3. Homogeneity Test

The homogeneity test was conducted to determine the similarity of the initial ability variance between the control class and the experimental class. The homogeneity test results are presented in table 3.

Table 3. Homogeneity Test Result

Data	Levene Statistic	df 1	df 2	Sig.
Pretest (Based on Mean)	0.286	1	36	0.596

Based on the results of the homogeneity test above, a significance value of 0.596. This value indicates that the significance value is greater than 0.05 ($p > 0.05$), indicating that the variance of the two classes was homogeneous.

4. Wilcoxon Test

The Wilcoxon test was used to determine the difference in student learning outcomes before and after treatment in each class. The results of the Wilcoxon test for the control class are presented in Table 4.

Table 4. Wilcoxon Test Results for the Control Class

Data	Negative Ranks	Positive Ranks	Ties	Z	Sig. (2-tailed)
Posttest-Pretest	6	13	0	-1.652	0.099

Based on the Wilcoxon test results above, it was found that of the 19 students in the control class, 13 students experienced an increase in learning outcomes (positive ranks), 6 students experienced a decrease in learning outcomes (negative ranks), and no students had the same scores on the pretest and posttest (ties). The above test results show a significance value of 0.099, which means that there is no significant difference between the pretest and posttest scores of the control class.

The Wilcoxon test was also applied to the experimental class to determine the increase in learning outcomes after receiving treatment. The results of the Wilcoxon test for the experimental class are presented in Table 5.

Table 5. Wilcoxon Test Results for the Experimmental Class

Data	Negative Ranks	Positive Ranks	Ties	Z	Asymp Sig. (2-tailed)
Posttest-Pretest	1	18	0	-3.585	< 0.001

Based on the Wilcoxon test results above, it was found that of the 19 students in the experimental class, 18 students expericed an increase in learning outcomes (positive ranks), 1 student experienced a decrease in learning oucomes (negative ranks), and no students had the same scores on the pretest and posttest (ties). The Wilcoxon test results for the experimental class showed a significance value of 0.001. The significance value was ≤ 0.05, indicating a statistically significant difference between pretest and posttest scores in the experimental class.

5. N-Gain Analysis

Table 6. N-Gain Analysis Results

Class	N	Mean N-Gain	Std. Deviation
Control	19	0.1480	0.54129
Experiment	19	0.5505	0.36035

The results of the N-Gain analysis in Table 6 show that the increase in learning outcomes in the experimental class was higher than in the control class. The N-gain analysis results show that the control class average score is 0.1480 with a standard devation of 0.54129, which is in the low category. Meanwhile, the experimental class

N-Gain score is 0.5505 with a standard deviation of 0.36035, which is in the moderate category.

6. Mann-Whitney Test

The Mann-Whitney test was conducted to determine the difference in learning outcomes between the control class and the experimental class. The test results are presented in Table 7.

Table 7. Mann-Whitney Test Results

Data	Mann-Whitney U	Z	Sig. (2-tailed)
N-Gain (Experimen vs Control)	96.500	-2.454	0.014

The Mann-Whitney test results above show that the significance value is 0.014. This value is ≤ 0.05, so it can be concluded that there is a significant difference in mathematics learning outcomes between the experimental class and the control class.

7. Student Responses and Observations on the Implementation of Learning

A student respon questionnaire was administered to determine students' responses to the use of Math Games media in the experimental class. This questionnaire was only given to students in class IVA, as this was the class that received treatment using Math Games media.

Table 8 Student Responses to Math Games Media

No	Aspect	Percentage	Category
1	Joy	88	Excellent
2	Interesting Game	87	Excellent
3	Easy to Understand	83	Excellent
4	Enthusiasm for Learning	86	Excellent
5	Understanding the Material	83	Excellent
6	Usage	84	Excellent
	Average	85	Excellent

Based on the results of the student response questionnaire regarding the use of Math Games learning media, it was found that all aspects assessed were in the excellent category. The aspect of enjoyment received a score of 88%, the aspect of interesting games received a score of 87%, while the aspect of easy to understand received a score of 83%. In addition, the learning enthusiasm aspect received a score of 86%, the material comprehension aspect received a score of 83%, and the media usage aspect received a score of 84%, all of which were in the excellent category. Overall, the average percentage of student responses was 85% in the excellent category. In addition, the results of the learning implementation observation are presented in Table 9 and Table 10.

Table 9. Observation Results of Learning Implementation in the Control Class

No	Aspect	Implementation
1	Media appropriate to the material	√
2	Teacher explains the material	√
3	Question and Answer	√
4	Active students	√
5	Media aids understanding	√
6	Learning evaluation	√
7	Learning coclusion	√
8	Learning according to the lesson plan	√
	Total	**8**
	100	**Excellent**

The results of the observation of learning implementation in the control class showed that learning using smart multiplication boards was carried out well. All observed aspects were implemented, with a total score of 100% in the excellent category.

Table 10. Observation Results of Learning Implementation in the Experimental Class

No	Aspect	Implementation
1	Media is easily accessible	√
2	Media appropriate to the material	√
3	Media aids understanding	√
4	Students actively use media	√
5	Students are enthusiastic	√
6	Teachers guiding students	√
7	Learning according to the lesson plan	√
	Total	**7**
	100	**Excellent**

Based on the results of observations of the implementation of learning in the experimental class, all aspects observed were carried out well. Teachers were able to manage learning using Math Games media, and students also showed enthusiasm and active involvement during the learning process.

3.2 Discussion

The results of the study indicate that the use of Math Games learning media has a positive effect on the mathematics learning outcomes of fourth-grade students at SD Labschool UNNES. This is demonstrated by the higher posttest scores of the experimental class compared to the control class, and is reinforced by the results of non-parametric statistical tests that show a significant difference after treatment.

Specifically, the Wilcoxon test results show that there is a significant difference between the pretest and posttest scores in the experimental class, while in the control class the difference is not significant. These findings indicate that learning using Math Games media is able to provide a more meaningful learning experience compared to learning using conventional multiplication board media. Math Games media allows students to learn actively through play-based learning activities, so that students do not only receive information passively, but are also directly involved in the learning process. This condition is in line with the constructivist view which states that knowledge is actively constructed by students through meaningful learning experiences. (Masgumelar & Mustafa, 2021).

The difference in effectiveness between the control class and the experimental class is also reinforced by the Mann-Whitney test results, which show a significant difference in learning outcomes between the two classes. These results confirm that the use of Math Games learning media is more effective than conventional learning media. Game-based media is interactive, challenging, and provides immediate feedback, thereby helping students understand mathematical concepts better. These findings are in line with the research (Ardani & Humaira Salsabila, 2020) and (Herawati et al., 2022), which states that game-based learning media can improve elementary school students' understanding of mathematical concepts and numeracy skills.

In addition, the results of the N-gain analysis show that the increase in learning outcomes in the experimental class was in the moderate category, while the control class was in the low category. This difference in improvement categories indicates that Math Games not only significantly improves student learning outcomes but also provides more optimal improvement compared to conventional learning media. These findings are in line with the results of studies (Benavides-Varela et al., 2020), which state that digital-based learning interventions have been proven to be effective in improving students' mathematical abilities more consistently than traditional approaches.

From an affective perspective, the results of the student response questionnaire show that students responded very positively to the use of Math Games. Students felt more motivated and found it easier to understand mathematical material. This shows that Math Games can increase students' interest and motivation to learn, which ultimately has an impact on improving learning outcomes. These findings are in line with the opinion of (Aisyah & Ramadhan, 2023), which states that interesting learning media plays an important role in increasing students' interest in learning.

The results of the observation of the implementation of learning show that all aspects of learning were carried out very well. Teachers were able to manage learning using Math Games media in accordance with the learning plan, and students showed high involvement and enthusiasm during the learning process. This shows that the success of using Math Games is not only determined by the media, but also by the teacher's skills in integrating the media into learning. This finding is in line with (Jamaludin et al., 2023) which emphasizes the importance of learning media suitability with learning objectives and processes.

Based on these overall results, it can be concluded that the implementation of Math Games learning media not only has an impact on improving students' cognitive learning outcomes but also has a positive impact on motivation, engagement, and the quality of the

mathematics learning process in elementary schools. Thus, Math Games can be used as an effective and innovative alternative learning media to support mathematics learning for fourth-grade elementary school students.

The study was conducted with a limited sample in a single school, and the intervention was carried out over a short period. These factors may limit the generalizability of the findings. Further research with larger samples and extended intervention time is recommended.

4. CONCLUSION

Based on the results of the research and discussion, it can be concluded that the use of Math Games learning media has a positive and significant effect on the mathematics learning outcomes of fourth-grade students at Labschool UNNES. The improvement in student learning outcomes in the experimental class shows that Math Games can help students understand multiplication material better than conventional learning media. In addition to cognitive imrovements, Math Games also had a positively influenced students' motivation, engagement, and the overall quality of the learning process. Therefore, Math Games can be considered an effective and innovative learning medium to support mathematics instruction in elementary schools. Future studies are recommended to involve larger samples and longer intervention periods to strengthen the generalizability of these findings.

ACKNOWLEDGEMENTS

The author would like to thank the supervising lecturer who provided guidance and direction during the research process and the writing of this article. Thanks, are also extended to the Principal of SD Labschool UNNES, the classroom teachers, and all employees of SD Labschool UNNES for their permission, assistance, and support during the implementation of this research. The author also thanks the students of classes IVA and IVB who participated well in this research activity.

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