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The Effectiveness of Fractional Chalkboard Media in Reducing Misconceptions and Improving Learning Outcomes Among Elementary School Students

[1] Aiman Khairun Nazata Dini, [2] Yoppy Wahyu Purnomo, [3] Heri Kiswanto

[1,2,3] Elementary Education Program, Yogyakarta State University
Email: diniaiman1324@gmail.com

*** correspondence:** diniaiman1324@gmail.com

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ABSTRACT

This study aimed to determine the effectiveness of the fraction shading board manipulative media in reducing misconceptions and improving mathematics learning outcomes among fourth-grade students at SD Muhammadiyah 3 Denpasar. This study employed a quantitative approach using a quasi-experimental design with a nonequivalent control group. The sample consisted of 45 students divided into an experimental group (23 students) and a control group (22 students). The instruments used were misconception tests and mathematics learning outcome tests. Data were analyzed using the N-Gain test and the Independent Samples t-test. The results showed that the posttest mean score of the experimental group was higher than that of the control group. The N-Gain score of the experimental group was 0.55, falling into the moderate category, while the control group obtained 0.23, falling into the low category. Additionally, misconceptions in the experimental group decreased significantly. The hypothesis test yielded a significance value of 0.000 ($p < 0.05$). Therefore, the fraction shading board manipulative media were effective in reducing misconceptions and improving students' mathematics learning outcomes.

Article Information

Kata Kunci:

lhasil belajar; media manipulatif; miskonsepsi; pecahan; sekolah dasar

ABSTRAK

Penelitian ini bertujuan untuk mengetahui efektivitas media manipulatif papan arsiran pecahan dalam mengurangi miskonsepsi dan meningkatkan hasil belajar matematika siswa kelas IV SD Muhammadiyah 3 Denpasar. Penelitian ini menggunakan pendekatan kuantitatif dengan desain quasi eksperimen jenis nonequivalent control group design. Sampel penelitian terdiri atas 45 siswa yang terbagi menjadi kelompok eksperimen sebanyak 23 siswa dan kelompok kontrol sebanyak 22 siswa. Instrumen penelitian berupa tes miskonsepsi dan tes hasil belajar matematika. Analisis data dilakukan menggunakan uji N-Gain dan Independent Sample t-test. Hasil penelitian menunjukkan bahwa rata-rata nilai posttest kelas eksperimen lebih tinggi dibandingkan kelas kontrol. Nilai N-Gain kelas eksperimen sebesar 0,55 dengan kategori sedang, sedangkan kelas kontrol sebesar 0,23 dengan kategori rendah. Selain itu, terjadi penurunan miskonsepsi yang signifikan pada kelas eksperimen. Hasil uji hipotesis menunjukkan nilai signifikansi sebesar 0,000 ($p < 0,05$). Dengan demikian, media manipulatif papan arsiran pecahan efektif dalam mengurangi miskonsepsi dan meningkatkan hasil belajar matematika siswa sekolah dasar.

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Corresponding Author: (1) Aiman Khairun Nazata Dini, (2) Elementary Education Program (3) Yogyakarta State University (4) Jalan Mekar II Blok E1 No. 04, Pemogan, South Denpasar, Denpasar City, Bali., (5) Email: diniaiman1324@gmail.com

1. Introduction

Mathematics instruction in elementary schools still faces challenges in helping students understand abstract concepts, particularly regarding fractions. Various studies indicate that fractions are one of the most difficult topics for students to grasp due to their non-intuitive nature and the need for strong conceptual representation skills[1],[2]. These difficulties often lead to persistent misconceptions, such as errors in understanding the relationship between the numerator and denominator and mistakes in performing fraction addition[3].

Preliminary observations at SD Muhammadiyah 3 Denpasar indicate that the majority of students exhibit misconceptions regarding the addition of fractions. Students tend to make incorrect generalizations from the concept of whole numbers, such as directly adding the numerator and denominator. These misconceptions not only result in low learning outcomes but also hinder the development of mathematical concept understanding at subsequent levels. This aligns with research findings stating that misconceptions regarding fractions are persistent and difficult to correct if not addressed early on [4].

One contributing factor to the emergence of misconceptions is the use of learning approaches that remain abstract and fail to engage students' concrete experiences. However, according to cognitive development theory, elementary school students are in the concrete operational stage, thus requiring learning media capable of representing concepts visually and through manipulation [5]. The use of manipulative media in mathematics instruction has been proven to help students build conceptual understanding through direct experience [6].

Previous studies have shown that manipulative media are effective in improving mathematics learning outcomes [7]. Most of these studies have focused solely on learning outcomes and have not specifically examined the role of manipulative media in reducing students' misconceptions in depth, particularly using diagnostic instruments such as the Three-Tier Test (TTT) [8].

Although various studies have discussed the use of manipulative media in mathematics learning, research specifically examining the effectiveness of fraction-gridding boards in reducing misconceptions among elementary school students remains limited. Furthermore, the use of the Three-Tier Test diagnostic instrument to identify misconceptions regarding fractions has not been widely applied in elementary school settings. Therefore, this study is important to provide empirical evidence regarding the effectiveness of manipulative media in improving students' understanding of fraction concepts.

2. Method

2.1 Research Type and Design

This study employs a quantitative approach using a quasi-experimental method based on a pretest-posttest control group design [9]. This method was chosen because conditions at the school did not allow the researcher to randomize participants; thus, existing classes were used as the experimental and control groups.

The experimental group was given treatment in the form of learning using fractional grid manipulatives, while the control group was given conventional instruction without using these materials. Before the treatment was administered, both groups were first given a pretest to measure students' initial abilities. After the learning process was completed, both groups were given a posttest to determine changes in students' learning outcomes following the treatment. The research design is presented in Table 1.

Group	Pre-test	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	—	O_4

Table 1. Pretest-Posttest Control Group Design

Notes:
O_1 = pretest in the experimental group
O_2 = posttest in the experimental group
O_3 = pretest in the control group
O_4 = posttest in the control group
X = *treatment in the form of learning using manipulative*

fractional board media
— = learning using the lecture method

2.2 Research Location and Subjects

The research was conducted at SD Muhammadiyah 3 Denpasar. The subjects of this study were fourth-grade students at SD Muhammadiyah 3 Denpasar, divided into two groups: the experimental group and the control group. The experimental group consisted of 23 students, comprising 11 girls and 12 boys. Meanwhile, the control group consisted of 22 students, comprising 10 girls and 12 boys. Thus, the total number of research subjects was 45 students.

2.3 Data Collection Techniques and Instruments

The data collection techniques in this study utilized tests and documentation. The instruments used consisted of a misconception test and a learning outcome test. The misconception test was designed in the form of a Three-Tier Test (TTT) diagnostic item adapted from the concept developed by David Treagust (1988), aimed at identifying students' conceptual understanding of fraction material. In this test, students are not only asked to provide answers but also to include their reasoning and the level of confidence in their answers. The indicators measured include understanding of the concepts of numerators and denominators, equivalence of fractions, and fraction addition operations.

Meanwhile, the achievement test is designed in the form of multiple-choice and/or essay questions that refer to basic competency indicators and are adapted from Bloom's cognitive assessment instrument [10], which has been revised by Anderson *and* Krathwohl *[11]. This test is used to objectively measure students' mastery of fraction addition material.*

Data collection was conducted in three stages, namely:
(1) a pretest to measure students' initial ability;
(2) the implementation of instruction using the fraction-shading board manipulative in the experimental class;
(3) a posttest to measure learning outcomes after the intervention. The instruments used underwent validity and reliability testing before being used in the study.

2.4 Research Procedure

The research procedure consisted of three stages: preparation, implementation, and conclusion. During the preparation stage, the researcher developed instructional materials, learning media, and research instruments, then pilot-tested the instruments to determine their validity and reliability. During the implementation stage, the study was conducted over six sessions, with each session allocated 2 × 35 minutes. Details of the instructional activities:
(1) The first session began with administering a pretest to both groups to measure students' initial abilities;
(2) The second through fifth sessions consisted of instructional activities, during which the experimental group received instruction using the fraction-shading board manipulative, while the control group used conventional teaching methods;
(3) The sixth session concluded with a posttest to measure students' learning outcomes following the intervention. In the final stage, the researcher processed and analyzed the data and drew conclusions based on the research results.

2.5 Data Analysis Techniques

The research instruments used in this study consisted of a misconception test and a learning achievement test. The misconception test was used to identify students' conceptual errors regarding fraction material, while the learning achievement test was used to measure students' mastery of the taught material. The obtained data were analyzed using descriptive analysis to determine the general picture of the research results. Subsequently, prerequisite tests for analysis were conducted, including normality and homogeneity tests. Hypothesis testing was performed using the Independent Sample t-test to determine differences between the experimental and control groups. Additionally, improvements in learning outcomes were analyzed using the N-Gain test to assess the effectiveness of the intervention. All data analysis was conducted with the assistance of statistical software.

3. *Results and Discussion*

This study was conducted at SD Muhammadiyah 3 Denpasar over six sessions. The experimental class was given an intervention involving learning using a fractional shading board manipulative, which helped students understand concepts concretely through visualization.

3.1 *Results*

3.1.1 Pretest Results

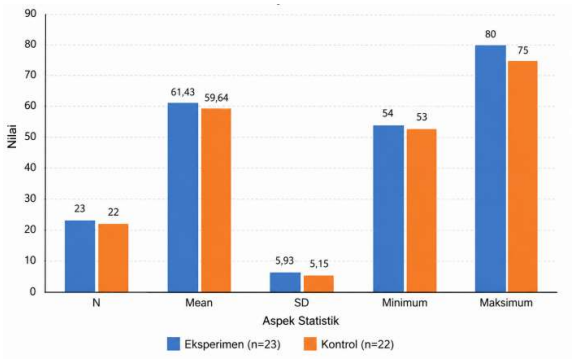

Figure 1. Descriptive Statistics Diagram of the Pretest

The pretest bar chart shows that the initial abilities of students in the experimental and control classes were relatively balanced. This is indicated by the mean score of 61.43 for the experimental class and 59.64 for the control class. The difference in the means of the two groups was not significant, so it can be concluded that the students' initial abilities before the intervention were in nearly the same condition.

The standard deviation (SD) for the experimental class is 5.93 and for the control class is 5.15. This indicates that the data distribution in both groups is relatively homogeneous. Additionally, the minimum and maximum values of both groups also do not show significant differences. The minimum score in the experimental class was 54 and in the control class was 53, while the maximum score in the experimental class was 80 and in the control class was 75. Thus, it can be interpreted that both groups had relatively equivalent initial conditions before the learning process was carried out. Consequently, any differences in results during the posttest phase can be attributed to the interventions administered to each group.

3.1.2 Posttest Results

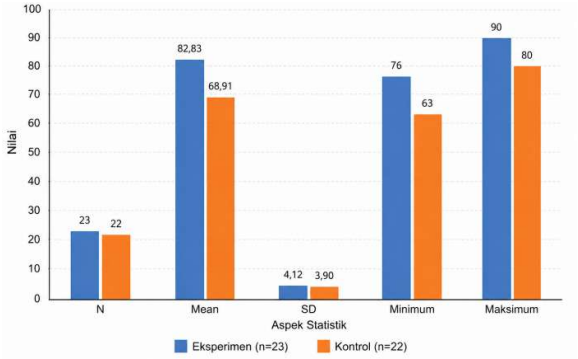

Figure 2. Descriptive Statistics Diagram of the Posttest

Based on the posttest bar chart, it is evident that student learning outcomes in the experimental class were higher than those in the control class. This is indicated by the mean score of the experimental class at 82.83, while that of the control class was 68.91. This difference in means suggests that learning using the manipulative medium of the fraction-shading board has a positive influence on improving students' mathematics learning outcomes.

The standard deviation (SD) for the experimental class is 4.12 and for the control class is 3.90. This indicates that the distribution of scores in both groups is relatively homogeneous and that the improvement in learning outcomes in the experimental class occurred evenly across most students.

Additionally, the minimum and maximum scores in the experimental class were higher than those in the control class. The minimum score in the experimental class was 76, while it was 63 in the control class. The maximum score in the experimental class reached 90, while it was 80 in the control class. These data indicate that students' abilities in the experimental class were better overall compared to the control class.

Based on these results, it can be concluded that the use of the fraction-shading board manipulative medium is effective

in improving students' mathematics learning outcomes on fraction material. Manipulative media help students understand concepts more concretely and visually, making learning more effective compared to conventional methods.

3.2 Prerequisite Tests for Analysis

3.2.1 Normality Test

Data	Significance	Description
Experimental pretest	0.010	Not normal
Control pretest	0.009	Not normal
Experimental posttest	0.513	Normal
Control posttest	0.148	Normal

Table 2. Results of the Normality Test

The posttest data are normally distributed and can therefore be used for parametric tests. The significance values for the pretest data for both groups are less than 0.05, so the pretest data are not normally distributed. Meanwhile, the significance values for the posttest data for both groups are greater than 0.05, so the posttest data are normally distributed. Thus, further analysis can be conducted using parametric tests on the posttest data.

3.2.2 Homogeneity Test

Data	Sig.	Description
Pre-test	0.634	Homogeneous
Posttest	0.676	Homogeneous

Table 3. Homogeneity Test Results

The significance values in the homogeneity test for both the pretest and posttest were greater than 0.05. This indicates that the variances of the two groups are homogeneous. Thus, the two groups have equal variances, thereby fulfilling one of the assumptions in parametric analysis.

3.2.3 Hypothesis Testing

Test Statistics	Value
t	11.624
df	43
Sig. (2-tailed)	0.000
Mean Difference	13.91

Table 4. Results of the Independent Samples t-test

The *Levene's test* results show a significance value of 0.676 > 0.05, so it can be concluded that the variances of the two groups are homogeneous. Therefore, the interpretation of the t-test refers to the "equal variances assumed" row. The results of *the Independent Sample t-test* show a t-value of 11.624, df = 43, and Sig. (2-tailed) = 0.000 ($p < 0.05$). This indicates that there is a significant difference between the learning outcomes of students in the experimental class and the control class. Thus, the null hypothesis (H_0) is rejected, or it can be interpreted that the use of the fraction-based drawing board medium does indeed yield better results than conventional learning.

Parameters	***Value***
Mean Difference	*13.91*
Pooled SD	*4.01*
Cohen's d	*2.90*
Category	*Very Large Effect*

Table 5. Effect Size (Cohen's d)

In addition to the significance test, the strength of the treatment's effect was also analyzed using *effect size (Cohen's d)*. The results showed a *Cohen's* d value of 2.90, which falls into the *very large effect* category. This indicates that the use of fractional grid manipulative media not only produced a statistically significant difference but also had a very strong practical effect on improving student learning outcomes.

3.2.4 N-Gain Test

Group	Mean Pretest	Posttest Mean	N-Gain	Category
Experimental	61.43	82.83	0.55	Moderate
Control	59.64	68.91	0.23	Low

Table 6. N-Gain Results

Based on Table 6, the *N-Gain* value in the experimental class was 0.55 (moderate category), while in the control class it was 0.23 (low category). This indicates that learning using manipulative media is more effective in improving learning outcomes compared to conventional learning.

3.2.5 Misconception Results

Misconception analysis was conducted using the *Three-Tier Test* (TTT) diagnostic test. The results are presented in Table 7.

Group	Before	After	Decrease
Experimental	65%	25%	40%
Control	63%	45%	18

Table 7. Percentage of Student Misconceptions

In Table 7, the analysis results show a 40% reduction in misconceptions in the experimental class, while the control class saw only an 18% reduction.

This finding indicates that manipulative media not only improves learning outcomes but also plays a role in correcting students' conceptual structures. This is important because uncorrected misconceptions can hinder learning at higher levels. Students can see visual representations of fractions, thereby facilitating the understanding of concepts that were previously abstract.

The significant reduction in misconceptions in the experimental class demonstrates that this medium not only improves learning outcomes but also corrects students' conceptual errors. This is important because misconceptions regarding fractions often act as barriers in mathematics learning.

3.3 Discussion of Research Findings

These findings align with research stating that the use of manipulative media can enhance students' conceptual understanding. According to Jean Piaget's cognitive development theory [6], elementary school students are in the concrete operational stage, thus requiring visual and tangible media. Additionally, *Jerome Bruner's* theory also supports that learning progresses from the concrete to the abstract [12].

The use of the fraction grid manipulative has proven effective because it helps students understand fraction concepts through visual and concrete representations. During the learning process, students not only receive verbal explanations but can also manipulate and observe the forms of fractions directly. This facilitates students' understanding of the relationship between the numerator and denominator as well as the process of adding fractions. Learning that involves concrete activities helps students build more meaningful conceptual understanding compared to learning that focuses solely on lectures and abstract symbols.

Manipulative media also play a crucial role in helping to reduce students' misconceptions regarding fractions. Before the intervention, most students held conceptual errors, such as directly adding the numerator and denominator. After using the fraction grid board, students could see a visual representation of the fraction addition process, making it easier for them to understand the concept of fraction equivalence and denominator equalization. This visualization helps students correct previously flawed conceptual structures. Therefore, the use of manipulative media not only improves learning outcomes but also helps deepen students' understanding of mathematical concepts.

Conversely, student learning outcomes in the control class tended to be lower because instruction still relied on conventional teacher-centered methods. This type of instruction leads students to memorize procedures rather than deeply understand concepts. Consequently, students are more prone to misconceptions and difficulties when solving problems that require conceptual understanding. The lack of visual media and concrete experiences makes it difficult for students to build mental representations of the abstract concept of fractions.

The findings of this study have pedagogical implications for mathematics instruction in elementary schools. Teachers can utilize manipulatives as an alternative teaching method to help students understand mathematical concepts in a more concrete and engaging way. Additionally, the use of manipulatives can serve as a strategy to reduce students' misconceptions early on, preventing conceptual errors from persisting into subsequent learning levels. This study also indicates that the use of diagnostic tools such as the Three-Tier Test can help teachers identify students' misconceptions more accurately, allowing instruction to be tailored to students' needs.

This study has several limitations, namely:

1. The study subjects were limited to a single school, so the generalizability of the findings remains limited;
2. The duration of the study was relatively short, so it was not yet possible to observe long-term effects;
3. The study focused only on cognitive aspects and did not examine affective aspects or student learning motivation

Therefore, further research with a broader scope and more diverse variables is essential to strengthen these findings.

4. Conclusion

Based on the research results, it can be concluded that the fractional grid manipulative board is effective in improving learning outcomes and reducing students' misconceptions regarding fraction material. This effectiveness is demonstrated by significant differences between the experimental and control groups, higher N-Gain scores, and a greater reduction in misconceptions in the experimental class. The use of manipulative media helps students understand fraction concepts more concretely and visually, making learning more meaningful. Therefore, the fraction grid manipulative media is recommended as an alternative mathematics learning strategy in elementary schools to help improve students' conceptual understanding.

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