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The Influence of Manipulative Media Usage on Students' Understanding of Fraction Operations in Elementary Schools

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Abstract

This study aims to analyze the influence of using manipulative media on students' understanding of fraction operations at MIS Muslimin Ciririp. A quantitative method with an explanatory approach was employed, involving 28 students selected through simple random sampling. The instruments used were questionnaires and tests. Data analysis included the Kolmogorov-Smirnov normality test, linearity test, as well as correlation and regression tests using SPSS version 26. The normality test results showed that the data were normally distributed, with significance values for manipulative media and fraction operation understanding of 0.064 and 0.200, respectively. The correlation test revealed a very strong relationship, with a correlation coefficient of 0.750, indicating a significant correlation between the use of manipulative media and students' understanding. The linear regression test produced the equation Y=47.186+0.479X, with a determination coefficient (R^2) of 56.2%. This indicates that 56.2% of students' understanding of fraction operations is influenced by manipulative media, while the remaining 43.8% is influenced by other factors. This study confirms that the use of manipulative media significantly enhances students' understanding of fraction operations. These findings provide valuable insights for developing effective mathematics teaching strategies in elementary schools.

INTRODUCTION

Mathematics is a universal discipline and serves as a fundamental basis for technological advancements and various other fields of study. The development of information and communication technology, for instance, heavily relies on the application of mathematics in number theory, algebra, analysis, and other areas. To address the complexities of today's technological era, mastering mathematics from an early age is crucial. Mathematics education in elementary schools aims to develop students' numerical understanding, logical reasoning, analytical thinking, and creativity, as well as their collaborative skills within group settings. These competencies are essential for equipping students to face rapid changes and global competition. However, many

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students still struggle to grasp the practical benefits of learning mathematics. This highlights the need for engaging and relevant approaches to make mathematics easier to understand and applicable to real-life contexts (Yuliwijayanti & Madjdi, 2021).

Most mathematics teaching today relies on conventional methods, which tend to be abstract and less engaging for students. Manipulative materials, as an effective teaching medium, are particularly useful in enhancing students' understanding of mathematical concepts, especially in operations that are difficult to comprehend visually or symbolically (Hajar, 2024). Manipulative media helps students internalize mathematical concepts concretely, providing a more enjoyable learning experience. Although numerous studies have explored the use of manipulative media, few have specifically examined their impact on understanding fraction operations at the elementary school level. Most research focuses on the general impact of manipulative media without considering local contexts and student characteristics, which could significantly influence learning outcomes (Bonal & González, 2020).

Manipulative materials as teaching aids positively influence students' ability to grasp mathematical concepts better than abstract symbols alone. Meanwhile, the rapid advancement of constructivist theories and ICT (Information and Communication Technology) in education has driven significant shifts in teaching approaches. These developments challenge mathematics teachers to leverage ICT as a supporting medium in students' learning processes. One commonly adopted solution by educators is the use of manipulative materials designed to assist students in understanding abstract concepts, particularly in mathematics (Nurhikmah, Nursalam, 2024). By employing mathematical manipulatives, students are better equipped to comprehend abstract ideas. Manipulative materials have been shown to positively impact students' mathematics learning outcomes. Many mathematics teachers agree that using manipulative materials creates a more enjoyable and effective mathematics learning environment (Perbowo et al., 2019).

Despite substantial research on the use of manipulative tools in mathematics education, significant gaps persist. For instance, while many studies have highlighted the positive effects of manipulative tools on student engagement and understanding (Bonal & González, 2020), others have questioned their effectiveness when not properly integrated into instructional strategies. Furthermore, few studies have specifically focused on the role of manipulative media in improving comprehension of fraction operations, a topic that poses unique challenges for learners due to its abstract nature (Tamphu et al., 2024). Additionally, much of the existing literature neglects local contexts and the developmental characteristics of elementary school students, which are critical in shaping learning outcomes (Reiska Primanisa & Rocmah, 2024). For example, studies conducted in Western educational settings may not fully account for cultural and pedagogical differences in other regions, such as Indonesia. These gaps highlight the need for a more nuanced exploration of manipulative media within diverse educational and cultural frameworks.

This research also seeks to evaluate the effectiveness of manipulative media in improving elementary students' understanding of fraction operations. By combining

qualitative and quantitative approaches, this study offers a fresh perspective compared to previous research that often focuses on only one approach. The objective is to provide a deeper understanding of the influence of manipulative media on students' ability to grasp fraction operations. With a focus on elementary students, this study is expected to make a significant contribution to designing more efficient mathematics teaching methods.

The hypothesis of this study is that the use of manipulative media significantly enhances students' understanding of fraction operations compared to conventional teaching methods. The research will test this hypothesis by measuring students' understanding before and after using manipulative media and conducting interviews to explore their learning experiences. This study aims to provide empirical evidence supporting the use of manipulative media in elementary mathematics education while offering valuable recommendations for educators and curriculum developers.

METHOD

This research employed a quantitative method with an explanatory research approach. This study aimed to describe the relationship and causal influence between the independent variable and the dependent variable, which in this case are the use of manipulative media and students' understanding of fraction operations. Therefore, the study adopted a causal-correlational design. A causal-correlational study is a method used to examine the relationship or influence between the independent variable (variable X) and the dependent variable (variable Y) without direct manipulation.

The research was conducted at MIS Muslimin Ciririp, involving the entire student population, with a sample of 28 students selected through probability sampling using a simple random sampling method. The instruments used to collect data included tests and questionnaires. The test instrument was designed to measure students' understanding of fraction operations and consisted of 10 multiple-choice items and 5 open-ended problem-solving questions, ensuring a balance between conceptual understanding and practical application. Each test item was validated through expert judgment by two mathematics education lecturers and a pilot study involving 10 students from a similar population. The reliability of the test was confirmed using Cronbach's Alpha, resulting in a value of 0.82, indicating high reliability. The questionnaire instrument aimed to assess students' perceptions and attitudes toward the use of manipulative media during learning. It comprised 15 statements, including both positive and negative items, using a 4-point Likert scale (Strongly Agree to Strongly Disagree). The questionnaire was validated through content validation by experts and underwent a trial run with a small group of students, yielding a reliability coefficient of 0.78. The data analysis prerequisites included normality testing using the Kolmogorov-Smirnov test and linearity testing. Hypotheses were analyzed using correlation and regression tests with the assistance of SPSS version 26. These comprehensive instruments ensured the validity and reliability of the data, leading to accurate and significant findings.

If the data were normally distributed, the analysis proceeded with Pearson correlation testing, followed by regression analysis to predict the dependent variable

based on the independent variable. However, if the data were not normally distributed, Spearman correlation testing was conducted without performing regression analysis. The following statistical hypotheses were proposed: H_0 (Null Hypothesis): There is no significant relationship between the use of manipulative media and students' understanding of fraction operations, and H_1 (Alternative Hypothesis): There is a significant relationship between the use of manipulative media and students' understanding of fraction operations.

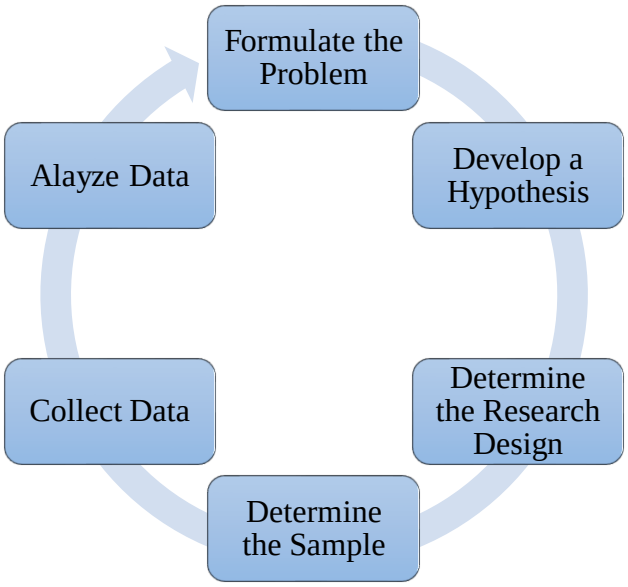

Figure 1. Research Design Steps

RESULTS

The normality test was conducted to determine whether the data obtained came from a population with a normal distribution, as this is a prerequisite for inferential statistical testing. In this study, the Kolmogorov-Smirnov test was used for the normality assessment.

Table 1. Data Normality Test Output

		Statistic	Sig.
Value	Manipulative Media	.160	.064
	Understanding of Fraction Operations	.125	.200*

Based on the data in Table 1, the significance values for manipulative media and the understanding of fraction operations were 0.064 and 0.200, respectively. Since these values are greater than 0.05, according to the decision-making criteria, H_0 is accepted, indicating that the data are normally distributed.

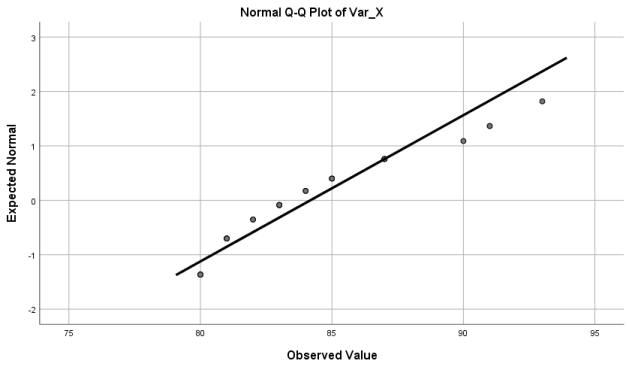

Figure 2. Normal Q-Q Plot Var_X

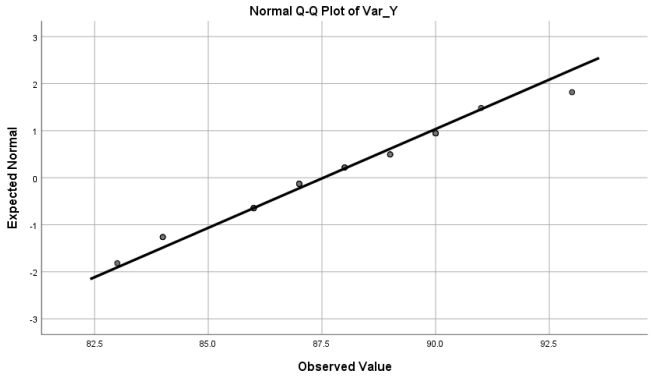

Figure 3. Normal Q-Q Plot Var_Y

The Normal Q-Q Plot for the use of manipulative media and the understanding of fraction operations shows that the data points are scattered around and along the diagonal line, further confirming that the data are normally distributed. The strength of the correlation was analyzed as follows:

Table 2. Correlations

		Var_X	Var_Y
Manipulative Media	Pearson Correlation	1	.750**
	Sig. (2-tailed)		.000
Understanding of Fraction Operations	Pearson Correlation	.750**	1
	Sig. (2-tailed)	.000	

According to Table 2, the significance value for manipulative media and the understanding of fraction operations is 0.000. Since this value is less than 0.05, H_0 is rejected, indicating that manipulative media significantly influence students' understanding of fraction operations.

Table 3. Correlation Values

Coefficient Interval	Strength of Relationship
0,00 – 0,19	Very Weak
0,20 – 0,39	Weak
0,40 – 0,59	Moderate
0,60 – 0,79	Strong
0,80 – 1,00	Very Strong

The correlation coefficient value is 0.750, which falls within the interval 0.60–0.79. Based on the interpretation guidelines in Table 3, this indicates a very strong relationship between the use of manipulative media and students' understanding of fraction operations. Furthermore, the Correlations table shows that variables x (manipulative media) and y (understanding of fraction operations) are marked with **, signifying a significant correlation between the two variables.

Table 4. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.750[a]	.562	.545	1.605

Table 4 displays the R Square or determination coefficient, which indicates how well the regression model explains the interaction between manipulative media usage and the understanding of fraction operations. The R Square value is 0.562, or 56.2%, meaning that manipulative media contribute 56.2% to students' understanding of fraction operations, while the remaining 43.8% is influenced by other factors beyond variables x and y.

Table 5. ANOVA[a]

Model		Sum of Square	df	Mean Square	F	Sig.
1	Regression	85.954	1	85.954	33.351	.000[b]

Table 5 shows that the significance value for regression is 0.000. Since this value is less than 0.05, H_0 is rejected, indicating that the linear regression model meets the linearity criteria and can be used to predict the independent variable (manipulative media) and the dependent variable (understanding of fraction operations).

Table 6. Coefficients[a]

Model		Unstandardized Coef.		t	Sig.
		B	Std. Error		
1	(Constant)	47.186	6.994	6.747	.000
	Var_X	.479	.083	5.775	.000

From the Coefficients table, the regression equation is determined using the constant coefficient and the variable coefficient in the Unstandardized Coefficients B column: Y=47.186+0.479X. This indicates that if the value of variable xxx (manipulative media) is zero, the understanding of fraction operations among students is 47.186. The regression coefficient of 0.479 means that for every unit increase in the use of manipulative media, students' understanding of fraction operations improves by 1.479. Furthermore, since the significance value is less than 0.05, H_0 is rejected, confirming that manipulative media have a significant effect on students' understanding of fraction operations, particularly at the elementary school level.

DISCUSSION

The results presented above show that the data from this study follows a normal distribution, as evidenced by the normality test using the Kolmogorov-Smirnov method.

The significance values for the use of manipulative media and understanding of fractional operations are 0.064 and 0.200, respectively, which are both greater than 0.05. This indicates that the null hypothesis (H_0) is accepted, and the data follows a normal distribution. This is further supported by the Normal Q-Q Plot visualization, where the data points are scattered around the diagonal line. Furthermore, the correlation test results show a significance value of 0.000, which is smaller than 0.05, leading to the rejection of the null hypothesis (H_0). This means that there is a significant relationship between the use of manipulative media and understanding fractional operations. The correlation coefficient of 0.750 falls within the interval of 0.60–0.79, indicating a strong relationship between the two variables.

The coefficient of determination (R Square) of 56.2% indicates that the use of manipulative media has a 56.2% effect on students' understanding of fractional operations, while the remaining 43.8% is influenced by other factors outside of the variables being studied. Additionally, the linear regression test results yield the equation $Y = 47.186 + 0.479X$, indicating that for each unit increase in the use of manipulative media, students' understanding of fractional operations will increase by 0.479. This shows that manipulative media significantly contributes to helping students understand the concept of fractional operations in elementary school. With a regression significance value of 0.000, which is smaller than 0.05, it can be concluded that the regression model meets the linearity criteria and can be used to predict the relationship between the use of manipulative media and students' understanding of fractional operations. Overall, this study demonstrates that manipulative media is effective in enhancing students' understanding of fractional operations.

Understanding Manipulative Media and Mathematics

Manipulative media are tools or materials designed to be physically operated by students, such as turning, arranging, or assembling. The primary purpose of using manipulative media in teaching is to help students understand mathematical concepts that are difficult to grasp abstractly (Al Ayyubi, Rohmatulloh, et al., 2024). These media are particularly effective in teaching mathematics, especially topics such as addition and subtraction of whole numbers, which require a concrete understanding for students to master the material more effectively. By involving students directly in the physical manipulation of learning objects, manipulative media transforms abstract material into more tangible forms, making it easier for students to understand mathematical concepts more deeply (Yuliwijayanti & Madjdi, 2021).

Moreover, manipulative media are highly beneficial in teaching more complex concepts, such as fractions. These tools allow students to learn through direct, hands-on experiences and interactions with objects that can be touched and observed. With this approach, students are better able to internalize and understand the mathematical concepts being taught. The concrete and interactive experiences fostered by manipulative media are expected to deepen students' conceptual understanding of fractional operations. Therefore, using manipulative media in mathematics education has a positive impact on enhancing students' overall understanding.

Mathematics itself is understood as a discipline focused on the study of numbers, shapes, structures, and patterns. In an educational context, mathematics serves as a tool to solve problems and understand more complex concepts. This journal links mathematics to computational thinking (CT) skills, which include problem-solving, data analysis, modeling, abstraction, and algorithm development. CT is considered crucial in mathematics education as it helps students develop structured and logical ways of thinking. Additionally, the journal emphasizes the use of technology, specifically Augmented Reality (AR), in teaching mathematics, aiming to improve students' understanding of mathematical concepts, particularly in the field of geometry (Nurhikmah, Yuspiani, 2024). The research focuses on understanding flat shapes, such as triangles and quadrilaterals, which are key components in the mathematics curriculum at the secondary school level. The applied method focuses on creating a more interactive and immersive learning experience to help students develop critical thinking skills and problem-solving abilities relevant to real-world situations (Lilis et al., 2024).

In the context of mathematics education, manipulative media includes various types of physical tools used to help students understand mathematical concepts, particularly in topics like fractions (Mandasari & Rosalina, 2021). Common manipulatives include pattern blocks, fraction circles, and fraction tiles (Syavira & Novtiar, 2021). These tools allow students to directly see the relationships between parts and the whole, making it easier for them to visually and concretely understand fractions. Another advantage of manipulative media is its ability to increase student engagement in the learning process, facilitating a deeper understanding of the concepts being studied and helping students who struggle with the material. Furthermore, with advances in technology, virtual manipulatives are now available online, providing additional flexibility in mathematics learning.

Research has shown that students who use manipulative media in their learning demonstrate significant improvements in their academic achievement compared to students who only use traditional teaching methods. This suggests that manipulative media not only makes learning more engaging and interactive but is also effective in enhancing students' overall understanding of mathematical concepts. Manipulative media are physical objects that engage various senses, allowing students to feel, move, arrange, and handle the objects during the learning process (Nursalam., Nurhikmah., & Purnamasari, N, 2019). In this way, students can experience and visualize the relationships between mathematical concepts that may be difficult to grasp if only presented verbally or symbolically. Manipulative media are "physical objects used as teaching tools to engage students in hands-on mathematics learning." By using manipulative media, students can reduce the difficulties that arise due to the abstract nature of mathematics and gain a clearer, more concrete understanding of the concepts being taught (Larbi & Mavis, 2016).

Manipulative media, such as materials that can be held, moved, and arranged, play a significant role in helping students overcome barriers to understanding difficult mathematical concepts. A concrete example of this is the use of building blocks or other

learning aids that allow students to interact directly with learning objects. This approach ensures that students not only listen to and observe explanations but also feel and visualize the connections between concepts. This is crucial for deepening students' understanding of mathematical material, especially when it is complex and abstract.

The use of manipulative media in elementary school students has shown significant results in enhancing understanding of fractional concepts, such as through fraction circles that are divided into several parts (Nursalam et al., 2019). These teaching aids make abstract mathematical concepts more concrete and easier to understand. Active student involvement in the learning process also makes the lessons more engaging and enjoyable. Students who struggle with the material will find it easier to comprehend due to the engaging and effective teaching approach used by educators. Manipulative media in fractional operations also fosters critical thinking skills and helps students solve problems. Additionally, students are faced with challenges that encourage them to think critically in finding solutions. Overall, the implementation of manipulative media has a positive influence on students' understanding and creates an engaging learning experience (Susanta & Koto, 2022).

Moreover, manipulative media also have benefits in increasing students' interest and motivation in learning. Manipulative learning, involving physical objects, tends to be more fun and engaging for students, reducing boredom and increasing their activity in class. This interactive learning environment also plays a role in developing students' creativity in solving various mathematical problems (Tamphu et al., 2024). Therefore, manipulative media not only clarify abstract mathematical concepts but also contribute to creating a more enjoyable learning environment and motivate students to learn better. Teachers can also use manipulative media to explain complex concepts in a more visual and easily understandable way. Teacher creativity in utilizing local materials can provide an effective solution in areas with limited resources (Al Ayyubi et al., 2018; Al Ayyubi, Bukhori, et al., 2024; Al Ayyubi, Hayati, et al., 2024; Al Ayyubi, Rohaendi, et al., 2024). Thus, manipulative media proves to be an effective tool in helping students understand difficult mathematical concepts and providing a more interactive and enjoyable learning experience (Perbowo et al., 2019).

The Importance of Understanding Fraction Operations

According to Saparwadi (2022) the importance of understanding fraction operations in the journal can be summarized as follows: 1) Foundation for Future Material, a solid understanding of fractions is essential for grasping more complex mathematical concepts in the future. This shows that the concept of fractions is a foundation that students must have. 2) Basic Skills Needed, students need to have basic skills in number operations, understanding common multiples, as well as basic knowledge of fractions and fraction addition. This is crucial for solving fraction addition problems correctly. 3) Avoiding Mistakes, a good understanding of fractions helps students reduce errors when performing fraction operations, whether due to carelessness or conceptual misunderstandings. Mistakes often occur when students don't understand how to properly add fractions.4) Increasing Interest in Learning, a strong grasp of fractions can boost students' interest in

learning mathematics because they will feel more confident in solving various fraction-related problems. 5) Reflection and Problem Solving, a deep understanding of fraction operations encourages students to reflect on their problem-solving process, which is important for ensuring they can verify and understand the results of their work.

Relevant Learning Theories

The constructivist theory in Rytilä (2021) refers to the view that mathematical entities are social constructs that exist as a result of social practice, similar to well-known social entities like institutions and money. The author discusses social constructivism based on John Searle's theory of the construction of social reality. Social constructivism in mathematics argues that mathematical reality is a product of imposing functions on reality, where the existence of mathematical entities depends on collective recognition (Boaler, 2022; Perbowo et al., 2019; Rosmaiyadi et al., 2023; Sabat et al., 2021; Sulistya & Susanto, 2023). While social constructivism shows potential as a mathematical ontology, the author notes that Cole's specific theory does not provide a satisfactory explanation regarding the objectivity and applicability of mathematics (Birgin & Acar, 2022; Karuniakhalida et al., 2019; Zaenuri et al., 2020). This explanation is seen as weak and limited by the theoretical model underlying Cole's account of constructing mathematical reality. In general, social constructivism seeks to explain how mathematical entities can be considered real without contradicting scientific views of reality and provides insight into how mathematical entities can have objective and applicable features. Participatory Learning Theory: Participatory learning emphasizes the importance of student involvement in the educational process. According to Bonwell and Eison, this approach can enhance motivation and learning outcomes. The use of manipulative tools encourages active student participation in the learning process, which in turn deepens their understanding of fraction operations (Ardina et al., 2019).

The Influence of Manipulative Media on Understanding Fractions

Mathematics is one of the most important subjects in the development of knowledge and technology (Berkhout et al., 2024; Chytry & Kubiatko, 2021; Cilesiz, 2011; Lugosi & Uribe, 2022; Nikou et al., 2022; Pordelan & Hosseinian, 2022; Sirojuddin, 2023; Yuliwijayanti & Madjdi, 2021). Mathematics not only helps students understand abstract concepts but also trains them to think logically and analytically, skills that are useful in everyday life. As a subject taught at all educational levels, from elementary to higher education, mathematics helps students develop essential skills for solving various problems that require an understanding of numbers and calculations. Furthermore, mathematics involves deductive reasoning and concept structures that are hierarchically organized, providing a strong foundation for critical thinking and problem-solving (Murni et al., 2022).

Concept Visualization: Manipulative media help students see and feel fractions directly. This makes it easier for them to understand fraction operations like addition and subtraction. The use of manipulative media in teaching fractions has proven effective in improving students' understanding of the concept. Improving Understanding: The impact of manipulative media on understanding fractions can be seen from research results

showing that the use of manipulative media significantly enhances students' comprehension of fraction operations (Nurhikmah, 2024). The manipulative media developed in this study were proven effective in increasing students' engagement and helping them understand mathematics more practically and applicably. By using manipulative media, students can more easily construct and understand mathematical concepts, especially in addition and subtraction of fractions, which ultimately leads to improved overall learning success (Yuliwijayanti & Madjdi, 2021).

Increasing Motivation and Interest: The use of manipulative media in mathematics learning has been shown to effectively improve students' understanding of mathematical concepts, including fraction operations. Manipulative media provide a tangible representation of abstract ideas, so students can better understand and absorb mathematical concepts through direct interaction with the materials. In this way, students actively engage and develop a deeper understanding visually and practically. Moreover, manipulatives encourage active participation in the learning process. Students can explore and experiment with various mathematical concepts, which increases their motivation and interest in learning. This is particularly beneficial for students who require a more concrete approach or face challenges in understanding abstract concepts. Overall, the use of manipulative media in mathematics not only increases student engagement but also contributes to better learning outcomes, especially for students with special needs or those struggling with traditional methods of understanding mathematics.

Model-Eliciting Activities: This approach is used to understand and explore teachers' preferences for using various models and manipulatives to teach fraction concepts (Rahim et al., 2024). Model-eliciting tasks (MET) are designed to help educators and students develop a deeper understanding of mathematical concepts by encouraging them to create or use relevant models. Teachers are asked to choose the models they prefer to solve fraction tasks and explain the reasons behind their choices. This activity aims to uncover teachers' pedagogical thinking and how they evaluate the effectiveness of various representations in teaching fractions. Thus, model-eliciting activities serve as a tool to identify and analyze teachers' preferences and the reasoning behind the models they use in their teaching (Wilkie & Roche, 2023).

CONCLUSION

Based on the research results, the use of manipulative media has been proven to have a significant impact on students' understanding of fraction operations in elementary school. This is evidenced by the normality test, which shows that the data follows a normal distribution, making it suitable for further analysis. The correlation value of 0.750 indicates a very strong relationship between the use of manipulative media and the understanding of fraction operations. This means that the more effectively manipulative media is used, the better students' understanding of fraction operation concepts. The linear regression analysis shows that the regression model obtained, $Y = 47.186 + 0.479X$, has good accuracy. The coefficient of determination (R Square) of 56.2% indicates that more than half of the students' understanding of fraction operations is influenced by the use of manipulative media, while the rest is influenced by other factors such as teaching methods, learning environment, or students' motivation levels.

Additionally, the significance value of 0.000 in the regression test confirms that the regression model is valid and significant. This means that the use of manipulative media is not only effective but also has a tangible impact on improving students' learning outcomes, particularly in the area of fraction operations. Therefore, manipulative media can be considered an innovative and relevant teaching strategy to help students understand abstract mathematical concepts.

Overall, this study provides empirical evidence that the use of manipulative media significantly contributes to students' success in learning mathematics. Integrating these media into the learning process not only improves understanding but also encourages active student engagement, which can enhance the quality of education at the elementary school level. Further research is recommended to explore other factors that influence students' understanding of fraction operations, such as the role of teaching methods, students' motivation levels, and parental support at home. This could provide a more comprehensive understanding of efforts to improve students' learning outcomes.

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