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Numeracy Skills and Mathematical Self-Concept: Case Study of Students in AKM-Type Problems

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Abstract

This study aims to determine the relationship between numeracy skills and mathematical self-concept. The research was conducted using a correlational method with a quantitative approach. The subjects of this study were students of classes VIII-D and VIII-F at a junior high school in Magelang City. Data collection techniques included a numeracy skills test and a mathematical self-concept questionnaire. The data analysis technique simple linear regression analysis. The results showed a significant and fairly strong positive relationship between numeracy skills and mathematical self-concept, as indicated by a correlation coefficient of 0.589. Furthermore, the regression analysis showed a significance value of 0.000, which is less than $\alpha = 0.05$, indicating that mathematical self-concept significantly and positively predicts numeracy skills. These findings highlight the importance of strengthening students' mathematical self-concept as part of efforts to support the development of numeracy skills.

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Introduction

Mathematics is a core subject that serves as the foundation of natural sciences and is one of the essential subjects in education (Tong et al., 2020). The role of mathematics in life is crucial because mastering mathematics provides students with the necessary tools to face the rapid advancement of science and technology (Maslihah et al., 2020; Mumcu, 2018). Students are not only expected to understand mathematical concepts but also to optimize that knowledge in solving increasingly complex problems (Wardono et al., 2016). Mathematics is studied and developed with the aim of equipping students with logical, analytical, systematic, critical, and creative thinking skills (Apino & Retnawati, 2017). Teachers play a vital role in the learning process by facilitating students' understanding of mathematical concepts so that they can apply them to solve contextual problems relevant to daily life (OECD, 2019). Mathematics is closely related to various aspects of life, particularly in the ability to calculate, measure, and identify and analyze patterns in the surrounding environment (Mumcu, 2018). Thus, mathematics becomes a highly important tool in helping individuals make informed decisions and address various practical challenges in life.

With the implementation of the Kurikulum Merdeka in Indonesia, the urgency of mathematics education has become increasingly prominent. This curriculum provides flexibility for teachers to design and implement learning activities tailored to the needs and potential of students (Wahyudin et al., 2024, p. 12). In the Kurikulum Merdeka, mathematics learning emphasizes the development of

student independence, critical reasoning skills, and creativity (Kemdikbudristek, 2022). Furthermore, the Kurikulum Merdeka highlights the strengthening of numerical literacy or numeracy skills as one of its main focuses (Aini et al., 2024). Numeracy is the ability to apply mathematical understanding and skills to solve problems encountered in everyday life, particularly in complex environments (Connolly et al., 2023). Numeracy is not merely basic mathematical skills; it also involves applying mathematics in real-world contexts (Geiger et al., 2015). From its inception, the concept of numeracy has extended beyond basic numerical and arithmetic operations to encompass mastery of general mathematical concepts and reasoning skills (Cockcroft, 1982).

The emphasis on improving numeracy skills is driven by one of the main factors: Indonesia's low scores in the Programme for International Student Assessment (PISA) conducted by the Organisation for Economic Co-operation and Development (OECD). PISA is a global evaluation that measures the abilities of 15-year-old students in reading, mathematics, and science. Indonesia's PISA scores from 2003 to 2022 show a trend that requires significant attention, with average scores still below international standards. The following graph illustrates the development of Indonesia's PISA scores. This data highlights the challenges faced by Indonesia's education system in enhancing numeracy literacy and underscores the importance of strategic interventions to improve student performance in mathematics at the global level.

Based on the data, Indonesia's average PISA score in 2022 reached 366, which is still below the OECD countries' average score of 472 (OECD, 2023). This score indicates a decline compared to the 2018 results, where Indonesia achieved a score of 379 (OECD, 2019). One contributing factor to this low score is the lack of experience and familiarity of Indonesian students with PISA-type questions. PISA questions tend to emphasize problem-solving and the application of concepts in real-life contexts, which students may not frequently encounter in their daily learning processes.

To address this issue, it is essential for schools and teachers to familiarize students with PISA-type questions from an early stage (Charmila et al., 2016). Through regular and targeted practice, students can better understand the approaches used in such questions, thereby enhancing their critical thinking, reasoning, and problem-solving skills effectively. This initiative also helps strengthen students' numeracy skills, which is one of the main focuses of the Kurikulum Merdeka. As a result, it is expected that Indonesia's PISA scores will improve in the future (Nissa & Darmawan, 2024). To tackle these challenges, the Ministry of Education and Culture (Kemdikbud) has launched a new program called the Asesmen Kompetensi Minimum (AKM), designed to meet global demands where students are expected to adapt to rapid changes and actively contribute to society (Wijaya & Dewayani, 2021). One of the key competencies supporting this goal is numeracy, which serves as a critical foundation for students to face the challenges of the modern world. The Ministry of Education and Culture has released the 2024 education report card, which involved 267,381 schools and madrasahs

across all provinces in Indonesia. The results for students' numeracy skills as reflected in the education report are as follows.

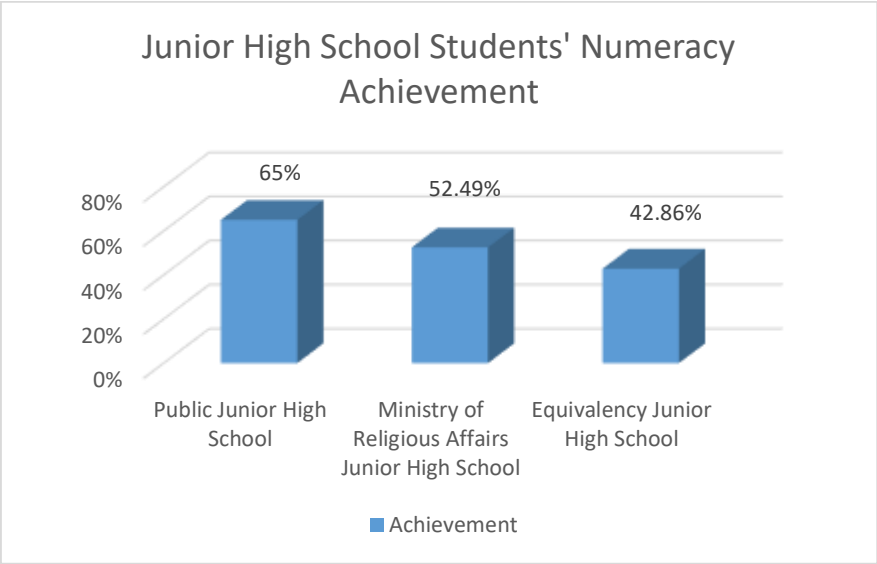

Figure 1. Junior High School Students' Numeracy Skills Based on the 24 Education Report

Based on the Figure 1, the average achievement of students at the junior high school level (SMP/equivalent) indicates that 53.45% of students possess numeracy skills above the minimum threshold within the moderate category (Kemdikbudristek, 2024). This achievement shows an improvement from the previous year, which was 40.63%. However, this figure also reveals that 46.55% of students have not yet reached the expected numeracy competency. This highlights the need for more intensive efforts to improve students' numeracy skills to meet higher standards.

One affective factor influencing students' numeracy skills is mathematical self-concept. Mathematical self-concept refers to students' perceptions and beliefs about their abilities in mathematics (John et al., 2022; Sewasew et al., 2018). When students possess a positive mathematical self-concept, they are more likely to feel confident, motivated to learn, and willing to tackle challenges in solving mathematical problems (Rajagukguk, 2016). With a favorable view of their capabilities, students are better equipped to face difficulties in mathematics, making these challenges less of a barrier to their academic progress.

Research shows that a strong mathematical self-concept directly impacts students' achievements, as those who believe in their abilities typically adopt a more proactive attitude toward learning (Passiatore et al., 2023). Thus, interventions aimed at enhancing mathematical self-concept are crucial for improving students' numeracy skills. Teachers and schools can take steps such as providing positive feedback, guiding students toward realistic yet challenging goals, and creating a supportive learning environment where failures are seen as part of the learning process. Small successes, such as correctly solving math problems, can also help reinforce students' self-confidence. Therefore, conducting in-depth research on the relationship between numeracy skills and mathematical self-concept is essential.

Understanding how these two aspects are interconnected will provide deeper insights into the factors influencing students' performance in mathematics.

Methods

Design

This study employs a correlational method with a quantitative approach. The correlational method aims to determine the relationship between two or more variables, while the quantitative approach is used to obtain numerical data that can be statistically analyzed.

Participants

The population of this study includes all eighth-grade students at a junior high school in Magelang City. From this population, a sample of 58 students was selected, consisting of 30 students from class VIII-D and 28 students from class VIII-F, using a random sampling technique. This method aims to provide an equal opportunity for all members of the population in the selection of the sample.

Instruments

The instruments used in this study consist of a numeracy skills test and a mathematical self-concept questionnaire. The numeracy skills test was developed based on the types of questions found in the Asesmen Kompetensi Minimum (AKM), comprising 16 items with various question types, such as multiple-choice, complex multiple-choice, matching, short-answer, and essay questions. The numeracy test questions are designed to cover four domains: (1) numbers, (2) geometry and measurement, (3) algebra, and (4) data and uncertainty. Additionally, the numeracy test is structured according to three cognitive levels, in line with the classification described by Wijaya & Dewayani (2021). The explanations of these three cognitive levels are presented in Table 1 below.

Table 1. Cognitive Levels of Numeracy Skills

Indicator	Description
Knowing	Questions at the cognitive level of knowing are designed to measure students' ability to understand and master basic knowledge related to facts, processes, concepts, and procedures. At this level, common keywords include recalling, recognizing, classifying, counting, obtaining, and measuring.
Applying	Questions at the cognitive level of applying measure students' mathematical ability to use knowledge and understanding of facts, relationships, processes, concepts, procedures, and methods in real-world contexts. Some common keywords used at this level include selecting, formulating or creating mathematical models, and applying concepts.
Reasoning	Questions at the cognitive level of reasoning are designed to measure students' ability to reason, including analyzing data and information, drawing conclusions, and developing their understanding when faced with new situations, whether unfamiliar or in more complex contexts. Some common keywords used at this level include analyzing, synthesizing, evaluating, concluding, and providing justification.

Meanwhile, the mathematical self-concept questionnaire in this study is designed to evaluate students' self-perception of their mathematical abilities. This instrument consists of 24 statements, divided into two types: positive statements and negative statements. Positive statements aim to identify students' optimistic beliefs about their abilities, such as feeling capable of solving mathematical

problems well. In contrast, negative statements are used to assess potential doubt or lack of confidence in students' mathematical skills. The indicators used in the mathematical self-concept questionnaire are displayed in Table 2 below.

Table 2. Indicators of Mathematical Self-Concept

Aspect	Indicator
Competence	Students' perception of mathematics learning Students' perception of their mathematical abilities
Affective	Students' interest in learning mathematics Students' enjoyment of participating in activities related to mathematics

Data Analysis

In data analysis, the technique used is correlation analysis to determine the relationship between numeracy skills and mathematical self-concept. The first step is to analyze the numeracy test scores and the mathematical self-concept questionnaire based on the established scoring guidelines. The formulas used for scoring the numeracy test and the mathematical self-concept questionnaire are as follows.

$$\text{Numeracy Skill Score} = \frac{\text{Total obtained score}}{\text{Maximum possible score}} \times 100$$

Similarly, the mathematical self-concept score was calculated using:

$$\textit{M}\text{athematical Self} - \text{Concept Score} = \frac{\text{Total obtained score}}{\text{Maximum possible score}} \times 100$$

The scores obtained from both formulas were then interpreted according to five categories: very low (0–20), low (21–40), moderate (41–60), high (61–80), and very high (81–100).

The second step is to perform correlation analysis. Before conducting correlation analysis, assumption tests are carried out, including normality and linearity tests. The normality test aims to ensure that the data is normally distributed, while the linearity test ensures that the relationship between the variables is linear. Meeting these two assumption tests is crucial to maintain the validity of the correlation analysis results, allowing for accurate interpretation. Once the assumptions are met, correlation analysis is conducted using simple linear regression analysis. This analysis aims to measure and describe the linear relationship between two variables, namely the dependent and independent variables.

Result and Discussion

Result

Descriptive Analysis

The data obtained in this study includes two types of data: numeracy test scores and students' mathematical self-concept scores. In this study, the dependent variable used is numeracy skills, while the independent variable used is mathematical self-concept.

The results of both data sets are analyzed using descriptive statistics to provide an overview of the data distribution. The descriptive statistics used include minimum value, maximum value, mean, variance, and standard deviation. All the results of the descriptive statistical analysis for both variables are presented in Table 3 below.

Table 3. Descriptive Statistics for Numeracy Skills and Mathematical Self-Concept

Description	Numeracy Skills	Mathematical Self-Concept
Highest Score	67,57	73,33
Lowest Score	24,32	49,16
Mean	48,93	61,51
Variance	107,04	45,73
Standard Deviation	10,35	6,76

The results of the descriptive statistical analysis provide an overview of students' numeracy skills and mathematical self-concept. For numeracy skills, the highest score achieved by students was 67.57, while the lowest score was 24.32. The average numeracy score was 48.93, meaning that most students had scores close to this value. The variance for numeracy skills was 107.04, indicating a significant spread in the data, supported by a standard deviation of 10.35. This suggests that students' scores in numeracy skills have a relatively high variation around the average.

On the other hand, the mathematical self-concept showed a highest score of 73.33 and a lowest score of 49.16. The average mathematical self-concept score was 61.51. The variance for mathematical self-concept was smaller than that of numeracy skills, at 45.73, indicating a narrower spread in the data. The standard deviation for mathematical self-concept was 6.76, suggesting that students' scores were more closely clustered around the average compared to numeracy skills.

If we look at the students' numeracy skills in each domain, namely (1) numbers, (2) geometry and measurement, (3) algebra, and (4) data and uncertainty, it can be seen in Figure 3 below.

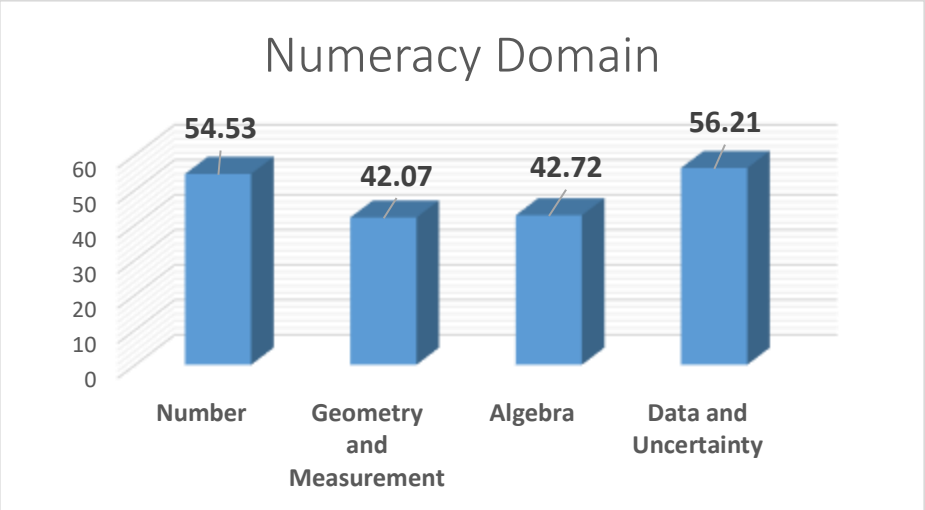

Figure 3. Student Numeracy Skill Score by Numeracy Domain

The figure shows a graph depicting student numeracy achievement across four domains: numbers, geometry and measurement, algebra, and data and uncertainty. The numbers domain had an average score of 54.53, which was the second highest among the domains. This indicates that students were relatively better at understanding and processing numerical concepts. The geometry and measurement domain had the lowest average score at 42.07, suggesting that students faced challenges in comprehending these concepts. Similarly, the algebra domain had an average score close to that of geometry, at 42.72. This is particularly concerning as it indicates that students also struggle with algebraic concepts. The data and uncertainty domain had the highest average score at 56.21, indicating that students performed better in analyzing data and understanding concepts related to probability and uncertainty.

Test the Assumptions

Before conducting the hypothesis test, specifically the simple linear regression analysis, it is necessary to perform assumption tests that must be met, namely the normality test and the linearity test. The results of the normality test are as follows.

Table 4. Normality Test of Numeracy Skill and Mathematical Self-Concept Score

Variable	Sig. Value	Conculsion
Numeracy Skills	0,170	Normally Distibuted
Mathematical Self-Concept	0,100	Normally Distibuted

Based on the data in Table 4, the results of the normality test show that the significance value (sig.) for numeracy skills is 0.170. Since this significance value is greater than the established significance level ($\alpha = 0.05$), it can be concluded that the numeracy skills data is normally distributed. The significance value for mathematical self-concept was obtained as 0.100. Similar to numeracy skills, this significance value is also greater than $\alpha = 0.05$. Therefore, it can be concluded that the mathematical self-concept data is also normally distributed.

In addition to conducting the normality test, this study also involved a linearity test. The purpose of the linearity test is to ensure that the relationship between numeracy skills and mathematical self-concept is linear. Linearity is important to meet as it is one of the requirements for conducting simple regression analysis. The results obtained are as follows.

Table 5. Linearity Test of Numeracy Skills and Mathematical Self-Concept

Variable	Sig. Value
Numeracy Skills and Mathematical Self-Concept	0,125

Based on the results of the linearity test presented in Table 5, a significance value (sig.) of 0.125 was obtained for the relationship between numeracy skills and mathematical self-concept. Since the significance value of 0.125 is greater than 0.05, this indicates that the relationship between the two variables is linear. In other words, this linearity test ensures that the relationship between numeracy

skills and mathematical self-concept meets the linearity assumption. Linearity means that changes in mathematical self-concept are followed by proportional changes in numeracy skills.

Hyphotesis Test

After the data meets the assumption tests, the next step is to conduct a hypothesis test to examine the relationship between the two variables, namely the independent variable and the dependent variable. This hypothesis test is carried out using simple linear regression analysis. The aim is to determine whether there is a significant linear relationship between the two variables. The magnitude of the correlation can be seen in Table 6 below.

Table 6. Simple Linear Regression Analysis

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0,589	0,347	0,335	8,43386

Based on the results of the linear regression analysis in Table 6, the *R* value of 0.589 indicates a moderately strong relationship between numeracy skills and mathematical self-concept. The R^2 value of 0.347 indicates that approximately 34.7% of the variation in numeracy skills can be explained by the mathematical self-concept variable in the model. This means that the mathematical self-concept variable contributes 34.7% to numeracy skills, while 65.3% is influenced by other factors. Next, the significance level can be seen in Table 7 below.

Table 7. ANOVA Test Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2117,759	1	2117,759	29,773	0,000
Residual	3983,282	56	71,130		
Total	6101,041	57			

Based on Table 7, it can be seen that the regression model linking mathematical self-concept as the independent variable with numeracy skills as the dependent variable shows significant results. The F value is 29.773 with a significance level (sig.) of 0.000, which is less than $\alpha = 0.05$. Therefore, it can be stated that the mathematical self-concept variable statistically has a significant effect on numeracy skills. The coefficients in the regression equation can be seen in Table 8 below.

Table 8. Regression Equation Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	f	Sig.
	B	Std. Error			
(Constant)	-6,512	10,221		-0,637	0,527
SelfConcept	0,901	0,165	0,589	5,456	0,000

Based on Table 8, numeracy skills are significantly influenced by mathematical self-concept. The obtained regression equation is $Y = -6{,}512 + 0{,}901X$. Here, Y represents numeracy skills and X represents mathematical self-concept. The constant value of -6.512 indicates that when the mathematical self-concept is zero, numeracy skills are predicted to have a negative value of -6.512.

However, this value is theoretical and less relevant in practical contexts because mathematical self-concept is typically positive. The regression coefficient for mathematical self-concept of 0.901 indicates that for every one-unit increase in mathematical self-concept, numeracy skills are predicted to increase by 0.901 units, assuming other variables remain constant. The standardized coefficient value of 0.589 suggests that mathematical self-concept has a moderate to strong influence on numeracy skills. Additionally, the *f* value of 5.456 with a significance level of 0.000, which is less than 0.05, indicates that the effect of mathematical self-concept on numeracy skills is statistically significant.

Discussion

This study explores the relationship between numeracy skills and mathematical self-concept among eighth-grade students at a junior high school in Magelang. The study was conducted on September 19, 2024, during two math class periods in classes VIII-D and VIII-F at one of the junior high schools in Magelang. Before starting the activity, the researcher provided an explanation to the students about the purpose of the study to ensure they understood the purpose and benefits of their participation. After that, the students were asked to take a numeracy skills test and complete a mathematical self-concept questionnaire prepared by the researcher.

The numeracy skills test was developed based on the types of questions found in the Minimum Competency Assessment (AKM) and consisted of 16 items covering various types, such as multiple-choice, complex multiple-choice, matching, fill-in-the-blank, and essay questions. These questions were divided into four main domains: algebra, number theory, geometry and measurement, and data and uncertainty, with each domain containing 4 questions. Meanwhile, the mathematical self-concept questionnaire comprised 24 statements, including both positive and negative statements, designed to measure students' self-perception of their mathematical abilities. The questionnaire referred to pre-established indicators of mathematical self-concept. Students were given 60 minutes to complete the numeracy skills test and 10 minutes to fill out the mathematical self-concept questionnaire.

After data on the numeracy skills test and mathematical self-concept were collected, the researcher compiled and analyzed the results to evaluate the findings from both variables. The analysis revealed that the average numeracy skills score of the students was 48.93, while the average mathematical self-concept score was 61.51. Additionally, the highest and lowest scores for numeracy skills were 67.57 and 24.32, respectively, whereas for mathematical self-concept, they were 73.33 and 49.16. These figures indicate variation in numeracy skills and mathematical self-concept levels among the students. The results suggest that students' numeracy skills are still relatively low, which is likely due to the lack of practice in solving numeracy problems during the learning process (Ain et al., 2023; Maysarah et al., 2024; Rohmah et al., 2022; Rosnelli & Ristiana, 2023). This low numeracy score also highlights the need for increased numeracy practice so that students can become more accustomed to and skilled at solving problems requiring numeracy skills (Febriyana & Suyitno, 2018). In contrast,

students' mathematical self-concept had a higher average, which may reflect a relatively positive self-perception of their mathematical abilities, even though their numeracy skills still need improvement.

Next, to examine the relationship between numeracy skills and mathematical self-concept, the researcher used simple linear regression analysis. This analysis aimed to measure the strength of the relationship between the two variables. Before conducting simple linear regression analysis, assumption tests were necessary, including normality and linearity tests, to ensure the data were suitable for correlation analysis. The normality test was conducted to confirm that the data was normally distributed, allowing the correlation results to be considered representative and unbiased. On the other hand, the linearity test aimed to ensure that the relationship between numeracy skills and mathematical self-concept was linear, which is one of the main requirements for Pearson's correlation analysis. Based on the assumption tests, it was found that the data was normally distributed and the relationship between the variables was linear, meeting the criteria to proceed to the simple linear regression analysis stage.

The results of the simple linear regression analysis indicate a relatively strong relationship between numeracy skills and mathematical self-concept. The mathematical self-concept variable contributes 34.7% to numeracy skills, while 65.3% is influenced by other factors. Mathematical self-concept has proven to play an important role in supporting students' numeracy skills. Research by Afifah et al. (2024) and Pertiwi & Setyaningsih (2024) revealed that students' mathematical self-concept directly impacts their numeracy skills. This is reinforced by Holenstein et al. (2021), who stated that students' mathematical self-concept significantly influences numeracy skills. Consistent with these findings, Fahrudin (2023) also reported a significant relationship between mathematical self-concept and numeracy skills. Therefore, teachers should actively foster students' mathematical self-concept to boost their motivation to learn math, which, in turn, will contribute to the improvement of their math skills, especially numeracy skills

Furthermore, the regression equation obtained is $Y = -6{,}512 + 0{,}901X$, where the regression coefficient of 0.901 indicates that each one-unit increase in mathematical self-concept will increase numeracy skills by 0.901 units. The *f* value of 5.456 with a significance level of 0.000, which is less than 0.05, indicates that the effect of mathematical self-concept on numeracy skills is significant. Thus, mathematical self-concept can be considered a significant and positive predictor of students' numeracy skills. This finding aligns with the study by Amidi et al. (2024), which revealed a positive effect of mathematical self-concept on numeracy skills. Additionally, Mahuda et al. (2021) also pointed out that mathematical self-concept has a significant impact on numeracy skills. Students with a high mathematical self-concept tend to have a positive outlook and high expectations for their math abilities, motivating them to study and practice more diligently. This finding highlights the importance of self-concept in improving students' numeracy skills. Therefore, teachers should pay special attention to developing students' self-concept to encourage better achievements in mathematics, particularly in numeracy skills.

Conclusion

This study concludes that there is a significant and fairly strong relationship between numeracy skills and the mathematical self-concept of eighth-grade students at a junior high school in Magelang City, as indicated by a correlation coefficient of 0.589. The regression model can be used to predict the variable of mathematical self-concept. This is demonstrated by a significance value of 0.000, which is less than α=0.05, suggesting that the mathematical self-concept statistically has a significant and positive influence on numeracy skills.

The study highlights that mathematical self-concept significantly contributes to numeracy skills, indicating the need for teachers to strengthen this aspect through appropriate teaching strategies. However, numeracy skills are also influenced by other factors, necessitating a comprehensive teaching approach, such as varied practice questions and contextual learning. Future research is advised to expand the population scope, utilize more diverse instruments, and develop innovative teaching strategies to effectively enhance both numeracy skills and mathematical self-concept.

Recommendation

The study has several limitations that need to be considered. First, the research was conducted with eighth-grade students in two classes at a junior high school in Magelang City, so the results may not be generalizable to students at the same educational level in other locations. The characteristics of the students, learning environments, and school cultures can affect the relationship between numeracy skills and students' mathematical self-concept, limiting the generalizability of this study's findings. Second, while the instruments used to measure numeracy skills and mathematical self-concept have been validated, there is a possibility of response bias, particularly because the mathematical self-concept questionnaire relies on students' subjective perceptions.

Future research is recommended to expand the population scope by including students from different grades and schools, both at the district/city and provincial levels, to enhance the generalizability of the research findings. Additionally, using a more varied set of instruments, such as interviews or observations, is advised to support the results of numeracy tests and mathematical self-concept questionnaires. Future studies could also focus on designing instructional strategies, including teaching models, learning approaches, and teaching methods, that can help facilitate improvements in students' numeracy skills and mathematical self-concept.

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