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ANALYSIS OF MATHEMATICAL REASONING ABILITY IN THIRD GRADE ELEMENTARY SCHOOL STUDENTS

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Abstract: Mathematical reasoning ability is a crucial competency to be developed at the elementary school level, as it enables students to understand concepts, connect ideas, and explain problem-solving processes logically. This study aims to analyze the mathematical reasoning abilities of third-grade elementary school students in the topic of length measurement using standard units. A mixed-methods survey design was employed, involving 10 third-grade students from Lidah Wetan State Elementary School, Surabaya. Data were collected through written tests, classroom observations, and teacher interviews. The assessment instrument was developed based on three indicators of mathematical reasoning: understanding basic concepts and procedures, connecting concepts through comparison and unit conversion, and explaining reasoning and solution steps. The findings reveal an average score of 69, categorized as good, although students' abilities were uneven. Achievement levels across the three indicators reached 70 percent, 50 percent, and 40 percent, respectively. These results indicate that students' mathematical reasoning remains predominantly procedural, highlighting the need for instructional practices that emphasize conceptual connections and logical justification.

Keywords: Mathematical reasoning ability, standard units, elementary school students

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INTRODUCTION

Basic education shapes students' thinking structures, particularly their ability to think rationally, logically, and responsibly. At this stage, education not only imparts knowledge; it also cultivates a way of thinking that enables students to make rational decisions by understanding cause-and-effect relationships. Early learning experiences shape the "brain architecture," which serves as the foundation for further learning processes (Harvard University, n.d.). Therefore, primary school education should not focus on achieving academic grades; instead, education should focus on instilling deep cognitive skills and the ability to understand what is meant simply.

Mathematical reasoning demonstrates the development of thinking abilities in mathematics learning. Mathematics is a field of study that focuses more on logical and argumentative thinking processes than just calculation techniques and formulas. As stated by the National Council of Teachers of Mathematics (NCTM), reasoning and proof are essential components of mathematics learning (NCTM, 2000). This fact shows that mathematical reasoning is not only taught as an addition but is an essential part of learning mathematics. On the contrary, it is an essential component that helps someone understand concepts and solve problems. Due to poor reasoning abilities, learning mathematics becomes mechanical and does not provide students with significant conceptual understanding.

Mathematical reasoning allows students to connect various concepts, understand the reasoning behind the solution steps used, and logically justify their answers. Mathematical power encompasses the ability to explore and formulate conjectures, reason logically, solve non-routine problems, communicate mathematical ideas, and connect various ideas within mathematics (Sumarmo as cited in Jusniani & Nurmasidah, 2021). Thus, mathematical reasoning serves as a bridge between conceptual understanding and its application in problem-solving.

Mathematical reasoning is closely related to quantitative reasoning because both require students to process relationships between quantities to make informed decisions. Quantitative reasoning emphasizes the ability to interpret magnitudes, compare quantities, and understand relationships between units within the context of a problem. Steen calls it an ability related to "habits of mind" when facing quantitative situations in

life and work (Tampubolon et al., n.d.). In mathematics learning, students need to do more than just calculations; they also need to understand the quantitative relationships contained within a problem. Fu'adiah's (2017) findings indicate that when confronted with contextual problems, students frequently resort to memorizing algorithms without comprehending the correlation between the provided information and the question, leading to a deficient reasoning process.

Theoretically, mathematical reasoning encompasses two main categories: inductive and deductive reasoning. Inductive reasoning relates to students' ability to draw general conclusions from specific examples, while deductive reasoning is the process of deriving logical consequences from general mathematical principles or rules. Rott's research shows that both types of justification are central aspects of students' epistemological beliefs and critical thinking abilities in mathematics learning (Rott, 2021). Additionally, a study by Manurung and Kartono found that inductive and deductive reasoning skills significantly influence students' mathematical representation abilities, indicating that both are important indicators in assessing the quality of mathematical thinking (Manurung & Kartono, 2016). Thus, the simultaneous development of inductive and deductive reasoning needs to be a focus in mathematics learning to improve students' overall thinking abilities.

Developing mathematical reasoning skills from the elementary school level is highly time-sensitive because this phase is the initial stage of forming students' cognitive foundation. Reasoning that is not developed from an early age has the potential to cause students difficulty in understanding more abstract mathematical concepts in subsequent levels (Sari, 2016). Additionally, mathematics learning that is overly procedure-oriented without engaging reasoning processes and logical justification tends to hinder the development of students' critical thinking (Khoirina et al., 2023).

One of the elementary school mathematics topics that directly demands mathematical reasoning skills is measuring length using standard units. In this material, students are not only asked to read measuring instruments but also to understand the relationships between units, compare quantities, and explain the reasons for choosing a measuring instrument and the results obtained. This process requires students to use both inductive and deductive reasoning simultaneously (Sari, 2016). Therefore, measurement

materials become a relevant context for analyzing students' mathematical reasoning abilities, particularly in terms of connecting concepts and justifying solutions (Fajri, 2017; Khoirina et al., 2023).

Various findings suggest that procedural skills still dominate elementary school students' mathematical abilities. Students are often able to follow the steps in solving a problem, but they don't yet understand the conceptual reasons behind the procedures used, which leads to difficulties when faced with problems in a different context (Skemp, 1978). Students' low mathematical reasoning skills are shown by their inability to explain why and give mathematical proof, even though they can solve simple problems (Khoirina et al., 2023).

Supporting factors, such as the ability to understand problem texts and learning interest, also influence students' mathematical reasoning abilities. The inability of students to comprehend word problems hinders them from recognizing the crucial information required for logical reasoning (Khoirina et al., 2023). When understanding of the problem text is not well-formed, students will experience difficulties in determining the appropriate strategy and explaining the correct solution steps.

Additionally, teacher-centered learning patterns further exacerbate the problems in developing students' mathematical reasoning. Learning that lacks discussion and reflection tends to encourage students to memorize solution steps without understanding the conceptual reasons behind them (Hiebert et al., 1997). As a result, students become passive and reliant on the examples provided by the teacher; thus, their reasoning abilities do not develop optimally.

Based on observations at Lidah Wetan State Elementary School in Surabaya, third-grade students demonstrate varying abilities in solving length measurement problems using standard units. Although the class average was considered adequate, a deeper analysis revealed disparities in mathematical reasoning abilities, particularly in the aspects of connecting concepts and explaining the reasons for the solution. This condition indicates a gap between students' procedural mastery and their mathematical reasoning abilities, necessitating a study that can analyze students' mathematical reasoning abilities in detail through measurable indicators.

Considering these various problems, this research focuses on analyzing the mathematical reasoning abilities of third-grade elementary school students in the topic of length measurement using standard units. The research focus is directed toward uncovering students' ability to understand basic measurement concepts and procedures, connect concepts through unit comparison and conversion, and explain the reasoning and steps used in problem-solving. This research is expected to give an in-depth assessment of the current state of third-grade students' mathematical reasoning abilities and serve as a foundation for improving mathematics instruction, with a greater emphasis on conceptual understanding, connecting ideas, and logical justification from the elementary level.

METHODS

This research uses a survey method with a mixed quantitative and qualitative approach to obtain a comprehensive overview of students' mathematical reasoning abilities. This approach was chosen because mathematical reasoning ability can be seen not only from test results but also from students' thinking processes in understanding concepts, connecting ideas, and explaining problem-solving steps (Khoirina et al., 2023). The research was conducted on third-grade students at Lidah Wetan State Elementary School in Surabaya, with a total of 10 subjects. The topic of length measurement with standard units was chosen because it requires an understanding of basic concepts, the ability to relate units, and the use of logical reasoning in solving contextual problems, making it relevant for examining the mathematical reasoning of elementary school students (Sari, 2016).

Data collection was done through written tests, observation, and interviews. The written test was developed based on three indicators of mathematical reasoning, namely understanding basic concepts and procedures, the ability to connect concepts through comparison and unit conversion, and the ability to explain reasons and solution steps, which refers to the framework of mathematical power that includes logical reasoning and justification (Sumarmo as cited in Jusniani & Nurmasidah, 2021). Observations were conducted throughout the learning process to observe student engagement and emerging difficulties, while interviews with the homeroom teacher were used to gather supporting information related to the learning process and student constraints. All data was analyzed

descriptively to provide a complete picture of the mathematical reasoning abilities of third-grade students.

RESULTS

The results of the mathematical reasoning ability test for third-grade students show an average score of 69, which falls into the good category. However, this average score does not fully reflect the students' overall mathematical reasoning ability because the distribution of student scores shows considerable variation, ranging from 40 to 100, as indicated in Table 1. This variation suggests significant differences in mathematical reasoning abilities among students.

Table 1. Criteria for Categorizing Levels of Mathematical Reasoning Ability

Category	Score Interval (*N*)	Reasoning Skill Interpretation
Very Good (VG)	$81 \leq N \leq 100$	The individual demonstrates a mature mastery of concepts, is capable of deductive reasoning and logical justification, and minimizes misconceptions.
Good (G)	$61 \leq N \leq 80$	Strong procedural reasoning, capable of solving multi-step problems; justification still needs clarification.
Fair (F)	$41 \leq N \leq 60$	Basic concept mastery is adequate, with difficulty with contextual questions and justification.
Poor (P)	$21 \leq N \leq 40$	Fundamental and procedural misconceptions, Unable to connect information.
Very Poor (VP)	$0 \leq N \leq 20$	Failure to understand instructions and basic concepts.

Table 2 presents the grouping of student scores based on these criteria. The data shows that most students are in the fair and poor categories, while only a small percentage of students achieved the very good category. This condition suggests that a select few students dominate the high scores.

Table 2. Student Mathematical Reasoning Scores

No.	Student's Code	Score	Category
1	AM	50	Fair
2	AP	60	Fair
3	AIS	90	Very Good
4	AA	40	Poor

5	AAP	80	Good
6	RAA	60	Fair
7	API	90	Very Good
8	GWE	60	Fair
9	SAS	100	Very Good
10	TFA	60	Fair
Average Scores		69	Good

The distribution of student scores in Table 2 is clarified through the graphical visualization in Figure 1, which shows that the majority of students scored in the middle range, while the number of students with high scores is relatively smaller.

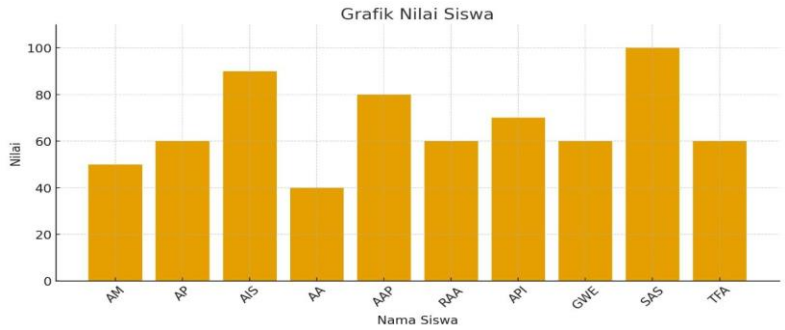

Figure 1. Graph of Students' Mathematical Reasoning Scores

Further analysis was conducted based on three indicators of mathematical reasoning, the results of which are presented in Table 3. The first indicator, understanding basic measurement concepts and procedures for length, showed an achievement level of 70%. The second indicator, the ability to connect concepts through comparison and unit conversion, showed an achievement level of 50%. The third indicator, the ability to explain reasoning and solution steps, showed the lowest achievement level of 40%.

Table 3. Distribution of Students' Mastery Based on Mathematical Reasoning Indicators

Indicator	Assessed Aspect	Percentage of Students Achieving	Mastery Level
Indicator 1	Understanding the basic concepts and procedures of length measurement	70%	Adequate
Indicator 2	Connecting concepts by comparing different ideas and converting units	50%	Moderate
Indicator 3	Explaining reasoning and solution steps	40%	Critical (Low)

DISCUSSION

This study was conducted to analyze the mathematical reasoning ability of third-grade elementary school students in the context of length measurement using standard units. The findings reveal that students' mathematical reasoning remains unevenly developed, with procedural understanding appearing stronger than conceptual connection and justification skills. This pattern directly addresses the research objective by demonstrating that satisfactory achievement scores do not necessarily reflect well-developed mathematical reasoning.

Students' relatively adequate performance in basic measurement procedures suggests that instructional practices have supported routine task completion, such as reading measurement scales and selecting appropriate units. However, frequent errors related to reference points and unit interpretation indicate that this procedural success is not grounded in conceptual understanding. This finding aligns with Skemp's distinction between instrumental and relational understanding, where students may apply procedures correctly without comprehending the underlying mathematical meaning (Skemp, 1978). In measurement contexts, such superficial understanding limits students' ability to reason flexibly when problem structures change.

The most critical finding of this study is students' limited ability to explain reasoning and solution steps. The low achievement on this indicator indicates that deductive reasoning and mathematical justification are not yet well developed. Explanation and justification are essential components of mathematical reasoning because they support conceptual consolidation and metacognitive regulation (Hiebert et al., 1997). When students are unable to articulate why a strategy works, their understanding remains procedural and context-dependent.

Qualitative evidence from the teacher interview strongly supports this interpretation. The classroom teacher stated, *"Students usually memorize the steps. When the problem is slightly different, they become confused and cannot explain the reason behind their answers."* This statement confirms that classroom learning emphasizes procedural repetition rather than reasoning-oriented engagement. Similar instructional patterns have been identified in previous studies, where teacher-centered approaches limit opportunities for students to express reasoning and develop justification skills (Khoirina et al., 2023; Fajri, 2017).

When compared with previous research, the results of this study are largely consistent. Several studies have reported that elementary students tend to perform well on routine tasks while experiencing difficulty in conceptual explanation and reasoning justification (Manurung & Kartono, 2017; Jusniani & Nurmasidah, 2021). However, this study extends existing findings by demonstrating how these difficulties emerge specifically within measurement topics, which inherently require coordination of quantities, units, and logical explanations. This contextual focus strengthens the argument that measurement learning can serve as an effective lens for diagnosing reasoning gaps at an early stage.

Furthermore, the findings support the view that mathematical reasoning development is influenced by instructional design. Learning environments that prioritize correct answers over explanation and reflection may inadvertently suppress reasoning development (Kilpatrick et al., 2001). Without explicit emphasis on justification and conceptual linkage, students remain dependent on exemplars and struggle to transfer knowledge to new situations.

Overall, this study highlights the importance of shifting elementary mathematics instruction from procedural dominance toward reasoning-oriented learning. Length measurement using standard units provides a meaningful context for fostering inductive and deductive reasoning because it requires students to interpret quantities, compare units, and justify conclusions. Strengthening these aspects in classroom practice is essential to support deeper and more sustainable mathematical understanding.

CONCLUSION

This study aims to analyze the mathematical reasoning abilities of third-grade elementary school students in the topic of length measurement using standard units. The research results indicate that students' mathematical reasoning abilities have not developed evenly. Students possess a fundamental comprehension of measurement concepts and procedures; however, they encounter difficulties in integrating concepts across units and articulating the rationale and methodology for problem-solving. This finding confirms that achieving good grades does not necessarily reflect adequate mathematical reasoning skills, as mathematics instruction in the early grades is still dominated by procedural approaches rather than conceptual reasoning and mathematical justification.

Theoretically and practically, this research contributes by emphasizing the importance of analyzing students' thinking processes in elementary school mathematics learning. Strengthening mathematical reasoning needs to be directed toward learning that encourages students to connect concepts, explain the reasons for solutions, and reflect on the thinking processes used. For future research, it is recommended that it be conducted with a larger number of subjects and in a wider range of school contexts, as well as testing the application of learning models specifically designed to train mathematical reasoning, such as problem-based learning or structured mathematical discussions. This approach is expected to sustainably strengthen students' mathematical reasoning abilities from the elementary level.

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