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Students' Mathematical Reasoning Ability in Junior High School Mathematics Learning with Contextual Reasoning

Samsul Hadi[1*], Abdur Rahman[2], Abdul Gafur[3]
[1] *Department of Science Education, Nusantara Global Institute of Education, Indonesia*
[2] *Master of Education, Sunway University, Petaling Jaya, Selangor, Malaysia*
[3] *Master's Degree in Education, Universiti Brunei Darussalam, Brunei Darussalam*
[1] samsulha@gmail.com *; [2] abdrahman@gmail.com; [3] abdgafr@gmail.com
* Corresponding author:

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ABSTRACT

The purpose of this study was to provide a comprehensive description of the mathematical reasoning abilities of students in elementary mathematics learning within the context of reasoning. This research employed a qualitative approach with a case study design involving 35 first-semester students of the Elementary School Teacher Education Program (PGSMP) in the 2021–2022 academic year, consisting of 12 female and 23 male participants. Data were collected using both test and non-test techniques, including interviews, classroom observations, questionnaires, and documentation studies, in order to obtain a holistic understanding of the students' reasoning abilities. The analysis focused on identifying indicators of mathematical reasoning such as the ability to make logical connections, construct arguments, provide justifications, identify patterns, and draw conclusions. The findings revealed that the mathematical reasoning abilities of the PGSMP students in the context of elementary mathematics learning were generally categorized as good. Furthermore, the study highlights the importance of integrating reasoning-oriented tasks in mathematics learning to strengthen students' critical thinking and problem-solving skills. These results suggest that mathematics educators should continue to emphasize reasoning in instructional practices, as it not only enhances students' cognitive development but also prepares them to apply mathematical knowledge in real-world contexts.

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INTRODUCTION

Mathematical reasoning is one of the essential competencies that students must possess in order to solve various problems related to mathematical literacy. Mathematical literacy itself is part of the basic competencies in mathematics learning, which demands critical, analytical, and logical thinking skills in solving problems that are not only simple but also complex and context-based (Tukaryanto, 2018). This ability is not only useful in solving mathematical tasks but also plays an important role in equipping students to face real-life problems that require mathematical reasoning.

Students with strong mathematical reasoning skills tend to understand concepts more easily, connect ideas, and apply appropriate problem-solving strategies in various contexts. Conversely, students with weak reasoning abilities often face difficulties in understanding concepts, generalizing ideas, and solving higher-level problems (Hodiyanto, 2017). Thus, mathematical reasoning serves as the fundamental basis for developing higher-order thinking skills (HOTS), which are among the main demands of modern curricula (OECD, 2019).

However, in practice, many students as well as prospective teachers still face challenges in developing their mathematical reasoning skills. One of the main causes is the lack of habituation in working on problems that demand higher-order thinking skills, along with the limited exposure to real-world contextual problems requiring conceptual and relational understanding (Rahmawati & Permana, 2021). This condition was confirmed by preliminary findings from first-semester students of the Junior High School Teacher Education (PGSMP) Program at the Institut Pendidikan Nusantara Global, which indicated that students were still struggling to understand and solve contextual problems that demand deeper reasoning.

Indeed, Ball, Lewis, and Thamel emphasize that "mathematical reasoning is the foundation for the construction of mathematical knowledge" (Ball et al., 2008). Similarly, Suprihatin (2018) asserts that reasoning ability is closely linked to logical, analytical, and critical thinking, which serve as the foundation for drawing conclusions and making decisions in everyday life. Therefore, strengthening mathematical reasoning in learning is an urgent need to ensure that prospective teachers not only understand mathematical concepts but are also able to transfer such skills into their teaching practices and real-life situations.

Furthermore, international research highlights the importance of reasoning in mathematics education. The National Council of Teachers of Mathematics (NCTM, 2000) states that mathematical reasoning should be a primary focus of mathematics instruction, as it allows students to build conceptual understanding, connect ideas, and develop argumentative skills. Likewise, the OECD (2021), through the PISA report, reaffirms that reasoning-based mathematical literacy is crucial in preparing students to adapt to 21st-century challenges.

Previous studies also reveal that mathematical reasoning positively influences academic achievement and students' critical thinking skills (Stylianides, 2016; Buteau & Muller, 2017). Strong reasoning enables students to identify patterns, construct logical arguments, justify chosen solutions, and draw accurate conclusions. Accordingly, mathematics learning that emphasizes reasoning does not only enhance conceptual understanding but also prepares students to become competent educators.

Based on the preliminary findings and the urgency of developing mathematical reasoning, this research seeks to further investigate the mathematical reasoning skills of prospective teachers within the context of junior high school mathematics learning. The focus of this study is to describe students' abilities in solving contextual problems requiring reasoning skills. By employing a qualitative approach with a case study design, this research aims to provide a comprehensive understanding of students' mathematical reasoning indicators, such as the ability to connect ideas, construct arguments, provide justification, identify patterns, and draw conclusions (Rahardi, 2020).

Therefore, this study is expected to provide theoretical contributions to the development of literature on mathematical reasoning, as well as practical contributions to the development of mathematics curricula and teaching strategies oriented toward reasoning. More broadly, the findings of this study are expected to serve as valuable input for educators in designing mathematics learning that not only emphasizes procedural mastery but also fosters critical, analytical, and reflective thinking skills through reasoning-based contexts.

Based on the description above, this research is entitled: "Mathematical Reasoning Ability of Prospective Teachers in Context-Based Junior High School Mathematics Learning." The research problem is formulated as follows: How can the mathematical reasoning ability of prospective teachers in context-based junior high school mathematics learning be described? The purpose of this study is to comprehensively examine students' mathematical reasoning abilities through reasoning-oriented contextual tasks.

METHOD

Research Design

This research employed a qualitative approach with a case study design. A case study is an exploratory method that investigates a bounded system—such as an event, activity, process, or individual—through extensive data collection and in-depth analysis (Creswell, 2015). The case study design was chosen because it allows for a comprehensive exploration of students' reasoning abilities in mathematical problem-solving within a specific educational context.

Research Site and Participants

The study was conducted at the Institut Pendidikan Nusantara Global. The participants consisted of 35 first-semester undergraduate students, including 12 male and 23 female students. The selection of participants was based on purposive sampling, which is a non-probability sampling technique commonly used in qualitative research to identify and select individuals who are especially knowledgeable or experienced with the phenomenon under study (Palinkas et al., 2015). The chosen participants were considered representative of the research focus, namely students' mathematical reasoning skills in early stages of higher education.

Data Collection

Data were collected using both test and non-test instruments. The test instrument consisted of mathematical reasoning problems designed to assess students' ability to analyze, evaluate, and solve contextual mathematical tasks requiring logical thinking. The non-test instruments included interviews, observations, questionnaires, and documentation studies.

Interviews were conducted to explore students' thought processes, problem-solving strategies, and perceptions about reasoning in mathematics.

Observations focused on classroom interactions and students' problem-solving behavior.

Questionnaires were distributed to gather supporting information about students' learning experiences and difficulties.

Documentation study was used to analyze relevant academic records, instructional materials, and previous assessments.

Data Analysis

The data obtained were analyzed using qualitative data analysis techniques, including data reduction, data display, and conclusion drawing/verification (Miles, Huberman, & Saldaña, 2014). Test results were analyzed to identify patterns of reasoning and common errors in solving contextual mathematical problems. Non-test data were triangulated to strengthen the validity of findings and to provide a holistic understanding of students' mathematical reasoning abilities.

Trustworthiness of Data

To ensure the credibility and trustworthiness of the research findings, several strategies were employed, including triangulation of data sources and methods, member checking, and peer debriefing. Triangulation was achieved by comparing data obtained from different instruments (test and non-test). Member checking was conducted by confirming interpretations with participants to avoid researcher bias. Peer debriefing was used to refine the analysis through discussions with fellow researchers.

RESULTS AND DISCUSSION

Based on the research findings obtained through both test and non-test methods, the questionnaire results indicate that the learning aspect falls into the "good" category with a score of 77, the scientific approach into the "good" category with a score of 80, and students' reasoning ability in junior high school mathematics learning into the "good" category with a score of 78. These findings suggest that most students possess adequate mathematical reasoning skills, particularly in the context of logical learning. This strengthens the view that contextual mathematics learning encourages students to be more critical, analytical, and systematic in solving problems (Sumartini, 2015).

Furthermore, the study revealed that students' ability to comprehend problems was also relatively strong. About 78% of students demonstrated logical thinking, 75% were able to model word problems into mathematical form, 74% succeeded in formulating and executing problem-solving strategies, and 73% were able to review their results. These percentages reflect that students not only manage to solve problems but also possess the ability to reflect on and evaluate their solutions. This confirms that problem-based learning fosters a comprehensive cycle of mathematical thinking, starting from problem comprehension, model formulation, and execution of strategies to the evaluation of results (Polya, 2004).

These findings are consistent with Sumarmo (2014), who emphasized that problem-based learning can enhance students' critical thinking and mathematical reasoning abilities. By presenting students with contextual problems, they are encouraged to use both deductive and inductive reasoning simultaneously. Deduction assists in drawing logical conclusions from established rules or concepts, while induction supports generalizing patterns or relationships based on observations of specific examples.

The primary characteristic of mathematics learning is deductive reasoning, where the truth of a concept is obtained as a logical consequence of previously established truths. However, mathematics learning at the junior high school level also requires the integration of inductive reasoning to build more meaningful understanding. This aligns with Harel and Sowder (2005), who asserted that mathematical understanding develops through the dynamic interplay of induction and deduction. Therefore, problem-based learning that emphasizes personal, social, cultural, and scientific contexts can strengthen both reasoning processes.

Moreover, the findings highlight that mathematics learning is not only oriented toward current academic achievement but also carries long-term relevance in facing future industrial challenges. Students accustomed to mathematical problem-solving will be better prepared to tackle complex real-world problems in technology, economics, and social contexts (NCTM, 2000). Thus, mathematical reasoning ability becomes an essential competence to be developed continuously.

Differences in students' mathematical reasoning abilities in this study were also influenced by variations in conceptual understanding, prior experiences, and interactions between internal and external factors. Internal factors include motivation, interest, and self-confidence, while external factors involve teaching quality, learning environment support, and the characteristics of given problems (Zimmerman, 2000). This explains why, although most students performed well, variation in achievement levels still exists among them.

Regarding internal factors, students with high learning motivation tend to be more persistent in tackling difficult problems and less likely to give up when facing obstacles. Conversely, students with low motivation often encounter difficulties in problem-solving. Schunk et al. (2014) similarly found that intrinsic motivation significantly contributes to the development of critical thinking and reasoning skills.

From the perspective of external factors, the application of the scientific approach plays a key role in encouraging students to observe, question, experiment, reason, and communicate their learning outcomes. The average score of 80 on the scientific approach aspect shows that most students can follow systematic learning steps, ranging from problem exploration to solution presentation. This supports Bybee's (2014) assertion that the scientific approach can enhance 21st-century skills, including critical thinking and problem-solving.

Additionally, the data indicate that students who are accustomed to practicing contextual problem-solving are quicker in identifying solution strategies. This is consistent with Piaget's (1972) constructivist theory, which emphasizes that knowledge is built through direct experience in interacting with the environment. Thus, constructive mathematics learning strongly supports the development of students' reasoning abilities.

The results also demonstrated significant improvement in students' ability to model problems. This skill is vital as it requires connecting real-world phenomena with abstract mathematical representations (Lesh & Doerr, 2003). Therefore, problem-based mathematics learning not only cultivates logical thinking skills but also strengthens mathematical representation competence.

Another noteworthy finding is that although students were capable of logical thinking, some still struggled with reflecting on their solutions. Only 73% of students consistently reviewed their problem-solving results. According to Schoenfeld (1992), the ability to reflect is a hallmark of mature mathematical thinking. Consequently, instructional strategies should place greater emphasis on reflection so that students become accustomed to self-evaluation.

From a practical standpoint, these findings have implications for curriculum development and instructional strategies in higher education. Instructors need to incorporate more context-based logical problems that challenge students to integrate deductive and inductive reasoning. Moreover, learning should be designed not only to focus on the final results but also on the thinking processes involved.

Overall, this study confirms that problem-based learning with a scientific approach is effective in improving students' mathematical reasoning abilities. These results are consistent with previous research emphasizing the importance of context, reflection, and constructivism in mathematics learning (Hiebert & Grouws, 2007; Gravemeijer & Doorman, 1999). Therefore, the application of such strategies should be expanded so that more students can develop critical, logical, and creative thinking skills.

CONCLUSION

The findings of this study demonstrate that problem-based learning supported by a scientific approach has a significant positive impact on the development of students' mathematical reasoning abilities. The results reveal that students achieved good scores in learning aspects, the application of the scientific approach, and mathematical reasoning, indicating that most students are capable of logical, critical, and systematic thinking within mathematics learning contexts. Furthermore, the ability to comprehend problems, model real-life situations into mathematical forms, execute problem-solving strategies, and reflect on solutions highlights the comprehensive nature of mathematical thinking fostered through this approach.

The study also emphasizes the dual importance of deductive and inductive reasoning in mathematics learning, aligning with theoretical perspectives that view understanding as a dynamic interaction between the two. In addition, both internal factors (such as motivation, interest, and confidence) and external factors (including teaching quality and contextual problem design) were found to influence variations in students' reasoning abilities.

Practically, these findings imply the need for mathematics instruction to place greater emphasis on contextual, reflective, and constructivist-based strategies. By doing so, students are not only prepared to achieve current academic success but are also equipped with essential competencies for facing future challenges in technology, economics, and society. In conclusion, problem-based learning with a scientific approach is an effective strategy for fostering critical, logical, and creative reasoning skills, making it a vital component in the continuous development of mathematics education.

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