

Mathematical Reasoning and Mathematical Problem-Solving Skills of Elementary School Students: A Correlational Study

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Abstract—This study aims to analyze the relationship between mathematical reasoning and mathematical problem-solving skills among elementary school students. Mathematical reasoning is an essential competency in mathematics education, playing a key role in helping students understand concepts, construct logical arguments, and determine systematic problem-solving strategies. The study employed a quantitative approach with a correlational design. The participants consisted of 59 fifth-grade students from SDN Kanigoro in Kartoharjo District, Madiun City, East Java, Indonesia, selected through purposive sampling. Data were collected using mathematical reasoning and mathematical problem-solving tests with established validity and reliability (content validity index = 0.92; Cronbach's alpha = 0.88 and 0.91). Data were analyzed using Pearson correlation and simple linear regression. The results revealed a very strong positive relationship between mathematical reasoning and mathematical problem-solving skills, with $r = 0.874$ and $p < 0.001$. Furthermore, the coefficient of determination ($R^2 = 0.763$) indicates that mathematical reasoning accounts for 76.3% of the variance in students' mathematical problem-solving scores. These findings suggest that higher mathematical reasoning skills correspond to better performance in solving mathematical problems. The novelty of this study lies in providing empirical evidence from the elementary school context that quantifies the substantial proportion of problem-solving performance explained by mathematical reasoning through a correlational approach. Therefore, fostering mathematical reasoning should be a primary focus in elementary mathematics instruction to enhance students' mathematical problem-solving capabilities.

Keywords—mathematical reasoning, problem-solving, elementary school

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I. Introduction

Mathematics is a fundamental subject that plays a crucial role in shaping students' logical, systematic, critical, and creative thinking skills (Dewey, 1933; Facione, 1992; Gun & Bossé, 2025). In the context of 21st-century education, mathematics instruction is no longer solely oriented toward mastering procedures and calculations; rather, it aims to develop higher-order thinking skills that enable students to address real-life challenges (Ding & Cai, 2023; Kain et al., 2024; Vanhees et al., 2025). A primary focus of mathematics education is mathematical problem-solving ability. This skill is considered the core of mathematical activity, as it encompasses the processes of understanding the problem, devising a solution strategy, executing that strategy, and evaluating the results (Polya, 1945; Powell et al., 2020; Vessonen et al., 2025). Research has consistently emphasized that effective problem-solving requires students to integrate conceptual understanding, strategic thinking, and metacognitive regulation throughout the solution process (Amalina & Vidákovich, 2023; Bahar et al., 2024).

Mathematical problem-solving holds a highly strategic position in the primary education curriculum (Ding & Cai, 2023). Through this skill, students not only learn to arrive at correct answers but also gain an understanding of the thought processes underlying the solution (Possamai & Allevato, 2024; Sanders et al.,

2025). Problem-solving abilities enable students to connect various mathematical concepts they have learned, thereby fostering a deeper and more meaningful understanding (Harris et al., 2023; Rittle-Johnson & Siegler, 2022). Furthermore, this skill serves as a key indicator for assessing students' readiness to face the increasingly complex learning challenges of subsequent educational levels (Breit et al., 2025; Vanhees et al., 2025). In elementary education, students who develop strong problem-solving competence are better prepared to transfer mathematical knowledge into unfamiliar situations and real-world contexts (Aguirre et al., 2024; Johar et al., 2025).

Nevertheless, various research findings indicate that the mathematical problem-solving skills of elementary school students remain low. Many students struggle to comprehend the information provided in problems, identify relevant concepts, select appropriate solution strategies, and reason through the steps they employ (Amalina et al., 2026; Powell et al., 2020; Vessonen et al., 2025). Difficulties are particularly evident when students encounter non-routine or contextual problems requiring conceptual understanding rather than memorized procedures (Clerjoste et al., 2024; Im & Jitendra, 2020; Liu & Jacobson, 2022). Moreover, students often experience challenges in connecting mathematical representations and justifying their reasoning logically, which ultimately affects the quality of their solutions (Doz et al., 2026; Knox & Kontorovich, 2023; Possamai & Allevato, 2024).

Results from the Programme for International Student Assessment (PISA) over several cycles indicate that the ability of Indonesian students to solve contextual mathematical problems remains at a level requiring improvement (OECD, 2023). The majority of students are only able to solve basic-level problems requiring simple procedures, while their capacity to analyze, evaluate, and solve more complex problems remains relatively limited. These findings highlight the need for greater attention to the factors influencing mathematical problem-solving skills starting at the elementary school level. Consistent with these international findings, recent studies have emphasized that mathematical achievement and problem-solving performance are influenced by multiple cognitive and instructional factors, including executive functions, mathematical knowledge, classroom quality, and learning engagement (Breit et al., 2025; Morgan et al., 2024; Zheng & Xiao, 2026; Zhu et al., 2025). Furthermore, effective instructional approaches such as problem-based learning, STEM integration, and technology-enhanced mathematics learning have been shown to improve students' mathematical problem-solving performance (Chairwut et al., 2025; Hu & Wang, 2024; Ibrahim et al., 2024; Liu et al., 2025).

Mathematical reasoning is considered a key factor strongly linked to mathematical problem-solving ability. It is a cognitive process used to draw conclusions based on available facts, concepts, patterns, relationships, or evidence (Marasabessy, 2021; Mata-Pereira & da Ponte, 2017; Sukirwan et al., 2018). In mathematics education, mathematical reasoning helps students understand the connections between concepts, formulate conjectures, verify the validity of statements, and construct logical, sound arguments (Hawthorne et al., 2022; Knox & Kontorovich, 2023; Zachariades et al., 2025). Mathematical reasoning also enables learners to generalize mathematical ideas and justify solutions beyond procedural computation, making it a central component of meaningful mathematical learning (Bahar et al., 2024; Gun & Bossé, 2025).

Mathematical reasoning serves as a crucial foundation for problem-solving, as every step of the process requires thinking that involves analysis, interpretation, and decision-making (Mata-Pereira & da Ponte, 2017; Polya, 1945). When faced with a mathematical problem, students must be able to identify relevant information, determine relationships between the problem's components, select appropriate solution strategies, and evaluate their results. This entire process relies heavily on the ability to reason mathematically (He & Xin, 2025; Stenberg Hartviksen & Haavold, 2025; Xin et al., 2020). Previous studies have demonstrated that students with stronger mathematical reasoning skills consistently exhibit higher levels of mathematical problem-solving performance because they are more capable of constructing logical arguments, adapting strategies to unfamiliar situations, and evaluating the correctness of their solutions (Amalina & Vidákovich, 2023; Doz et al., 2026; Johar et al., 2025; Sadak et al., 2022; Sholikhah et al., 2026).

According to the National Council of Teachers of Mathematics, reasoning and proof constitute one of the essential process standards that must be cultivated in mathematics education (NCTM, n.d.). Reasoning enables students to develop robust conceptual understanding rather than merely memorizing formulas and procedures. Through reasoning, students understand why mathematical procedures work and are able to justify their solutions logically (Gun & Bossé, 2025; Hawthorne et al., 2022; Mata-Pereira & da Ponte, 2017). Consequently, students with strong mathematical reasoning skills are generally more capable of solving mathematical problems effectively than those who rely solely on procedural memorization (Rittle-Johnson & Siegler, 2022; Sukirwan et al., 2018).

Various prior studies indicate a positive relationship between mathematical reasoning and problem-solving ability. Research has shown that students who are capable of constructing logical mathematical arguments demonstrate superior performance in solving mathematical problems and selecting appropriate solution

strategies (Bahar et al., 2024; He & Xin, 2025; Xin et al., 2020). Furthermore, mathematical reasoning facilitates students in recognizing relationships among mathematical concepts, evaluating alternative solution paths, and constructing valid justifications throughout the problem-solving process (Knox & Kontorovich, 2023; Stenberg Hartviksen & Haavold, 2025; Zachariades et al., 2025). Studies on mathematical creativity and problem solving have likewise confirmed that reasoning serves as one of the strongest cognitive predictors of successful mathematical performance (Doz et al., 2026; Sadak et al., 2022).

At the elementary school level, the relationship between mathematical reasoning and problem-solving ability is particularly significant, as this stage represents a critical period for establishing students' cognitive foundations in mathematics (Morgan et al., 2024; Purpura et al., 2011). Learning experiences provided during primary education strongly influence students' future mathematical achievement and higher-order thinking skills (Breit et al., 2025; De Keersmaecker et al., 2025). Research has demonstrated that elementary students with stronger reasoning abilities tend to perform better in solving contextual and non-routine mathematical problems because they are more capable of integrating conceptual knowledge with strategic thinking (Harris et al., 2023; Johar et al., 2025; Liu & Jacobson, 2022). Therefore, teachers need to understand the extent to which mathematical reasoning supports students' problem-solving skills in order to design more effective, meaningful, and cognitively demanding mathematics instruction (Aguirre et al., 2024; Russo et al., 2020).

Furthermore, the evolution of the constructivist learning paradigm positions students as active agents in constructing knowledge through processes of exploration, reflection, and reasoning (Dewey, 1933; Piaget, 1972). From this perspective, success in learning mathematics is determined not merely by the ability to recall information, but also by students' capacity to construct meaning and apply their knowledge to solve authentic problems (Ding & Cai, 2023; Vanhees et al., 2025). Mathematical reasoning functions as a primary mechanism through which learners connect prior knowledge with new mathematical ideas, formulate generalizations, and justify conclusions based on logical evidence (Bahar et al., 2024; Gun & Bossé, 2025; Mata-Pereira & da Ponte, 2017).

Theoretically, the relationship between mathematical reasoning and problem-solving ability can also be explained through information processing theory. This perspective suggests that individuals possessing well-developed cognitive structures are more capable of organizing information, recognizing patterns, monitoring their thinking processes, and selecting effective solution strategies (Chan et al., 2022; Morgan et al., 2024). Mathematical reasoning strengthens these cognitive processes by enabling students to interpret mathematical relationships systematically and evaluate the validity of their solutions (Amalina & Vidákovich, 2023; Zhu et al., 2025). Consequently, students with higher reasoning abilities are generally able to solve mathematical problems more accurately, efficiently, and flexibly than students who depend primarily on memorized procedures (Doz et al., 2026; He & Xin, 2025).

Although numerous studies have investigated mathematical reasoning and problem-solving ability, important gaps remain in understanding the strength of their relationship among elementary school students. Most existing evidence has been derived from secondary-level or non-Indonesian samples, while studies focusing on Indonesian elementary students remain relatively scarce. In addition, many previous studies have relied on composite mathematics achievement scores rather than measuring mathematical reasoning and mathematical problem-solving as distinct constructs, and few have quantified the magnitude of their relationship at the elementary level. Existing studies suggest that mathematical performance is influenced by multiple interacting factors, including executive functions, conceptual understanding, language ability, classroom instruction, and learning engagement (Breit et al., 2025; De Keersmaecker et al., 2025; Morgan et al., 2024; Zheng & Xiao, 2026). Consequently, variations in learner characteristics, instructional practices, and educational environments may produce different findings regarding the relationship between mathematical reasoning and mathematical problem-solving ability. This study addresses these gaps by providing empirical evidence from Indonesian elementary school students using separate measures of mathematical reasoning and mathematical problem-solving and by quantifying the strength of their relationship through correlational analysis.

This research is significant because it provides empirical evidence regarding the contribution of mathematical reasoning to students' mathematical problem-solving abilities. The findings are expected to provide valuable insights for teachers in designing instructional strategies that emphasize not only learning outcomes but also the development of students' reasoning processes, conceptual understanding, and strategic thinking (Aguirre et al., 2024; Russo et al., 2020; Vanhees et al., 2025). Furthermore, the results may serve as a reference for curriculum developers in strengthening mathematical reasoning as an integral component of mathematics education, thereby promoting students' higher-order thinking skills and long-term mathematical competence (Ding & Cai, 2023; Gun & Bossé, 2025).

Based on this background, the present study aims to analyze the relationship between mathematical reasoning and mathematical problem-solving ability among elementary school students. Specifically, it seeks

to determine the extent to which mathematical reasoning contributes to students' mathematical problem-solving capabilities. The findings are expected to provide empirical evidence supporting the role of mathematical reasoning as a fundamental determinant of successful mathematical problem-solving and to contribute to the improvement of mathematics teaching practices at the elementary school level through evidence-based instructional design (Doz et al., 2026; Johar et al., 2025; Vessonen et al., 2025; Xin et al., 2020).

II. Literature Review

A. Mathematical Reasoning

Mathematical reasoning is widely recognized as one of the most fundamental competencies in mathematics education because it enables students to construct logical arguments, identify mathematical relationships, formulate generalizations, and justify conclusions based on evidence. Rather than simply applying memorized procedures, reasoning allows learners to understand why mathematical concepts and algorithms work, thereby promoting meaningful and transferable learning (Gun & Bossé, 2025; Mata-Pereira & da Ponte, 2017). Consequently, mathematical reasoning has become a central objective of mathematics curricula worldwide, particularly in elementary education, where students begin developing conceptual understanding and logical thinking.

The National Council of Teachers of Mathematics (NCTM) identifies reasoning and proof as one of the five fundamental mathematical process standards (NCTM, n.d.). Students are expected to recognize patterns, formulate conjectures, evaluate mathematical arguments, and communicate logical justifications throughout mathematical activities. Similarly, recent studies emphasize that reasoning enables learners to move beyond procedural fluency toward conceptual understanding and flexible mathematical thinking (Hawthorne et al., 2022; Zachariades et al., 2025).

From a cognitive perspective, mathematical reasoning involves analyzing information, recognizing relationships among mathematical concepts, drawing logical conclusions, and evaluating the validity of solutions. Reasoning is closely associated with executive functions that regulate students' cognitive processes during mathematics learning. Likewise, Executive functions significantly support mathematical reasoning by improving students' ability to organize information, monitor thinking processes, and adapt solution strategies (Morgan et al., 2024; Zhu et al., 2025). Recent research demonstrates that students with stronger reasoning skills consistently exhibit higher levels of conceptual understanding and mathematical achievement. Bahar et al. (2024) found that originality and flexible reasoning substantially improve students' mathematical problem-solving performance. Similarly, Stenberg Hartviksen and Haavold (2025) reported that expert problem solvers differ from novice learners primarily in their ability to reason logically, identify mathematical structures, and justify solutions. Furthermore, Doz et al. (2026) showed that mathematical reasoning facilitates students' creative thinking during word problem solving, enabling them to develop more effective solution strategies (Bahar et al., 2024; Doz et al., 2026; Stenberg Hartviksen & Haavold, 2025).

Constructivist learning theory also provides a strong theoretical foundation for mathematical reasoning. According to Piaget (1972) and Dewey (1933), knowledge is actively constructed through learners' interactions with meaningful experiences. During mathematics learning, reasoning enables students to connect new concepts with prior knowledge, reorganize conceptual structures, and construct deeper mathematical understanding. Contemporary research similarly indicates that knowledge-rich curricula emphasizing conceptual exploration significantly strengthen students' reasoning abilities (Ding & Cai, 2023; Vanhees et al., 2025).

Overall, mathematical reasoning represents a higher-order cognitive process that enables students to think logically, analyze mathematical relationships, formulate arguments, evaluate evidence, and construct conceptual understanding. Therefore, strengthening mathematical reasoning from the elementary school level is essential for developing students' mathematical competence and preparing them for increasingly complex mathematical challenges.

B. Mathematical Problem-Solving Skills

Mathematical problem-solving is considered one of the primary goals of mathematics education because it enables students to apply mathematical knowledge to unfamiliar situations. Rather than merely executing algorithms, effective problem solving requires learners to analyze problem situations, select appropriate strategies, implement solutions, and evaluate the correctness of their answers (Polya, 1945). Consequently, mathematical problem-solving ability reflects students' capacity to integrate conceptual understanding, reasoning, and strategic thinking.

Polya (1945) proposed four stages of mathematical problem solving: understanding the problem, devising a plan, carrying out the plan, and looking back at the solution. These stages remain one of the most influential frameworks in mathematics education and continue to be supported by contemporary empirical research

(Possamai & Allevato, 2024; Powell et al., 2020; Vessonen et al., 2025). Successful completion of each stage requires students to interpret information accurately, select efficient solution strategies, monitor procedural consistency, and verify solution validity.

Research consistently demonstrates that mathematical problem solving relies heavily on conceptual understanding rather than procedural knowledge alone. Xin et al. (2020) reported that conceptual model-based instruction significantly improves students' mathematical problem-solving performance by strengthening conceptual reasoning. Likewise, Liu and Jacobson (2022) found that students who understand mathematical concepts deeply are more successful in solving contextual mathematical problems than those relying primarily on memorized procedures (Liu & Jacobson, 2022; Xin et al., 2020). Recent studies further indicate that higher-order thinking skills substantially influence mathematical problem solving. Amalina et al. (2026) found that prior mathematical knowledge and text comprehension significantly predict students' integrated STEM-based mathematical problem-solving performance. Similarly, Johar et al. (2025) demonstrated that contextual mathematical problems encourage learners to integrate cognitive and affective processes while selecting effective solution strategies. Doz et al. (2026) also reported that mathematical creativity and reasoning jointly enhance students' ability to solve non-routine mathematical problems (Amalina et al., 2026; Doz et al., 2026; Johar et al., 2025).

Various instructional approaches have been shown to improve mathematical problem-solving ability. Inquiry-based learning, constructivist instruction, STEM education, technology-supported mathematics learning, and collaborative mathematical discussion all provide meaningful opportunities for students to explore mathematical concepts while developing effective problem-solving strategies (Chairwut et al., 2025; Hu & Wang, 2024; Ibrahim et al., 2024; Liu et al., 2025). Consequently, contemporary mathematics instruction increasingly emphasizes authentic problem-solving experiences rather than procedural practice alone (Chairwut et al., 2025; Hu & Wang, 2024; Ibrahim et al., 2024; Liu & Jacobson, 2022).

In summary, mathematical problem-solving ability reflects students' capacity to analyze mathematical situations, formulate solution strategies, implement logical procedures, and evaluate solution accuracy. Developing these competencies from elementary school provides a foundation for lifelong mathematical learning and higher-order thinking.

C. Relationship Between Mathematical Reasoning and Mathematical Problem-Solving Skills

Theoretically, mathematical reasoning and mathematical problem-solving are closely interconnected because reasoning serves as the cognitive mechanism underlying every stage of the problem-solving process. Students use reasoning to interpret information, identify mathematical relationships, compare solution alternatives, justify procedures, and evaluate the validity of conclusions (Gun & Bossé, 2025; Mata-Pereira & da Ponte, 2017). Consequently, stronger reasoning abilities are expected to facilitate more effective mathematical problem solving. Information processing theory also explains this relationship by suggesting that successful problem solving depends on learners' ability to organize, retrieve, evaluate, and regulate information efficiently. Mathematical reasoning supports these cognitive processes by enabling students to recognize meaningful patterns, organize mathematical information logically, and monitor the effectiveness of solution strategies (Morgan et al., 2024; Zhu et al., 2025).

Empirical evidence consistently supports the positive relationship between mathematical reasoning and mathematical problem-solving ability. He and Xin (2025) reported that students possessing stronger reasoning skills demonstrate superior performance when solving probability problems. Bahar et al. (2024) similarly found that mathematical originality and reasoning significantly contribute to successful mathematical problem solving. Furthermore, Stenberg Hartviksen and Haavold (2025) showed that expert problem solvers consistently employ more sophisticated reasoning strategies than novice learners. Doz et al. (2026) also concluded that reasoning facilitates students' ability to generate flexible and creative mathematical solutions (Bahar et al., 2024; Doz et al., 2026; Stenberg Hartviksen & Haavold, 2025).

Studies conducted in elementary mathematics classrooms likewise indicate that instructional practices emphasizing mathematical discussion, justification, conceptual exploration, and collaborative reasoning significantly improve students' mathematical problem-solving performance (Aguirre et al., 2024; Joswick et al., 2025; Russo et al., 2020). These findings suggest that strengthening mathematical reasoning through classroom instruction provides an effective pathway for improving elementary students' mathematical problem-solving skills. The conceptual framework of this study is presented in Figure 1.

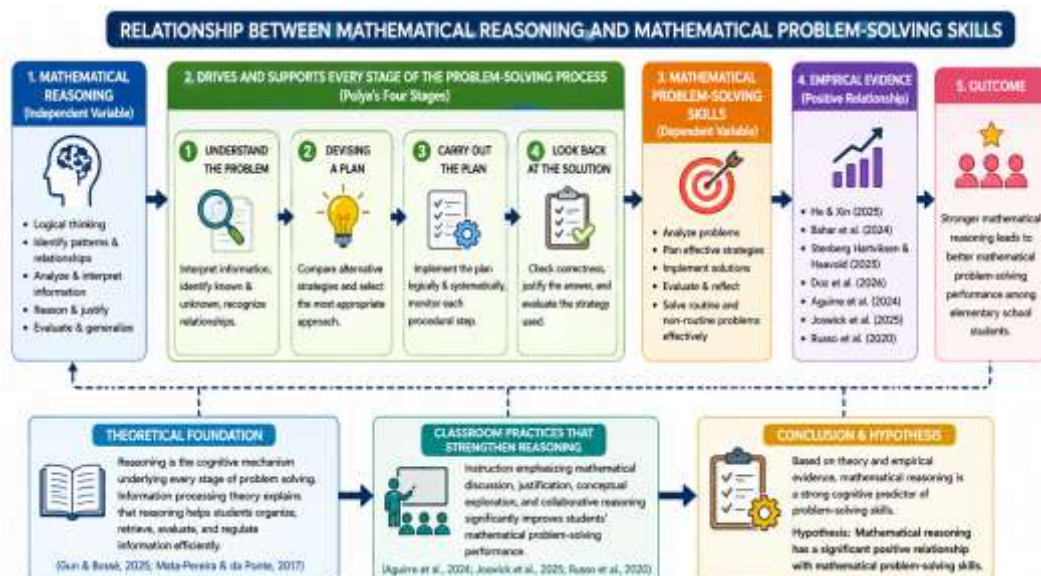


Figure 1. Relationship between Mathematical Reasoning and Mathematical Problem-Solving Skills

Based on theoretical perspectives and empirical evidence, mathematical reasoning can be regarded as one of the strongest cognitive predictors of mathematical problem-solving ability. As illustrated in Figure 1, the conceptual framework proposes that mathematical reasoning is positively associated with mathematical problem-solving skills among elementary school students. Accordingly, this study tests the following directional hypothesis: H1: Mathematical reasoning has a significant positive relationship with the mathematical problem-solving skills of elementary school students. This hypothesis is grounded in constructivist learning theory and information processing theory, which suggest that students with stronger reasoning abilities are better able to analyze mathematical relationships, select appropriate solution strategies, and evaluate the validity of their solutions.

III. Method

A. Research Design

This study employed a quantitative approach with a correlational research design to examine the relationship between mathematical reasoning and mathematical problem-solving among elementary school students. A correlational design was considered appropriate because the primary objective of the study was to determine the strength and direction of the relationship between the two variables without implementing any experimental treatment or intervention. This design has been widely used in educational research to investigate relationships among cognitive variables and learning outcomes. The data were collected during the even semester of the 2025/2026 academic year from fifth-grade students attending public elementary schools in Kartoharjo District, Madiun City, East Java, Indonesia. Prior to data collection, permission to conduct the study was obtained from the participating schools. Written informed consent was obtained from parents or guardians before students participated, and all student data were anonymized to ensure confidentiality throughout the research process.

B. Population and Sample

The population of this study consisted of 71 fifth-grade students enrolled in mathematics classes at SDN Kanigoro in Kartoharjo District, Madiun City, East Java, Indonesia, during the even semester of the 2025/2026 academic year. The research sample comprised 59 students ($N = 59$), representing 83.1% of the total population, who were selected using purposive sampling. The sampling criteria included (1) enrollment in fifth grade during the data collection period, (2) regular participation in mathematics instruction, (3) completion of both the mathematical reasoning and mathematical problem-solving tests, and (4) complete response data suitable for statistical analysis. These criteria were established to ensure that all participants contributed complete and comparable data for the correlational analysis. Regarding statistical power, an a priori power analysis indicates that a sample of 59 participants provides approximately 0.80 power to detect a correlation of approximately $r = .36$ at $\alpha = .05$ using a two-tailed test. In comparison, detecting a moderate correlation of $r = .30$ with 0.80 power would require approximately 84 participants. Therefore, the present sample size was sufficient to detect relationships of approximately $r = .36$ or larger under the specified parameters.

C. Data Collection Instrument

Data were collected using two essay-based test instruments designed to measure mathematical reasoning and mathematical problem-solving ability. The mathematical reasoning test consisted of 5 essay items with a maximum score of 20, while the mathematical problem-solving test consisted of 5 essay items with a maximum score of 20. Each test was administered within 45 minutes. Student responses were scored using an analytic scoring rubric in which each item was evaluated on a 0–4 scale based on predetermined performance criteria, ensuring consistent assessment of students' written mathematical reasoning and problem-solving processes. The mathematical reasoning instrument was developed based on indicators including identifying patterns, drawing logical conclusions, providing logical justifications, making generalizations, and constructing mathematical arguments (Facione, 1992; Hawthorne et al., 2022; Marasabessy, 2021; Mata-Pereira & da Ponte, 2017). Meanwhile, the mathematical problem-solving instrument was constructed according to Polya's four stages: understanding the problem, devising a plan, carrying out the plan, and looking back (Johar et al., 2025; Possamai & Allevato, 2024; Powell et al., 2020; Vessonen et al., 2025). To improve scoring consistency, all essay responses were evaluated independently by two raters using the same scoring rubric. Inter-rater agreement was assessed using Cohen's kappa, yielding a coefficient of 0.86, indicating excellent scoring consistency. Examples of one mathematical reasoning item and one mathematical problem-solving item are provided in Appendix A to facilitate replication.

Prior to administration, both instruments were developed according to the fifth-grade elementary mathematics competency indicators and underwent expert validation involving three mathematics education experts, comprising two university lecturers in mathematics education and one experienced fifth-grade elementary school teacher. Content validity was evaluated using the Content Validity Index (CVI), resulting in a value of 0.92, indicating excellent content validity. Subsequently, a pilot test was conducted to examine the psychometric quality of the instruments. The mathematical reasoning instrument demonstrated Cronbach's $\alpha = 0.88$, while the mathematical problem-solving instrument demonstrated Cronbach's $\alpha = 0.91$, indicating good internal consistency.

D. Data Analysis

The collected data were analyzed quantitatively using IBM SPSS Statistics version 24. Descriptive statistics were first employed to summarize the characteristics of the data, including the minimum score, maximum score, mean, and standard deviation. Subsequently, prerequisite analyses consisting of Shapiro–Wilk normality tests and linearity tests were conducted before performing inferential statistical analyses. The Shapiro–Wilk test was selected because it is recommended for samples smaller than 100 participants. Data were considered normally distributed when $p > .05$. Linearity was evaluated using the Deviation from Linearity test in the ANOVA table, where a non-significant deviation ($p > .05$) indicated that the relationship between the variables could be treated as linear. The relationship between mathematical reasoning and mathematical problem-solving ability was analyzed using the Pearson Product-Moment correlation coefficient to determine both the strength and direction of the relationship between the variables. Subsequently, simple linear regression analysis was performed to estimate the proportion of variance in mathematical problem-solving ability explained by mathematical reasoning through the coefficient of determination (R^2). All statistical analyses were conducted using a significance level of 5% ($\alpha=.05$), following commonly accepted standards in educational research.

IV. Results and Discussion

A. Research Results

Data analysis was conducted on 59 fifth-grade students ($N = 59$) to examine the relationship between mathematical reasoning and mathematical problem-solving ability. Descriptive statistics indicated that students obtained a mean mathematical reasoning score of 74.12 ($SD = 12.87$) and a mean mathematical problem-solving score of 75.20 ($SD = 11.73$). Overall, both variables showed relatively high average performance while maintaining sufficient score variation for correlational analysis.

Table 1. Descriptive Statistics of the Study Variables

Variable	N	Minimum	Maximum	M	SD	Skewness	Kurtosis
Mathematical Reasoning	59	45	98	74.12	12.87	-0.28	-0.64
Mathematical Problem-Solving	59	48	97	75.20	11.73	-0.19	-0.51

Before conducting inferential analyses, the assumptions of normality and linearity were examined. The Shapiro–Wilk test showed that both variables were normally distributed, while the Deviation from Linearity test indicated that the relationship between mathematical reasoning and mathematical problem-solving was linear.

Table 2. Results of Assumption Tests

Test	Statistic	p	Decision
Shapiro–Wilk (Reasoning)	W = 0.978	.213	Normal
Shapiro–Wilk (Problem-Solving)	W = 0.983	.381	Normal
Deviation from Linearity	F = 1.287	.274	Linear

The non-significant results ($p > .05$) confirmed that the assumptions required for Pearson correlation and simple linear regression analyses were satisfied.

Pearson Product-Moment correlation analysis revealed a very strong positive relationship between mathematical reasoning and mathematical problem-solving ability. The correlation coefficient was $r(57) = .874$, $p < .001$ (two-tailed), with a 95% confidence interval of [.79, .92]. Based on the correlation classification proposed by Evans (1996), this coefficient falls within the very strong category (0.80–1.00), indicating that students with higher mathematical reasoning scores tended to achieve higher mathematical problem-solving scores. To further examine this relationship, a simple linear regression analysis was conducted. The resulting regression equation was:

$$Y = 16.137 + 0.797X$$

The regression model was statistically significant, $F(1, 57) = 183.60$, $p < 0.001$, with $R^2 = 0.763$ and Adjusted $R^2 = 0.759$. The slope coefficient was statistically significant ($t(57) = 13.55$, $p < 0.001$, 95% CI = [0.68, 0.92]), indicating that each one-unit increase in mathematical reasoning score was associated with an estimated 0.797-point increase in mathematical problem-solving score. These findings indicate that mathematical reasoning explained 76.3% of the variance in students' mathematical problem-solving scores, while the remaining 23.7% of the variance was associated with other factors beyond the scope of this study. Because the study employed a correlational design, these results should be interpreted as evidence of a strong positive association, rather than a causal effect, between mathematical reasoning and mathematical problem-solving ability.

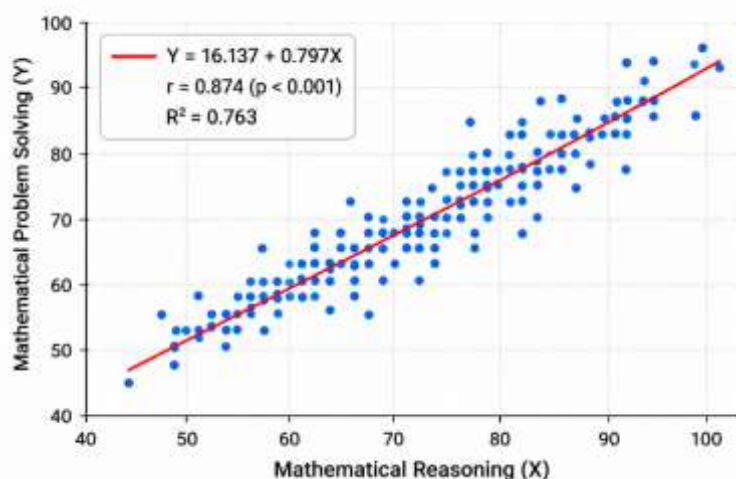


Figure 2. Scatter Plot of Mathematical Reasoning and Mathematical Problem-Solving Ability

Based on these results, the research hypothesis is accepted: there is a positive and significant relationship between mathematical reasoning and the mathematical problem-solving abilities of elementary school students. These findings indicate that mathematical reasoning serves as a crucial foundation for the development of mathematical problem-solving abilities.

B. Discussion

The research results indicate a very strong positive relationship between mathematical reasoning and the mathematical problem-solving abilities of elementary school students. These findings suggest that improvements in students' mathematical reasoning skills are accompanied by corresponding improvements in their mathematical problem-solving abilities. Furthermore, mathematical reasoning contributes substantially to

students' mathematical problem-solving performance. These results reinforce the theoretical assumption that mathematical reasoning serves as a fundamental cognitive basis for the problem-solving activities students engage in during mathematics learning (Gun & Bossé, 2025; He & Xin, 2025; Mata-Pereira & da Ponte, 2017; Sukirwan et al., 2018). Similar findings have been reported in previous studies showing that students with stronger reasoning abilities consistently demonstrate superior performance in solving mathematical problems because they are better able to analyze relationships, justify solutions, and adapt strategies to unfamiliar situations (Bahar et al., 2024; Doz et al., 2026; Stenberg Hartviksen & Haavold, 2025).

These findings align with the perspective that mathematics is fundamentally an activity of reasoning rather than merely the application of algorithms or memorized procedures (Gun & Bossé, 2025; Hawthorne et al., 2022). When students encounter a mathematical problem, they are required not only to recall formulas but also to analyze available information, identify relationships among mathematical elements, formulate appropriate solution strategies, and evaluate the validity of the obtained results (Knox & Kontorovich, 2023; Xin et al., 2020). This entire process depends heavily on mathematical reasoning, which functions as the cognitive mechanism underlying decision-making throughout problem solving (Morgan et al., 2024; Zhu et al., 2025). Consequently, students possessing stronger mathematical reasoning skills tend to understand the structure of mathematical problems more effectively, recognize relevant concepts more accurately, and determine efficient solution procedures with greater confidence (Amalina et al., 2026; Johar et al., 2025; Liu & Jacobson, 2022).

The results of this study support Polya's (1945) theory of mathematical problem solving, which consists of four stages: understanding the problem, devising a plan, carrying out the plan, and looking back at the solution. Each of these stages requires adequate reasoning skills to ensure successful problem resolution (Polya, 1945; Powell et al., 2020; Vessonen et al., 2025). During the stage of understanding the problem, students must interpret the given information, identify known and unknown quantities, and recognize the mathematical relationships involved (Powell et al., 2020). In the planning stage, reasoning enables students to compare alternative solution strategies and determine the most appropriate approach (Possamai & Allevato, 2024; Sanders et al., 2025). During implementation, students apply mathematical concepts logically and systematically while monitoring the consistency of each procedural step (Chan et al., 2022; Xin et al., 2020). Finally, at the evaluation stage, reasoning is required to verify the correctness of the solution, justify the obtained answer, and reflect on the effectiveness of the selected strategy (Mata-Pereira & da Ponte, 2017; Zachariades et al., 2025). Therefore, mathematical reasoning is not merely one component of problem solving but rather the cognitive foundation that supports every stage of the entire problem-solving process.

The present findings are also consistent with recent empirical studies emphasizing that mathematical reasoning is closely associated with higher-order thinking skills and conceptual understanding in elementary mathematics education. Students who are able to formulate logical arguments, identify mathematical patterns, and provide evidence-based justifications generally demonstrate better performance in solving contextual and non-routine mathematical problems (Bahar et al., 2024; Doz et al., 2026; Sadak et al., 2022). Likewise, studies have shown that classroom learning environments emphasizing reasoning, mathematical discussion, and conceptual exploration significantly improve students' mathematical problem-solving abilities compared with instruction focusing primarily on procedural fluency (Aguirre et al., 2024; Joswick et al., 2025; Russo et al., 2020). These findings indicate that strengthening mathematical reasoning through classroom instruction has the potential to improve students' overall mathematical competence.

From a practical perspective, the findings imply that mathematics teachers should provide learning experiences that actively foster students' reasoning processes rather than emphasizing procedural mastery alone. Learning activities involving problem posing, mathematical argumentation, collaborative discussion, contextual problem solving, and opportunities for students to explain and justify their thinking can facilitate the development of mathematical reasoning (Aguirre et al., 2024; Joswick et al., 2025; Kavanagh et al., 2025; Possamai & Allevato, 2024). In addition, instructional approaches such as constructivist learning environments, STEM-based learning, and technology-supported mathematics instruction have been reported to enhance both reasoning and mathematical problem-solving abilities among elementary school students (Chaiarwut et al., 2025; Hu & Wang, 2024; Ibrahim et al., 2024; Liu et al., 2025). Therefore, strengthening mathematical reasoning should become one of the primary objectives of mathematics instruction to prepare students for increasingly complex mathematical challenges in the future.

The very strong correlation between mathematical reasoning and mathematical problem-solving ability indicates that these two competencies are closely interconnected and mutually reinforcing. Mathematical reasoning enables students to establish meaningful connections among previously acquired mathematical concepts, allowing them to apply these concepts flexibly in a variety of mathematical situations (Gun & Bossé, 2025; Hawthorne et al., 2022; Mata-Pereira & da Ponte, 2017). Students who are able to recognize patterns, formulate generalizations, construct logical arguments, and draw conclusions based on mathematical evidence tend to develop more effective and efficient problem-solving strategies (Bahar et al., 2024; Zachariades et al.,

2025). In contrast, students with limited reasoning ability frequently experience difficulties identifying relevant information, selecting appropriate strategies, and justifying their solutions when confronted with non-routine mathematical problems (Amalina & Vidákovich, 2023; Doz et al., 2026; Liu & Jacobson, 2022; Powell et al., 2020).

The findings of this study also reinforce the mathematics process standards proposed by the National Council of Teachers of Mathematics, which identify reasoning and proof as essential components of mathematics learning. According to these standards, students should be provided with opportunities to develop reasoning through activities such as identifying patterns, formulating conjectures, testing hypotheses, constructing mathematical arguments, and communicating their thinking. Contemporary research likewise emphasizes that classroom environments promoting mathematical discussion, justification, and collaborative reasoning substantially improve students' conceptual understanding and problem-solving performance (Aguirre et al., 2024; Joswick et al., 2025; Kavanagh et al., 2025). Furthermore, learning activities that encourage productive struggle and mathematical argumentation have been shown to strengthen students' reasoning processes and deepen conceptual understanding (Kalinec-Craig & Rios, 2024; Russo et al., 2020). Consequently, mathematics instruction emphasizing reasoning has considerable potential to improve students' mathematical problem-solving abilities.

The significant contribution of mathematical reasoning to mathematical problem-solving ability, accounting for 76.3% of the explained variance, demonstrates that reasoning is a highly influential predictor of students' mathematical performance. This finding suggests that success in solving mathematical problems depends largely on students' capacity to think logically, systematically, and analytically. Students who can connect mathematical concepts, analyze relationships among pieces of information, formulate logical justifications, and evaluate the validity of their solutions are more likely to solve mathematical problems successfully (He & Xin, 2025; Stenberg Hartviksen & Haavold, 2025; Xin et al., 2020). These findings are consistent with recent studies demonstrating that mathematical reasoning represents one of the strongest cognitive predictors of higher-order mathematical thinking and successful mathematical problem solving (Amalina et al., 2026; Johar et al., 2025; Sadak et al., 2022).

From the perspective of constructivist learning theory, the results of this study can be explained through the active knowledge construction process undertaken by students during learning (Dewey, 1933; Piaget, 1972). Constructivism posits that knowledge cannot simply be transmitted from teacher to learner but must be actively constructed through meaningful learning experiences. Within this process, mathematical reasoning functions as a cognitive mechanism that enables students to integrate new mathematical ideas with their prior knowledge, reorganize conceptual structures, and construct deeper mathematical understanding (Ding & Cai, 2023; Vanhees et al., 2025). Research has shown that students who develop stronger conceptual understanding through reasoning are better equipped to transfer mathematical knowledge to unfamiliar situations and solve complex contextual problems requiring flexible thinking (Harris et al., 2023; Knox & Kontorovich, 2023; Rittle-Johnson & Siegler, 2022).

In addition to constructivist theory, information processing theory provides another explanation for the findings of this study. According to this perspective, successful problem solving depends on how efficiently learners encode, organize, retrieve, and evaluate information within their cognitive systems. Mathematical reasoning supports these cognitive processes by enabling students to organize mathematical information, identify meaningful patterns, monitor their thinking, and select effective solution strategies (Chan et al., 2022; Morgan et al., 2024). Executive functions and reasoning abilities have also been shown to facilitate students' capacity to regulate cognitive processes during mathematical problem solving, thereby improving both accuracy and efficiency (Morgan et al., 2024; Zhu et al., 2025). Consequently, students possessing stronger reasoning skills are able to process mathematical information more effectively, adapt their strategies to different problem contexts, and generate more accurate and logically justified solutions than students with weaker reasoning abilities (Breit et al., 2025; Doz et al., 2026; Gun & Bossé, 2025).

The results of this study are consistent with numerous previous studies demonstrating a positive relationship between mathematical reasoning and mathematical problem-solving ability. Recent research has shown that students who are capable of constructing logical mathematical arguments, recognizing patterns, and providing valid justifications consistently outperform their peers in mathematical problem-solving tasks (Hawthorne et al., 2022; Mata-Pereira & da Ponte, 2017; Zachariades et al., 2025). Likewise, studies have found that successful mathematical problem solving depends not only on procedural fluency but also on students' ability to employ reasoning flexibly when selecting and evaluating solution strategies (Bahar et al., 2024; He & Xin, 2025; Stenberg Hartviksen & Haavold, 2025). Furthermore, mathematical creativity and reasoning have been identified as complementary cognitive processes that enable learners to solve both routine and non-routine mathematical problems effectively (Doz et al., 2026; Sadak et al., 2022). These findings reinforce the results of

the present study, confirming that mathematical reasoning is one of the strongest predictors of students' mathematical problem-solving success.

In the context of primary education, these findings have important educational implications. Elementary school represents the foundational stage in the development of mathematical thinking, during which students acquire the conceptual understanding and reasoning abilities required for more advanced mathematics learning (Morgan et al., 2024; Purpura et al., 2011). Research indicates that learning experiences emphasizing reasoning during the primary years positively influence students' long-term mathematical achievement and higher-order thinking skills (Breit et al., 2025; De Keersmaecker et al., 2025). Therefore, mathematical reasoning should be intentionally fostered from an early age through instructional activities that encourage students to explore ideas, discuss mathematical concepts, justify their thinking, and reflect on alternative solutions (Aguirre et al., 2024; Russo et al., 2020). Conversely, instructional practices that emphasize procedural drills and memorization without conceptual understanding may limit the development of reasoning skills and ultimately reduce students' ability to solve unfamiliar mathematical problems (Liu & Jacobson, 2022; Rittle-Johnson & Siegler, 2022).

Teachers play a pivotal role in creating classroom environments that promote mathematical reasoning. One effective strategy is providing students with non-routine and cognitively demanding mathematical problems requiring them to analyze situations, identify mathematical relationships, formulate hypotheses, and develop solution strategies independently (Possamai & Allevato, 2024; Powell et al., 2020). Research also suggests that learning approaches such as problem-based learning, inquiry-based learning, constructivist instruction, STEM-based learning, and technology-supported mathematics instruction provide meaningful opportunities for students to strengthen their reasoning and problem-solving abilities simultaneously (Chaiarwut et al., 2025; Hu & Wang, 2024; Ibrahim et al., 2024; Liu et al., 2025). These instructional approaches encourage students to become active participants in constructing mathematical knowledge rather than passive recipients of procedural information (Vanhees et al., 2025).

The use of open-ended mathematical tasks also represents an effective strategy for strengthening students' reasoning abilities. Open-ended problems allow multiple solution methods and encourage students to explain, justify, and compare different mathematical strategies (Possamai & Allevato, 2024; Sanders et al., 2025). Through classroom discussions and mathematical argumentation, students develop deeper conceptual understanding while simultaneously improving their capacity to communicate mathematical ideas logically (Joswick et al., 2025; Kavanagh et al., 2025). In addition, research has demonstrated that productive mathematical discussions and opportunities for collaborative reasoning significantly enhance students' higher-order thinking skills and mathematical problem-solving performance (Aguirre et al., 2024; Russo et al., 2020). Consequently, mathematics instruction should provide students with frequent opportunities to explain not only "what" solution they obtained but also "why" the solution is mathematically valid.

These research findings also have important implications for curriculum development. Mathematics curricula should be designed not merely to ensure mastery of mathematical content but also to cultivate reasoning, problem-solving, and other higher-order thinking skills that are essential for lifelong learning (Ding & Cai, 2023; Vanhees et al., 2025). Recent research has emphasized that knowledge-rich curricula combined with reasoning-oriented instructional practices produce deeper conceptual understanding and more transferable mathematical competencies (Gun & Bossé, 2025; Kain et al., 2024). Therefore, mathematical reasoning should be integrated systematically into learning objectives, instructional activities, classroom assessment, and evaluation so that students become accustomed to using logical thinking to understand mathematical concepts and solve increasingly complex problems (Aguirre et al., 2024; Bicer et al., 2024).

Although this study demonstrates a very strong relationship between mathematical reasoning and mathematical problem-solving ability, approximately 23.7% of the variance in students' problem-solving scores remains unexplained by the variables included in this study. Previous research suggests that mathematical problem-solving is influenced by numerous additional cognitive, affective, and instructional factors, including executive functions, numeracy skills, mathematical literacy, language ability, motivation, classroom quality, learning engagement, and conceptual understanding (Breit et al., 2025; De Keersmaecker et al., 2025; Morgan et al., 2024; Zheng & Xiao, 2026; Zhu et al., 2025). Other studies have also highlighted the importance of computational thinking, creativity, self-regulated learning, and digital learning environments in supporting mathematical reasoning and problem-solving performance (Hu & Wang, 2024; Liu et al., 2025; Moreno-León et al., 2025; Nufus et al., 2024). Therefore, future studies should incorporate these variables to obtain a more comprehensive understanding of the determinants of mathematical problem-solving ability among elementary school students.

Despite these findings, this study has several limitations that should be considered when interpreting the results. First, the cross-sectional correlational design identifies the strength and direction of the association between mathematical reasoning and mathematical problem-solving but does not permit causal inference. Second, the use of purposive sampling involving 59 fifth-grade students from SDN Kanigoro in Kartoharjo

District, Madiun City, East Java, Indonesia, limits the generalizability of the findings to other grade levels, schools, and educational contexts. Third, data were collected on a single measurement occasion using two paper-based essay tests, which may introduce shared method variance and may not fully capture the stability of students' reasoning and problem-solving abilities over time. Future research could address these limitations by employing longitudinal or experimental designs, involving more diverse samples across multiple schools and regions, and incorporating multiple assessment methods to provide a more comprehensive understanding of the relationship between mathematical reasoning and mathematical problem-solving.

Overall, the results of this study provide strong empirical evidence that mathematical reasoning serves as a crucial foundation for the mathematical problem-solving abilities of elementary school students. The very strong relationship identified between these two variables indicates that improvements in students' problem-solving ability cannot be separated from systematic efforts to strengthen mathematical reasoning. Consequently, mathematics instruction should be intentionally designed to provide rich opportunities for reasoning, mathematical argumentation, conceptual exploration, collaborative discussion, and reflective thinking, enabling students to develop the higher-order thinking skills required to address both mathematical and real-world problems effectively. These findings further demonstrate that investing in the development of mathematical reasoning during the elementary years represents a strategic approach to improving the quality of mathematics education while preparing students to become logical, systematic, creative, and adaptive problem solvers capable of meeting the increasingly complex demands of the twenty-first century.

V. Conclusion

This study demonstrates that mathematical reasoning contributes significantly to students' mathematical problem-solving abilities. The findings confirm that students with strong mathematical reasoning skills are better equipped to understand problems, devise solution strategies, execute procedures accurately, and evaluate the solutions obtained. Consequently, mathematical reasoning can be viewed as a fundamental basis for developing mathematical problem-solving skills. Therefore, mathematics instruction in primary schools should be designed to foster reasoning activities, thereby supporting the enhancement of students' mathematical problem-solving capabilities.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

Author Contributions

H.T.W.P. collected and analyzed the data and drafted the manuscript. O.H.S. conceived and designed the study, supervised the research process, and reviewed and edited the manuscript. U.W.N.P. contributed to instrument development and field data collection. N.I. contributed to manuscript review and editing. All authors have read and approved the final version of this manuscript.

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