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# STRUCTURAL EQUATION MODELS: MATHEMATICAL REASONING ABILITIES AND GEOMETRIC PROBLEM-SOLVING ABILITIES

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**Abstrak**

Penelitian ini bertujuan untuk menguji kecocokan model persamaan struktural (SEM) guna mengetahui hubungan antara kemampuan penalaran matematis dan kemampuan pemecahan masalah geometri. Dengan menggunakan desain penelitian ex-post facto, studi ini mengambil sampel acak sebanyak 100 mahasiswa dari total 296 populasi mahasiswa pendidikan matematika di sebuah universitas di Lubuklinggau. Data dikumpulkan melalui tes penalaran matematis dan tes pemecahan masalah geometri, kemudian dianalisis menggunakan program Lisrel 8.8 dan SPSS. Hasil analisis menunjukkan adanya koefisien jalur yang sangat signifikan, yang membuktikan bahwa kemampuan penalaran matematis memiliki hubungan langsung yang positif dengan kemampuan pemecahan masalah geometri. Hal ini mengartikan bahwa peningkatan pada kemampuan penalaran akan diikuti oleh peningkatan pada kemampuan memecahkan masalah geometri. Kesimpulannya, penelitian ini menegaskan adanya hubungan langsung antara kedua variabel tersebut, di mana kemampuan penalaran matematis berkontribusi sebesar 15,13% terhadap peningkatan kemampuan pemecahan masalah geometri.
**Kata kunci:** Kemampuan, Penalaran matematika, Pemecahan Masalah Geometri, SEM, Lisrel

***Abstract***

*This study aims to test the compatibility of structural equation (SEM) models to determine the relationship between mathematical reasoning ability and geometry problem solving ability. Using an ex-post facto research design, this study took a random sample of 100 students from a total of 296 mathematics education student population at a university in Lubuklinggau. Data were collected through mathematical reasoning tests and geometry problem-solving tests, then analyzed using the Lisrel 8.8 and SPSS programs. The results of the analysis show a very significant path coefficient, which proves that mathematical reasoning ability has a positive direct relationship with geometry problem-solving ability. This means that an increase in reasoning skills will be followed by an increase in the ability to solve geometry problems. In conclusion, this study confirms the existence of a direct relationship between the two variables, where mathematical reasoning ability contributes 15.13% to the improvement of geometry problem-solving ability.*
***Keywords:*** *Ability, Mathematical reasoning, Geometric Problem Solving, SEM, Lisrel*

## INTRODUCTION

A preliminary survey, conducted from August to December 2024, revealed that mathematics education students at a university in Lubuklinggau City scored low in geometry problem-solving. Specifically, only 24.24% could understand problems (red), and a mere 16.67% were able to formulate mathematical models (blue), as shown in Figure 1.

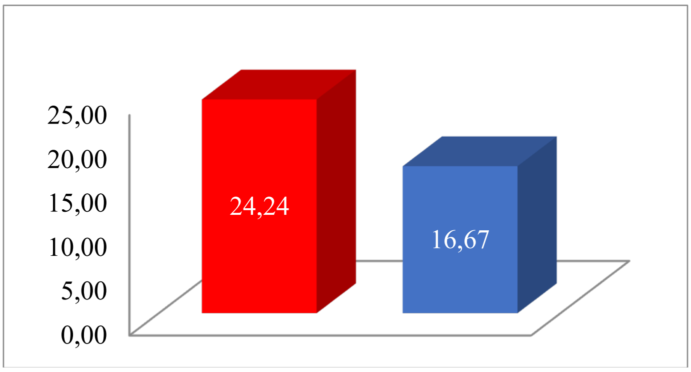

**Figure 1**. Geometry Problem-Solving Abilities of Mathematics Education Students at a Lubuklinggau City University

As shown in Figure 1, most students (75.76%) struggle to understand math problems, failing to identify the "what is known" and "what is asked" parts of a question. Additionally, about 83.24% can't correctly create mathematical models, often trying to solve problems directly without this crucial modeling step. The researcher points to weak mathematical reasoning skills as a primary cause for these low geometry problem-solving abilities.

To Improving Mathematical Reasoning Skills Students should be given the opportunity to relate mathematical objects to daily life (Bayuningsih et al., 2018; Setiawan et al., 2024; Weigand et al., 2024; Widada et al., 2021; Wittmann, 2020). Mathematical reasoning skills are closely related to Mathematical connection activity that links mathematical objects to everyday life (McDaid, 2020; Weigand et al., 2024). A student's ability to solve mathematics problems is tied to their prior knowledge, their readiness, and the mathematical content itself. A problem acts as a barrier, clear or otherwise, that students must creatively overcome by finding new information, approaches, and actions. This barrier, however, isn't the sole component of a problematic situation, as other elements also play a role (Dostál, 2015; Rarasati et al., 2020; Weigand et al., 2024).

The nature of problems in a problem-centered curriculum is vital (Berlyand & Jabin, 2023; Cristia & Cueto, 2020; Lappan et al., 2002). These problems should embody critical concepts and skills and be designed to involve students in comprehending mathematics. Since students build understanding through reflection and communication, problems should actively promote these processes.

Effective mathematics problems typically adhere to some or all of these principles.

a). They contain relevant and valuable mathematical content.
b). They permit diverse solution strategies.
c). They allow for multiple solutions or varied interpretations.
d). They are engaging and motivational.
e). They necessitate advanced and critical thinking.
f). They support conceptual growth.
g). They link to other core mathematical concepts.
h). They foster the proficient use of mathematics.
i). They offer practice for important skills.

Moreover, problems serve as valuable tools for teachers to gauge student learning and pinpoint difficulties (Lappan et al., 2002).

To successfully tackle mathematical problems, you need to have well-developed mathematical thinking abilities. Solving problems means finding a way out of difficulties, a way out of obstacles, achieving goals that cannot be achieved immediately (Polya, 1981; Weigand et al., 2024; Widada et al., 2021; Wittmann, 2020) Furthermore, Polya explained that solving problems is a special achievement of intelligence, and intelligence is a special gift of humanity. Problem-solving is perhaps the most common and defining human endeavor. Although in the study, it was found that students' original thinking skills can be improved through open-ended problem-solving learning (Bintoro et al., 2021; Mhlongo et al., 2024; Nguyen et al., 2024; Ramirez, 2024; Urrutia et al., 2023; Waluya, 2018). Problem-solving is a cognitive process that includes physical activity (if necessary) to discover a solution to a given problem. There are four activities carried out in problem solving, namely understanding the problem, compiling a solution plan through a mathematical model, solving problems according to the mathematical model, and returning the solution of the mathematical model to the initial problem (Darto et al., 2024; Rohman & Retnowati, 2018; Wittmann, 2020). In the context of mathematics, a model is the result of an abstraction of real-world situations that are mathematically formulated to simplify the problem-solving process. The solution of the model is obtained by applying mathematical rules, but this modeling process is often a point of difficulty for students in understanding various mathematical concepts and principles.

To effectively solve problems, students must employ critical thinking and high-level thinking abilities. Critical thinking, in this context, refers to a student's aptitude for carefully and logically dissecting information and ideas, considering them from various perspectives. This skill, according to Moursund (2007), is demonstrated through several indicators, namely being able to analyze complex problems to make informed decisions, synthesize information to reach reasonable conclusions, evaluate the logic and relevance of data, and utilize knowledge to explore new questions. In general, ability is defined as the mastery of skills by a person to perform various tasks. Meanwhile, Polya (1973) defines problem-solving ability as a person's ability to find a way out of an obstacle or achieve a goal through a cognitive process. According to him, these ability indicators include: identifying problems (writing down what is known and asked), planning their solutions (making sketches, models, or formulas), solving problems according to the plan made, and reinterpreting the solution into the context of the original problem. Based on this description, it can be synthesized as follows. Geometric problem-solving ability (Ypm) is a cognitive process that may include physical activity, aimed at finding a solution to a problem. This ability is measured by the following indicators: 1) understanding the problem (Y7), 2) creating a mathematical model (Y8), 3) applying the mathematical model to solve the problem (Y9), and 4) explaining the results in relation to the original problem (Y10). You can see the relationship between the latent variable "Mathematical Solving Ability" and its indicators in Figure 2.

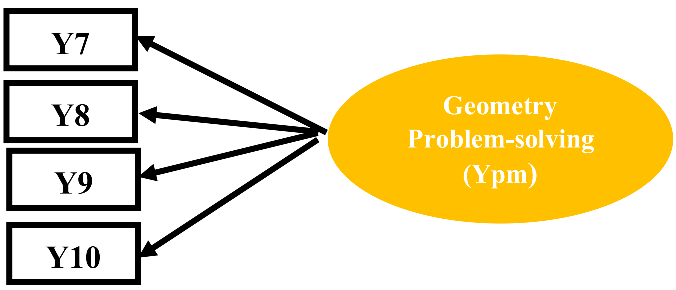


**Figure 2.** Relationship of Problem-Solving Ability and Its Indicators

Mathematical reasoning skills are an important ability in mathematics learning because using reasoning can interpret mathematics (Lestari, 2019). Mathematical reasoning is one of the cognitive processes that is very important for students and teachers of mathematics in various conceptualizations of reasoning (Hjelte et al., 2020). According to Hjelte, Schindler, & Nilsson (2020), mathematical reasoning is a skill that can be applied in general without being limited to certain branches of mathematics. Reasoning is defined as a process of drawing conclusions. Furthermore, their research employs a hierarchical interactionism framework to investigate the intrinsic and extrinsic factors that contribute to the processes of mathematical reasoning and learning.

Indicators of mathematical reasoning according to NCTM (2000) are (1) proposing conjectures, performing mathematical manipulations, drawing conclusions; (2) compiling evidence; (3) provide reasons or evidence for the correctness of solutions, draw conclusions from statements, examine the validity of an argument, and find patterns or properties of mathematical phenomena to make generalizations. In mathematics learning, mathematical reasoning skills are crucial competencies that are important, both in solving problems and in understanding mathematical objects. Therefore, this ability can be measured through three main indicators: making a conjecture, structuring evidence, and providing a logical reason for each step of proof. As a cognitive process, mathematical reasoning can be inductive or deductive.

According to Mhlolo (2012), inductive and deductive reasoning is a series of activities that consciously apply logic to draw a conclusion from one or more pre-existing statements. This process often starts with specific examples that are then abstracted and generalized to form a concept (Cristia & Cueto, 2020). However, reasoning is a mathematical ability with very complex implications, making it difficult for students to master. Although superior reasoning skills are essential for solving mathematical problems, research by (Reyhani et al., 2021; Sukirwan et al., 2018) revealed that students in general still have difficulty in reasoning. Their reasoning tends to be imitative, that is, simply following existing procedures on a regular basis. Instead, research from Hasanah et al. (2019) It shows that students who have high mathematical ability also have good mathematical reasoning skills. According to (Guimaraes & Mervis, 2024; Reyhani et al., 2021) The mathematical reasoning skills of students of the Mathematics Education Study Program can be improved through the approach *Problem-solving*, due to the improvement of the mathematical reasoning skills of students who use the *Problem-solving* better than students using conventional learning (Lestari, 2019). This also means that students' mathematical reasoning skills affect students' ability to solve geometry problems in geometry (Sandy et al., 2019), students with a high level of mathematical reasoning are able to meet all indicators of the reflective thinking process (Tisngati & Genarsih, 2021). The reflective thinking process unfolds in several stages: it begins with identifying facts and questions, moves to explaining the necessary operations, proceeds to executing a plan, and concludes with providing a logical conclusion. The key indicator here is whether students write the correct final answer, aligning with the steps of the problem-solving process.

Based on this, we define mathematical reasoning ability (X) in this study as a cognitive process in mathematics where a student connects available data or facts to reach a conclusion. This ability is measured using three indicators:

a). Making a conjecture (X1)
b). Constructing evidence (X2)
c). Justifying each step of the proof (X3)

Figure 3 illustrates the relationship between the latent variable of mathematical reasoning ability and these indicator variables.

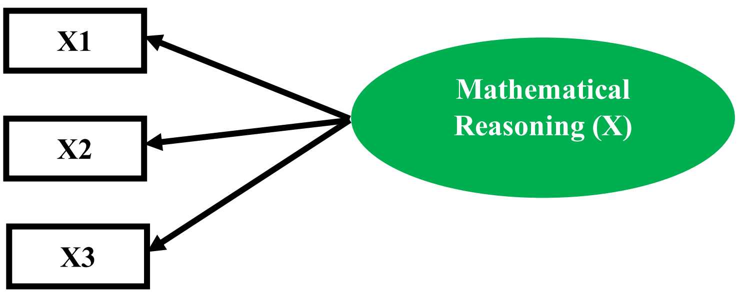


**Figure 3.** How the Mathematical Reasoning Variable Relates to Its Indicators

A consistent body of research indicates a direct correlation between proficiency in mathematical reasoning and problem-solving capabilities. Study by (Sandy et al., 2019; Tisngati & Genarsih, 2021) stating that there is a link between problem-solving skills, mathematical reasoning, and students' reflective thinking skills. Similar findings from other studies concluded that students with high levels of mathematical reasoning were able to solve geometry problems, while students with low reasoning skills were only able to reach the stage of understanding problems (Hasanah et al., 2019; Masfingatin et al., 2020) Inayah (2016). In fact, students with low creative reasoning need help (*scaffolding*) to solve problems that contain elements of novelty. In addition, learning approaches such as *Problem-solving* It has been proven to improve reasoning skills, and different logical reasoning styles also affect students' ability to solve mathematical problems.

The study also revealed a direct link between mathematical connection skills and geometry problem-solving ability. Students with strong mathematical connection skills generally succeed at solving problems, whereas those with weaker skills often struggle.
The interesting thing is that mathematical reasoning skills actually encourage students to be able to build connections (Kadir et al., 2020; Mueller et al., 2014; Pambudi et al., 2020; Zakir, 2015). This means, in addition to direct relationships, there are also indications Direct contact between mathematical reasoning skills and geometric problem-solving skills that occur through mathematical connection skills. Therefore, we can assume that mathematical reasoning ability causally influences geometry problem-solving ability, as shown in Figure 4.

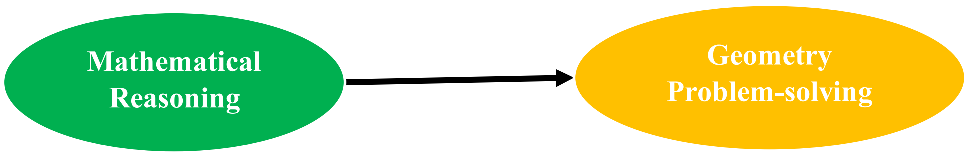


**Figure 4.** Illustrating the Direct Relationship Between Reasoning and Problem-Solving

With reference to Figures 2, 3, and 4, a model of theoretical equations that summarizes the relationship between geometric problem-solving abilities and their relation to mathematical reasoning can be presented, as seen in Figure 5.

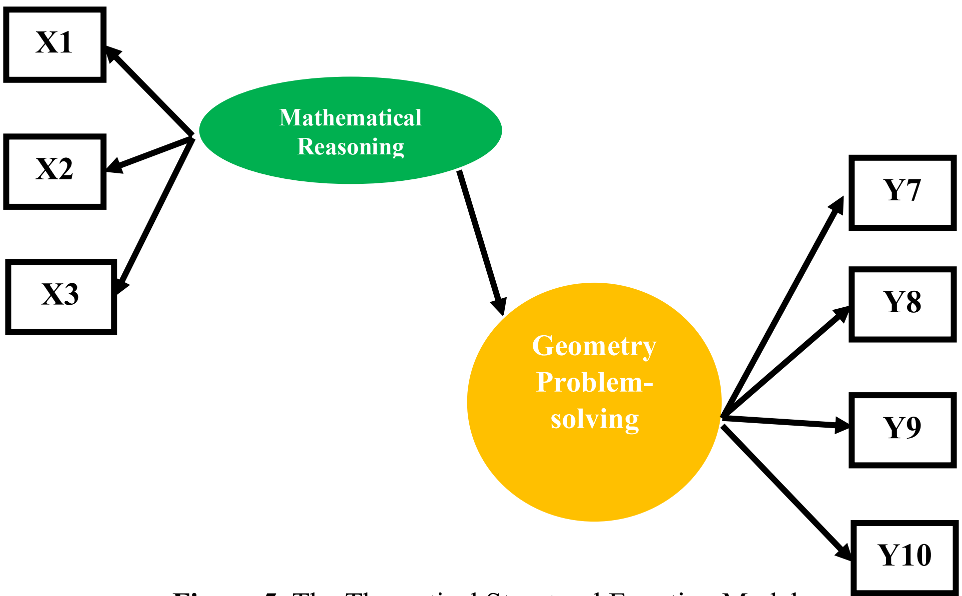


**Figure 5.** The Theoretical Structural Equation Model

Based on Figure 5, it can be understood that the process of solving geometry problems is highly dependent on the possession of students' mathematical reasoning skills. This relationship is described as a direct path of influence from mathematical reasoning ability to geometric problem-solving ability. In this model, each variable is measured using specific indicators. Mathematical reasoning ability (X) is assessed by a student's capacity to propose conjectures (X1), construct evidence (X2), and justify each step of their proof (X3). On the other hand, geometry problem-solving ability (Ypm) is evaluated based on how well a student understands the problem (Y7), develops a mathematical model (Y8), applies that model to find a solution (Y9), and explains their final answer in line with the original problem's context (Y10). This model is built on the theoretical assumption that improving mathematical reasoning skills will directly enhance geometry problem-solving abilities.

Based on this description, the problem of this research is "is the model of theoretical structural equations related to mathematical reasoning ability and geometry problem-solving ability compatible with the empirical model?" Also, "are mathematical reasoning abilities directly related to geometry problem-solving abilities?"

## METHOD

This study employed an ex-post facto design to investigate existing data on students' geometry problem-solving skills. Our population included all 296 mathematics education students in Lubuklinggau City, who represent a range of mathematical abilities (low, medium, and high). We then selected a sample of 100 students using a simple random sampling technique, ensuring every individual had an equal chance of being chosen. The selection process was systematic: we assigned numbers 001 to 296 to each student in the population and then randomly picked the sample using SPSS software.

The research, which is scheduled to run from March to May 2025, uses two main instruments: a problem-solving ability test and a mathematical reasoning ability test. Both instruments have been confirmed to be valid and reliable through two stages of testing.

1) Expert Validation: A panel of 7 experts (6 Mathematics Education lecturers and 1 mathematics supervisor) validated the test items using the Aiken Test for validity and the Anava Hoyt (ICC) for reliability. As a result, both problem-solving instruments (Aiken mean = 0.85; ICC = 0.833) and mathematical reasoning instruments (Aiken mean = 0.99; ICC = 0.833) is stated to have a very high level of validity and reliability

2) (Ismunarti et al., 2020).

3) Field Trials: Instruments are tested on students and the results are analyzed. All of the questions on both tests were proven to be valid (with a sig. of 0.000). The level of reliability measured with *Alpha Cronbach* also showed high results for both instruments (0.780 for problem solving and 0.783 for reasoning).

Data Analysis and Hypothesis Testing

Data analysis unfolded in stages, beginning with descriptive statistics (like mean, median, and mode), then progressing to inferential statistics for hypothesis testing. Our primary analytical approach was path analysis within Structural Equation Modeling (SEM), performed using Lisrel 8.8 software. Before running the SEM analysis, we first checked the data for normality and linearity.

A theoretical model is considered a "good fit" with empirical data if it satisfies several Goodness-of-Fit criteria, including a P-value of $\geq 0.05$, an RMSEA of $\leq 0.08$, and GFI and CFI values of $\geq 0.90$. We tested the hypothesis concerning the relationship between Mathematical Reasoning Ability (X) and Geometric Problem-Solving Ability (Ypm) by examining the null hypothesis ($H0:\beta ypmx = 0$, meaning no relationship) against the alternative hypothesis ($H1:\beta ypmx > 0$, indicating a positive relationship). The null hypothesis would be rejected if the obtained path coefficient's significance value (sig.) was below 0.05.

## RESULTS AND DISCUSSION

The research data consisted of tabulated test scores for the three abilities. We analyzed each ability test using both descriptive and inferential statistical methods, based on this tabulated data. Descriptive statistical analysis is a simple statistical analysis in the form of a calculation of descriptive statistical values in the form of averages, medians, modes, and standard deviations from the data of each variable. Meanwhile, inferential statistical analysis was carried out to test the statistical hypothesis in this study, to answer the problems of this research. A summary of descriptive statistical data analysis is presented in Table 1.

**Table 1.** Summary of Descriptive Statistical Analysis

| Statistics | Mathematical Reasoning Skills | Geometry Problem-Solving Capabilities |
|---|---|---|
| N | 100 | 100 |
| Average | 22,91 | 14,06 |
| Standard Deviation | 1,326 | 3,848 |
| Median | 23 | 14 |
| Mood | 23 | 9 |

Based on Table 1, the average scores for the mathematical reasoning ability test and the problem-solving ability test were 22.91 and 14.06, respectively. The standard deviations for these tests were 1.326 and 3.848, in that order. For the same tests, the median scores were 23 and 14, and the modes were 23 and 9, consecutively. You can see a more detailed description of these test scores in the histograms provided in Figures 6 and 7.

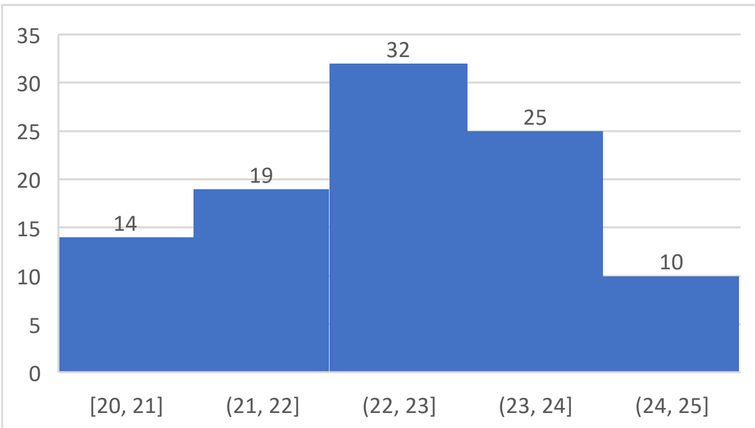


**Figure 6.** Histogram of Mathematical Reasoning Ability Score

Based on Figure 6, the mathematical reasoning ability score data tends to form a normal curve, further the normality of the data will be tested. It also shows that there are 14 students whose scores are in the range of 20-21, 19 students in the range of 21-22, the most in the range of 22-23, namely 32 students. As for the score range of 23-24, there are 25 students and 10 students in the range of 24-25.

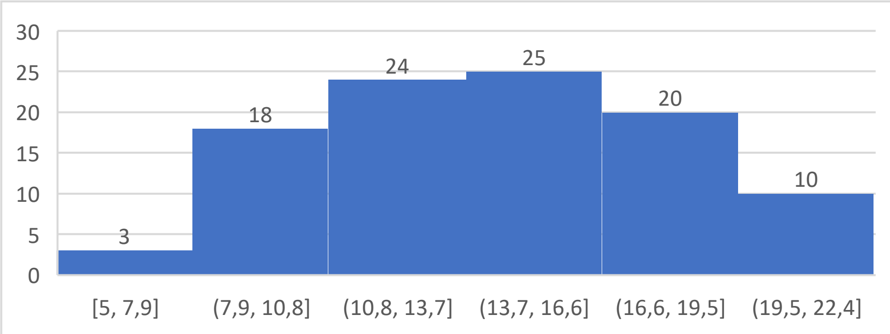

**Figure 7.** Histogram of Geometric Problem-Solving Ability Score

Based on Figure 7, the geometry problem-solving ability score data tends to form a normal curve, further the normality of the data will be tested. It also shows that there are 3 students whose scores are in the range of 5-7.9; 18 students in the range of 7.9-10.8; The most 24 students in the range of 10.8-13.7 in the range of 13.7-16.6, namely 25 students. As for the score range of 16.6-19.5, there were 20 students and 10 students in the range of 19.5-22.4.

Next, we performed inferential statistical analysis on the test scores for mathematical reasoning ability, mathematical connection ability, and problem-solving ability. Our statistical method was path analysis within structural equations. Before conducting this inferential test, we first ran prerequisite tests: specifically, the Normality Test and the Linearity Test.

**Normality Test**

We analyzed the normality of the mathematical reasoning ability (X) data using SPSS, and the output is presented in Table 2.

**Table 2.** Normality Test of Variable X Data

| **Variable** | **Kolmogorov-Smirnova** | | |
|---|---|---|---|
| | **Statistics** | **Df** | **Sig.** |
| Mathematical Reasoning Ability (X) | 1.149 | 100 | .157 |

Based on the normality test results in Table 3 for the geometry problem-solving ability (Ypm) variable, a Kolmogorov-Smirnov statistical value of 1.084 was obtained. The significance value (Sig.) obtained was 0.275. Since this significance value is greater than 0.05, according to the criteria, it can be concluded that the data for the geometry problem-solving ability variable come from a normally distributed population.

**Table 3.** Normality Test of Ypm Variable Data

| **Variable** | **Kolmogorov-Smirnova** | | |
|---|---|---|---|
| | **Statistics** | **Df** | **Sig.** |
| Geometry Problem-Solving Ability (Ypm) | 1.084 | 100 | .275 |

Based on Table 3, the normal distribution test, it can be seen that the statistic value is 1.084 with the *Sig.* value in the *Kolmogorov-Smirnov* column is 0.275. Based on the normality test criteria, that if the value *of Sig.* more than 0.05 then $H_0$ is accepted. This means that data whose geometry problem-solving ability (Ypm) comes from a normally distributed population.

**Linearity Test**

In addition to the normality test, a linearity prerequisite test was also carried out to ensure that there was a linear relationship between the variables of mathematical reasoning ability (X) and geometry problem-solving ability (Ypm). The complete results of this linearity test analysis are presented in Table 4.

**Table 4. Anava Relationship between X and Ypm**

| | | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|---|
| Problem-Solving Skills * Mathematical Reasoning Skills | Between Groups | (Combined) | 1322.049 | 5 | 264.410 | 173.093 | .000 |
| | | Linearity | 1292.773 | 1 | 1292.773 | 846.298 | .000 |
| | | Deviation from Linearity | 9.276 | 4 | 2.319 | 1.517 | .231 |
| | Within Groups | | 143.591 | 94 | 1.528 | | |
| | Total | | 1465.640 | 99 | | | |

**Prerequisite Test Results and Model Fit**

Based on Table 4, the prerequisite test results confirm a linear relationship between Mathematical Reasoning Ability (X) and Geometric Problem-Solving Ability (Ypm). This conclusion is supported by a significance value *of Deviation from Linearity* of 0.231 (greater than 0.05) and an F-calculated value (1.517) which is smaller than the F-table (2.31).

After all prerequisite tests (normality and linearity) were met, the analysis continued with a structural equation model fit test using Lisrel 8.8. The results show that the proposed theoretical model fits with the empirical data of the research. This match is confirmed by various *goodness-of-fit* indices that meet the required criteria, including:

Chi-Square = 14.85 with P-value = 0.127 (≥ 0.05)
RMSEA = 0.021 (≤ 0.08)
CFI = 0.95 and NFI = 0.93 (≥ 0.90)
SRMR = 0.045 (≤ 0.05)
AGFI = 0.83 (including *marginal fit*)

Therefore, we can conclude that this empirical model is appropriate for addressing our research questions.

**Research Variables and Their Indicators**

The data of this study measured two main latent variables, namely the ability to solve geometric problems (called PMASALAH in analysis) and mathematical reasoning ability (NALAR). Each variable is measured using several specific indicators as follows:

**Geometry Problem-Solving Ability (Ypm),** measured through four indicators:

a) Understanding the problem (Y7)
b) Building mathematical models (Y8)
c) Using the model to solve problems (Y9)
d) Explaining results in the context of the original problem (Y10).

**Mathematical Reasoning Ability (X),** measured through three indicators:

a) Proposing a conjecture (X1)
b) Gathering evidence (X2)
c) Justifying the steps of the proof (X3)

The results of the analysis of the structural equation model involving these variables are presented in the form of a Standard Solution Flow Diagram in Figure 8.

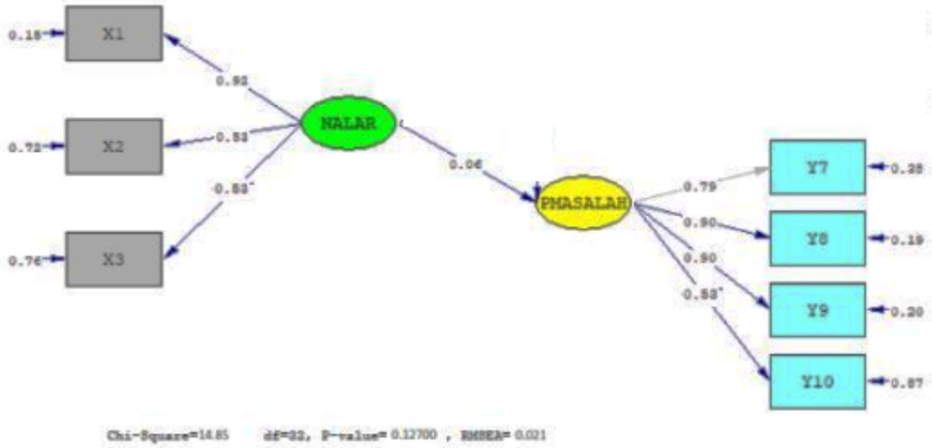


**Figure 8.** Basic Model Standard Solutions

In addition to the standard solution diagram, the results of data analysis using Lisrel 8.8 also produced a T-Value Basic Model diagram, which is presented in Figure 3.4. This T-value chart is a complement to the standard solution diagram and is used to determine two things: the validity level of each indicator variable and the reliability of the measuring tool for the latent variable. Based on the standard solution model, an indicator variable is declared valid if it meets two criteria, namely having a value *Loading Factor* at least 0.50 and a grade of *t-value* at least 1.96 (the value obtained from the T-Value diagram). As for determining the level of reliability of latent variable measuring instruments provided that The reliability of the latent variable measuring instrument is reliable if *Construct Reliability* (*CR*) ≥ 0.70 and the value *Variance Extracted* (*VE*) ≥ 0.50 (Wijayanto, 2008).

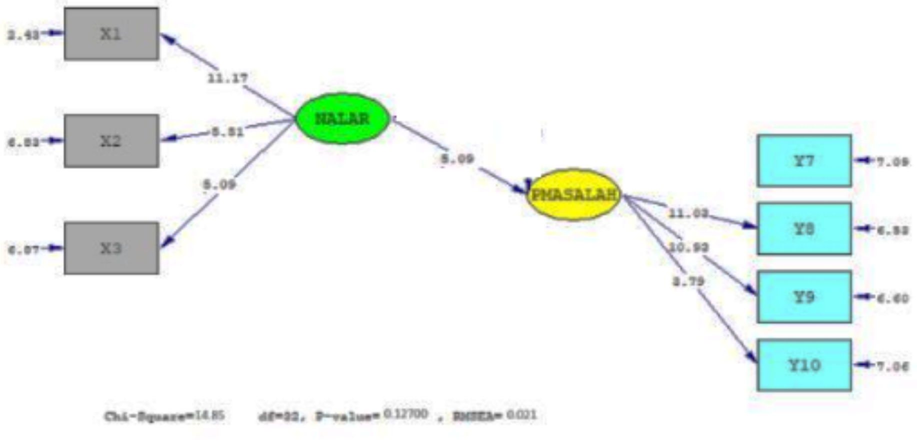


**Figure 9.** Basic Model T-Values

Figure 9 shows that the three observed variables for mathematical reasoning ability (X1, X2, and X3) are each highly valid. Their validity was confirmed because their loading factor values were all ≥0.50 and their t-values were all ≥1.96. As for the reliability of the mathematical reasoning ability measurement tool, we found a Composite Reliability (CR) of 0.71 (which is >0.70) and a Variance Extracted (VE) of 0.56 (which is >0.50). This indicates the mathematical reasoning ability variable is very reliable, meaning its instrument has strong consistency.

Similarly, for the geometry problem-solving ability variable, all indicator variables (Y7-Y10) had loading factor values of ≥0.50 and t-values greater than 1.96. This means each indicator variable for geometry problem-solving ability is also highly valid. Furthermore, the reliability of the geometry problem-solving ability latent variable's construct had a CR of 0.80 (>0.70) and a VE of 0.51 (>0.50), demonstrating good reliability for this variable. Therefore, the instruments used to measure geometry problem-solving ability are highly consistent.

With all prerequisite tests and the structural equation model's compatibility with empirical data confirmed, we moved to the hypothesis testing stage. Here, we'll present the path coefficient describing the relationship between Geometry Problem Solving Ability (Ypm) and Mathematical Reasoning Ability (X), based on SPSS calculations. We'll then individually test the study's data by analyzing the structural equation's path coefficients, with the results viewable in Table 5.

**Table 5.** Substructural Path Coefficient-1

| Type | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 35.754 | 2.029 | | 17.623 | .000 |
| | Mathematical Reasoning Ability (X) | 1.128 | .171 | .389 | 6.589 | .000 |
| a. Dependent Variable: Problem-Solving Ability (Ypm) | | | | | | |

To test the relationship between Mathematical Reasoning Ability (X) and Geometric Problem-Solving Ability (Ypm), we used a pair of hypotheses: the null hypothesis (H0) stating no relationship (βypmx=0), and the alternative hypothesis (H1) proposing a positive relationship (βypmx>0).

Based on the analysis in Table 5, the test results are as follows. The path coefficient from X to Ypm (ρypmx) is 0.389. The calculated t-value is 6.589. The significance value (sig.) is 0.000, which is less than 0.05.

Since the significance value (0.000) is lower than the 0.05 significance level, we reject H0 and accept H1. This means the path coefficient is highly significant, proving that mathematical reasoning ability has a direct, positive relationship with the ability to solve geometric problems. In simpler terms, better mathematical reasoning skills lead to improved geometry problem-solving skills.

To determine the magnitude of the error term (ϵypm), we used the R2 value, finding ϵypm=0.238. Therefore, the structural equation for Substructure-1 is: Ypm=0.389X+0.238ϵypm

This structural equation for Substructure-1 allowed us to draw an empirical path diagram illustrating the causal relationship between these variables, which you can see in Figure 10.

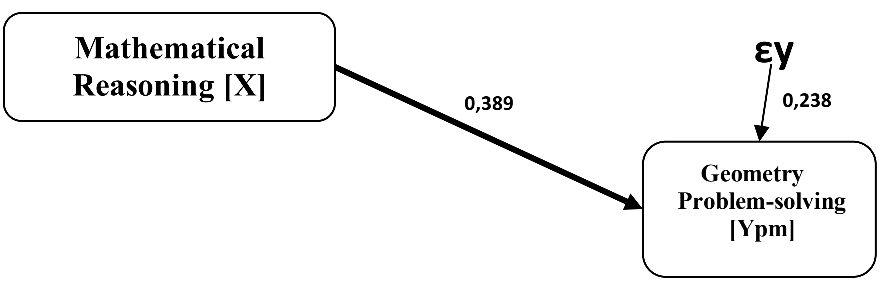


**Figure 10.** Empirical Model Path Diagram

Based on our hypothesis testing and the analysis shown in Figure 10, we can conclude that mathematical reasoning ability directly impacts geometry problem-solving ability.

This means that as an individual's mathematical reasoning skills improve, so does their ability to solve geometry problems. Quantitatively, mathematical reasoning skills contribute 15.13% to the improvement of geometry problem-solving ability (calculated from 0.3892).

This conclusion is further supported by the data in Figure 3.4, which shows a t-value of 5.09 for this direct relationship. Since this value is significantly higher than the critical limit of 1.96, the relationship is indeed significant, reinforcing that mathematical reasoning directly affects geometric problem-solving ability. These findings align with previous research indicating that students with strong mathematical reasoning skills are adept at solving mathematical problems. Conversely, students with weak mathematical reasoning skills often only manage to understand the problem (Hasanah, Tafrilyanto, & Aini, 2019). Therefore, enhancing mathematical reasoning leads to better geometry problem-solving.

Our study specifically found a 15.13% contribution from mathematical reasoning ability to geometry problem-solving ability. This resonates with Masfingatin, Murtafiah, & Maharani (2020), who noted that only one out of thirty-two students displayed creative mathematical reasoning in geometry problem-solving. Students with low creative mathematical reasoning struggle with novelty aspects of problems and require scaffolding. This highlights the crucial role of mathematical reasoning in problem-solving. Tisngati & Genarsih (2021) also support our results, confirming a link between problem-solving skills, mathematical reasoning, and reflective thinking skills, signifying a direct relationship between mathematical reasoning and problem-solving. Students with high mathematical reasoning ability can solve problems involving geometric flat shapes, further demonstrating the positive correlation between mathematical reasoning and geometric problem-solving (Sandy, Inganah, & Jamil, 2019).

Our findings also align with Hasanah, Tafrilyanto, & Aini's (2019) research, which states that students with high mathematical reasoning can solve mathematical problems. Students' mathematical reasoning skills improve when they learn through a problem-solving approach, suggesting a connection between reasoning ability and the problem-solving approach itself (Sustainable, 2019). Additionally, Zakir (2015) and Helviyana et al. (2020) support our findings, indicating that students' mathematical logical reasoning, even with varying thinking styles, impacts their ability to solve mathematical problems.

In summary, the conclusion that mathematical reasoning ability is directly related to geometry problem-solving ability is highly supported by this study's results.

This study introduces several novel elements. We used SEM (Structural Equation Modeling) analysis to test and validate a theoretical model regarding the causal relationship between mathematical reasoning ability and geometry problem-solving using empirical data. Beyond simply proving a significant relationship, we quantitatively measured the exact contribution of mathematical reasoning skills to geometry problem-solving ability, which is 15.13%. Our research examined the relationship model between these two abilities within a specific context: mathematics education students in Lubuklinggau. This provides relevant empirical evidence for curriculum development and learning environments with similar characteristics. We comprehensively tested the model's fit using various indices (P-value, RMSEA, NFI, CFI, etc.) to ensure the proposed theoretical model accurately matched the empirical data.

Based on our findings, there are a few limitations to consider: This research was conducted at only one university in Lubuklinggau City, specifically with mathematics education program students. This limits the generalizability of our findings to student populations at other universities, in different regions, or across diverse study programs.

The results of this study have several important implications, especially for the practice of mathematics learning in higher education: Pedagogical Implications: The existence of a significant direct relationship in which an increase in mathematical reasoning skills leads to an increase in geometry problem-solving skills implies that lecturers or teachers need to prioritize the development of mathematical reasoning skills as a foundation before or in conjunction with training problem-solving skills. Curriculum Development: The learning curriculum, especially for geometry courses, should be designed to explicitly integrate activities that can stimulate and train reasoning skills, such as making conjectures, constructing evidence, and providing logical reasoning. Learning Interventions: The discovery that *the problem-solving* approach can improve mathematical reasoning skills implies that the use of active learning methods like this is more effective than conventional learning in building both skills simultaneously.

## CONCLUSION

Data analysis reveals a direct relationship between mathematical reasoning ability and geometry problem-solving skills. An improvement in students' mathematical reasoning directly enhances their ability to solve geometry problems, contributing 15.13% to this skill.

As a practical implication for teaching, it is recommended that educators ensure students have a solid grasp of mathematical reasoning skills before moving on to topics that require geometry problem-solving abilities.

Instructors are advised to focus more on the problem-solving process, not just the final outcome. They should apply teaching methods that can enhance reasoning, such as a problem-based approach, and train students on specific reasoning indicators: making conjectures, compiling evidence, and providing logical reasons.

For future research, it is recommended to expand the research sample to a more diverse population to test the validity of this model. Furthermore, it should be tested whether a similar relationship between reasoning and problem-solving also applies in other mathematical fields like algebra, calculus, or statistics.

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