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The Influence of Critical Thinking, Logical Thinking, and Belief on Students' Mathematical Problem Solving Abilities

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Abstract

Problem solving ability is an essential skill in mathematics education. Several abilities influence the ability to solve mathematical problems, including logical thinking, critical thinking, and belief. This study aims to describe the levels of logical thinking, critical thinking, belief, and problem-solving abilities in mathematics; analyze the effects of logical thinking and belief on critical thinking; and analyze the effects of critical thinking and belief on problem-solving ability. This quantitative survey involved 388 eighth-grade students in Yogyakarta, selected through purposive cluster random sampling. Data were analyzed using path analysis. The results showed that logical and critical thinking abilities were in the low category, while belief and problem-solving abilities were in the high category; logical thinking and belief influenced critical thinking with a contribution of 18.6%; and critical thinking and belief influenced problem-solving ability with a contribution of 41.5%. These findings suggest that critical thinking acts as a mediator between logical thinking, belief, and problem-solving ability. Future research should explore other cognitive and affective factors that may contribute to students' mathematical reasoning and investigate instructional models that can strengthen logical and critical thinking in classroom contexts.

Abstrak

Kemampuan memecahkan masalah merupakan keterampilan yang penting dalam pembelajaran matematika. Beberapa aspek mempengaruhi kemampuan pemecahan masalah matematika, diantaranya kemampuan berpikir logis, kemampuan berpikir kritis, dan belief. Penelitian ini bertujuan untuk: menggambarkan tingkat kemampuan berpikir logis, kemampuan berpikir kritis, keyakinan, dan kemampuan pemecahan masalah dalam matematika, menggambarkan pengaruh kemampuan berpikir logis dan keyakinan terhadap kemampuan berpikir kritis, dan menggambarkan pengaruh kemampuan berpikir kritis dan keyakinan terhadap kemampuan pemecahan masalah. Penelitian ini merupakan penelitian survei dengan desain penelitian kuantitatif. Sampel penelitian ini terdiri dari 388 siswa kelas VIII di Yogyakarta yang dipilih menggunakan metode purposive cluster random sampling. Analisis data yang digunakan adalah analisis jalur. Hasil penelitian menunjukkan bahwa: (1) Tingkat kemampuan berpikir logis berada pada kategori kurang, kemampuan berpikir kritis pada kategori rendah, keyakinan peserta didik terhadap matematika dan kemampuan pemecahan masalah pada kategori tinggi; terdapat pengaruh antara kemampuan berpikir logis dan keyakinan peserta didik terhadap kemampuan berpikir kritis dengan persentase kontribusi 18,6%; terdapat pengaruh antara kemampuan berpikir kritis dan keyakinan peserta didik terhadap kemampuan pemecahan masalah dengan kontribusi sebesar 41,5%. Temuan ini menunjukkan bahwa berpikir kritis berperan sebagai mediator antara berpikir logis, keyakinan, dan kemampuan memecahkan masalah. Penelitian selanjutnya harus mengeksplorasi faktor kognitif dan afektif lain yang mungkin berkontribusi pada penalaran matematika siswa dan menyelidiki model pembelajaran yang dapat memperkuat berpikir logis dan kritis dalam konteks kelas.

Keywords:
Belief, Critical Thinking, Logical Thinking, Problem Solving Ability

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INTRODUCTION

Nowadays, education is facing changes in the era of the 4.0 industrial revolution. This era of the 4.0 industrial revolution impacts most aspects of human life, unlike the previous industrial revolution eras (Maryanti, Rohana, & Kristiawan, 2020; Schwab, 2016). These transformations require individuals to master complex cognitive and digital skills to remain competitive in the modern workforce. Consequently, education serves as a strategic medium for equipping students with the competencies needed to adapt and thrive in this rapidly changing environment. Education plays an important role in the changes brought about by the 4.0 industrial revolution. This is because education plays a role in preparing students to compete in this era (Mariana, 2019). Innovations in education are needed so that students have the necessary skills to face this era. According to Penprase and Gleason (2018), one of the competencies required to navigate this era is the ability to solve complex problems. Mathematical problem solving has long been recognized as a central competency in mathematics education, shaping curriculum frameworks and instructional practice worldwide. Recent research underscores its foundational role in developing students' reasoning, representation, and analytical skills, which are essential for mathematical understanding and application beyond the classroom (Santos-Trigo, 2024). In the era of the 4.0 industrial revolution, problem-solving is increasingly viewed as a critical skill for navigating complex real-world contexts and technological challenges, making it an essential focus of contemporary mathematics learning (Maryanti, Rohana, & Kristiawan, 2020).

Meanwhile, according to Inam (2016), problem solving is a mental process that requires a person to think critically and creatively to find alternative ideas and specific steps to deal with each obstacle. Brookhart and Nitko (2013) state that problem-solving skills are higher order thinking skills used to choose the right solution to achieve a specific goal. Problem-solving ability is an individual's capacity to find solutions through understanding the problem, determining solutions, implementing them, and evaluating their suitability.

However, in reality, the problem-solving skills of students in Indonesia are relatively low (Latifah & Widjajanti, 2017; Utami & Wutsqa, 2017; Widiastika, Mertasari, & Ardana, 2019). In Indonesia, particularly in the Special Region of Yogyakarta, previous assessments have shown that students' mathematical problem-solving performance varies considerably among schools. Yogyakarta was chosen as the research location because it represents a diverse educational landscape with schools that vary in resources and instructional quality. This diversity provides an ideal context for examining how cognitive and affective factors such as logical thinking, critical thinking, and belief interact to influence students' problem-solving abilities. One effort that can be made to improve students' problem-solving skills is to describe the factors that influence problem-solving skills. This is because various aspects influence students' problem-solving skills. According to Ozturk and Guven (2016), several factors influence students' problem solving abilities. These factors are grouped into three aspects: cognitive, affective, and experiential.

In the cognitive aspect, one of the thinking skills related to problem-solving is critical thinking. Critical thinking skills in mathematics involve prior knowledge, mathematical reasoning, and cognitive strategies to effectively generalise, prove, or evaluate unfamiliar mathematical situations (Widyatiningtyas, Kusumah, Sumarmo, & Sabandar, 2015). In addition, critical thinking skills include: applying available information to new situations, analysing the causes or motives of a situation, and evaluating opinions on a subject (Aizikovitsh-Udi & Cheng, 2015). Critical thinking skills involve the ability to analyse, evaluate, and determine appropriate conclusions. Several studies show that there is a relationship between critical thinking skills and problem-solving skills (Dianita, 2018; Kanbay & Okanli, 2017). If critical thinking skills are improved, problem-solving skills will also improve (Kanbay & Okanli, 2017). Logical thinking skills are also related to critical thinking skills (Rusyana, 2017; Sumarmo, Hidayat, Zukarnaen, Hamidah, & Sariningsih, 2012). According to Sumarmo, Hidayat, Zukarnaen, Hamidah, and Sariningsih (2012), logical thinking skills have a significant association with critical thinking skills. This is in line with the results of a study (Rusyana, 2017), which shows that there is a regular relationship between logical and critical thinking skills. Based on the results of this study, logical thinking skills contribute 8% to critical thinking skills.

One important affective aspect in mathematics learning is students' belief in mathematics (Goldin, Epstein, Schorr, & Warner, 2011; Yavuz & Erbay, 2015). Klostermann defines belief as a conviction that underlies students' decisions or actions (Prendergast, Breen, Bray, Faulkner, Carroll, Quinn, & Carr, 2018). Furthermore, Schoenfeld Muhtarom and Siswono (2017) defines students' beliefs about mathematics as individual understanding and feelings that shape the way individuals conceptualise and engage in mathematical behaviour. According to Sumpter (in Jader, Sidenvall, & Sumpter, 2017), student beliefs about mathematics are individual understandings that shape how individuals conceptualise and engage in mathematical behaviour, resulting in thoughts in the mind. The definition of student beliefs about mathematics (belief) in this study refers to the individual views of students regarding mathematics education and themselves in the context of mathematics, which influence their behavior towards the subject. Several studies reveal that students' beliefs about mathematics are related to problem-solving abilities (Dianita, 2018; Hakasinawati, Widada, & Hanifah, 2017; Ozturk & Guven, 2016). Students' beliefs about mathematics are also related to critical thinking skills (Febriano, Sugiatno, & Suratman, 2019; Rott, 2021). In addition, students with good critical thinking skills tend to have strong beliefs about the usefulness of mathematics (Febriano, Sugiatno, & Suratman, 2019). In line with this, students who have good self-belief can improve their critical thinking skills (Gazali, 2017). Based on this, it can be concluded that students' beliefs in mathematics influence their critical thinking skills.

Logical thinking, critical thinking, and belief were chosen as the focus of this study because they represent key cognitive and affective components of higher-order thinking in mathematics education. Logical thinking enables students to structure reasoning processes systematically (Hidayat & Sumarmo, 2013), while critical thinking allows them to analyze and evaluate problem situations effectively (Aizikovitsh-Udi & Cheng, 2015). Belief, as an affective variable, influences motivation and persistence in problem-solving tasks (Goldin, Epstein, Schorr, & Warner, 2011). Investigating these three interrelated constructs together provides a comprehensive understanding of the cognitive affective mechanisms underlying mathematical problem-solving.

Previous studies have explained how logical thinking skills influence critical thinking skills (Rusyana, 2017; Sumarmo, Hidayat, Zukarnaen, Hamidah, & Sariningsih, 2012), and shown how critical thinking skills (Kanbay & Okanlı, 2017; Dianita, 2018) and beliefs (Dianita, 2018; Hakasinawati, Widada, & Hanifah, 2017; Ozturk & Guven, 2016), influence problem solving skills. However, previous studies analyzed each variable separately. There remains a lack of empirical evidence that simultaneously analyzes the combined influence of logical thinking, critical thinking, and belief on problem solving skills in mathematics learning. Therefore, this study aims to analyze the influence of logical thinking, critical thinking, and belief on students' problem solving skills.

METHODS

This research is a survey study using a quantitative approach. A survey study is a type of research used to collect data from a population group to describe the relationship between variables. This type of research is suitable for describing the relationship between variables from a large data population (Cohen, Manion, & Morrison, 2018). The research design is cross-sectional, where data is taken from a sample of a specific population selected at a given time. This research design is effective for describing the behaviour of a population (Gay, Mills, & Airasian, 2019).

The population of this study consisted of all eighth grade students from 113 public and private Islamic junior high schools in the Special Region of Yogyakarta during the 2020/2021 academic year, totaling 26,248 students. The sample was selected using a purposive cluster random sampling technique, which is appropriate for geographically dispersed populations (Gay, Mills, & Airasian, 2019). The sampling procedure involved four stages: (1) identifying the population size, (2) determining the minimum representative sample size, (3) identifying clusters, and (4) allocating samples proportionally across clusters. Based on Cohen, Manion, and Morrison (2018), a minimum of 377 respondents was required for a representative sample. The population was grouped by district Bantul, Gunungkidul, Sleman, Kulonprogo, and the city of Yogyakarta. Each cluster contributed a proportional number of students to the total sample: 102 students from Bantul, 80 from Gunungkidul, 42 from Yogyakarta City, 38 from Kulonprogo, and 117 from Sleman, resulting in a total of 379 students. This distribution ensured that the sample represented the population's geographic and demographic diversity within the region.

The research instruments used in this study were tests and non-tests. The test instrument, in the form of essay questions, was used to measure critical thinking and problem-solving skills. A total of 6 essay questions were used to measure critical thinking skills, with a minimum possible score of 0 and a maximum possible score of 15. The test instrument, in the form of 5 multiple-choice questions, was used to measure logical thinking skills. The highest possible score was five, and the lowest possible score was 0. The non-test instrument in the form of a questionnaire was used to measure belief. Students' belief scores (self confidence) in mathematics were obtained using a questionnaire. The questionnaire contained 22 statements used to measure and describe students' self-confidence in mathematics. The scale used is a Likert scale with scores from 1 to 5, so that the lowest possible score is 22 and the highest is 110. Each instrument used in this study was tested for validity and reliability to ensure data quality. The logical thinking test, consisting of five multiple-choice items, showed item validity coefficients above 0.40, indicating moderate validity. The Cronbach's alpha value was 0.47, which, although relatively low, is still considered acceptable for instruments with few items (Taber, 2018). The critical thinking test, composed of six essay questions, demonstrated item validity above 0.60 (moderate validity) with a Cronbach's alpha of 0.803, indicating high reliability. The students' belief questionnaire, consisting of 22 Likert-scale statements, achieved moderate validity and a Cronbach's alpha of 0.87, showing strong internal consistency. Meanwhile, the problem-solving test, consisting of three items with four sub-questions each, yielded item validity above 0.50 and a Cronbach's alpha of 0.829, which indicates high reliability.

The data analysis used in this study is descriptive data analysis and path analysis. In descriptive data analysis, descriptive statistics were sought from the scores obtained in the form of mean, median, standard deviation, highest score, and lowest score for each variable. In addition, a frequency distribution table was created for all research variables, where the scores were divided into interval classes. Meanwhile, in path analysis, a prerequisite test was conducted first to examine the suitability of the collected data for the analysis technique applied. The prerequisite tests used in this study were normality, linearity, homoscedasticity, and multicollinearity tests. After the prerequisite tests were carried out, the data were analysed using path analysis. Path analysis was used to see the relationships and patterns of several variables. The results of this analysis were presented as a diagram illustrating how these variables were interrelated (Gay, Mills, & Airasian, 2019). Based on the theory presented earlier, the path diagram between variables in this study is as follows.

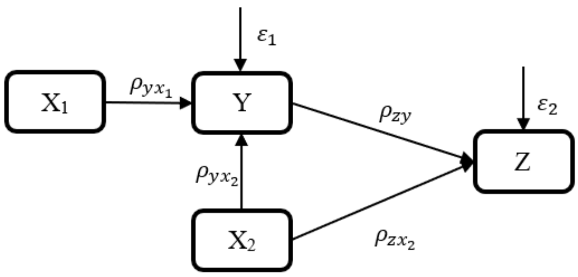

Figure 1. Hypothetical Diagram of the Influence Path Between Variables

Description

X_1 : Logical Thinking Ability

X_2 : Belief

Y : Critical Thinking Ability

Z : Problem Solving Ability.

ρ_{yx_1} : Coefficient of Influence of Variable X1 on Variable Y

ρ_{yx_2} : Coefficient of influence of variable X2 on variable Y

ρ_{zy} : Coefficient of influence of variable Y on variable Z

ρ_{zx_2} : Coefficient of influence of variable X2 on variable Z

ε_1 ε_2 : Residual coefficient (√(1-R Square))

RESULTS

The data in this study were collected based on the location of each school. There were 11 schools in 4 districts and one city in the Special Region of Yogyakarta Province that were sampled in this study. In the Sleman district, three schools were sampled with a total of 117 students. In the Bantul district, four schools were sampled with a total of 107 students. In the Gunungkidul district, two schools were sampled with a total of 84 students. In the Kulonprogo district, one school was sampled with a total of 38 students. In Yogyakarta city, one school was sampled with a total of 42 students.

1. Descriptive Analysis

Based on the descriptive analysis in table 1, it can be seen that the average score for logical thinking skills of eighth-grade MTs students in the Special Region of Yogyakarta Province is 1.96. This shows that, overall, the logical thinking skills of eighth grade MTs students in the Special Region of Yogyakarta Province are in the low category. The critical thinking skills of eighth grade MTs students in the Special Region of Yogyakarta Province are 5.72. This shows that overall, the critical thinking skills of eighth grade MTs students in the Special Region of Yogyakarta Province are in the low category. Based on the table, the average belief score of eighth grade MTs students in the Special Region of Yogyakarta Province towards mathematics is 73.62. This shows that overall, the belief of eighth-grade MTs students in the Special Region of Yogyakarta Province is in the high category. Based on the table, the average problem-solving ability score of eighth grade MTs students in the Special Region of Yogyakarta Province is 13.78. This shows that, overall, eighth-grade MTs students in the Special Region of Yogyakarta Province have high problem solving abilities.

Table 1. Summary of Descriptive Analysis Results

Variable	Mean	Median	Std. Deviation	Minimum	Maximum
Logical Thinking	1,96	2	1,328	0	5
Critical Thinking	5,72	6	2,743	0	15
Belief	73,62	73	11,56	31	108
Problem Solving	13,78	14	4,907	0	26

Overall, the descriptive analysis results show that although students' problem-solving abilities and beliefs are relatively high, their critical and logical thinking abilities remain low. These findings indicate that, while affective factors such as beliefs may not directly influence cognitive performance, the relationships among these variables warrant further study.

Therefore, additional analysis is needed to examine how interactions among variables influence students' problem-solving abilities.

2. Assumption Test Results

The normality test used is the residual normality test. The method used in the residual normality test is the Shapiro-Wilk test. The hypotheses used in this method are.

H_0 : Residual data is normally distributed

H_1 : Residual data is not normally distributed

If the test results are significant, then the residual data is normally distributed. From the results obtained, a p-value of 0.0725 was obtained. This value is greater than 0.05, which indicates that the distribution of residual data is not significantly different from the normal distribution. It can be concluded that the residual data is normally distributed.

The linearity and homoscedasticity tests use a scatter plot of the residual data.

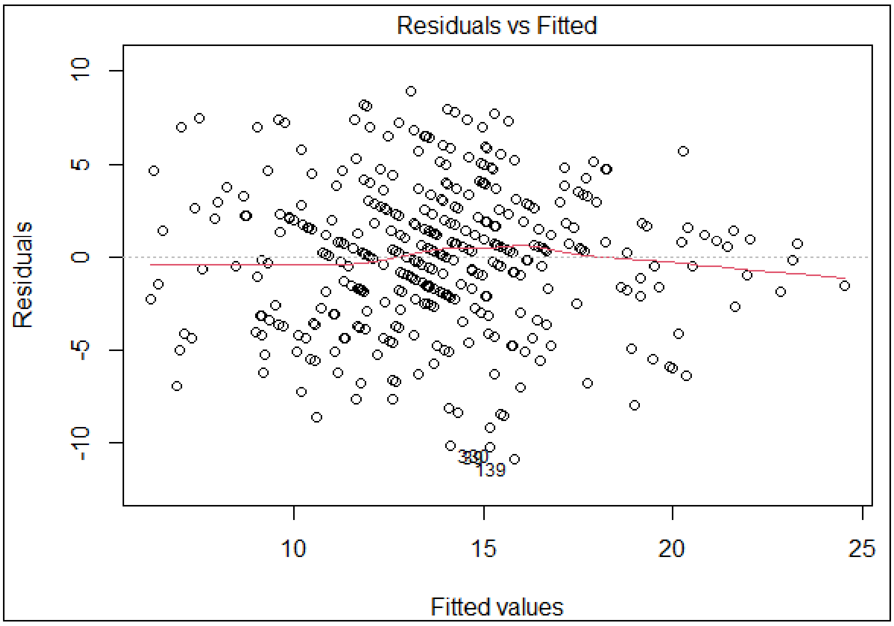

Figure 2. Scatter Plot of Residual Data Versus Estimated Values

From figure 2, it can be seen that there is no specific pattern in the distribution of points on the graph. It can also be seen that the red line on the graph approaches the horizontal line at the zero point. This indicates that the assumption of linearity is fulfilled, leading to the conclusion that there is a linear relationship between the dependent and independent variables in this study. In addition, based on this, it can be concluded that the assumption of homoscedasticity is fulfilled.

This test was conducted to avoid multicollinearity, which is a strong correlation ($r \geq 0.9$) between independent variables (L. Cohen et al., 2018). It is necessary to avoid a perfect linear combination between the independent variables, namely critical thinking skills (X_1), logical thinking skills (X_2), and belief (X_3). This test is measured using tolerance and variance inflation factor (VIF) values, with the testing criteria H_0 accepted if the tolerance value is ≥ 0.10 and VIF ≤ 10.00 (Gazali, 2017). The testing hypotheses are as follows.

H_0: There is no multicollinearity between independent variables
H_1: There is multicollinearity between independent variables

The following table shows the results of the variance inflation factor (VIF) calculations for each independent variable.

Table 2. VIF Value Results for Each Variable

Variable	VIF Values
Logical Thinking	1.206962
Critical Thinking	1.217263
Belief	1.189114

Based on table 2, the VIF value for each variable is less than 10. This indicates that the null hypothesis in this test is accepted. Therefore, there is no multicollinearity between the independent variables.

3. The Influence of Logical Thinking, Critical Thinking, and Belief on Problem-Solving

To determine the effect of logical thinking skills, critical thinking skills, and belief on problem-solving skills, a regression test was conducted with these independent variables on the dependent variable of problem-solving skills.

Table 3. ANOVA Results Between Logical Thinking Ability, Critical Thinking Ability, and Beliefs on Problem-Solving Ability

Nilai F	Sig.	Category
90,696	0,000	Sig. < 0,05

From table 3 above, it can be seen that the sig. The value of 0.00 is smaller than 0.05, so it can be concluded that there is a significant effect of logical thinking ability, critical thinking ability, and belief simultaneously on problem-solving ability. The effect of each independent variable on the dependent variable is evident in the calculation results in the table below.

Table 4. Coefficients of Logical Thinking Ability, Critical Thinking Ability, and Belief in Problem-Solving Ability

Variabel	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Logical Thinking	0,21	0,159	0,006	0,13	0,897
Critical Thinking	1,00	0,77	0,559	12,978	0,000
Belief	0,76	0,18	0,180	4,22	0,000

From table 4 above, we can see the sig. value of each independent variable. The sig. The value for the logical thinking ability variable is 0.897. Because this value is greater than 0.05, there is no significant effect of logical thinking ability on problem-solving ability. The sig. value for the critical thinking ability variable is 0.00. Because this value is less than 0.05, it can be concluded that there is a significant effect between critical thinking ability and problem-solving ability. The sig. value for the belief ability variable is 0.00. Because this value is less than 0.05, it can be concluded that there is a significant effect between belief and problem-solving ability.

4. The Influence of Belief and Logical Thinking Ability on Critical Thinking Ability

From the ANOVA test results, it was obtained that the sig value was 0.000 < 0.05, so it can be concluded that students' beliefs about mathematics and logical thinking ability have a significant effect on critical thinking ability. Next, each variable will be tested individually.

Table 5. Coefficients of Logical Thinking Ability and Belief in Critical Thinking Ability

Variabel	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Logical Thinking	0,582	0,096	0,284	6,037	0,000
Belief	0,06	0,011	0,257	5,456	0,000

In table 5 above, it can be seen that the sig. value for the logical thinking variable is 0.000 < 0.05, so it can be concluded that logical thinking ability has a significant effect on students' critical thinking ability. In addition, it can be seen that the sig. value for the variable of students' self confidence in mathematics (belief) is 0.000 < 0.05, so it can be concluded that students' self-confidence in mathematics (belief) has a significant effect on students' critical thinking skills.

Based on table 5, the contribution value of logical thinking to critical thinking ability is $0.284^2 = 0.081$. This shows that logical thinking ability contributes 8.1% to students' critical thinking ability. In addition, it can be seen that the contribution value of students' confidence in mathematics to critical thinking skills is 0.257^2, which is equivalent to 0.066. Thus, it can be concluded that students' self-confidence in mathematics has a 6.6% influence on critical thinking skills. Next, the coefficient of determination of the two variables on critical thinking skills will be determined.

Table 6. Summary of the Influence of Logical Thinking Ability and Belief on Critical Thinking Ability

R	R Square	Adjusted R-Square	Std. Error
0,413	0,186	0,182	2,47

Based on table 6 above, the value of the coefficient of determination, which represents the joint contribution of the two variables, can be seen from the R-squared value. The table shows that the R-squared value is 0.186. This indicates that logical thinking skills and self-confidence contribute 18.6%, while the remaining 81.4% is attributed to other variables not explained in this study. In addition, the residual coefficient obtained is 0.902.

5. **The Influence of Belief and Critical Thinking Skills on Problem-Solving Skills**

From the ANOVA test results, it was found that the sig value was 0.000<0.05, so it can be concluded that belief and critical thinking skills have a significant influence on problem-solving skills. Next, each variable will be tested individually.

Table 7. Coefficients of Critical Thinking Ability and Belief in Critical Thinking Ability

Variabel	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Critical Thinking	1,003	0,074	0,561	13,552	0,000
Belief	0,077	0,018	0,181	4,377	0,000

In table 7 above, it can be seen that the sig. value for the critical thinking ability variable on problem-solving ability is 0.000 < 0.05. This shows that critical thinking ability has a significant effect on problem-solving ability. This finding aligns with previous studies showing that students who can reason critically are better able to plan, evaluate, and implement problem-solving strategies effectively (Dianita, 2018; Kanbay & Okanli, 2017). It reinforces the idea that critical thinking serves as a cognitive foundation for problem-solving in mathematics.

For the belief variable, it is 0.000 < 0.05, so it can be concluded that belief has a significant effect on problem-solving ability. This result supports earlier evidence that students' positive beliefs about mathematics foster persistence and confidence when facing challenging problems (Febriano, Sugiatno, & Suratman, 2019; Rott, 2021). In this context, belief may act as a motivational factor that enhances the application of critical thinking skills during problem-solving tasks. Based on the table above, the contribution value of critical thinking ability to problem solving ability is 0.561^2, which equals 0.315. This shows that critical thinking ability contributes 31.5% to problem-solving ability. The contribution of students' self-confidence can be seen from the belief coefficient, which is 0.181^2, equivalent to 0.033. From this value, it can be concluded that belief contributes 3.3% to problem-solving ability. Next, the coefficient of determination of the two variables on problem-solving ability will be determined.

Table 8. Summary of the Influence of Critical Thinking Ability and Belief on Critical Thinking Ability

R	R Square	Adjusted R-Square	Std. Error
0,644	0,415	0,412	3,764

Based on table 8 above, the coefficient of determination or joint contribution of the two variables can be seen from the R-squared value. The table shows that the R-squared value is 0.415. This indicates that critical thinking skills and beliefs contribute 41.5%, while the remaining 58.5% is attributed to other variables not explained in this study.

Based on the calculation of the influence coefficient of each variable in the discussion above, a path diagram can be constructed to illustrate the relationship between each variable in this study. The resulting path diagram is shown in figure 3 below.

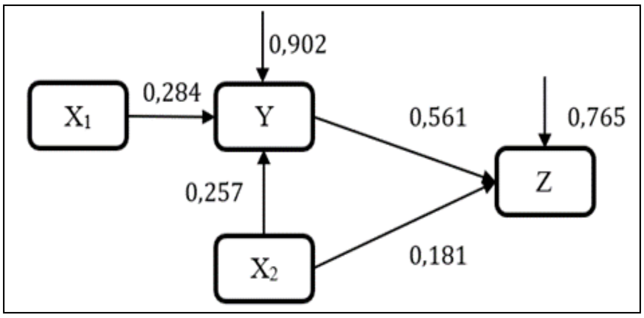

Figure 3. Inter-Variable Influence Path Diagram

This study examined the relationships among logical thinking, critical thinking, belief, and problem-solving ability in mathematics learning. The results of the path analysis revealed that logical thinking and belief influenced problem-solving ability indirectly through critical thinking, while critical thinking and belief had direct effects on problem-solving ability. These findings emphasize the central role of critical thinking as a mediating factor linking students' reasoning processes and affective dispositions with their capacity to solve mathematical problems. This pattern reinforces theoretical perspectives that describe problem-solving as an integrated cognitive process involving analysis, evaluation, and reflection (Yavuz & Erbay, 2015).

The present findings are consistent with previous studies that have identified strong associations between critical thinking and problem-solving

(Dianita, 2018; Kanbay & Okanli, 2017). However, this study extends the literature by integrating logical thinking and belief within the same analytical model. The inclusion of both cognitive and affective factors provides a broader understanding of how these variables interact in the mathematics learning context.

The novelty of this research lies in its comprehensive and integrative examination of three interrelated constructs logical thinking, critical thinking, and belief within a single quantitative framework. Unlike most previous studies that have predominantly investigated these variables in isolation or through partial relationships, this study systematically analyzes their simultaneous and interdependent effects. By empirically demonstrating how logical thinking and critical thinking interact with students' beliefs to influence mathematical problem solving abilities, this research offers a more holistic understanding of the cognitive and affective dimensions involved in mathematical learning. Consequently, the findings contribute new empirical evidence to the literature by highlighting the combined predictive power of these constructs in explaining students' performance in mathematical problem solving.

The findings imply that mathematics educators should place greater emphasis on fostering students' logical and critical reasoning skills through the deliberate implementation of instructional strategies that encourage exploration, justification, and reflective thinking. Such strategies may include problem based learning, guided inquiry, and classroom discourse that requires students to articulate and defend their reasoning processes. Simultaneously, strengthening students' beliefs about mathematics such as their confidence in their own abilities and their perceptions of mathematics as meaningful and learnable can significantly enhance motivation, engagement, and persistence when confronting complex problem solving tasks.

Despite these contributions, this study is limited by its regional sample and cross-sectional design. Future research should examine diverse populations, employ longitudinal or experimental approaches, and consider additional variables such as metacognitive awareness or learning motivation to deepen understanding of the mechanisms underlying mathematical problem-solving.

CONCLUSION

This study aimed to analyze the influence of logical thinking skills, critical thinking skills, and beliefs on students' problem-solving abilities. The results showed that students' critical thinking and logical thinking skills were in the low category, while their beliefs and problem-solving abilities were in the high category. Path analysis showed that logical thinking skills, critical thinking skills, and beliefs together influenced problem-solving abilities. Logical thinking skills and beliefs have an indirect effect through critical thinking skills, while critical thinking skills and beliefs have a direct effect on problem-solving skills. This study's results align with the research objectives and confirm that critical thinking skills act as a link between logical thinking skills, beliefs, and problem-solving skills. Therefore, to improve students' problem-solving abilities, educators need to develop logical and critical thinking skills through learning that emphasises the reasoning process. In addition, teachers need to foster students' positive beliefs in mathematics by supporting the problem-solving process through learning.

DECLARATIONS

Author Contribution	:	HAF: Conceptualization, Writing–Original Draft, Methodology, Writing-Review, Editing, Data analysis, and Supervision. KH: Data analysis, Formal Analysis, Writing-Review, and Editing.
Funding Statement	:	This research was not funded.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available from the corresponding author upon reasonable request.

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