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Improving Mathematical Problem-Solving Skills: The Roles of Reasoning, Connections, Communication, and Students' Self-Efficacy

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Abstract

This study investigates the direct and indirect effects of mathematical reasoning, mathematical connections, mathematical communication, and self-efficacy on students' mathematical problem-solving abilities. Mathematical problem-solving ability refers to the capacity to identify, analyze, and resolve mathematical problems using cognitive skills, procedural knowledge, and prior learning experiences. The research employed a quantitative method with an ex-post facto design. The population comprised all Grade X students from senior high schools (SMA) and Islamic senior high schools (MA) in Maros Baru District, Maros Regency. A total of 119 Grade X students were selected as the sample. Data were collected using tests and questionnaires. The tests measured students' mathematical problem-solving abilities, reasoning, connections, and communication skills, while the questionnaires assessed their self-efficacy. Descriptive statistics were used to describe the data characteristics, and path analysis was conducted to examine the direct and indirect relationships among the variables. The findings indicate that mathematical reasoning, connections, communication, and self-efficacy significantly influence students' mathematical problem-solving abilities directly. In addition, mathematical reasoning, connections, and communication also exert indirect effects on problem-solving abilities through the mediation of self-efficacy.

Keywords: Mathematical Communication, Mathematical Connection, Mathematical Reasoning, Problem Solving, Self-Efficacy.

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INTRODUCTION

The era of the Industrial Revolution 5.0 has brought about major changes in the development of science and technology (IPTEK), affecting almost all aspects of human life. This transformation not only changes the way we work and interact, but also creates new demands for the younger generation, especially students, to develop various abilities relevant to the challenges of the times, such as critical, systematic, logical, and creative thinking, as well as the ability to collaborate effectively (Mandur et al., 2013). These abilities are essential for facing the complexity of problems in an increasingly connected and technology-driven world. One way to develop these abilities is through education. Education serves as a means to shape human capabilities in using rationality to solve problems and make sound decisions. Through education, individuals can prepare themselves to face the future with competencies that align with the developments of the times, which, in turn, will contribute to the creation of a more advanced and prosperous society.

Mathematics education plays a crucial role, especially for students at the high school level, as it is one of the fundamental skills that support the development of their cognitive abilities. Mathematics not only serves to teach basic concepts but also acts as a tool to develop logical, rational, critical, careful, effective, and efficient thinking skills (Yusdiana & Hidayat, 2018). These thinking skills are essential for tackling a wide range of more complex problems, both in the academic world and in everyday life. As a science that forms the foundation for the development of modern technology, mathematics also plays a vital role in various other disciplines. Furthermore, mathematics helps to enhance human thinking abilities, where learning mathematics sharpens students' ability to reason and argue logically. Therefore, mathematics is not just a subject to be mastered in school, but also makes a significant contribution to solving everyday problems. Additionally, mathematics supports the advancement of science and technology, which, in turn, will have a profound impact on societal progress as a whole. Thus, mastering mathematics is essential to preparing students to face challenges in an increasingly complex and globally interconnected world.

Mathematical problem-solving is an important skill in developing students' critical and analytical thinking skills. Problem-solving is an effort that can be made to find solutions to problems faced through cognitive abilities, skills, and previously possessed knowledge (Hidayat W., 2018). Several research results show that students' problem-solving skills are still low, which is indicated by students' difficulties in understanding problems, designing solution strategies, and evaluating the final results. This can be seen from the low achievement in questions that require logical reasoning, critical thinking, and contextual application of concepts (Vebrian, 2021). Factors that influence include learning approaches that do not emphasize high-level thinking skills, lack of problem-solving-based practice questions, and low student motivation and involvement in the learning process (Saadati, 2019). These findings are an important basis for educators to develop more innovative and challenging learning methods to improve students' problem-solving abilities as a whole.

This is in line with the results of the researcher’s observations at a high school in Maros City, which showed that the teaching methods used by teachers were still relatively conventional, focusing on memorizing formulas and solving routine problems, without providing sufficient opportunities for students to explore ideas, link mathematical concepts to real-world situations, and express their thoughts both orally and in writing. Additionally, students are rarely given the chance to build self-confidence through reflection activities, group discussions, and open problem-solving tasks. As a result, students tend to be passive, lack confidence in solving challenging problems, and are unable to explain or connect mathematical concepts in depth. This indicates that high school students still struggle with the use of mathematical reasoning, mathematical connections, mathematical communication, and self-efficacy in solving mathematical problems. Therefore, to become effective mathematical problem solvers, individuals must master various aspects, including reasoning, connections, communication, and self-efficacy.

Mathematical reasoning is an important skill that needs to be developed by students in the process of learning mathematics because it allows them to apply logical and deductive thinking in finding solutions. This reasoning is related to the ability to draw conclusions or make new true statements, based on statements that have been proven or assumed previously. In this context, mathematical reasoning helps students not only solve mathematical problems but also critically assess various existing solutions and express ideas logically and systematically. Therefore, the development of mathematical reasoning skills is very important for students so that they can think critically, creatively, and rationally and can apply mathematical knowledge in everyday life (Hidayat, 2018).

Mathematical connections refer to the ability to connect different mathematical concepts, which allows students to understand mathematical problems more deeply and solve them effectively (Goldin, 2020). Students who have good mathematical connections are better able to analyze problems, identify relevant information, and formulate appropriate problem-solving strategies. These connections allow them to see relationships between previously seemingly separate mathematical concepts, so they can integrate existing knowledge and apply it in different contexts or situations. This ability also helps students transfer mathematical knowledge from one situation to another, making it easier for them to solve more complex and diverse problems. Good mathematical connections not only improve students' understanding of the subject matter but also strengthen their ability to think critically and creatively in dealing with mathematical challenges.

Effective mathematical communication is essential in helping individuals to articulate mathematical thinking clearly and share ideas with others. Tarigan (2022) emphasized that mathematical communication plays a crucial role in the process of acquiring mathematical knowledge because, through communication, individuals can share ideas and improve their understanding of mathematical concepts. Mathematical communication skills include the ability to express and interpret mathematical ideas both verbally and in writing, which can be in the form of pictures, tables, diagrams, formulas, or other demonstrations (Anggriani & Septian, 2019). With this ability, students can more easily understand mathematical concepts and clarify their ideas to others, thereby enriching the learning and teaching process. Mathematical communication also allows students to collaborate in solving problems, develop logical arguments, and deepen their understanding of the material being studied.

Self-efficacy refers to an individual's belief in their ability to solve mathematical problems, which plays an important role in the learning process. Research conducted by Zilfit (2023) shows that self-efficacy has a significant influence on mathematical problem-solving ability, with an influence of 30.3%. This indicates that students who have a high level of self-efficacy tend to be more confident when facing mathematical challenges. They are more open to trying various strategies to solve problems, do not give up easily when confronted with difficulties, and are more willing to learn from their mistakes. This self-confidence encourages them to be more actively engaged in the learning process, which, in turn, improves their understanding and performance. Conversely, low self-efficacy can lead to feelings of anxiety, avoidance of mathematical tasks, and a lack of participation in learning activities. Therefore, developing self-efficacy in learning mathematics is crucial to helping students overcome challenges, reduce psychological barriers, and ultimately improve their problem-solving abilities.

Mathematical reasoning, mathematical connections, mathematical communication, and self-efficacy have a close relationship and support each other in improving students' problem-solving abilities because the four aspects strengthen each other in the process of learning mathematics. Mathematical reasoning is the basis for logical and systematic thinking in solving problems. With good reasoning, students can identify the right steps and construct valid arguments in solving problems. This reasoning encourages students to think critically and rationally and to make conclusions based on existing evidence or mathematical rules. Meanwhile, mathematical connections allow students to connect various concepts they have previously learned with new concepts they encounter. This ability helps students see patterns and relationships between different topics in mathematics, as well as apply relevant concepts or strategies in solving more complex problems. Mathematical communication is essential in enabling students to express and explain their ideas and problem-solving processes clearly. Through effective communication, students can share their thoughts orally or in writing, explain the steps they take, and discuss various solutions with friends or teachers. This not only clarifies their understanding but also helps them learn from different perspectives—finally, self-efficacy acts as an internal motivational factor that gives students the confidence to face math challenges. Students who have high levels of self-efficacy tend to be more confident, more proactive in finding solutions, and do not give up easily when faced with difficulties. This self-efficacy encourages students to keep trying despite obstacles, and they are more open to trying different approaches to problem solving. When these four aspects develop in balance, students will have the ability to not only solve math problems more effectively but also have a deeper understanding and more diverse strategies in dealing with increasingly complex math challenges. As a result, they are better prepared to face various types of math problems with greater confidence and skills.

Many previous studies have discussed students' mathematical problem-solving abilities, such as those conducted by Siagan (2019), Simamora (2019), and Halawa (2024). These studies provide important insights into the factors that influence students' ability to solve mathematical problems, which is the main focus of mathematics learning. In addition, a number of studies have linked mathematical problem-solving abilities with various other skill components. For example, Hasanah (2019) examined the relationship between mathematical problem-solving abilities and mathematical reasoning, which showed that good mathematical reasoning can strengthen students' ability to solve mathematical problems. Furthermore, Anggoro (2022) revealed the relationship between mathematical problem-solving abilities and mathematical connections, which showed that students who were able to link various mathematical concepts were more effective in solving problems. Kamaruddin (2023) examined mathematical communication and found that students who were able to communicate clearly about their problem-solving process had higher levels of problem-solving abilities. Likewise, Ulandari's (2019) research shows a relationship between self-efficacy and mathematical problem-solving ability, where students with high self-efficacy are more confident in facing mathematical problems. However, although many studies have focused on the relationship between mathematical problem-solving ability and each component, such as mathematical reasoning, mathematical connections, mathematical communication, and self-efficacy, it is still very rare to find research that connects the four components in the context of mathematical problem-solving. Therefore, new research is needed to update and deepen our understanding of how mathematical reasoning, mathematical connections, mathematical communication, and self-efficacy interact in improving students' mathematical problem-solving abilities holistically.

METHODS

The type of research used is quantitative with an ex-post facto approach. This study consists of exogenous variables, namely mathematical reasoning (X1), mathematical connections (X2), and mathematical communication (X3), intervening variables, namely Self-Efficacy variables, and dependent variables, namely mathematical problem solving (Y). The following is the design of the relationship between these variables.

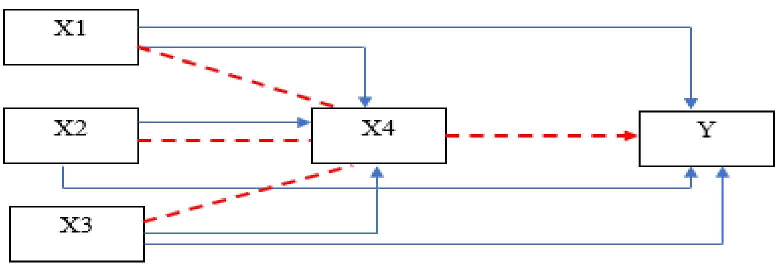

Figure 1. Research Design

This research was conducted at SMA and MA in Maros Baru District. The population in this study was all grade X SMA and MA students in Maros Baru District, Maros Regency in the 2024/2025 academic year, consisting of 4 schools, namely SMAN 11 Maros, SMAS PGRI Maros, MA Miftahul Muin, and MAS Ainus Syamsi, with a total of 334 students. The sampling technique used was stratified cluster random sampling. A total of 119 students, consisting of classes X.2 and X.6 (SMA N 11 Maros), classes X-IPA-Putra, X-IPA-Putra, and X-IPS-Putra (MAS Ainus Syamsi), and X (MA Miftahul Muin), were the samples in the study.

The data collection techniques used in this study consisted of tests and questionnaires. Tests were employed to measure students' mathematical problem-solving abilities, mathematical reasoning, mathematical connections, and mathematical communication. The mathematical problem-solving test was objective in the form of an essay, designed to obtain direct information about students' problem-solving abilities. The mathematical reasoning test was also objective in the form of an essay, aimed at gathering direct information about students' mathematical reasoning skills. The mathematical connection test was a true-false test, intended to collect direct information about students' abilities to make mathematical connections. The mathematical communication test was likewise a true-false test, used to gather direct information about students' mathematical communication abilities. Questionnaires were used to assess self-efficacy, employing a Likert scale with four response options: very appropriate (SS), appropriate (S), inappropriate (TS), and very inappropriate (STS). The indicators for the self-efficacy questionnaire are as follows.

Table 1. Self-efficacy Questionnaire Grid

Aspects	Indicators
Level	Students' confidence in their abilities regarding the level of difficulty of mathematical tasks
Generality	Students' confidence in their ability to carry out mathematical tasks in various activities
Strenght	The level of strength of individual belief or expectation regarding their ability to learn mathematics

Source: Bandura (1997)

The research data were analyzed using two analysis techniques, namely descriptive analysis and inferential analysis. Descriptive statistics are used to describe the characteristics of the data in the form of calculations of mean, median, mode, variance, maximum value, minimum value, frequency distribution table of data for problem solving, mathematical reasoning, mathematical connections, and mathematical communication using the SPSS 20 statistical tool. The results of the self-efficacy questionnaire were obtained using Microsoft Excel. Before conducting inferential statistical analysis, researchers must conduct prerequisite tests, namely normality tests, linearity tests, multicollinearity tests, and heteroscedasticity tests. The path analysis technique is used to determine the direct effect and the influence of indirect effects from the research variables.

RESULTS & DISCUSSION

Results

Table 2. Descriptive Statistics Results

Statistics	Statistical Values				
	Reasoning	Connection	Communication	Self-Efficacy	Problem-Solving
Mean	78.9496	77.2269	75.6050	78.8739	80.9916
Std. Error of Mean	.79530	1.14255	.95365	.69584	.88889
Median	80.0000	80.0000	77.0000	80.0000	82.0000
Mode	80.00	70.00	85.00	80.00	86.00
Std. Deviation	8.67575	12.46380	10.40308	7.59076	9.69667
Variance	75.269	155.346	108.224	57.620	94.025
Range	47.00	65.00	48.00	45.00	39.00
Minimum	48.00	35.00	45.00	50.00	59.00
Maximum	95.00	100.00	93.00	95.00	98.00
Sum	9395.00	9190.00	8997.00	9386.00	9638.00

Table 2 shows that there are 119 students as respondents with an average value of mathematical reasoning results of 78.95, a median of 80, and a variance of 75.27. Most of these students obtained a score of 80, with a minimum score of 48 and the highest score of 95. Based on this, the results of the mathematical reasoning of 119 students can be classified into the high category. Table 2 shows the average value of mathematical connection results of 77.23, a median of 80, and a variance of 155.35. Most of these students obtained a score of 70, with a minimum score of 35 and the highest score of 100. Based on this, the results of the mathematical connection of 119 students can be classified into the moderate category. Table 2 shows that the average value of the mathematical connection results is 75.60, the median is 77, and the variance is 108.224. Most of the students scored 85, with a minimum score of 45, and the highest score was 93. Based on this, the mathematical connection results can be classified into the medium category. Table 2 shows that the average value of the students' self-efficacy results is 78.87, the median is 80, and the variance is 57.60. Most of the students scored 80, with a minimum score of 50, and the highest score was 95. Based on this, the results of the students' self-efficacy can be classified into the high category. Table 2 shows that the average value of the problem-solving results is 80.99, the median is 82, and the variance is 94.02. Most of the students obtained a score of 86, with a minimum score of 59 and the highest score of 98. Based on this, the results of solving mathematical problems can be classified into the high category.

Before conducting the hypothesis test, a prerequisite test or classical assumption test is first conducted, consisting of a normality test, a linearity test, a multicollinearity test, and a heteroscedasticity test. The test is conducted on data from mathematical problem-solving results (Y), mathematical-reasoning results (X1), mathematical-connection results (X2), mathematical-communication results (X3), and self-efficacy results (X4). Based on Table 3, it can be concluded that the data is normally distributed.

Table 3. Normality Test

Ascpect	Value
Asymp. Sig. (2-tailed)	0.200

Source: SPSS data analysis (2025)

Table 4. Linearity test

Dependent Variable	Independent Variable	Sig Value
Y	X1	0,481
	X2	0,249
	X3	0,651
	X4	0,190

Source: SPSS data analysis (2025)

Based on Table 4, it can be concluded that the regression model is linear.

Table 5. Multicollinearity Test

Variable	Tolerancy	VIF
X1	0,407	2,456
X2	0,391	2,558
X3	0,558	1,794
X4	0,512	1,952

Source: SPSS data analysis (2025)

Based on Table 5, it can be seen that the tolerance value of the four variables is greater than 0.1. Therefore, it can be concluded that the regression equation model does not have a multicollinearity problem, or can be said to be free from multicollinearity problems, and can be used in this study.

Table 6. Glesjer Test

Dependent Variable	Independent Variable	Sig. Value	description
Y	X1	0,541	No heteroscedasticity
	X2	0,128	No heteroscedasticity
	X3	0,077	No heteroscedasticity
	X4	0,177	No heteroscedasticity

Source: SPSS data analysis (2025)

Based on Table 6, it can be seen that the significance value of the independent variables is greater than the significance level (0.05). This indicates that there is no heteroscedasticity in the regression model, so the regression model is feasible.

The first hypothesis in this study states that mathematical reasoning has a direct effect on solving mathematical problems. Hypothesis testing is carried out using a partial regression analysis model to determine the strength of the relationship between variables. The following are the results of SPSS processing related to partial regression analysis.

Table 7. Partial Regression Coefficients (X1 against Y)

Dependent Variable	Independent Variable	B	Std. Error	t	Sig
Y	(Constant)	19,329	5,870	3,293	0,001
	X1	0,781	0,074	10,567	0,000

Source: SPSS data analysis (2025)

Based on Table 7, it is obtained that the results of the partial regression test on the relationship between mathematical reasoning variables (X1) and mathematical problem solving (Y) show that the significance value of X1 is 0.00 <0.05, so that H0 is rejected and H1 is accepted. This shows that the mathematical reasoning variable (X1) has a significant direct effect on mathematical problem solving.

Table 8. Test of Determination Coefficient X1 Against Y

Statistic	Value
R	0.699
Rsquare	0,488
Adjusted R Square	0,484
Std. Error	6,96571

Source: SPSS data analysis (2025)

Based on Table 8, it can be obtained that the coefficient of determination value is 0.488, which indicates that 48.8% of the mathematical problem-solving variable (Y) is explained by the mathematical reasoning variable (X1). At the same time, the remaining 0.512 or 51.2% is explained by other factors not included in this research model.

The second hypothesis in this study states that mathematical connections have a direct effect on mathematical problem solving. Hypothesis testing is carried out using a partial regression analysis model to determine the strength of the relationship between variables. The following are the results of SPSS processing related to partial regression analysis.

Table 9. Partial Regression Coefficients (X2 against Y)

Dependent Variable	Independent Variable	B	Std. Error	t	Sig
Y	(Constant)	38,684	3,995	9,684	0,000
	X2	0,548	0,051	10,727	0,000

Source: SPSS data analysis (2025)

Based on Table 9, it is obtained that the results of the partial regression test on the relationship between mathematical connection variables (X2) and mathematical problem solving (Y) show that the significance value of X2 is 0.00 <0.05, so that H0 is rejected and H1 is accepted. This shows that the mathematical connection variable (X2) has a significant direct effect on mathematical problem solving.

Table 10. Test of Determination Coefficient X2 Against Y

Statistic	Value
R	0, 704
RSquare	0,496
Adjusted R Square	0,492
Std. Error	6,91434

Source: SPSS data analysis (2025)

Based on Table 10, it can be obtained that the coefficient of determination value is 0.496, which indicates that 49.6% of the mathematical problem-solving variable (Y) is explained by the mathematical connection variable (X2). At the same time, the remaining 0.504 or 50.4% is explained by other factors not included in this research model.

The third hypothesis in this study states that mathematical communication has a direct effect on solving mathematical problems. The following are the results of SPSS processing related to partial regression analysis.

Table 11. Partial Regression Coefficients (X3 against Y)

Dependent Variable	Independent Variable	B	Std. Error	t	Sig
Y	(Constant)	35,538	5,025	7,072	0,000
	X3	0,601	0,066	9,130	0,000

Source: SPSS data analysis (2025)

Based on Table 11, it is obtained that the results of the partial regression test on the relationship between mathematical communication variables (X3) and mathematical problem solving (Y) show that the significance value of X3 is 0.00 <0.05, so that H0 is rejected and H1 is accepted. This shows that the mathematical communication variable (X3) has a significant direct effect on mathematical problem solving.

Table 12. Test of Determination Coefficient X3 Against Y

Statistic	Value
R	0,645
RSquare	0,416
Adjusted R Square	0,411
Std. Error	7,44163

Source: SPSS data analysis (2025)

Based on Table 12, it can be obtained that the coefficient of determination value is 0.416, which indicates that 41.6% of the mathematical problem-solving variable (Y) is explained by the mathematical communication variable (X3). At the same time, the remaining 0.584 or 58.4% is explained by other factors not included in this research model.

The fourth hypothesis in this study states that self-efficacy has a direct effect on solving mathematical problems. The following are the results of SPSS processing related to partial regression analysis.

Table 13. Partial Regression Coefficients (X4 against Y)

Dependent Variable	Independent Variable	B	Std. Error	Beta	t	Sig
Y	(Constant)	1,123	5,705	-	0,197	0,844
	X4	1,013	0,072		14,065	0,000

Source: SPSS data analysis (2025)

Based on Table 13, it is obtained that the results of the partial regression test on the relationship between self-efficacy variables (X4) and mathematical problem solving (Y) show that the significance value on X4 is 0.00 <0.05, so that H0 is rejected and H1 is accepted. This shows that the self-efficacy variables (X4) have a significant direct effect on mathematical problem solving.

Table 14. Test of Determination Coefficient X4 Against Y

Statistic	Value
R	0,793
RSquare	0,628
Adjusted R Square	0,625
Std. Error	5,93647

Source: SPSS data analysis (2025)

Based on Table 14, it can be obtained that the coefficient of determination value is 0.628, which indicates that 62.8% of the mathematical problem-solving variable (Y) is explained by the self-efficacy variable (X4). At the same time, the remaining 0.382 or 38.2% is explained by other factors not included in this research model.

The fifth hypothesis states that mathematical reasoning has an indirect effect on solving mathematical problems through self-efficacy. The results of the statistical test can be seen in Table 15.

Table 15. Results of Path Coefficient Test of Model 2 (X1 against X4)

Dependent Variable	Independent Variable	B	Std. Error	Beta	t	Sig
X4	(Constant)	32,569	4,876	-	6,680	0,000
	X1	0,272	0,088	0,311	3,096	0,002

Source: SPSS data analysis (2025)

Based on Table 15, it is obtained that mathematical reasoning (X1) has a significance of 0.002 <0.05 and has a t count of 3.096, which is greater than the t table of 1.98, so it can be concluded that mathematical reasoning (X1) has a significant effect on self-efficacy. In addition, Table 15 shows that the beta value of the standardized coefficients between variables X1 and X4 is 0.311.

Table 16 Results of Path Coefficient Test of Model 2 (X4 against Y)

Dependent Variable	Independent Variable	B	Std. Error	Beta	t	Sig
Y	(Constant)	4,809	5,331		0,902	0,369
	X4	0,612	0,087	0,479	7,073	0,000

Source: SPSS data analysis (2025)

Based on Table 16, it is obtained that self-efficacy (X4) has a significance of 0.000 <0.05 and has a t count of 7.073, which is greater than the t table of 1.98, so it can be concluded that self-efficacy (X4) has a significant effect on problem-solving ability. In addition, Table 16 shows that the beta value of the standardized coefficients between variables X4 and Y is 0.479. Therefore, mathematical reasoning has an indirect effect on solving mathematical problems through self-efficacy of 0.149.

The sixth hypothesis states that mathematical connections have an indirect effect on mathematical problem solving through self-efficacy. The results of the statistical test can be seen in Table 17.

Based on Table 17, it is obtained that the mathematical connection (X2) with a significance of 0.015 <0.05 and has a t count of 2.478, which is greater than the t table of 1.98, so it can be concluded that the mathematical connection (X2) has a significant effect on self-efficacy. In addition, Table 17 shows that the beta value of the standardized coefficients between variables X2 and X4 is 0.258.

Based on Table 16, it is obtained that self-efficacy (X4) has a significance of 0.000 <0.05 and has a t count of 7.073, which is greater than the t table of 1.98, so it can be concluded that self-efficacy (X4) has a significant effect on problem-solving ability. In addition, Table 16 also shows that the beta value of the standardized coefficients between variables X4 and Y is 0.479. Therefore, mathematical connections have an indirect effect on solving mathematical problems through self-efficacy of 0.123.

Table 17. Results of Path Coefficient Test of Model 2 (X2 against X4)

Dependent Variable	Independent Variable	B	Std. Error	Beta	t	Sig
X4	(Constant)	32,569	4,876		6,680	0,000
	X2	0,157	0,063	0,258	2,478	0,015

Source: SPSS data analysis (2025)

The seventh hypothesis states that mathematical communication has an indirect effect on mathematical problem solving through self-efficacy. The results of the statistical test can be seen in Table 18.

Table 18. Results of Path Coefficient Test of Model 2 (X3 against X4)

Dependent Variable	Independent Variable	B	Std. Error	Beta	t	Sig
X4	(Constant)	32,569	4,876		6,680	0,000
	X3	0,168	0,063	0,230	2,653	0,009

Source: SPSS data analysis (2025)

Based on Table 18, it is obtained that mathematical communication (X3) has a significance of 0.009 <0.05 and has a t count of 2.653, which is greater than the t table of 1.98, so it can be concluded that mathematical communication (X3) has a significant effect on self-efficacy. In addition, Table 18 shows that the beta value of the standardized coefficients between variables X3 and X4 is 0.230.

Based on Table 16, it is obtained that self-efficacy (X4) has a significance of 0.000 <0.05 and has a t count of 7.073, which is greater than the t table of 1.98, so it can be concluded that self-efficacy (X4) has a significant effect on problem-solving ability. In addition, Table 16 shows that the beta value of the standardized coefficients between variables X4 and Y is 0.479. Therefore, it can be concluded that mathematical communication has an indirect effect on solving mathematical problems through self-efficacy of 0.110.

Based on the description, the relationship between these variables can be described in Figure 2.

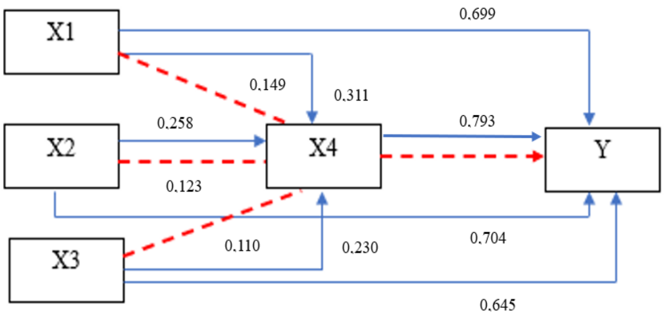

Figure 2. Path Diagram Between Variables

Discussion

The results of this study indicate that there is a direct influence between mathematical reasoning and students' problem-solving abilities. The more students apply mathematical reasoning, the better their problem-solving outcomes will be, and vice versa. Mathematical reasoning has a positive and significant effect on students' problem-solving abilities. These findings are consistent with previous research, which shows that students with strong reasoning skills tend to understand problems better comprehensively, develop effective solution strategies, and evaluate or revise their solutions independently (Syaripuddin, 2020). Mathematical reasoning also enhances logical, analytical, and systematic thinking skills that are essential for solving non-routine or problem-based tasks. With strong reasoning abilities, students can deeply understand problems, design appropriate solution strategies, and evaluate their solutions logically and systematically. Maximizing the use of reasoning encourages students not only to seek final answers but also to understand the thought processes behind them, making learning more meaningful. Reasoning strengthens conceptual understanding and plays a vital role in developing higher-order thinking skills, which are crucial in solving mathematical problems (Sakinah, 2024). Therefore, optimal mathematical reasoning helps students become independent, rational, and innovative problem solvers.

Mathematical connections are essential in problem-solving because they enable students to link various mathematical concepts, procedures, and representations to understand and solve problems effectively. These connections allow students to see relationships between topics, transfer knowledge to new situations, and select the most appropriate strategy for each problem. Furthermore, they promote flexible, creative, and logical thinking, as students are not merely memorizing formulas but understanding when and how to apply concepts. Students with strong mathematical connections can more easily recognize patterns, relate problems to prior knowledge or experiences, and transfer learning across different contexts (Jawad, 2022). When students are able to fully utilize their mathematical connections, their problem-solving abilities improve significantly (Kleden, 2021). They can comprehend problems more deeply, choose appropriate strategies, and explore various alternative solutions. With a solid understanding of interrelated concepts, students are not limited to a single method but can approach problems from multiple perspectives, enhancing their flexibility and creativity (Kusuma, 2019). Additionally, these students tend to be more confident and independent in tackling mathematical challenges, as they can adapt their knowledge to new or complex situations (Hidayati, 2020). Thus, mathematical connections not only enrich students' understanding but also strengthen their logical, analytical, and creative thinking in solving problems.

Students who apply mathematical communication optimally in solving mathematical problems tend to be able to explain each step of the solution clearly, both verbally and in writing, and provide logical reasons behind the strategies they use (Amany, 2024). Students not only focus on the final answer, but are also able to express their thought processes, consider various alternative solutions, and use representations such as graphs, tables, or symbols effectively. In group discussions, these students actively ask questions, explain ideas, and respond to friends' opinions with arguments supported by mathematical concepts (Hartinah, 2019). Mathematical communication skills can make students more confident, critical, and flexible in dealing with various types of problems, and they are able to transfer knowledge to a broader context.

The results of this study are in line with the results of other researchers, namely Hovey (2020), who found that self-efficacy contributed 90.25% to students' mathematical problem-solving abilities. Regression analysis shows that every one-unit increase in self-efficacy can increase problem-solving abilities by 2.32 points. Azis (2021) found that self-efficacy affects students' mathematical problem-solving abilities by 56.25%. The regression equation obtained is $Y = 8.41 + 0.83X$, which means that a one-unit increase in self-efficacy can increase problem-solving abilities by 0.83 points. This shows that self-efficacy has a significant positive effect on students' mathematical problem-solving abilities. Therefore, increasing students' self-efficacy can be an effective strategy for improving their ability to solve mathematical problems.

The results of this study are in line with the findings of other researchers, namely Shimizu (2022), who showed that self-efficacy moderates the relationship between mathematical knowledge and problem-solving ability. Students who have good mathematical reasoning tend to have high self-efficacy, which helps them persist and overcome difficulties in solving mathematical problems. Zhou et al. (2020) found that self-efficacy functions as a mediator between cognitive abilities (including mathematical reasoning) and achievement in problem-solving. Good mathematical reasoning increases students' confidence in solving problems. Self-efficacy functions as a mediating factor that strengthens the relationship between mathematical reasoning and problem-solving ability. This means that although mathematical reasoning is important, self-efficacy plays a role in ensuring that mathematical reasoning is applied optimally in solving mathematical problems.

The results of this study are in line with those found by other researchers, namely Ulfa (2020), who found that when students are able to connect various mathematical concepts and relate them to real-life situations, students show increased self-efficacy in learning mathematics. This increase in self-efficacy contributes to their persistence and effectiveness in solving complex mathematical problems. Zubaidah (2019) found that conceptual connections in mathematics are very important in developing deep understanding and then increasing self-efficacy and problem-solving strategies. This study shows that students who are able to see the relationship between concepts tend to have higher self-confidence in applying that knowledge in the context of problem-solving. Hutneriana (2024) found that mathematical connection-based learning can improve students' conceptual understanding and self-efficacy, which ultimately has a positive impact on problem-solving abilities. These studies consistently show that the ability to make mathematical connections not only improves students' understanding but also builds students' self-efficacy, which indirectly strengthens students' ability to solve mathematical problems.

The results of this study are in line with the findings of another study, namely, Marasabessy (2020), who found that students who are accustomed to discussing and communicating mathematical ideas in study groups show increased self-confidence and problem-solving abilities. The mathematical communication process helps students strengthen their understanding of concepts and feel more confident in solving problems. Agustini (2024) found that communication skills in mathematics learning contribute significantly to students' self-efficacy. Students who actively participate in discussions tend to be more confident and show better performance in problem-solving. Ningsih (2020) found that good mathematical communication has a positive effect on students' self-efficacy and that self-efficacy plays an important role in improving mathematical problem-solving abilities. These studies support that mathematical communication can strengthen students' self-efficacy, which then has a positive impact on students' ability to solve mathematical problems, thus clarifying the indirect effect through the self-efficacy pathway.

CONCLUSION

Based on the analysis and discussion of the research data, several conclusions can be drawn from this study. Students' mathematical reasoning ability falls into the high category, with an average score of 78.95. Their mathematical connection ability is in the medium category, with an average score of 77.23. Mathematical communication ability is also categorized as medium, with an average score of 75.60. Meanwhile, students' self-efficacy is in the high category, with an average score of 78.87. Students' mathematical problem-solving ability is also categorized as high, with an average score of 80.99. The analysis shows that mathematical reasoning ability has a direct, significant, and positive effect on students' mathematical problem-solving ability in Grade X SMA/MA in Maros Baru District, with a path coefficient of 0.699. Mathematical connection ability also has a direct, significant, and positive effect, with a path coefficient of 0.704. Similarly, mathematical communication ability shows a significant and positive effect, with a path coefficient of 0.645. Self-efficacy has the strongest significant and positive effect, with a path coefficient of 0.793. Furthermore, mathematical reasoning ability has an indirect effect through self-efficacy on students' problem-solving ability, with a path coefficient of 0.149. Mathematical connection ability also has an indirect effect through self-efficacy, with a coefficient of 0.123. Finally, mathematical communication ability has an indirect effect through self-efficacy, with a coefficient of 0.110.

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