



Structural Model of Self-Efficacy, Self-Regulated Learning, and Self-Determination on Mathematics Learning Achievement through Reasoning Ability

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Abstract

This study examines the effects of self-efficacy, self-regulated learning, and self-determination on students' mathematics achievement through mathematical reasoning ability. A quantitative ex post facto design was employed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The sample consisted of 170 ninth-grade students at a state junior high school in Makassar, Indonesia, selected through cluster random sampling. Data were collected using validated questionnaires and a mathematical reasoning test. The results show that self-efficacy and self-regulated learning significantly influence mathematical reasoning ability, which in turn has a significant effect on mathematics achievement. Both variables also show indirect effects on achievement through reasoning ability. In contrast, self-determination does not have a significant effect on either mathematical reasoning or mathematics achievement. These findings indicate that mathematical reasoning plays a mediating role in linking self-efficacy and self-regulated learning factors to mathematics learning achievement.

Keywords: *Self-efficacy; Self-regulated learning; Self-determination; Mathematical Reasoning Ability; Mathematics Learning Achievement.*

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INTRODUCTION

Education plays a strategic role in developing high-quality, adaptive, and competitive human resources. Through education, students not only acquire knowledge but also develop thinking skills, problem-solving abilities, and character required to face life challenges. Within this context, mathematics occupies a crucial position as it serves to train logical reasoning, critical thinking, and the ability to connect concepts with real-world phenomena (Haris et al., 2025). However, mathematics learning in schools still faces various issues, such as students' difficulties in understanding concepts, a tendency to memorize formulas without comprehension, and a limited ability to relate mathematics to real-life situations. Consequently, when faced with contextual problems, including social arithmetic, many students cannot reason through solutions logically (Halidin et al., 2023;

Widiarti & Masri, 2021). This indicates that mathematics instruction remains outcome-oriented rather than fully emphasizing the mathematical thinking process.

These issues are also reflected in the OECD (2024) report on PISA 2022 results, which show that Indonesian students' mathematics achievement remains below the OECD average, with a mean score of 366 compared to the OECD average of 472 points (OECD, 2024). Similar concerns were observed at State Junior High School 12 Makassar. Preliminary classroom observations and an analysis of school academic records revealed variations in students' mathematical reasoning ability across classes. Students with stronger mathematical reasoning skills generally achieved higher mathematics scores, whereas those with weaker reasoning skills tended to demonstrate lower academic performance. These preliminary findings provide empirical indications of the potential importance of mathematical reasoning in supporting mathematics achievement and warrant further investigation into its role in students' learning outcomes.

Mathematics achievement in this study refers to students' mathematics performance measured by official semester examination scores obtained from school records, reflecting their mastery of concepts, skills, and problem-solving abilities based on curriculum assessment. It is influenced by both instructional and internal factors. Afifa et al. (2023) demonstrated that mathematics learning difficulties are more affected by internal factors, such as students' physiological and psychological conditions, than external supporting factors. Therefore, this study focuses on three essential internal factors: self-efficacy, self-regulated learning, and self-determination, with mathematical reasoning positioned as a potential mediator bridging the effects of these factors on mathematics achievement.

Self-efficacy refers to students' confidence in planning and executing strategies to effectively complete mathematical tasks. In mathematics learning, self-efficacy relates not only to conceptual mastery but also influences students' approach to challenges, choice of problem-solving strategies, and persistence in overcoming learning difficulties (Sari et al., 2024). Özcan and Kültür (2021) found that mastery experience is the strongest predictor of mathematics achievement compared to vicarious experience and social persuasion. This aligns with Putri and Juandy (2022), who reported that higher self-efficacy correlates with better mathematical problem-solving abilities. Rahmawati and Nopriana (2024) further confirmed that self-efficacy affects how students' complete tasks, face challenges, and participate actively in learning. Thus, self-efficacy serves as a psychological foundation supporting active engagement and optimal mathematics achievement.

Beyond self-efficacy, self-regulated learning (SRL) is also an essential internal factor in mathematics success. SRL describes students' ability to manage their learning processes independently, from planning and monitoring to evaluating learning strategies. This skill integrates cognitive, motivational, and metacognitive aspects that support academic achievement (Jin et al., 2023). Mustafa and Dewi (2024) found a positive, though low, correlation between self-regulation and mathematics achievement. Meifiani and Asmoro (2022) concluded that self-regulation significantly impacts mathematics learning outcomes in online learning contexts for junior high students. These findings indicate that SRL fosters academic autonomy and enables students to manage learning reflectively and adaptively.

Another relevant internal factor is self-determination, which reflects students' motivational orientation in sustaining independent learning. According to Ryan and Deci (2020), self-determination theory explains that motivation quality depends on the fulfillment of autonomy, competence, and relatedness. In mathematics learning, self-determination may support students' willingness to engage in learning activities and persist in facing difficulties. Previous studies have shown that self-determination is associated

with students' engagement in mathematics learning (Ihsani & Rikayanti, 2025), motivation and character development (Syahlumnata et al., 2025), and independent learning processes (Sujati et al., 2023). Therefore, self-determination is viewed as a motivational factor related to learning persistence, although its direct impact on mathematics achievement may vary depending on other cognitive and learning factors.

Mathematical reasoning is a key cognitive aspect in this study, as it not only relates to computational skills but also involves logical, critical, and systematic thinking in problem-solving (Nelzon et al., 2025). Mathematical reasoning connects conceptual understanding with problem-solving skills through the ability to draw logical conclusions, generalize, and relate mathematical ideas to real-world situations. Hilaliyah and Annisa (2022) found that mathematical reasoning positively influences students' conceptual understanding in mathematics. Lestari et al. (2023) further stated that reasoning helps students structure their thinking steps rather than merely following mechanical procedures. Similarly, Norhidayah (2023) emphasized that reasoning plays a vital role in enhancing mathematical literacy by enabling students to apply concepts in new situations and integrate cross-disciplinary knowledge.

In social arithmetic, reasoning becomes increasingly important, as students are required to interpret contextual problems, select appropriate strategies, and develop rational arguments for solutions. Ardhiyanti et al. (2019) found that students with moderate ability can meet reasoning indicators such as conjecturing, manipulating, constructing proofs, and drawing conclusions, while students with low ability do not fulfill all indicators. It also showed that students with moderate to high mathematical ability can choose problem-solving strategies accurately and construct logical arguments, whereas low-ability students struggle to organize systematic solution steps. Thus, mathematical reasoning functions as a bridge between conceptual knowledge, problem-solving skills, and mathematics achievement.

Although previous studies have examined self-efficacy, self-regulated learning, and self-determination separately in relation to mathematics achievement (Ihsani & Rikayanti, 2025; Meifiani & Asmoro, 2022; Putri & Juandy, 2022), limited research has integrated these internal factors within a single structural model. In addition, the mediating role of mathematical reasoning ability in explaining the relationship between these psychological factors and mathematics achievement has not been extensively explored, particularly in junior high school contexts. This highlights the need for a more comprehensive model that examines both direct and indirect effects among these variables.

Addressing this gap, the present study introduces a structural model integrating self-efficacy, self-regulated learning, and self-determination on mathematics achievement through students' mathematical reasoning. This study aims to examine the direct effects of self-efficacy, self-regulated learning, and self-determination on mathematical reasoning ability and mathematics achievement, as well as the indirect effects of these variables on mathematics achievement through mathematical reasoning ability in junior high school students. The findings are expected to provide theoretical contributions to mathematics education research and practical implications for teachers in designing instruction that strengthens students' self-efficacy, self-regulated learning, self-determination, and reasoning ability.

METHODS

This study employed a quantitative ex post facto approach analyzed using Structural Equation Modeling (SEM). The ex post facto design was used as the researcher did not manipulate variables directly but examined causal relationships based on existing data. SEM was chosen for its capability to analyze direct and indirect effects among latent

variables and their indicators. According to Thakkar (2020), SEM provides a conceptual and mathematical framework to test or validate theoretical models. Hidayat and Wulandari (2022) also highlight SEM's suitability for models involving multiple independent, dependent, and intervening variables. Thus, SEM was appropriate for examining the effects of self-efficacy, self-regulated learning, and self-determination on mathematics achievement through reasoning ability.

The population in this study consisted of all ninth-grade students at a state junior high school in Makassar, Indonesia, enrolled in the first semester of the 2024/2025 academic year, totaling 361 students across 11 classes. This population was selected because all students had received instruction on social arithmetic and were considered appropriate for measuring self-efficacy, self-regulated learning, self-determination, mathematical reasoning ability, and mathematics achievement. Cluster random sampling was applied by randomly selecting 7 out of 11 available classes, and all students within the selected classes were included as respondents. This procedure resulted in a final sample of 170 ninth-grade students, consisting of both male and female students. The study acknowledges that the sample was drawn from a single school, which limits the generalizability of the findings to similar educational contexts. Variables included self-efficacy (x_1), self-regulated learning (x_2), self-determination (x_3), mathematical reasoning ability (y_1), and mathematics achievement (y_2) (see Figure 1).

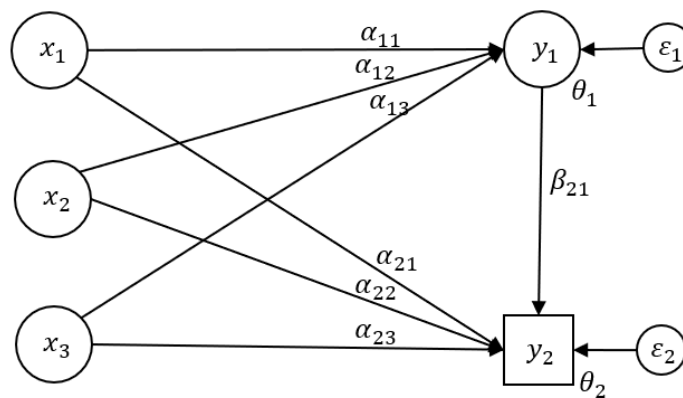


Figure 1. Research Design

Data were collected using validated questionnaires, a mathematical reasoning test, and students' mathematics achievement records. Self-efficacy, self-regulated learning, and self-determination were measured using Likert-scale questionnaires with four response options ranging from 1 (strongly disagree) to 4 (strongly agree). Each construct consisted of 15 items covering six indicators, including both favorable and unfavorable statements to minimize response bias. The instruments were developed based on established theoretical frameworks and were validated by two experts in mathematics education. The validity results confirmed that all items were appropriate for measuring the intended constructs, while reliability coefficients indicated acceptable internal consistency. The indicators used in the development of the research instruments were adapted and modified from relevant previous studies, as presented below.

Table 1. Indicators of self-efficacy

Dimensions of Self-efficacy	Indicators
Level	<ol style="list-style-type: none"> 1. Students' confidence in solving mathematics problems with varying levels of difficulty 2. Students' ability to determine appropriate solution strategies according to the level of problem difficulty
Strength	<ol style="list-style-type: none"> 1. Students' persistence in maintaining effort and self-confidence when facing learning obstacles 2. Students' ability to remain motivated after experiencing failure in mathematics learning
Generality	<ol style="list-style-type: none"> 1. Students' ability to apply self-confidence in various mathematics learning situations 2. Students' ability to adapt effective learning strategies across different mathematical contexts

Source: Bandura (1997)

Table 2. Indicators of self-regulated learning

Dimensions of Self-regulated learning	Indicators
Metacognition	<ol style="list-style-type: none"> 1. Evaluating learning processes and outcomes 2. Designing problem-solving strategies before starting learning activities
Motivation	<ol style="list-style-type: none"> 1. Setting learning goals 2. Assessing relevance and usefulness of learning materials
Behavior	<ol style="list-style-type: none"> 1. Utilizing and seeking relevant learning resources 2. Managing study time in a disciplined and proportional manner

Source: Schunk & Zimmerman (1998)

Table 3. Indicators of self-determination

Dimensions of Self-determination	Indicators
Autonomy	<ol style="list-style-type: none"> 1. Initiative in making learning decisions 2. Ability to maintain learning decisions despite external influence
Competence	<ol style="list-style-type: none"> 1. Ability to complete tasks well and feel satisfied with learning outcomes 2. Ability to seek feedback to improve learning outcomes
Relatedness	<ol style="list-style-type: none"> 1. Social support from peers and teachers 2. Active participation in collaborative learning activities

Source: Ryan & Deci (2020)

Mathematical reasoning ability was measured using four essay-based problems, each representing three indicators: conjecturing, reasoning and justification, and drawing logical conclusions. The test was also validated by two expert reviewers to ensure content validity. Mathematics achievement was obtained from official midterm examination scores provided by the mathematics teachers, reflecting students' academic performance based on curriculum-based assessment.

Data analysis involved descriptive statistics to summarize central tendency, dispersion, and frequency, and inferential statistics to test latent variable relationships and generalize findings (Ridha et al., 2024; Sugiyono, 2013). Hypotheses were tested using Partial Least Squares SEM (PLS-SEM) in SmartPLS, suitable for complex models with limited sample sizes (Kline, 2023). Analysis included evaluation of the measurement model (outer model) and structural model (inner model) (Hair et al., 2022; Kline, 2023). Outer

model assessment ensured indicator validity (outer loading ≥ 0.70 or > 0.50), composite reliability ($CR \geq 0.70$), Cronbach's Alpha (≥ 0.70), convergent validity ($AVE \geq 0.50$), and discriminant validity (Fornell-Larcker and HTMT < 0.90). Inner model assessment examined hypothesis paths, R^2 , Q^2 predictive relevance ($Q^2 > 0$), and significance via bootstrapping ($p < 0.05$). Mediation analysis tested whether mathematical reasoning mediated the effects of self-efficacy, self-regulated learning, and self-determination on mathematics achievement.

RESULTS AND DISCUSSION

Results of descriptive statistical analysis

To provide a general overview of the research data characteristics, the following presents the descriptive statistical analysis results for each variable examined.

Table 4. Descriptive Statistics

Variable	N	Min	Max	Mean	Std. Deviation
Self-efficacy (SE)	170	15	45	29,95	6,19
Self-regulated learning (SRL)	170	17	42	30,88	6,01
Self-determination (SDT)	170	17	50	35,48	6,71
Mathematical Reasoning Ability (MRA)	170	13	88	49,04	18,25
Mathematics Learning Achievement (MLA)	170	17	94	49,39	20,08

Based on Table 4, it can be seen that all research variables had 170 respondents (N). The self-efficacy variable had a mean of 29.95 with a standard deviation of 6.19, self-regulated learning had a mean of 30.88 with a standard deviation of 6.01, and self-determination had a mean of 35.48 with a standard deviation of 6.71. Meanwhile, mathematical reasoning ability had a mean of 49.04 with a standard deviation of 18.25, and learning achievement had a mean of 49.39 with a standard deviation of 20.08. Overall, the mean values indicate that the research variables are at a moderate level with considerable variation. To provide a more detailed overview of the data distribution for each variable, the following presents the frequency distribution based on the predefined categories.

Self-efficacy

Table 5. Frequency of Self-efficacy

Interval	Category	Frequency	Percentage
Score ≤ 21	Very Low	14	8,2%
$21 < \text{Score} \leq 30$	Low	79	46,5%
$30 < \text{Score} \leq 39$	High	67	39,4%
Score > 39	Very High	10	5,9%

Based on Table 5, it can be seen that the majority of respondents had self-efficacy at the low category, accounting for 46.5%, followed by the high category at 39.4%. Meanwhile, respondents in the very low category accounted for 8.2%, and the very high category 5.9%. This indicates that students' self-efficacy tends to range from low to high, with a predominance in the low category.

Self-regulated learning

Table 6. Frequency of Self-regulated learning

Interval	Category	Frequency	Percentage
Score ≤ 19	Very Low	7	4,1%
$19 < \text{Score} \leq 27$	Low	35	20,6%
$27 < \text{Score} \leq 35$	High	85	50%
Score > 35	Very High	43	25,3%

Based on Table 6, the distribution of self-regulated learning shows that most respondents fell into the high category at 50%, followed by the low category at 28.2%. Next, the very high category accounted for 25.3%, followed by moderate at 20.6%, and the very low category at 4.1%. This suggests that students' self-regulated learning ability generally falls within the high category.

Self-determination

Table 7. Frequency of Self-determination

Interval	Category	Frequency	Percentage
Score \leq 22	Very Low	7	4,1%
22 < Score \leq 32	Low	45	26,5%
32 < Score \leq 42	High	96	56,5%
Score > 42	Very High	22	12,9%

Based on Table 7, it was found that most respondents had self-determination in the high category, accounting for 56.5%. The low category accounted for 26.5%, followed by very high at 12.9%, and very low at 4.1%. This indicates that students' self-determination tends to be high.

Mathematical Reasoning Ability

Table 8. Frequency of Mathematical Reasoning Ability

Interval	Category	Frequency	Percentage
Score < 55	Low	107	62,9%
55 \leq Score < 70	Medium	35	20,6%
70 \leq Score	High	28	16,5%

Based on Table 8, the results show that the majority of respondents had mathematical reasoning ability in the low category, accounting for 62.9%. Meanwhile, the moderate category was 20.6%, and the high category 16.5%. This indicates that students' mathematical reasoning ability is still predominantly low.

Mathematics Learning Achievement

Table 9. Frequency of Mathematics Learning Achievement

Interval	Category	Frequency	Percentage
Score < 40	Very Low	76	44,7%
40 \leq Score < 60	Low	38	22,4%
60 \leq Score < 75	Medium	29	17,1%
75 \leq Score < 90	High	25	14,7%
90 \leq Score	Very High	2	1,2%

Based on Table 9, it can be observed that most respondents had learning achievement in the very low category, accounting for 44.7%, followed by the low category at 22.4%. The moderate category accounted for 17.1%, the high category 14.7%, and the very high category only 1.2%. This suggests that students' learning achievement is still predominantly in the very low to low categories.

Results of Inferential Statistical Analysis

Measurement Model Analysis (Outer Model)

In this study, self-efficacy (SE), self-regulated learning (SRL), and self-determination (SDT) were modeled as first-order reflective constructs in the PLS-SEM analysis. Each construct represents a single latent variable measured by multiple indicators derived from established theoretical dimensions. Specifically, self-efficacy is reflected through magnitude, strength, and generality; self-regulated learning is represented through metacognitive, motivational, and behavioral aspects; while self-determination is operationalized through autonomy, competence, and relatedness. All indicators were

analyzed collectively to form their respective latent constructs rather than being treated as separate higher-order constructs.

The measurement model analysis (outer model) was conducted to ensure that the indicators used were valid and reliable in measuring each latent variable. This testing is essential to guarantee the quality of the research instruments before further analysis. The evaluation of the outer model is assessed based on three main criteria: convergent validity, construct reliability, and discriminant validity.

Convergent Validity Test

The convergent validity test is performed to assess the extent to which the indicators of a latent variable are correlated and adequately represent the variable. Convergent validity is evaluated based on the outer loading values for each construct indicator. The results of the convergent validity test are presented in Table 10.

Table 10. Convergent Validity Test Results

Variable	Indicator	Outer Loading
Mathematical Reasoning Ability	MRA 1	0,752
	MRA 2	0,845
	MRA 3	0,919
Self-efficacy	SE 1	0,814
	SE 2	0,748
	SE 4	0,603
	SE 6	0,781
	SE 8	0,577
	SE 9	0,589
	SE 11	0,745
	SE 13	0,771
Self-regulated learning	SE 14	0,792
	SRL 1	0,641
	SRL 3	0,651
	SRL 6	0,768
	SRL 8	0,789
	SRL 10	0,576
	SRL 12	0,745
Self-determination	SRL 13	0,778
	SRL 15	0,792
	SDT 3	0,579
	SDT 6	0,713
	SDT 8	0,758
	SDT 9	0,700
	SDT 13	0,732
	SDT 14	0,736

Based on the data in Table 10, most indicators have outer loading values above 0.7. This indicates a very strong convergence between the indicators and their latent variables. On the other hand, some indicators have values ranging from 0.5 to 0.7. These indicators are retained in the model because outer loading values above 0.5 are considered the minimum acceptable threshold and are still deemed valid.

Construct Reliability Test

After evaluating convergent validity through outer loading values, the next step in the measurement model analysis is to assess the reliability and consistency of each latent variable. The results of reliability and Average Variance Extracted (AVE) tests for all constructs are presented in Table 11.

Table 11. Construct Reliability Test Results

Variable	Cronbach's alpha	Composite Reliability (CR)	Average Variance extracted (AVE)
MRA	0,790	0,878	0,707
SE	0,884	0,905	0,517
SRL	0,867	0,896	0,521
SDT	0,800	0,857	0,501

Based on Table 11, all research variables have Cronbach's Alpha and Composite Reliability values above 0.70, as well as AVE values above 0.50. These results indicate that all constructs meet the established threshold standards. Therefore, it can be concluded that all research instruments are reliable and possess good validity for use in subsequent analyses.

Discriminant Validity Test

The next step is to assess the discriminant validity of the constructs using the Heterotrait-Monotrait Ratio (HTMT) approach. This test aims to ensure that each construct is empirically distinct and different from the other constructs in the research model. The results of the discriminant validity test using the HTMT method are presented in Table 12.

Table 12. Discriminant Validity Test Results (HTMT)

Variabel	MRA	MLA	SE	SRL	SDT
MRA	-	0,721	0,496	0,537	0,493
MLA	0,721	-	0,274	0,287	0,212
SE	0,496	0,274	-	0,752	0,759
SRL	0,537	0,287	0,752	-	0,809
SDT	0,493	0,212	0,759	0,809	-

Based on the results presented in Table 9, it can be observed that all HTMT correlation values between the research variables are below 0.90. The highest value was recorded between the SRL and SDT variables at 0.809, which remains below the required threshold. These results confirm that all latent constructs in this research model meet the criteria for good discriminant validity and can be used for subsequent structural model analysis.

Structural Model Analysis (Inner Model)

After all measurement model (outer model) tests have been completed and the instruments deemed valid and reliable, the analysis proceeds with evaluating the structural model (inner model). The inner model assessment is conducted to predict the relationships among latent variables and to determine the model's ability to explain the variance of the dependent variables. In this study, the structural model is evaluated using several key criteria: R-Square (R^2) values, Predictive Relevance (Q^2) tests, and significance testing through hypothesis testing (direct, indirect, and total effects).

R-Square (R^2)

R-Square testing is performed to measure the model's ability to explain the variance of the endogenous (dependent) variables. This value serves as an indicator of the predictive strength of the structural model developed in the study. The results of the R-Square and Adjusted R-Square values for each endogenous variable are presented in Table 13.

Table 13. R-Square Test Results

Endogenous Variable	R Square	R Square Adjusted
MRA	0,252	0,238
MLA	0,426	0,412

Based on Table 13, the MRA variable has an R-Square value of 0.252, indicating that 25.2% of the variance in MRA can be explained by the exogenous variables in the model, while the remaining variance is accounted for by factors outside the model. Meanwhile, the MLA variable has an R-Square value of 0.426, which shows that the exogenous variables explain 42.6% of the variance in MLA.

Predictive Relevance Test (Q^2)

The Predictive Relevance (Q^2) test was conducted using the PLSpredict procedure to evaluate the predictive relevance of the structural model. The results of the Q^2 values for each endogenous variable are presented in Table 14.

Table 14. Predictive Relevance Test Results

Endogenous Variable	Q^2 Predict	Description
MRA	0,215	Has <i>Predictive Relevance</i>
MLA	0,055	Has <i>Predictive Relevance</i>

Based on Table 14, the analysis results indicate that the Q^2 Predict value for the MRA variable is 0.215, and for the MLA variable it is 0.055. Since both endogenous variables have Q^2 values greater than 0, it can be concluded that the structural model in this study demonstrates good predictive accuracy (*predictive relevance*).

Path Coefficients Analysis

a) *Direct Effect*

Hypothesis testing for direct effects was conducted to examine the significance of the linear impact of one exogenous variable directly on an endogenous variable without involving mediating variables. The results of direct effect hypothesis testing for each structural path are presented in Table 15 below:

Table 15. Direct Effect

Hypothesis	Structural Path	T Statistics	P Values	Description
H_1	SE → MRA	2,364	0,018	Significant
H_2	SRL → MRA	2,492	0,013	Significant
H_3	SDT → MRA	1,042	0,297	Not Significant
H_4	MRA → MLA	11,874	0,000	Significant
H_5	SE → MLA	0,330	0,742	Not Significant
H_6	SRL → MLA	0,306	0,759	Not Significant
H_7	SDT → MLA	1,229	0,219	Not Significant

Based on the data in Table 12, the analysis indicates that out of the seven direct effect paths tested, three paths were statistically significant, while four paths were not. The direct effects of SE on MRA (0.234), SRL on MRA (0.245), and MRA on MLA (0.662) were found to be positive and statistically significant. In contrast, the direct relationships of SDT to MRA, as well as SE, SRL, and SDT directly to MLA, exhibited P values greater than 0.05, indicating that these hypotheses were rejected or did not have a significant effect.

b) *Indirect Effect*

The indirect effect hypothesis testing was conducted to evaluate the mediating role of the intervening variable in bridging the relationship between exogenous and endogenous variables. The results of the indirect effect analysis, involving MRA as a mediator, are presented in Table 16 below:

Table 16. Indirect Effect

Hipotesis	Structural Path	T Statistics	P Values	Description
H_8	SE → MRA → MLA	2,340	0,019	Significant
H_9	SRL → MRA → MLA	2,437	0,015	Significant
H_{10}	SDT → MRA → MLA	1,022	0,307	Not Significant

Based on the results presented in Table 16, it can be seen that MRA significantly mediates the effects of SE on MLA (0.155) and SRL on MLA (0.162). This is indicated by the P values for each path, which are below 0.05. In contrast, MRA was found not to have a significant mediating role in the relationship between SDT and MLA (0.058), as the P value exceeded the critical threshold at 0.307. The results of the structural model are also presented visually in Figure 2, which illustrates the path coefficients and significance levels among the constructs, providing a clearer interpretation of the relationships between constructs.

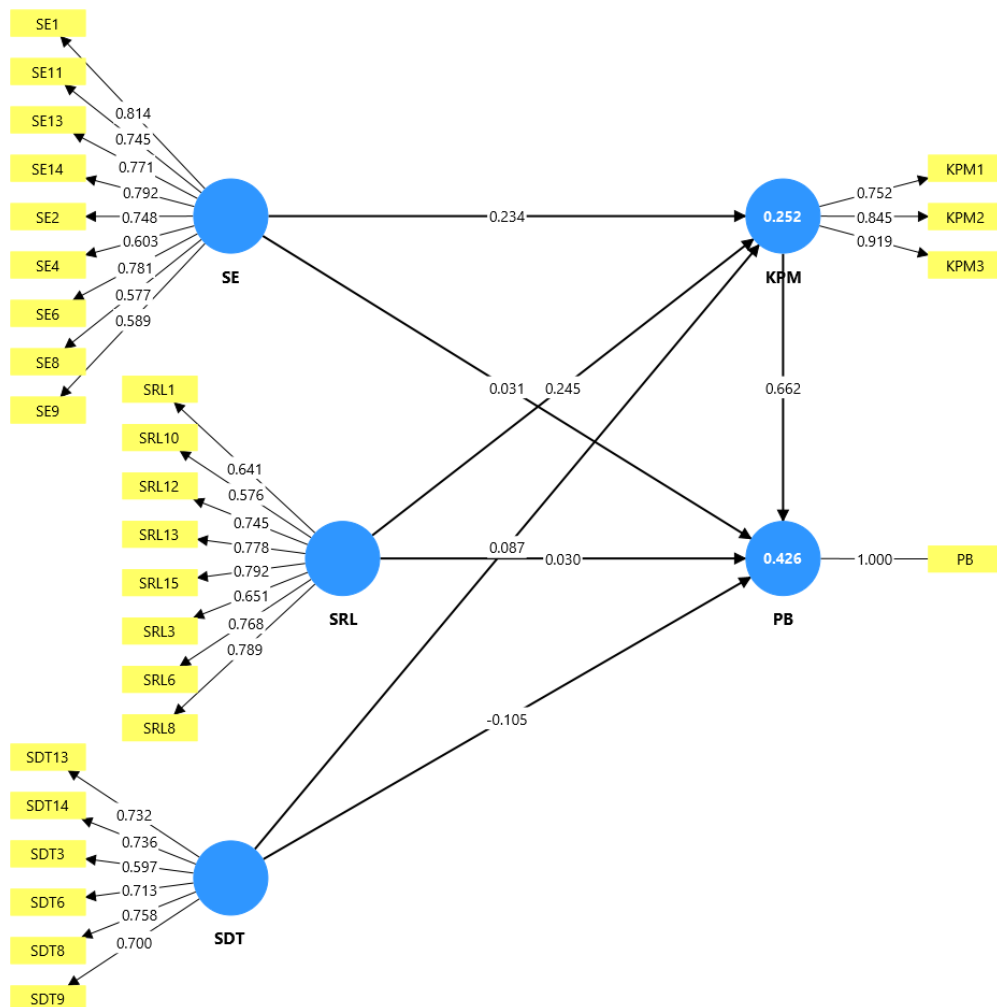


Figure 2. Final Structural Model and Path Coefficients of the Research Model

Discussion

This discussion interprets empirical findings based on descriptive and inferential statistical analyses, linking them to relevant theories and previous studies. Descriptive results from 170 respondents indicate that students' psychological variables self-efficacy, self-regulated learning, and self-determination have data distributions clustered around the mean, suggesting relatively homogeneous psychological characteristics. In contrast, mathematical reasoning ability and learning achievement show wider ranges and higher standard deviations, indicating substantial variability in students' academic performance. The structural model used meets the adequacy criteria, allowing interpretation of relationships among latent variables based on hypothesis testing. Overall, not all hypotheses were statistically significant, indicating that certain variables play more dominant roles in explaining mathematics learning achievement.

Hypothesis testing showed that self-efficacy significantly affects students' mathematical reasoning ability, confirming that students' confidence in completing academic tasks contributes to mathematical thinking and logical reasoning. This aligns with previous research demonstrating self-efficacy's critical role in mathematics learning and reasoning ability (Aprisal & Arifin, 2020; Samsuddin & Retnawati, 2022; Smit et al., 2022). Students with high self-efficacy tend to be more confident in solving mathematical problems, willing to try various strategies, and persistent when encountering difficulties in reasoning (Hadiat & Karyati, 2019; Nurussalamah & Marlina, 2022; Yuliani et al., 2025). Thus, self-efficacy can be understood as a psychological factor that strengthens students' readiness to employ mathematical reasoning optimally.

Self-regulated learning also significantly influences mathematical reasoning ability, indicating that students' capacity to plan, monitor, and evaluate their learning independently contributes to reasoning development. This finding aligns with Apriyani (2024), who emphasizes that self-regulated learning fosters independence and self-control in mathematics learning. Bernard et al. (2025) similarly show that students' mathematical reasoning in problem-solving is influenced by their level of self-regulated learning, a finding reinforced by Nugroho et al. (2025), who report that self-regulated learning-based instruction enhances reasoning and problem-solving skills. Other studies confirm that self-regulated learning supports mathematics learning success and academic achievement (Ridha et al., 2024; Salma & Alsa, 2023).

Mathematical reasoning ability significantly affects mathematics achievement, showing that better logical thinking, concept analysis, argument construction, and conclusion drawing correlate with higher achievement. This is consistent with Ariati and Juandi (2022), who highlight reasoning as a critical component of mathematics learning, relating to logical thinking and problem-solving. Purwanto et al. (2023) further emphasize that reasoning ability fosters critical thinking, contributing to academic success. Moreover, mathematical reasoning is associated with conceptual understanding and problem-solving success (Ardhiyanti et al., 2019; Hilaliyah & Annisa, 2022), supported by Gustiadi et al. (2021), and Rahmawati and Masriyah (2021), who report that students with strong reasoning skills achieve higher mathematics performance than those with weaker reasoning.

These findings indicate that self-determination does not have a statistically significant direct effect on mathematical reasoning ability. This can be explained by the fact that self-determination primarily functions as a motivational factor that influences the internalization of learning goals and student engagement, rather than directly activating higher-order cognitive processes such as mathematical reasoning. Within the framework of Self-Determination Theory, the fulfillment of basic psychological needs (autonomy, competence, and relatedness) mainly enhances intrinsic motivation and learning

engagement, whereas mathematical reasoning ability is more strongly influenced by cognitive strategies, problem-solving practice, and direct self-regulated learning processes (Ryan & Deci, 2020; Siacor et al., 2024). Previous educational research also suggests that the influence of self-determination on learning outcomes tends to be indirect and is mediated by cognitive variables such as self-efficacy or learning strategies rather than serving as a direct predictor of higher-order thinking skills (Lazaro et al., 2025).

In addition, the results also show that self-determination does not have a significant effect on mathematics achievement, even when mediated by mathematical reasoning ability. This indicates that the tested mediating pathway is not strong enough to transmit the influence of motivational factors into learning outcomes. This finding is consistent with studies suggesting that self-determination-based motivation does not always directly contribute to academic achievement, but rather operates through intermediary processes such as learning engagement, self-regulated learning, and specific cognitive abilities (Asare & Boateng, 2025; Paumier & Chanal, 2023). Therefore, self-determination is better understood as a supporting factor that strengthens the learning process indirectly, rather than a primary determinant of mathematics achievement.

These findings suggest that mathematics achievement is not directly enhanced solely by students' confidence and self-regulated learning abilities, but requires mathematical reasoning as an intermediary process. Self-efficacy boosts confidence in tackling tasks (Rahmawati & Nopriana, 2024; Tas et al., 2023), while self-regulated learning supports strategic, time, and process management (Salma & Alsa, 2023; Sari et al., 2024). Together, these factors cultivate mathematical reasoning, ultimately improving learning outcomes. The implication of this study is that instruction in social arithmetic should emphasize the development of students' reasoning ability through higher-order thinking activities, problem-solving tasks, logical reasoning, and reflective processes. Such instructional approaches are expected to strengthen students' cognitive processing in social arithmetic learning, thereby improving their achievement in this specific mathematical domain.

CONCLUSION AND SUGGESTIONS

Based on the findings of this study, it can be concluded that students' self-efficacy, self-regulated learning, and self-determination are at a moderate level, whereas mathematical reasoning ability remains low, which impacts suboptimal mathematics learning achievement. The analysis indicates that self-regulated learning and self-efficacy have a positive and significant effect on mathematical reasoning ability, which in turn has a positive and significant impact on mathematics achievement. These findings suggest that the better students' confidence and self-regulation in learning, the higher their mathematical reasoning ability, thereby enhancing their mathematics achievement. Conversely, self-determination does not have a significant direct effect on either mathematical reasoning ability or mathematics achievement. Thus, mathematical reasoning functions as a key mediating variable bridging the influence of self-regulated learning and self-efficacy on mathematics achievement, indicating that improvements in learning outcomes depend not only on internal student factors but also critically on strengthening mathematical reasoning as a core cognitive component.

This study has several limitations that should be acknowledged. First, the sample was limited to students from a single junior high school, which may restrict the generalizability of the findings to other educational contexts. Second, the study relied on self-reported questionnaires for psychological variables, which may be influenced by response bias. Third, the research only examined three internal psychological factors and one mediating variable, while other external factors that may affect mathematics

achievement were not included in the model.

Based on the findings of this study, it is recommended that teachers enhance students' mathematical reasoning through learning activities that promote logical, critical, and systematic thinking, while also strengthening self-efficacy and self-regulated learning by allowing students to manage their own learning processes. Students are encouraged to actively develop reasoning skills, deepen conceptual understanding, practice logical thinking, and improve learning independence. Schools should support this through a conducive learning environment and by facilitating instruction that emphasizes higher-order thinking, self-efficacy, and self-regulated learning. Future researchers are advised to examine additional variables affecting mathematical reasoning and learning achievement with a broader scope to obtain more comprehensive results.

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