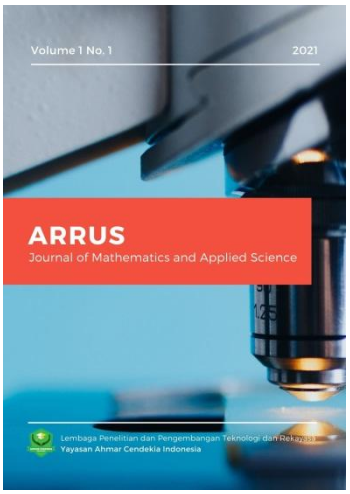
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RESEARCH ARTICLE

When Self-Regulated Learning Becomes the Key Determinant: Academic Self-Efficacy, Learning Environment, and Mathematics Achievement among Senior High School Students

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Abstract: This study examines the direct and indirect relationships among learning environment, academic self-efficacy, self-regulated learning, and mathematics achievement among secondary school students. The study employed a quantitative ex post facto design involving 112 students from State Senior High School 1 Parepare, Indonesia. Data on learning environment, academic self-efficacy, and self-regulated learning were collected using questionnaires, while mathematics achievement data were obtained from students' academic records. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS. The results revealed that the learning environment and academic self-efficacy had positive and significant effects on self-regulated learning. Self-regulated learning also had a positive and significant effect on mathematics achievement. However, the direct effects of the learning environment and academic self-efficacy on mathematics achievement were not significant. The coefficient of determination indicated that learning environment and academic self-efficacy explained 69.1% of the variance in self-regulated learning, while the model explained 12.0% of the variance in mathematics achievement. Furthermore, self-regulated learning significantly mediated the relationships between learning environment and mathematics achievement, as well as between academic self-efficacy and mathematics achievement. The findings suggest that self-regulated learning serves as a key mechanism through which learning environment and academic self-efficacy influence mathematics achievement. Students' ability to regulate, monitor, and evaluate their learning processes appears to play a more important role in mathematics achievement than the direct effects of environmental and personal factors.

Keywords: Academic Self-Efficacy, Learning Environment, Mathematics Achievement, PLS-SEM, Self-Regulated Learning

1. Introduction

Mathematics achievement remains a persistent concern in secondary education, as many students continue to fall short of expected learning competencies despite being exposed to

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relatively similar instructional experiences. Recent studies suggest that success in mathematics is influenced not only by cognitive ability but also by psychological factors, learning behaviors, and supportive learning environments that facilitate students' learning processes (Adler et al., 2025; de Mooij et al., 2025; Mutiah & Romsi, 2024; A. Rahayu et al., 2025; Wang et al., 2025). Mathematics learning requires students to comprehend abstract concepts, solve complex problems, and sustain motivation over time. Consequently, a more comprehensive understanding of the factors that shape mathematics achievement is needed.

Preliminary observations conducted at State Senior High School 1 Parepare (hereafter SHS 1 Parepare) revealed that several learning-related indicators were still at a moderate level, particularly students' confidence in expressing opinions (M = 2.86), ability to understand learning materials independently (M = 2.91), participation in asking and answering questions (M = 2.94), ability to maintain concentration during lessons (M = 3.00), and willingness to review materials and practice independently (M = 3.26). These findings indicate challenges related to academic self-belief, learning engagement, and learning autonomy. Similar patterns have been reported in previous studies, which have shown that limited self-confidence and inadequate learning management skills may negatively affect students' academic performance, particularly in mathematics (Fauziah et al., 2022; Jud et al., 2025; Martincová et al., 2025; Putri et al., 2025; R. M. Rahayu & Bernard, 2022).

One internal factor that may help explain these conditions is academic self-efficacy. Academic self-efficacy refers to students' beliefs in their capability to successfully perform academic tasks and achieve specific learning goals. Recent evidence indicates that students with higher levels of academic self-efficacy tend to demonstrate greater persistence when facing difficulties, employ learning strategies more actively, and maintain stronger motivation to achieve academic goals (Hadi & Al-Quraan, 2025; Jud et al., 2025; Landa et al., 2025; Martincová et al., 2025). Nevertheless, several studies have reported that academic self-efficacy does not always exert a direct influence on mathematics achievement, suggesting the need to identify additional variables that may explain the underlying mechanism linking these constructs (Martincová et al., 2025; A. Rahayu et al., 2025).

In addition to internal factors, the learning environment represents an important external influence on mathematics learning. The learning environment encompasses teacher support, peer relationships, classroom conditions, and the overall learning climate experienced by students. Contemporary research has consistently shown that a positive learning environment can enhance student engagement, motivation, and the quality of learning experiences (Adler et al., 2025; Dong et al., 2024; Pramesti & Suryadi, 2025; Wang et al., 2025). However, findings regarding its direct effect on mathematics achievement remain inconclusive. While some studies have identified a significant direct relationship, others suggest that the learning environment primarily influences achievement indirectly through psychological and behavioral factors rather than through a direct pathway (Abbas & Rizki, 2023; Chen et al., 2024; Dong et al., 2024; Wang et al., 2025).

One factor that may help explain this relationship is self-regulated learning. Self-regulated learning (SRL) refers to students' ability to set learning goals, select appropriate learning strategies, monitor their progress, and evaluate learning outcomes independently. Recent studies have demonstrated that SRL contributes substantially to academic achievement by enabling students to manage their learning processes more effectively (Dai et al., 2025; Mutiah & Romsi, 2024; Septiani et al., 2024). Furthermore, a growing body of research indicates that both academic self-efficacy and the learning environment play significant roles in fostering students' self-regulatory capacities (Adler et al., 2025; Putri et al., 2025; Wang et al., 2025).

Although the relationships among academic self-efficacy, learning environment, SRL, and mathematics achievement have been widely investigated, studies integrating these variables within a single mediation framework remain limited, particularly in the context of Indonesian senior high school students. Previous research has largely focused on direct relationships among variables, whereas the mechanisms through which internal and external factors

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influence mathematics achievement through self-regulated learning have received comparatively less empirical attention (Mutiah & Romsi, 2024; A. Rahayu et al., 2025; Septiani et al., 2024). Therefore, this study aims to examine the effects of academic self-efficacy and learning environment on mathematics achievement through SRL among students at SHS 1 Parepare. The novelty of this study lies in its investigation of the mediating role of self-regulated learning in explaining how internal factors (academic self-efficacy) and external factors (learning environment) contribute to mathematics achievement, thereby providing a more comprehensive understanding of the mechanisms underlying students' success in mathematics learning.

2. Literature Review

Mathematics achievement is widely recognized as an important indicator of students' success in attaining educational objectives. A substantial body of research has demonstrated that both personal and environmental factors play significant roles in shaping mathematics learning outcomes. From the perspective of Social Cognitive Theory, academic achievement emerges from the dynamic interaction among individual characteristics, behavioral processes, and environmental influences. One of the most extensively studied personal factors is academic self-efficacy, defined as students' beliefs in their capability to successfully perform academic tasks and achieve desired learning outcomes. According to Bandura (1997), self-efficacy comprises three primary dimensions: magnitude, strength, and generality. Magnitude refers to students' confidence in handling tasks of varying levels of difficulty, strength reflects the degree of persistence in maintaining such confidence when encountering obstacles, and generality describes the extent to which these beliefs can be generalized across different academic contexts. In the present study, academic self-efficacy was measured based on these three dimensions. Research by Yang et al. (2024) demonstrated that mathematics self-efficacy is positively associated with students' mathematics achievement. Moreover, students with higher levels of self-efficacy tend to employ more effective learning strategies and exhibit greater persistence in completing academic tasks.

In addition to personal factors, the learning environment plays a crucial role in supporting students' academic success. In this study, the learning environment encompasses teacher support, peer relationships, conducive classroom conditions, and learning comfort. These dimensions represent social and psychological conditions that may influence students' engagement in mathematics learning (Fraser, 1998; Moos & Van Dort, 1979). A positive learning environment provides social, emotional, and academic support that encourages active participation in the learning process. Niu et al. (2022) found that a supportive learning environment is positively associated with both self-regulation and mathematics achievement. Such an environment enables students to receive constructive feedback, enhances learning motivation, and fosters greater independence in learning.

Students' ability to manage their own learning processes is commonly referred to as self-regulated learning. Drawing on Zimmerman (2000), self SRL is conceptualized through students' abilities to establish learning goals (*goal setting*), employ appropriate learning strategies (*learning strategies*), monitor their learning progress (*self-monitoring*), and evaluate learning outcomes (*self-evaluation*). Self-regulated learning therefore encompasses the capacity to plan, manage, monitor, and evaluate one's learning activities independently. Numerous studies have shown that students with stronger self-regulatory skills generally achieve higher academic outcomes than those who struggle to regulate their learning processes effectively. Furthermore, high levels of self-efficacy encourage students to take a more active role in directing and controlling their own learning activities (Schunk & DiBenedetto, 2020).

Previous studies have also suggested that SRL may function as an underlying mechanism linking both personal and environmental factors to academic achievement. Niu et al. (2022) reported that self-regulation mediates the relationship between the learning environment and students' mathematics achievement. Similar findings were reported by Septian Ningrum & Rafsanjani (2024) who found that self-regulated learning mediates the effect of academic self-

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efficacy on learning outcomes. Furthermore, Du et al. (2021) demonstrated a positive reciprocal relationship between mathematics self-efficacy and mathematics achievement. Collectively, these findings suggest that academic self-efficacy and the learning environment influence learning outcomes not only through direct pathways but also indirectly through self-regulated learning, which serves as an important mechanism for enhancing students' academic performance.

Despite extensive research examining the relationships among academic self-efficacy, learning environment, and mathematics achievement, previous findings remain inconclusive. While some studies have reported significant direct effects, others have found weak or non-significant relationships. Moreover, empirical studies investigating self-regulated learning as a mediating mechanism between personal and environmental factors and mathematics achievement among Indonesian senior high school students remain relatively scarce. This study addresses this gap by examining the mediating role of self-regulated learning in the relationships among academic self-efficacy, learning environment, and mathematics achievement. Based on the theoretical framework and empirical evidence discussed above, this study investigates the effects of academic self-efficacy and learning environment on senior high school students' mathematics achievement through SRL. Accordingly, the following hypotheses are proposed:

H1: Academic self-efficacy positively influences self-regulated learning.
H2: Learning environment positively influences self-regulated learning.
H3: Academic self-efficacy positively influences mathematics achievement.
H4: Learning environment positively influences mathematics achievement.
H5: Self-regulated learning positively influences mathematics achievement
H6: Self-regulated learning mediates the relationship between academic self-efficacy and mathematics achievement.
H7: Self-regulated learning mediates the relationship between learning environment and mathematics achievement.

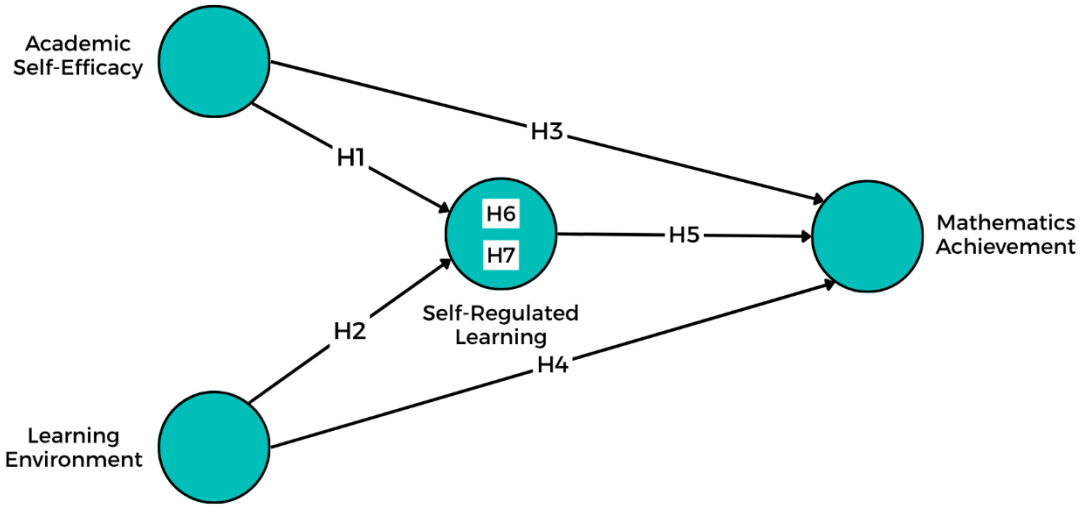


Figure 1: Reseacrh Model

3. Research Method and Materials

This study employed an explanatory research design to examine the causal relationships among the variables under investigation. The study was intended not only to identify associations among variables but also to explain the extent to which independent variables influence the dependent variable, both directly and indirectly through a mediating variable. The independent variables were academic self-efficacy and learning environment, while mathematics achievement served as the dependent variable and self-regulated learning (SRL)

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functioned as the mediating variable. To test the proposed relationships, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed using a path analysis framework (Hair et al., 2022). This approach was considered appropriate because it enables the simultaneous examination of direct and indirect effects among latent constructs and is suitable for predictive and explanatory research models.

The population consisted of all 11th Grade students enrolled in advanced mathematics courses at SHS 1 Parepare during the 2025/2026 academic year. A total of 166 students distributed across five classes constituted the study population. Based on the Slovin formula, the minimum required sample size was 117 students (Sugiyono, 2014). Using a simple random sampling technique, 112 valid responses were obtained and included in the final analysis. This sampling technique ensured that each student had an equal opportunity to be selected as a participant.

Data were collected using a structured questionnaire designed to measure academic self-efficacy, learning environment, and SRL. All questionnaire items were assessed using a five-point Likert scale ranging from strongly disagree to strongly agree. Academic self-efficacy was measured based on the dimensions of magnitude, strength, and generality (Bandura, 1997), while the learning environment construct included teacher support, peer relationships, classroom conditions, and learning comfort (Zimmerman, 2000). SRL was measured through four dimensions: goal setting, learning strategies, self-monitoring, and self-evaluation.

Mathematics achievement was assessed using a summative mathematics test consisting of 30 multiple-choice items and 5 essay questions covering trigonometric functions, exponential functions, and logarithmic functions. The test was collaboratively developed by the researcher and the mathematics teacher to ensure alignment with the curriculum and intended learning outcomes. Prior to administration, the test was reviewed by two mathematics education experts and the subject teacher to ensure content validity. Students' total test scores were used as indicators of mathematics achievement.

Data analysis was conducted using SmartPLS 4 software. The analysis proceeded in two stages. First, the measurement model was evaluated by examining indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Second, the structural model was assessed to examine the hypothesized relationships among constructs. The significance of direct and indirect effects was tested using a bootstrapping procedure, enabling the evaluation of the mediating role of SRL in the relationships between academic self-efficacy, learning environment, and mathematics achievement.

4. Results and Discussion

4.1. Results

The findings of this study are presented in two sections: descriptive analysis and inferential analysis. Descriptive analysis was conducted to describe the characteristics of the study variables, namely learning environment, academic self-efficacy, self-regulated learning (SRL), and mathematics achievement. Subsequently, inferential analysis was performed to test the proposed research model and hypotheses using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. Accordingly, the results not only describe the condition of each variable but also explain the relationships among variables within the proposed research model.

4.1.1. Description of Learning Environment, Academic Self-Efficacy, Self-Regulated Learning, and Mathematics Achievement

Table 1 presents the descriptive statistics for the learning environment, academic self-efficacy, and self-regulated learning variables.

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Table 1. Descriptive Statistics of Learning Environment, Academic Self-Efficacy, and Self-Regulated Learning

Variable	Indicator	Mean	Persentage	Category
Academic Self-Efficacy (X1)	Magnitude	3.71	74.3	Very High
	Strength	4.00	80.2	Very High
	Generality	3.74	74.8	Very High
	Average	**3.82**	**76.4**	**Very High**
Learning Environment (X2)	Teacher Support	4.41	88.4	Very High
	Peer Relationships	4.28	85.7	Very High
	Conducive Classroom Conditions	3.98	79.7	Very High
	Learning Comfort	4.13	82.8	Very High
	Average	**4.20**	**84.2**	**Very High**
Self-Regulated Learning (Z)	Goal Setting	4.37	87.4	Very High
	Learning Strategies	3.97	79.5	Very High
	Self-Monitoring	3.82	76.4	Very High
	Self-Evaluation	4.15	83.0	Very High
	Average	**4,07**	**81.6**	**Very High**

Based on the descriptive analysis of 112 respondents, the academic self-efficacy recorded a mean score of 3.82 (76.4%), likewise falling within the very high category. The learning environment variable obtained a mean score of 4.20 (84.2%), indicating a very high category. Similarly, self-regulated learning (SRL) achieved a mean score of 4.07 (81.6%), which was also classified as very high. These findings suggest that students generally perceived their learning environment positively, demonstrated strong self-regulation skills, and possessed relatively high levels of academic self-efficacy.

Regarding academic self-efficacy, the strength dimension achieved the highest mean score (M = 4.00, 80.2%), whereas the magnitude and generality dimensions obtained percentages of 74.3% and 74.8%, respectively. These results suggest that students generally possessed a strong belief in their ability to persist and maintain effort when encountering challenges in mathematics learning.

For the learning environment construct, teacher support exhibited the highest mean score (M = 4.41, 88.4%), followed by peer relationships (M = 4.28, 85.7%). In contrast, conducive classroom conditions recorded the lowest mean score (M = 3.98, 79.7%). This finding indicates that teacher support was the most prominent aspect of the learning environment perceived by students.

For self-regulated learning, goal setting emerged as the highest-rated dimension (M = 4.37, 87.4%), followed by self-evaluation (M = 4.15, 83.0%). Conversely, self-monitoring recorded the lowest mean score (M = 3.82, 76.4%). These findings indicate that students were generally capable of establishing clear learning goals, although their ability to monitor learning progress remained relatively less developed compared with other SRL dimensions.

Table 2. Descriptive Statistics of Students' Mathematics Achievement

Statistic	Value
Sample Size	112
Minimum Score	13.33
Maximum Score	96.67
Mean	68.63
Median	68.89
Standard Deviation	16.68

Based on the descriptive statistical analysis, students' mathematics achievement obtained a mean score of 68.63 with a standard deviation of 16.68. The highest score achieved was 96.67, whereas the lowest score was 13.33. The relatively large standard deviation indicates considerable variability in mathematics achievement among students. Furthermore, the median score of 68.89, which is close to the mean score, suggests that the distribution of mathematics achievement scores was relatively balanced.

4.1.2. Measurement Model Assessment

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To conduct the inferential statistical analysis through path analysis, the model specification was developed based on the measurement model (outer model) and the structural model (inner model). The structural model was specified according to the theoretical framework and research design, whereas the measurement model was constructed based on the indicators used to measure the latent variables, namely learning environment, academic self-efficacy, SRL, and mathematics achievement. The evaluation of the measurement model was conducted through three stages: convergent validity assessment, discriminant validity assessment, and reliability testing.

The measurement model was evaluated to assess the validity and reliability of the research instruments. Specifically, convergent validity was examined using outer loadings and the Average Variance Extracted (AVE), discriminant validity was assessed through cross-loadings, and reliability was evaluated using Cronbach's Alpha and Composite Reliability. The model specification is presented in Figure 1.

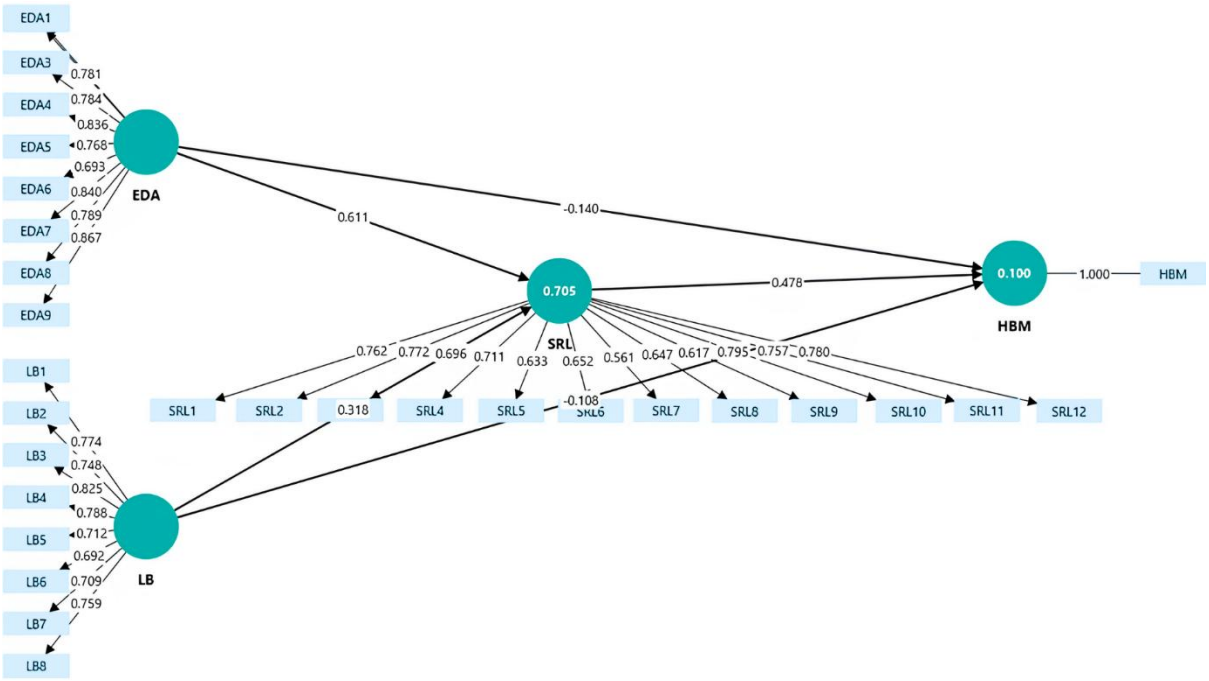


Figure 2. Initial Measurement Model Assessment

4.1.3. Convergent and Discriminant Validity Assessment

Convergent validity was assessed using outer loading values and the Average Variance Extracted (AVE). As shown in Figure 1, the results of the initial measurement model indicated that most indicators had outer loading values above the recommended threshold of 0.60. However, several indicators exhibited outer loading values below 0.60. Indicators with low outer loading values demonstrate insufficient capability to adequately represent the intended construct and may reduce the quality of the measurement model. Therefore, indicators with outer loading values below 0.60 were considered for removal to improve the validity and reliability of the constructs (Hair et al., 2022).

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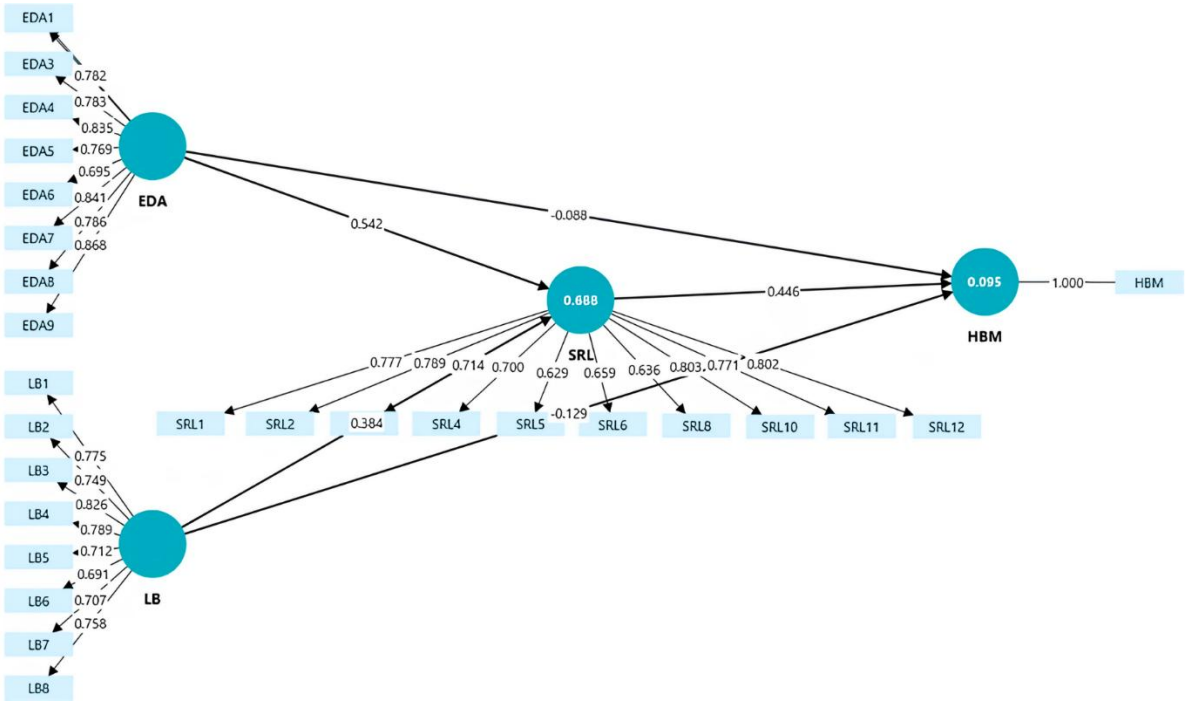


Figure 3. Measurement Model Assessment After Model Modification

After removing indicators with outer loading values below 0.60, the measurement model was re-estimated. The results indicated that all remaining indicators achieved outer loading values above 0.60, thereby satisfying the criteria for convergent validity. Furthermore, the values of the Average Variance Extracted (AVE), Cronbach's Alpha, and Composite Reliability for all constructs exceeded the recommended minimum thresholds. Therefore, the revised measurement model was considered valid and reliable and was deemed suitable for subsequent structural model analysis.

Convergent validity was further evaluated using the Average Variance Extracted (AVE). The results indicated that all constructs achieved AVE values greater than 0.50, suggesting that the variance of the indicators was adequately explained by their respective latent constructs. Accordingly, each construct was able to explain more than 50% of the variance in its indicators and therefore satisfied the criterion for convergent validity.

Table 3. Heterotrait–Monotrait Ratio (HTMT) Results

Construct	Academic Self-Efficacy	Mathematics Achievement	Learning Environment	Self-Regulated Learning
Academic Self-Efficacy	-			
Mathematics Achievement	0.219	-		
Learning Environment	0.648	0.143	-	
Self-Regulated Learning	0.843	0.332	0.771	-

Discriminant validity was assessed using the Heterotrait–Monotrait Ratio (HTMT) approach (Henseler et al., 2015). HTMT is recommended in PLS-SEM because it is considered more accurate in evaluating discriminant validity than traditional methods. A construct is considered to demonstrate adequate discriminant validity when its HTMT value is below 0.90. As shown in Table 3, all HTMT values ranged from 0.143 to 0.843. The highest HTMT value was observed between Academic Self-Efficacy and Self-Regulated Learning (0.843), whereas the lowest value was found between Learning Environment and Mathematics Achievement (0.143). Since all HTMT values were below the recommended threshold of 0.90, each construct demonstrated satisfactory discriminant validity and was empirically

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distinct from the others (Henseler et al., 2015; Hair et al., 2022). Therefore, the measurement model satisfied both convergent and discriminant validity requirements.

4.1.4. Reliability Assessment Using Cronbach's Alpha and Composite Reliability

Reliability was assessed using Cronbach's Alpha and Composite Reliability, as presented in Table 4. These indices were used to evaluate the internal consistency of the indicators measuring each construct. Values above 0.70 indicate satisfactory reliability (Hair et al., 2022).

Table 4. Reliability Assessment Results

Variable	Cronbach's Alpha	Composite Reliability	Interpretation
Academic Self-Efficacy	0.893	0.914	Reliable
Learning Environment	0.923	0.936	Reliable
Self-Regulated Learning	0.905	0.921	Reliable
Mathematics Achievement	–	–	–

As shown in Table 4, all latent constructs achieved Cronbach's Alpha and Composite Reliability values above the recommended threshold of 0.70. Mathematics achievement was represented by a single observed variable; therefore, reliability coefficients were not estimated. Consequently, all constructs were considered reliable and suitable for further analysis. These findings indicate that the measurement instrument demonstrated a high level of internal consistency.

4.1.5. Structural Model Evaluation

Following the assessment of the measurement model, the structural model (inner model) was evaluated to determine its ability to explain the relationships among the latent variables. The structural model assessment included the analysis of the coefficient of determination (R^2) to evaluate the explanatory power of the exogenous variables on the endogenous variables, the effect size (f^2) to assess the contribution of each structural relationship, and the path coefficients, including both direct and indirect effects, to test the proposed hypotheses. Through these analyses, the strength of the relationships among variables and the mediating role of SRL within the proposed model could be examined.

4.1.6. Coefficient of Determination (R^2)

The structural model was evaluated using the coefficient of determination (R^2). The R^2 value indicates the extent to which the exogenous variables explain the variance of the endogenous variables in the model. Higher R^2 values reflect greater explanatory power. The R^2 results for Self-Regulated Learning and Mathematics Achievement are presented in Table 5.

Table 5. Coefficient of Determination (R^2) Results

Endogenous Variable	R^2	Adjusted R^2	Category
Self-Regulated Learning	0.691	0.686	Substantial
Mathematics Achievement	0.120	0.095	Weak

The results of the coefficient of determination analysis revealed that SRL achieved an R^2 value of 0.691 and an adjusted R^2 value of 0.686. These values indicate that 69.1% of the variance in SRL was explained by learning environment and academic self-efficacy, whereas the remaining 30.9% was attributable to factors not included in the model. Based on the criteria proposed by Hair et al. (2022), an R^2 value of 0.691 can be classified as substantial.

In contrast, mathematics achievement obtained an R^2 value of 0.120 and an adjusted R^2 value of 0.095. This finding indicates that 12.0% of the variance in mathematics achievement was explained by learning environment, academic self-efficacy, and SRL, whereas the remaining 88.0% was influenced by other variables beyond the scope of the present study. According to the criteria of Hair et al. (2022), an R^2 value of 0.120 is considered weak.

4.1.7. Effect Size (f^2)

The effect size (f^2) was examined to determine the magnitude of the contribution of each exogenous variable to the endogenous variables in the structural model. According to

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Cohen's criteria, larger f^2 values indicate a greater contribution of a predictor to the explained variance of the endogenous construct, whereas smaller values indicate a weaker contribution (Cohen, 1988; Hair et al., 2022).

Table 6. Effect Size (f^2) Results

Relationship	f^2	Category
Academic Self-Efficacy → Self-Regulated Learning	0.612	Large
Learning Environment → Self-Regulated Learning	0.304	Medium
Academic Self-Efficacy → Mathematics Achievement	0.001	Negligible
Learning Environment → Mathematics Achievement	0.018	Negligible
Self-Regulated Learning → Mathematics Achievement	0.085	Small

The contribution of each structural relationship was assessed using the effect size (f^2) statistic. The results indicated that academic self-efficacy exerted a large effect on SRL ($f^2 = 0.612$), suggesting a substantial contribution to the development of students' self-regulation skills. Learning environment demonstrated a medium effect on SRL ($f^2 = 0.304$), indicating that the learning environment also played an important role in fostering students' self-regulated learning.

In contrast, the effects of academic self-efficacy and learning environment on mathematics achievement were negligible. Academic self-efficacy showed a negligible effect on mathematics achievement ($f^2 = 0.001$), and also learning environment exhibited a negligible effect ($f^2 = 0.018$). SRL demonstrated a small effect on mathematics achievement ($f^2 = 0.085$). Overall, these findings suggest that academic self-efficacy and learning environment contributed substantially to explaining variations in SRL, whereas their direct contributions to mathematics achievement were limited. this pattern indicates that SRL may serve as an important mechanism linking academic self-efficacy and learning environment to mathematics achievement.

4.1.8. Direct Effects

Direct effects were assessed to examine the relationships among the constructs in the proposed model (Hair et al., 2022). The analysis was conducted using the bootstrapping procedure in SmartPLS by evaluating the path coefficients (β), t-statistics, and p-values. A relationship was considered statistically significant when the p-value was less than 0.05.

Table 7. Direct Effects Results

Relationship	β	t-statistic	p-value	Decision
Academic Self-Efficacy → Self-Regulated Learning	0.543	5.414	< 0.001	Significant
Learning Environment → Self-Regulated Learning	0.383	3.823	< 0.001	Significant
Academic Self-Efficacy → Mathematics Achievement	-0.057	0.516	0.606	Not Significant
Learning Environment → Mathematics Achievement	-0.182	1.432	0.152	Not Significant
Self-Regulated Learning → Mathematics Achievement	0.492	3.766	< 0.001	Significant

The results presented in Table 7 indicate that academic self-efficacy had a positive and significant effect on SRL ($\beta = 0.543$, $t = 5.414$, $p < 0.001$). Likewise, learning environment exerted a positive and significant effect on SRL ($\beta = 0.383$, $t = 3.823$, $p < 0.001$). Furthermore, SRL positively and significantly predicted mathematics achievement ($\beta = 0.492$, $t = 3.766$, $p < 0.001$).

In contrast, academic self-efficacy did not have a significant direct effect on mathematics achievement ($\beta = -0.057$, $t = 0.516$, $p = 0.606$). Similarly, the direct effect of learning environment on mathematics achievement was not statistically significant ($\beta = -0.182$, $t = 1.432$, $p = 0.152$). These findings suggest that although academic self-efficacy and learning environment significantly influenced SRL, neither variable directly predicted mathematics achievement.

4.1.9. Indirect Effects

Indirect effects were examined to determine whether SRL mediated the relationships between the independent variables and mathematics achievement. The mediation analysis

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was conducted using the bootstrapping procedure by evaluating the indirect effect coefficients and their statistical significance (Hair et al., 2022). An indirect effect was considered significant when the *p*-value was below 0.05.

Table 8: Indirect Effects Results

Relationship	β	t-statistic	p-value	Decision
Academic Self-Efficacy → Self-Regulated Learning → Mathematics Achievement	0.267	3.247	0.001	Significant
Learning Environment → Self-Regulated Learning → Mathematics Achievement	0.188	2.396	0.017	Significant

The results presented in Table 8 indicate that academic self-efficacy exerted a positive and significant indirect effect on mathematics achievement through SRL ($\beta = 0.267$, $t = 3.247$, $p = 0.001$). Similarly, learning environment demonstrated a positive and significant indirect effect on mathematics achievement through SRL ($\beta = 0.188$, $t = 2.396$, $p = 0.017$).

These findings indicate that SRL significantly mediated the relationships between academic self-efficacy and mathematics achievement as well as between learning environment and mathematics achievement. Given that the direct effects of academic self-efficacy and learning environment on mathematics achievement were not significant, whereas the indirect effects through SRL were significant, the results suggest a pattern of full mediation, whereby the influence of academic self-efficacy and learning environment on mathematics achievement operates primarily through students' SRL processes.

4.2. Discussion

4.2.1. The Effect of Academic Self-Efficacy on Self-Regulated Learning

The hypothesis testing results revealed a path coefficient of 0.543, a t-statistic of 5.414, and a p-value of <0,001. These findings indicate that academic self-efficacy has a positive and significant effect on students' self-regulated learning at SHS 1 Parepare. In other words, the stronger students' beliefs in their academic capabilities, the greater their ability to regulate, monitor, and evaluate their learning processes independently. This finding is consistent with Bandura's (1997) Social Cognitive Theory, which defines self-efficacy as an individual's belief in their capability to organize and execute actions required to achieve specific goals. Students with high self-efficacy tend to exert greater effort, demonstrate stronger persistence, and manage their learning activities more effectively. Furthermore, Zimmerman (2000) emphasized that self-efficacy is a critical antecedent of SRL, particularly during the forethought phase involving goal setting and strategic planning.

The findings are supported by Putri et al. (2025) who reported a positive relationship between academic self-efficacy and SRL. Similar results were found by Hadi & Al-Quraan (2025), indicating that students with higher academic self-efficacy tend to possess stronger self-regulatory skills during learning. Likewise, Landa et al. (2025) found that confidence in one's abilities plays a crucial role in encouraging the use of self-regulation strategies in mathematics learning. These studies suggest that students who believe in their capabilities are more likely to plan learning activities, select appropriate strategies, monitor their progress, and evaluate their learning outcomes.

This finding is also consistent with other international studies identifying self-efficacy as a major predictor of SRL. Jud et al. (2025) reported that increases in self-efficacy contribute to the development of students' self-regulatory capacities in managing learning processes. Similarly, Martincová et al. (2025) found that students with high self-efficacy are more likely to engage in independent learning strategies, manage their study time effectively, and maintain motivation when facing academic challenges. Therefore, the present study reinforces the view that academic self-efficacy is an important personal factor contributing to the enhancement of SRL. The stronger students' confidence in their academic abilities, the greater their capacity to manage learning processes effectively and achieve desired educational goals.

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4.2.2. The Effect of Learning Environment on Self-Regulated Learning

The results of hypothesis testing yielded a path coefficient of 0.383, a t-statistic of 3.823, and a p-value of <0,001. These findings indicate that the learning environment has a positive and significant effect on students' SRL at SHS 1 Parepare. In other words, students who perceive their learning environment more positively tend to demonstrate stronger abilities to plan, monitor, control, and evaluate their learning processes independently.

This finding is consistent with Social Cognitive Theory by Bandura (1986), which posits that learning behavior emerges from reciprocal interactions among personal, behavioral, and environmental factors. Within educational settings, a supportive learning environment provides external conditions that facilitate the development of self-regulatory skills. Zimmerman (2000) further emphasized that learning environments play a crucial role in fostering SRL by creating opportunities for students to set goals, monitor their progress, and reflect on their learning experiences.

The present findings are supported by Pramesti & Suryadi (2025) whose systematic literature review identified school climate, teacher support, peer relationships, and academic interactions as important external factors contributing to the development of SRL. Similar conclusions were reported by Umairah & Dabi (2023) who found that students with stronger self-regulatory abilities are more capable of optimizing their learning environments to achieve academic goals effectively. Likewise, Adler et al. (2025) demonstrated that adaptive learning environments that encourage students to make learning-related decisions promote the development of SRL processes. Collectively, these studies suggest that learning environments function not only as settings where instruction takes place but also as contexts that nurture students' learning autonomy.

The findings are further corroborated by international research demonstrating that supportive learning environments enhance students' SRL. Learning environments characterized by constructive feedback, flexible learning opportunities, meaningful interaction, and reflective activities have been shown to strengthen students' abilities to plan, monitor, and evaluate their learning independently (Chen et al., 2024; Dong et al., 2024; Prasse et al., 2024; Wang et al., 2025). Furthermore, contextual and environmental characteristics contribute to the cognitive, metacognitive, affective, and motivational processes that constitute the core components of self-regulated learning (de Mooij et al., 2025). Therefore, the present findings provide additional evidence that a conducive learning environment represents an important external factor in the development of students' SRL.

4.2.3. The Effect of Academic Self-Efficacy on Mathematics Achievement

The hypothesis testing results produced a path coefficient of −0.057, with a t-statistic of 0.516 and a p-value of 0.606 (> 0.05). These findings indicate that academic self-efficacy does not have a significant direct effect on the mathematics achievement of students at SHS 1 Parepare. Consequently, the hypothesis proposing a positive relationship between academic self-efficacy and mathematics achievement was not supported.

This finding suggests that students' confidence in their academic capabilities alone may not be sufficient to improve mathematics achievement directly. According to Bandura (1997), self-efficacy influences individuals' choices, effort, persistence, and resilience when facing challenges. However, strong efficacy beliefs do not automatically lead to higher academic achievement unless they are translated into effective learning strategies and active engagement in the learning process.

The present findings differ from studies reporting a significant positive relationship between academic self-efficacy and mathematics achievement (Affuso et al., 2025; Baduri & Nurrahmah, 2024; Hasan et al., 2025; Ovalle et al., 2024). Nevertheless, they are consistent with recent evidence suggesting that the relationship between self-efficacy and mathematics achievement is often indirect and context-dependent. A comprehensive review conducted by Street et al. (2024) revealed substantial variability in the association between mathematics self-

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efficacy and achievement across student populations, educational contexts, and analytical models. Similar conclusions were reported by Yang et al. (2024) and Liu et al. (2024), who argued that the relationship becomes more complex when additional psychological and contextual variables are incorporated into explanatory models.

The findings of the present study suggest that academic self-efficacy may exert its influence on mathematics achievement through specific psychological and behavioral mechanisms rather than through a direct pathway. Previous studies have shown that the effects of self-efficacy on academic outcomes are frequently mediated by learning engagement, motivation, self-regulation, and cognitive processes (Al Umairi, 2024; Dai et al., 2025; Landa et al., 2025; Zhuofan et al., 2024). This interpretation is supported by the current results, which indicate that academic self-efficacy significantly predicts self-regulated learning, while self-regulated learning significantly predicts mathematics achievement. Therefore, students' confidence in their academic abilities may contribute to improved mathematics achievement only when accompanied by effective self-management, monitoring, and evaluation of learning activities. Accordingly, self-regulated learning appears to constitute a critical mechanism through which academic self-efficacy contributes to mathematics achievement.

4.2.4. The Effect of Learning Environment on Mathematics Achievement

The hypothesis testing results revealed a path coefficient of −0.182, with a t-statistic of 1.432 and a p-value of 0.152 (> 0.05). These findings indicate that the learning environment does not have a significant effect on the mathematics achievement of students at SHS 1 Parepare. Therefore, the hypothesis proposing a positive effect of the learning environment on mathematics achievement was not supported.

This finding suggests that a favorable learning environment does not necessarily translate directly into higher mathematics achievement. From the perspective of Social Cognitive Theory, academic achievement is influenced not only by environmental factors but also by the reciprocal interaction among personal, behavioral, and environmental determinants, known as triadic reciprocal causation (Bandura, 1986). Consequently, although students may learn in supportive environments, improvements in mathematics achievement may not occur unless such conditions are accompanied by active engagement and effective management of the learning process.

This result contrasts with previous studies reporting a significant positive relationship between the learning environment and mathematics achievement (Akbar et al., 2022; Evinjuniawati & Fitrayati, 2025; Halim & Rahma, 2020; Hardimansyah et al., 2021; Supriadi et al., 2023; Utaminingtyas et al., 2021). These studies argued that teacher support, positive peer relationships, adequate learning facilities, and conducive classroom conditions contribute to more effective learning experiences and subsequently enhance mathematics achievement. However, the present findings suggest that the learning environment is not a direct determinant of mathematics achievement. One possible explanation is that mathematics learning requires substantial cognitive engagement; therefore, achievement may depend more on how students utilize available learning resources than on the mere presence of supportive environmental conditions. In this sense, the learning environment functions as a facilitating factor rather than a direct predictor of academic success.

The present findings are more consistent with recent studies indicating that the influence of the learning environment on mathematics achievement tends to operate through students' psychological and behavioral processes. Niu et al. (2022) found that supportive learning environments affect mathematics achievement through autonomous self-regulation and creative thinking skills. Similarly, Dai et al. (2025) reported that technology-enhanced learning environments do not directly improve mathematics achievement but instead foster self-regulation and students' confidence in their learning capabilities. This interpretation is further supported by Abbas & Rizki (2023) who identified self-regulation as a mediator between the learning environment and mathematics achievement. Moreover, recent research on digital

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learning environments has demonstrated that academic success is more strongly influenced by self-regulated learning than by environmental characteristics alone (Bütüner et al., 2025).

Taken together, these findings suggest that a supportive learning environment may be insufficient to improve mathematics achievement unless students possess the ability to regulate, monitor, and evaluate their own learning processes effectively. This interpretation is reinforced by the significant positive effect of the learning environment on self-regulated learning and the significant effect of self-regulated learning on mathematics achievement observed in this study. Accordingly, self-regulated learning appears to serve as a key mechanism linking the learning environment to mathematics achievement.

4.2.5. The Effect of Self-Regulated Learning on Mathematics Achievement

The hypothesis testing results yielded a path coefficient of 0.492, a t-statistic of 3.766, and a p-value of <0.001. These results indicate that SRL has a positive and significant effect on mathematics achievement among students at SHS 1 Parepare. This implies that students who are more capable of planning, managing, monitoring, and evaluating their learning processes tend to achieve higher mathematics performance. This finding aligns with Zimmerman's (2000) Self-Regulated Learning Theory, which posits that students who actively regulate their learning processes are generally more effective in achieving academic goals.

The findings are supported by numerous studies highlighting SRL as a key determinant of academic success. Similar results were reported by El-Adl & Alkharusi (2020) nd other empirical studies demonstrating that goal setting, strategic learning management, self-monitoring, and self-evaluation positively contribute to academic achievement. In the context of mathematics education, studies by Duru et al. (2023), Septiani et al. (2024), Mutiah & Romsi (2024), and Rahayu et al. (2025) also found that SRL significantly enhances mathematics achievement.

Recent studies further confirm that self-regulation remains a critical factor for academic success across various learning contexts. SRL strategies help students manage time effectively, sustain motivation, select appropriate learning strategies, and independently overcome learning difficulties, thereby improving academic outcomes (Arvatz et al., 2025; Dai et al., 2025). Therefore, the findings of this study strengthen the argument that SRL learning is a significant internal factor contributing to mathematics achievement. Students with stronger self-regulatory skills are more likely to attain optimal learning outcomes in mathematics.

4.2.6. The Effect of Academic Self-Efficacy on Mathematics Achievement through Self-Regulated Learning

The hypothesis testing results revealed an indirect effect coefficient of 0.267, a t-statistic of 3.247, and a p-value of 0.001 (< 0.05). These results indicate that SRL significantly mediates the relationship between academic self-efficacy and mathematics achievement among students at SHS 1 Parepare. This finding suggests that academic self-efficacy does not directly improve mathematics achievement but instead encourages students to develop self-regulatory learning skills, which subsequently enhance achievement. This result is consistent with Bandura's (1997) Social Cognitive Theory, which argues that individuals' beliefs in their capabilities influence their effort, persistence, and learning strategies Zimmerman (2000) further emphasized that self-efficacy is a key antecedent of SRL, leading students with strong confidence in their abilities to become more active in planning, monitoring, and evaluating their learning processes to achieve academic goals.

The findings are supported by several international studies reporting positive effects of academic self-efficacy on SRL (Hadi & Al-Quraan, 2025; Jud et al., 2025; Landa et al., 2025; Putri et al., 2025). These findings are also consistent with the descriptive results showing that students' academic self-efficacy was categorized as very high (76.4%). The strength dimension obtained the highest score (80.2%), indicating that students possess strong confidence in their ability to persist when facing mathematical difficulties. Meanwhile, the magnitude (74.3%) and generality (74.8%) dimensions suggest that students are reasonably

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confident in completing various mathematical tasks and applying their abilities across different learning situations. Such confidence provides an important foundation for developing autonomous learning behaviors and effectively managing learning processes.

This interpretation is further supported by the descriptive results of SRL, which was also categorized as very high (81.6%). Goal setting (87.4%) and self-evaluation (83.0%) were the strongest dimensions, followed by learning strategies (79.5%) and self-monitoring (76.4%). These findings indicate that students with high academic self-efficacy tend to establish clear learning goals, employ appropriate learning strategies, monitor their progress, and evaluate their outcomes. Previous studies have demonstrated that these self-regulatory abilities contribute significantly to mathematics achievement by facilitating more focused and effective learning (Dai et al., 2025; Martincová et al., 2025; Mutiah & Romsi, 2024; A. Rahayu et al., 2025). Therefore, the present study suggests that the influence of academic self-efficacy on mathematics achievement operates primarily through enhanced SRL, making self-regulation an essential mechanism linking students' confidence in their academic abilities to successful mathematics learning outcomes.

4.2.7. The Effect of Learning Environment on Mathematics Achievement through Self-Regulated Learning

The hypothesis testing results indicated an indirect effect coefficient of 0.188, a t-statistic of 2.396, and a p-value of 0.017 (< 0.05). These findings demonstrate that SRL significantly mediates the relationship between learning environment and mathematics achievement among students at SHS 1 Parepare. This suggests that a favorable learning environment does not directly improve mathematics achievement; rather, it first promotes the development of students' self-regulatory abilities. This finding is consistent with Zimmerman's (2000) Self-Regulated Learning Theory, which proposes that environmental factors shape independent learning behaviors that subsequently influence academic performance.

The findings are supported by previous studies showing that positive learning environments enhance students' SRL (Adler et al., 2025; Pramesti & Suryadi, 2025; Wang et al., 2025). Learning environments characterized by teacher support, positive peer relationships, conducive classroom conditions, and learning comfort provide opportunities for students to develop independent learning management skills. This interpretation is also supported by the descriptive findings, which showed that the learning environment was perceived at a very high level (84.2%), with teacher support (88.4%) and peer relationships (85.7%) emerging as the strongest indicators. Such conditions provide students with assistance, motivation, and learning experiences that foster the development of self-regulation.

In addition, students' SRL was categorized as very high (81.6%), with goal setting (87.4%) and self-evaluation (83.0%) being the strongest dimensions. These findings suggest that students are capable of setting learning goals, applying appropriate learning strategies, monitoring their learning progress, and evaluating outcomes. Previous studies have shown that strong self-regulatory skills contribute to improved mathematics achievement by enabling students to learn more effectively and purposefully (Duru et al., 2023; Mutiah & Romsi, 2024; A. Rahayu et al., 2025). Therefore, the present study confirms that a conducive learning environment exerts a stronger influence on mathematics achievement when accompanied by well-developed SRL skills.

5. Conclusions

5.1 Conclusions

This study revealed that the learning environment and academic self-efficacy did not have significant direct effects on mathematics achievement among students of SHS 1 Parepare. However, both the learning environment and academic self-efficacy were found to have positive and significant effects on self-regulated learning (SRL), while SRL had a positive and significant effect on mathematics achievement. Furthermore, SRL significantly mediated the effects of the learning environment and academic self-efficacy on mathematics achievement. These findings suggest that improvements in mathematics achievement are not determined

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solely by external factors, such as the learning environment, or internal factors, such as academic self-efficacy, but are primarily influenced by students' ability to independently regulate, monitor, and evaluate their learning processes.

The novelty of this study lies in examining the mediating role of SRL in the relationship between the learning environment, academic self-efficacy, and mathematics achievement among secondary school students. Unlike most previous studies that primarily focused on the direct effects of these variables on academic achievement, this study demonstrates that self-regulated learning serves as a psychological mechanism through which the learning environment and academic self-efficacy influence mathematics achievement. These findings contribute theoretically to the advancement of Social Cognitive Theory and Self-Regulated Learning Theory by providing empirical evidence regarding the mediating function of self-regulated learning. Practically, the findings suggest that efforts to improve mathematics achievement should focus not only on creating supportive learning environments and strengthening students' academic self-efficacy but also on developing students' goal-setting, learning strategy, self-monitoring, and self-evaluation skills.

5.2 Implication

This study provides theoretical implications by highlighting self-regulated learning as an important mechanism linking external and internal factors to mathematics achievement. The finding that the learning environment and academic self-efficacy do not directly influence mathematics achievement, but instead exert their effects through SRL, supports Bandura's Social Cognitive Theory and Zimmerman's Self-Regulated Learning Theory, both of which emphasize the interaction among environmental factors, personal factors, and learning behaviors in determining academic success. Therefore, this study enriches the literature concerning the mediating role of SRL in mathematics education at the secondary school level.

From a practical perspective, the findings indicate that improving mathematics achievement requires more than simply creating a supportive learning environment or enhancing students' confidence in their academic abilities. Efforts should also focus on fostering students' SRL skills. Mathematics teachers are encouraged to design instructional activities that promote goal setting, effective learning strategies, self-monitoring, and self-evaluation. In addition, teachers can provide constructive feedback, opportunities for reflection, and learning activities that encourage autonomy, enabling students to manage their learning processes more effectively. Schools should also cultivate learning environments that support positive teacher–student interactions and promote a culture of independent learning to enhance mathematics achievement.

5.3 Limitation of Research

This study has several limitations. First, the study involved students from only one school, which limits the generalizability of the findings to broader populations. Second, mathematics achievement was measured using academic performance data collected at a single point in time, preventing an examination of long-term changes in achievement. Third, the study focused exclusively on the learning environment, academic self-efficacy, and self-regulated learning, whereas mathematics achievement may also be influenced by other factors, such as learning motivation, mathematics anxiety, student engagement, parental support, prior knowledge, and instructional strategies employed by teachers. Fourth, data on the learning environment, academic self-efficacy, and SRL were collected through self-report questionnaires, which may be subject to response bias and social desirability effects.

Future research is recommended to involve larger and more diverse samples to enhance the generalizability of the findings. Researchers may also extend the proposed model by incorporating additional mediating or moderating variables, such as learning motivation, student engagement, mathematics anxiety, or metacognitive skills, to provide a more comprehensive understanding of the factors influencing mathematics achievement. Furthermore, longitudinal studies are needed to examine changes in SRL and mathematics

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achievement over time and to better understand the developmental dynamics of these constructs.

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