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RESILIENCE AND LEARNING MOTIVATION AS PREDICTORS OF UNIVERSITY STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY

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ABSTRACT

The ability to solve mathematical problems is one of the key competencies expected from university students, especially those enrolled in mathematics education programs. In practice, however, many students still experience difficulties when dealing with contextual and higher-level mathematical tasks. Such difficulties may stem not only from cognitive limitations but also from internal factors such as resilience and motivation to learn. This study examined how resilience and learning motivation relate to students' mathematical problem-solving ability. The study used a quantitative ex post facto approach involving all 33 third-semester students of the Mathematics Education Program at STKIP Andi Matappa through a total sampling technique. Data were obtained using a resilience questionnaire, a learning motivation questionnaire, and a five-question essay test designed around Polya's problem-solving stages. The data were processed through descriptive statistics and multiple linear regression after the required assumptions had been checked. The results revealed that resilience and learning motivation significantly contributed to mathematical problem-solving ability, either separately or simultaneously. Among the two predictors, learning motivation showed the larger contribution. These findings suggest that mathematics instruction should pay attention not only to cognitive achievement but also to the development of students' motivation and resilience.

Keywords: Resilience, Learning Motivation, Mathematical Problem-Solving Ability.

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PRELIMINARY

Mathematical problem-solving ability is a fundamental competence in mathematics education, including the preparation of prospective mathematics teachers (Santos-Trigo, 2024). Beyond conceptual mastery and computational proficiency, mathematical problem solving requires critical thinking, logical reasoning, and reflective thinking to address complex tasks. Prior studies suggest that individuals with stronger logical–mathematical tendencies tend to perform better at solving mathematical problems (Laksono et al., 2023). However, many university students still struggle to develop critical thinking and propose

alternative strategies when solving complex problems (Anugraheni, 2020; Sulistyorini & Napfiah, 2019).

Mathematical problem solving supports active learning and the development of 21st-century competencies (Atteh, 2021; Szabo et al., 2020). It involves cognitive, metacognitive, and affective dimensions (Barkatsas & Hunting, 1995) and can be understood through complementary perspectives emphasizing processes and strategies (Yusuf et al., 2021). These characteristics highlight the importance of examining factors associated with prospective mathematics teachers' mathematical problem-solving ability.

Preliminary observations among students in the Mathematics Education Program at STKIP Andi Matappa indicated that only about 23% were able to solve higher-order contextual mathematical problems requiring creative and reflective thinking. Students experienced particular difficulties when interpreting problem conditions, developing solution plans, and continuing after initial strategies failed. These findings suggest that mathematical problem-solving difficulties may be associated not only with cognitive limitations but also with non-cognitive factors related to persistence, engagement, and responses to setbacks. Therefore, examining psychological factors that may support students during problem-solving is necessary.

One factor that is relevant in this context is resilience. In general, resilience can be understood as a person's ability to adjust and remain psychologically functional when facing difficulty, stress, or adversity (Kaye-Kauderer et al., 2021; Ong & Cammarata, 2020). Resilience is commonly viewed as a dynamic process that develops through interactions between a person and the surrounding environment. Resilient individuals tend to demonstrate optimism, emotional awareness, and adequate social skills (Babić et al., 2020). In mathematics learning, such characteristics may help students remain persistent and engaged when confronting challenging problems.

Another critical non-cognitive factor is learning motivation. Learning motivation refers to the processes that initiate, direct, and sustain students' learning behavior (Zhang, 2022). More broadly, learning motivation has been linked to students' learning outcomes (Fernando et al., 2024). In mathematics education, motivation is associated with students' competence, autonomy, and academic achievement (Wang et al., 2022). It may therefore support students' engagement and persistence when completing demanding mathematical tasks and responding to the learning environment created by instructors.

Previous research has identified relationships between resilience, learning motivation, and mathematical problem-solving ability. Mathematical resilience has been

associated with metacognitive skills and problem-solving performance (Attami et al., 2020; Cahyaningsih et al., 2021), while learning motivation has been linked to mathematical problem-solving outcomes (Irhamna et al., 2020). Related studies also highlight connections among motivation, adaptive coping, and academic resilience (Dubayová & Hafičová, 2023; Skinner, 2020; Zhang, 2022). These relationships can be interpreted in connection with Polya's four stages of problem solving: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution (Polya, 1945), which require concentration, persistence, and strategy revision. A recent study also applied Polya's stages to examine differences in mathematical problem-solving performance among junior high school students (Adzahra & Ramlah, 2025). However, the simultaneous predictive contributions of resilience and learning motivation among university mathematics education students remain insufficiently investigated.

The novelty of this study lies in its simultaneous examination of resilience and learning motivation as predictors of mathematical problem-solving ability among university students in a regional mathematics education context. While previous studies have often examined these psychological factors separately or across different educational levels, the present study evaluates their individual and joint statistical contributions within a single regression model. Theoretically, this approach highlights the relevance of affective and motivational factors alongside cognitive processes in understanding students' persistence, effort regulation, and engagement during mathematical problem solving. Practically, the findings may help mathematics lecturers design learning activities that strengthen students' motivation and resilience while supporting mathematical problem-solving ability.

Therefore, this study aims to examine the individual and simultaneous predictive contributions of resilience and learning motivation to mathematical problem-solving ability among students in the Mathematics Education Program at STKIP Andi Matappa. The findings are expected to inform instructional strategies that integrate cognitive development with efforts to foster students' resilience and learning motivation.

METHODS

This study employed a quantitative ex post facto design to examine the predictive contributions of resilience and learning motivation to students' mathematical problem-solving ability. This design was selected because the independent variables were naturally occurring student characteristics that were not manipulated by the researchers. Therefore,

the regression results were interpreted as statistical associations rather than evidence of causal effects.

Resilience (X_1) and learning motivation (X_2) served as the independent variables, while mathematical problem-solving ability (Y) was the dependent variable. The study was conducted in the Mathematics Education Program at STKIP Andi Matappa during the first semester of the 2025/2026 academic year. The population comprised all 33 third-semester students in the program. Since the population was relatively small, total sampling was employed, resulting in a sample of 33 students.

The instruments used in this study were developed by the researchers based on the theoretical aspects and indicators of each variable. The resilience questionnaire consisted of 20 items arranged on a four-point Likert scale and covered seven indicators: emotional regulation, impulse control, optimism, causal analysis, empathy, self-efficacy, and achievement orientation. The learning motivation questionnaire also consisted of 20 items arranged on a four-point Likert scale and covered six indicators: desire to succeed, learning drive and needs, future aspirations, learning rewards, engaging learning activities, and a supportive learning environment. Meanwhile, the mathematical problem-solving ability test consisted of five essay questions developed based on Polya's problem-solving stages, namely understanding the problem, devising a plan, carrying out the plan, and reviewing the solution.

The essay format allowed students to demonstrate their reasoning and solution steps rather than merely provide final answers. Aligning the test items with Polya's stages also helped connect the assessment with the theoretical framework used in this study. However, the regression model treated mathematical problem-solving ability as a single outcome rather than examining each problem-solving stage separately.

Before data collection, all instruments were validated by two experts. The validation results were 92.19% for the resilience questionnaire, 93.75% for the learning motivation questionnaire, and 90.63% for the mathematical problem-solving test, indicating that all instruments met the criteria for the very valid category. Reliability was assessed using Cronbach's alpha, yielding coefficients of 0.788, 0.892, and 0.876, respectively. These results indicated that all instruments demonstrated adequate internal consistency and were suitable for data collection.

Data collection was conducted after obtaining permission from the study program and informing participants about the research objectives and confidentiality of their responses. The process involved two activities. First, students completed the resilience and

learning motivation questionnaires under researcher supervision. Second, they completed the mathematical problem-solving essay test based on Polya's stages. The researchers checked response completeness, collected the instruments, and documented the process as supplementary material. The collected data were analyzed using descriptive statistics and multiple linear regression with SPSS. Before regression analysis, the assumptions of residual normality, linearity, multicollinearity, and homoscedasticity were examined, along with outlier screening.

RESULTS AND DISCUSSION

Results

Descriptive Statistics of the Research Variables

Descriptive statistics were used to summarize the central tendency and dispersion of each research variable.

Table 1. Descriptive Statistics of the Research Variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Resilience (X1)	33	46.00	74.00	59.6667	7.10487
Learning Motivation (X2)	33	42.00	80.00	66.5758	8.43738
Mathematical Problem-Solving Ability (Y)	33	15.00	78.00	46.7576	15.13694

As presented in Table 1, the mean resilience score of the 33 students was 59.6667 (SD = 7.10487), with scores ranging from 46.00 to 74.00. The mean learning motivation score was 66.5758 (SD = 8.43738), ranging from 42.00 to 80.00. Meanwhile, students' mathematical problem-solving ability showed a mean score of 46.7576 (SD = 15.13694), ranging from 15.00 to 78.00. The larger standard deviation for problem-solving ability indicates greater variability in students' performance than for resilience and learning motivation.

Assumption Tests for Multiple Linear Regression

Before hypothesis testing using multiple linear regression, several prerequisite tests were conducted, including tests for normality of residuals, multicollinearity, linearity, homoscedasticity, and outlier screening.

1. Residual Normality Test

Residual normality was tested using standardized residuals.

Table 2. Residual Normality Test Results

Test	Statistic	df	Sig.
Kolmogorov-Smirnov	0.087	33	0.200*
Shapiro-Wilk	0.971	33	0.520

*Note: *The significance value of the Kolmogorov-Smirnov test is a lower bound of the true significance.*

The Shapiro–Wilk test produced a significance value of 0.520, which exceeds 0.05. This result indicates that the residuals were normally distributed, so the normality assumption was fulfilled.

2. Multicollinearity Test

To assess whether the two predictor variables were excessively correlated, tolerance and VIF values were examined.

Table 3. Multicollinearity Test Results (Tolerance and VIF)

Variable	Tolerance	VIF
Resilience (X1)	0.644	1.552
Learning Motivation (X2)	0.644	1.552

Table 3 shows that both resilience and learning motivation had Tolerance values of 0.644 (> 0.10) and VIF values of 1.552 (< 10), suggesting no multicollinearity between the predictors.

3. Linearity Test

Linearity was assessed visually using partial regression plots for resilience (X_1) and learning motivation (X_2) in relation to mathematical problem-solving ability (Y), as presented in Figures 1 and 2.

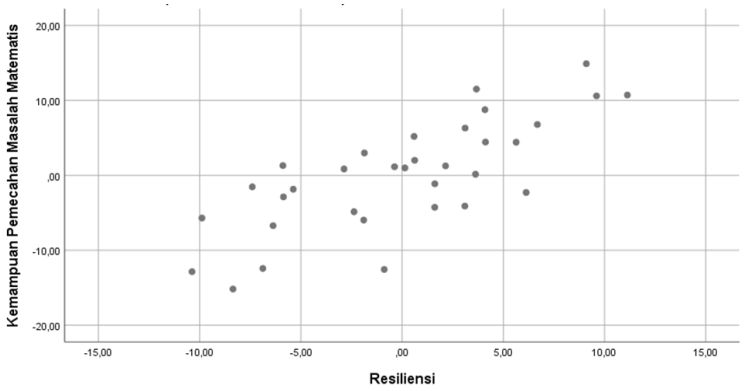


Figure 1. Partial Regression Plot For Resilience (X_1)

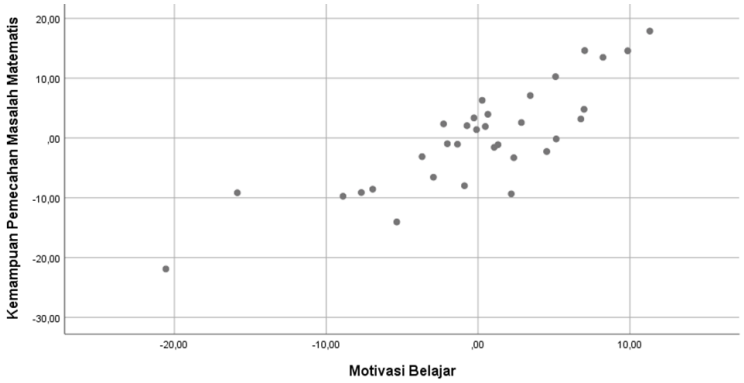


Figure 2. Partial Regression Plot for Learning Motivation (X_2)

Figures 1 and 2 show that the data points tend to follow an upward linear pattern, indicating that resilience and learning motivation each exhibit an approximately linear relationship with mathematical problem-solving ability. These visual findings support the linearity assumption.

4. Homoscedasticity Test

A scatterplot of ZPRED and ZRESID was reviewed to determine whether the residuals showed constant variance across predicted values.

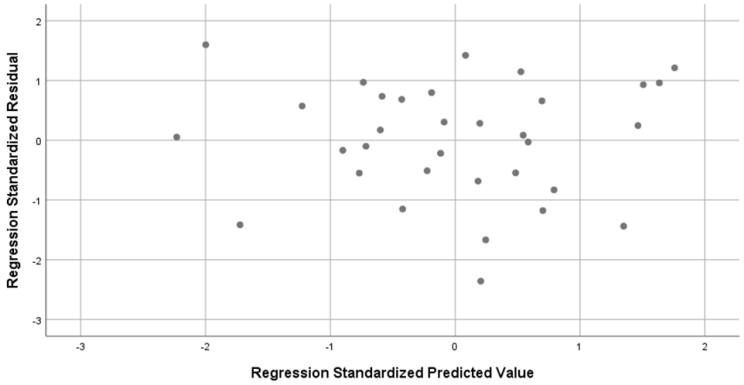


Figure 3. Scatterplot of Standardized Predicted Values (ZPRED) and Standardized Residuals (ZRESID)

Based on Figure 3, the residual points are randomly scattered around the zero line and do not form a specific pattern (e.g., a funnel shape). Thus, no signs of heteroscedasticity were detected, indicating that the equal-variance assumption was met.

5. Outlier Screening

Outlier screening was carried out by reviewing the standardized residual values. The findings from this screening are presented in Table 4.

Table 4. Regression Residual Statistics

Statistics	Predicted Value	Residual	Std. Predicted Value	Std. Residual
Minimum	14.7356	-11.69607	-2.231	-2.359

Statistics	Predicted Value	Residual	Std. Predicted Value	Std. Residual
Maximum	71.9858	7.92900	1.757	1.599
Mean	46.7576	0.00000	0.000	0.000
Std. Deviation	14.35522	4.80152	1.000	0.968

The standardized residuals ranged from −2.359 to 1.599 (not exceeding |3|), indicating no extreme outliers that could adversely affect the regression model.

Multiple Linear Regression Results

The hypotheses were tested through multiple linear regression using the enter procedure, with Resilience (X_1) and Learning Motivation (X_2) as predictors and Mathematical Problem-Solving Ability (Y) as the dependent variable.

1. Regression Equation

Table 5 displays the coefficient estimates, from which the following regression model was obtained:

$$\hat{Y} = -83.250 + 0.976X_1 + 1.078X_2$$

Table 5. Regression Coefficients (Partial Effects).

Variable	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	-83.250	8.053	-	-10.338	0.000	-	-
Resilience (X1)	0.976	0.154	0.458	6.350	0.000	0.644	1.552
Learning Motivation (X2)	1.078	0.129	0.601	8.326	0.000	0.644	1.552

The B coefficients in Table 5 indicate that each one-point increase in resilience was associated with a 0.976-point increase in mathematical problem-solving ability, holding learning motivation constant. Each one-point increase in learning motivation was associated with a 1.078-point increase in mathematical problem-solving ability, holding resilience constant.

2. Partial Significance Tests

The partial hypotheses tested were:

H_1: Resilience (X_1) significantly predicts mathematical problem-solving ability (Y).

H_2: Learning motivation (X_2) significantly predicts mathematical problem-solving ability (Y).

Decisions were made with reference to the significance values reported in Table 5. Resilience had Sig. = 0.000 ($p < 0.05$), therefore H1 was accepted. Learning motivation

also had Sig. = 0.000 ($p < 0.05$), therefore H2 was accepted. This indicates that each independent variable was significantly associated with mathematical problem-solving ability after controlling for the other predictor.

3. Simultaneous Significance Test

The simultaneous hypothesis tested was:

H_3: Resilience (X_1) and learning motivation (X_2) jointly predict mathematical problem-solving ability (Y).

The simultaneous test (F-test) results are presented in Table 6.

Table 6. ANOVA results (F-test)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	6594.314	2	3297.157	134.077	0.000
Residual	737.747	30	24.592	-	-
Total	7332.061	32	-	-	-

Based on Table 6, F = 134.077 with Sig. = 0.000 ($p < 0.05$). Thus, H_3 was accepted: resilience and learning motivation jointly predicted mathematical problem-solving ability at the 0.05 significance level.

4. Coefficient of Determination and Dominant Predictor

The strength of the model and the overall contribution of both predictors are indicated by the coefficient of determination (Table 7).

Table 7. Model Summary and Coefficient of Determination.

R	R Square	Adjusted R-Square	Std. Error of the Estimate	Durbin-Watson
0.948	0.899	0.893	4.95899	1.635

The R Square value of 0.899 indicates that 89.9% of the variance in mathematical problem-solving ability can be explained by resilience and learning motivation. The remaining 10.1% of the variance was not explained by the predictors included in the model. Based on the standardized beta coefficients in Table 5, learning motivation ($\beta = 0.601$) is more strongly associated with the outcome than resilience ($\beta = 0.458$).

Discussion

The multiple linear regression results indicate that resilience (X_1) was a statistically significant positive predictor of students' mathematical problem-solving ability (Y) (B = 0.976, t = 6.350, $p < 0.001$), with a p-value below the 0.05 significance threshold. In practical terms, holding learning motivation constant, a one-point increase in resilience was associated with a 0.976-point increase in mathematical problem-solving scores. This

association suggests that persistence and self-regulation may be relevant when students engage in mathematical tasks requiring repeated strategy use and evaluation.

The association between resilience and mathematical problem-solving ability is consistent with Schoenfeld's (1985) framework, which emphasizes monitoring, regulation, and beliefs alongside mathematical knowledge and strategies. Resilience may help students persist and revise unsuccessful approaches, particularly during Polya's (1945) stages of carrying out a plan and looking back. Similarly, Johnston-Wilder & Lee (2010) emphasize mathematical resilience as a factor supporting continued engagement despite difficulties, although the present study measured general resilience. From a cognitive–affective perspective, mathematical problem solving also requires sustained attention and strategic monitoring. Scheibe et al. (2023) highlight the interplay of working memory, metacognitive cues, and math anxiety, while Ji & Guo (2023) report an association between working memory and mathematical problem-solving performance. These theoretical perspectives help interpret the findings without establishing that resilience directly improves working memory or reduces anxiety.

In addition to resilience, learning motivation (X_2) was also a statistically significant positive predictor of mathematical problem-solving ability (Y) ($B = 1.078$, $t = 8.326$, $p < 0.001$), with a p-value below the 0.05 significance threshold. Holding resilience constant, a one-point increase in learning motivation was associated with a 1.078-point increase in mathematical problem-solving scores. This result suggests that motivation is associated with students' engagement and persistence when completing complex problem-solving tasks.

Self-Determination Theory emphasizes autonomy, competence, and relatedness as important foundations of learning motivation (Ryan & Deci, 2000). Consistent with this perspective, Wang et al. (2022) identified competence and autonomous motivation as predictors of university students' mathematics achievement. Expectancy–Value Theory further explains that students' persistence depends on their expectations of success and the value assigned to learning tasks (Wigfield & Eccles, 2000). These perspectives suggest that motivated students may be more willing to explore alternative strategies, evaluate solutions, and persist when encountering difficulties. Supriadi et al. (2024) also examined the relationship between mathematical problem solving and affective factors in learning motivation.

These theoretical perspectives suggest that motivation may be relevant at several points in the problem-solving process, from deciding to attempt an unfamiliar task to

evaluating the completed solution. However, the present regression model used an overall motivation score rather than examining the six motivation indicators separately. Further analysis of these dimensions could clarify which aspects of motivation are most strongly associated with mathematical problem-solving ability.

When considered jointly, resilience and learning motivation significantly predicted mathematical problem-solving ability ($F = 134.077$, $p < 0.001$). The model explained 89.9% of the variance in the sample ($R^2 = 0.899$; adjusted $R^2 = 0.893$), while the remaining 10.1% was not explained by the predictors. The standard error of the estimate was 4.95899. This strong association may be understood through complementary psychological processes. Motivation may sustain students' effort and engagement with mathematical tasks (Ryan & Deci, 2000; Wigfield & Eccles, 2000), consistent with findings on autonomous motivation and mathematics achievement (Wang et al., 2022). Meanwhile, resilience may help students remain engaged and recover from setbacks, as described in the motivational resilience framework (Skinner, 2023; Skinner et al., 2020). Nevertheless, these explanations remain theoretical interpretations, and the regression model does not establish causal effects or guarantee similar predictive performance in other samples.

The high R^2 should also be interpreted in the context of the study sample. All participants came from one cohort and academic program, potentially sharing similar educational experiences. Although the VIF value of 1.552 indicated no serious multicollinearity, it does not establish that the model will generalize to other populations. The small, homogeneous sample therefore warrants caution when interpreting the model's explanatory power beyond this setting.

Although the model accounted for a large proportion of the variance in this sample, its predictive performance has not been evaluated in an independent cohort. Repeating the analysis with students from other semesters or institutions would help determine whether the regression coefficients remain stable across educational settings. Such replication would strengthen the evidence for the model's applicability beyond the participants included in this study.

The findings are also consistent with the motivational resilience framework, which explains how students maintain engagement and recover from academic setbacks (Skinner, 2023; Skinner et al., 2020). Dubayová & Hafičová (2023) similarly reported a relationship between learning motivation and resilience. In mathematics education, successful problem solving requires exploring strategies, constructing representations, providing justification, and evaluating solutions (Santos-Trigo, 2024). These processes suggest that motivation and

resilience may support different aspects of mathematical problem solving, although their specific mechanisms were not directly examined in this study.

Learning motivation had a larger standardized regression coefficient (β = 0.601) than resilience (β = 0.458), indicating a stronger association with mathematical problem-solving ability in this model. The motivation indicators, including the desire to succeed, learning drive and needs, future aspirations, learning rewards, engaging activities, and a supportive environment, may encourage students to initiate and sustain problem-solving activities. This interpretation is consistent with findings on autonomous motivation and mathematics achievement (Wang et al., 2022) and research examining the relationship between mathematical problem solving and learning motivation (Supriadi et al., 2024). In contrast, resilience may become particularly relevant when students encounter mistakes, unsuccessful attempts, or unfamiliar mathematical problems, as these situations require continued effort and strategy revision. The motivational resilience framework emphasizes students' capacity to remain engaged and recover from setbacks (Skinner, 2023; Skinner et al., 2020). Thus, motivation may support engagement throughout the problem-solving process, whereas resilience may be especially important when difficulties arise. However, this distinction remains an interpretation of the regression findings rather than a mechanism directly tested in this study.

These findings suggest that mathematics lecturers should consider motivation and resilience alongside cognitive instruction. Based on Self-Determination Theory, competence can be supported through constructive feedback, autonomy through opportunities to select strategies, and relatedness through a supportive classroom environment (Ryan & Deci, 2000). Resilience may also be encouraged by treating mistakes as learning opportunities and guiding students to review and revise their solutions, consistent with Polya's (1945) problem-solving stages and contemporary practices (Santos-Trigo, 2024). Structured approaches such as Problem-Based Learning have been associated with improved mathematical problem-solving skills (Ramadhany et al., 2025), while innovative instructional designs have supported prospective mathematics teachers' pedagogical development (Fauziah et al., 2025). One possible classroom activity is to ask students to compare two solution strategies and explain why an initial attempt was unsuccessful. Lecturers could provide feedback on the reasoning process before evaluating the final answer, giving students opportunities to reconsider, justify, and refine their approaches. These implications provide instructional directions rather than interventions directly tested in the present study.

CONCLUSION

This study concludes that resilience and learning motivation are significant positive predictors of university students' mathematical problem-solving ability. The findings indicate that mathematical problem-solving ability is associated not only with cognitive competence but also with affective and motivational factors. Learning motivation showed a stronger association with mathematical problem-solving ability than resilience, highlighting the importance of students' willingness to engage in learning tasks, sustain effort, and complete mathematical activities.

Theoretically, this study contributes to mathematics education by emphasizing the relevance of affective and motivational factors in understanding mathematical problem-solving ability. Practically, the findings suggest that mathematics lecturers should design learning activities that foster motivation, resilience, and students' confidence in solving challenging mathematical problems. Providing meaningful tasks, constructive feedback, and opportunities to evaluate and revise strategies may help create a supportive learning environment that encourages persistence and engagement.

This study has several limitations. First, the ex post facto design does not allow causal conclusions, as the findings represent statistical associations rather than experimentally established effects. Second, the relatively small and homogeneous sample of 33 students from a single mathematics education program limits the generalizability of the findings. Future research should involve larger and more diverse samples, examine additional predictors such as metacognition, mathematics anxiety, and prior mathematical knowledge, and employ longitudinal or experimental designs to investigate potential causal mechanisms more rigorously.

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Author Contribution : Nuramaliyah Ramadhany: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, and Writing – Original Draft.

Fauziah: Supervision, Validation, and Writing – Review & Editing.

Eka Nurjannah: Investigation and Data Curation.

Andi Enil Fadillah Lestari: Investigation and Data Curation.

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