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Self-Efficacy and Self-Regulation as Predictors of University Students' Mathematics Learning Achievement

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Abstract

Learning achievement in mathematics at the university level is influenced by various internal factors, including students' beliefs in their abilities and their capacity to regulate learning processes. This study aims to examine the effects of self-efficacy and self-regulation, both individually and simultaneously, on university students' mathematics learning achievement. An ex post facto quantitative design was employed involving 98 mathematics education students selected through proportional random sampling from a population of 130 students. Data were collected using self-efficacy and self-regulation questionnaires, as well as students' grade point averages from first- and second-semester mathematics courses as indicators of learning achievement. The data were analyzed using simple and multiple linear regression after meeting classical assumption requirements. The results indicate that self-efficacy has a significant effect on mathematics learning achievement, contributing 15.5% of the variance, while self-regulation contributes 13.1%. When analyzed simultaneously, both variables significantly influence learning achievement with a combined contribution of 16.7%. Despite their statistical significance, the magnitude of these effects is relatively modest, suggesting that mathematics learning achievement is shaped by a combination of internal and external factors beyond self-efficacy and self-regulation alone. These findings imply that efforts to improve students' mathematics achievement should not only focus on strengthening self-efficacy and self-regulation but also be supported by effective instructional strategies, learning environments, and institutional support. This study provides empirical evidence for mathematics educators to design learning interventions that integrate psychological and pedagogical approaches in higher education contexts.

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INTRODUCTION

Mathematics learning achievement at the university level remains a significant concern, particularly in mathematics education programs where students are required to master abstract concepts, mathematical reasoning, and complex problem-solving. Empirical studies indicate that many university students experience difficulties in mathematics courses, which are reflected in moderate to low academic achievement and high levels of academic stress

and disengagement (Saha et al., 2024; Skilling et al., 2021; Wong & Chapman, 2024). These conditions suggest that success in university mathematics is not determined solely by cognitive ability but also by psychological factors that influence students' motivation, persistence, and learning behavior.

Among these internal factors, self-efficacy has been widely recognized as an important predictor of academic success. Self-efficacy refers to individuals' beliefs in their capability to organize and execute actions necessary to achieve specific goals (Bandura, 2023; Hussain & Khan, 2022; Schunk & Dibenedetto, 2022). According to Bandura, self-efficacy consists of three main dimensions: magnitude, strength, and generality. "Magnitude" refers to the level of task difficulty that individuals believe they can handle; "strength" refers to the degree of confidence in performing tasks, and "generality" refers to the extent to which efficacy beliefs generalize across different situations. In the context of mathematics learning, self-efficacy influences students' confidence in solving mathematical problems, persistence when facing difficulties, and willingness to engage in challenging tasks. Students with high self-efficacy tend to demonstrate greater effort, resilience, and academic performance.

Self-regulation, on the other hand, involves the ability to plan, monitor, and evaluate one's learning processes (Chen & Bonner, 2020; Greene et al., 2023). It encompasses goal setting, strategic planning, time management, and self-reflection. From a theoretical perspective, self-regulated learning consists of three main phases, namely the forethought phase (goal setting and planning), the performance phase (self-monitoring and strategy implementation), and the self-reflection phase (self-evaluation and adaptation). These phases describe how students actively control their learning processes. Russell et al., (2022) and Šteh & Šarić (2020) emphasize that self-regulated learning is fundamental for fostering autonomous learners in higher education. Similarly, Cleary et al. (2021) and Niu et al. (2022) report that self-regulation strategies significantly contribute to academic success, particularly in independent and complex learning environments such as mathematics.

Previous studies have reported positive relationships between self-efficacy, self-regulation, and academic achievement (Navarro et al., 2023; Zheng et al., 2021). However, a number of these studies focus on general academic outcomes or on primary and secondary education levels (Ardura & Galán, 2019; Supervía & Robres, 2021). Research examining these variables simultaneously within university-level mathematics education programs remains limited. Moreover, previous studies frequently emphasize statistical significance without critically discussing the magnitude of contribution of these psychological factors to achievement (Russell et al., 2022; Supervía & Robres, 2021; Zheng et al., 2021). Consequently, there is a need to provide a more integrated and realistic understanding of how internal psychological variables explain mathematics learning achievement in higher education contexts.

This study addresses this gap by examining self-efficacy and self-regulation simultaneously within a regression framework among university students in a mathematics education program. The novelty of this research lies in three aspects. First, it integrates both psychological constructs within a single predictive model in a higher education mathematics context. Second, it quantifies the combined explanatory power of these variables to provide insight beyond mere statistical significance. Third, it offers empirical implications for strengthening psychologically informed instructional strategies in mathematics teacher education. Therefore, this study aims to (1) examine the effect of self-efficacy on university students' mathematics learning achievement, (2) analyze the effect of self-regulation on mathematics learning achievement, and (3) investigate the simultaneous contribution of self-efficacy and self-regulation to mathematics learning achievement.

METHODS

Research Design

This study employed a quantitative approach using an ex-post facto design. Ex-post facto research examines relationships among variables without manipulating them, as the events have already occurred (Sugiyono, 2019). This design was selected to investigate the predictive relationships between self-efficacy, self-regulation, and mathematics learning achievement. The research was conducted at Tadulako University in December 2024.

Subject of Research or Population and Sample (Research Target)

The population consisted of 130 students from the 2023 cohort of the Mathematics Education Study Program, Faculty of Teacher Training and Education, Tadulako University. A total of 98 students were selected using proportional random sampling to ensure representative participation.

Instruments

Data were collected using questionnaires and documentation techniques. The self-efficacy instrument consisted of 32 Likert-scale items developed based on Bandura's self-efficacy theory, covering indicators such as confidence in completing tasks, ability to overcome difficulties, persistence in effort, and belief in one's own abilities. The self-regulation instrument consisted of 45 Likert-scale items developed based on Zimmerman's self-regulated learning framework, including goal setting, strategic planning, self-monitoring, time management, effort regulation, environmental structuring, and help-seeking behavior. The instruments were adapted and modified from previous research conducted in similar educational contexts (Ilham, 2020). Students' mathematics learning achievement was obtained through documentation of their academic records, specifically their Grade Point Average (GPA) in first- and second-semester mathematics courses. Prior to data collection, the instruments were reviewed by experts to ensure content validity. A pilot study was conducted to test the reliability of the instruments, and the results showed that the Cronbach's alpha coefficients for all variables were greater than 0.70, indicating acceptable reliability.

Data Analysis Technique

Data analysis consisted of descriptive and inferential statistics. Prior to hypothesis testing, regression assumptions, including normality, linearity, heteroscedasticity, and autocorrelation, were examined to ensure model suitability. Hypothesis testing was conducted using simple linear regression to determine the individual effects of self-efficacy and self-regulation on mathematics learning achievement, and multiple linear regression to examine their simultaneous contribution. The coefficient of determination (R^2) was used to measure the magnitude of contribution. Statistical analyses were performed using SPSS version 26.

To interpret the descriptive statistics, the scores of self-efficacy, self-regulation, and learning achievement were categorized into five levels: very low, low, medium, high, and very high. The categorization was determined using the ideal mean (Mi) and ideal standard deviation (SDi) method. The category intervals were calculated as follows: very high ($X > Mi + 1.5SDi$), high ($Mi + 0.5SDi < X \leqslant Mi + 1.5SDi$), medium ($Mi - 0.5SDi < X \leqslant Mi + 0.5SDi$), low ($Mi - 1.5SDi < X \leqslant Mi - 0.5SDi$), and very low ($X \leqslant Mi - 1.5SDi$). This categorization method was used to facilitate the interpretation of students' levels of self-efficacy, self-regulation, and learning achievement. In addition, a multicollinearity test was conducted to examine whether there was a high correlation between independent variables. Multicollinearity was assessed using tolerance and Variance Inflation Factor (VIF) values.

A tolerance value greater than 0.10 and a VIF value less than 10 indicate that there is no multicollinearity problem in the regression model.

Research Procedures

The research was conducted in several stages: (1) developing research instruments based on theoretical frameworks; (2) validating the instruments through expert review; (3) conducting pilot testing and reliability analysis; (4) selecting participants; (5) distributing questionnaires; (6) collecting academic achievement data; and (7) analyzing and interpreting the data statistically.

RESULTS AND DISCUSSION

Description of Research Variables

The descriptive statistics were calculated to examine the distribution patterns of self-efficacy, self-regulation, and mathematics learning achievement among participants. The frequency and percentage distributions of each variable are presented in Table 1.

Table 1 Frequency distribution of research variables (N = 98)

Category	Self-Efficacy n (%)	Self-Regulation n (%)	Learning Achievement n (%)
Very Low	5 (5.1%)	7 (7.1%)	3 (3.1%)
Low	29 (29.6%)	23 (23.5%)	30 (30.6%)
Medium	36 (36.7%)	46 (46.9%)	37 (37.8%)
High	22 (22.4%)	12 (12.2%)	21 (21.4%)
Very High	6 (6.1%)	10 (10.2%)	7 (7.1%)
Total	98 (100%)	98 (100%)	98 (100%)

The descriptive statistics presented in Table 1 indicate that the majority of students were categorized at the moderate level across all variables. Self-efficacy was predominantly moderate (36.7%), followed by low (29.6%) and high (22.4%). Similarly, self-regulation was largely moderate (46.9%), while learning achievement was mostly in the moderate (37.8%) and low (30.6%) categories. Only a small proportion of students reached the very high category across the three variables. Overall, the distribution pattern shows that students' psychological readiness and academic performance tend to cluster at a moderate level.

Regression Assumption Testing

Prior to hypothesis testing, several regression assumptions were examined to ensure the suitability of the analytical model. The normality test using the Kolmogorov–Smirnov method indicated that the residuals were normally distributed ($p = 0.200 > 0.05$). Linearity tests showed that the relationships between self-efficacy and mathematics learning achievement, as well as between self-regulation and mathematics learning achievement, were linear, as the deviation from linearity was not statistically significant ($p = 0.356$ and $p = 0.790$, respectively).

The heteroscedasticity test indicated that the independent variables did not significantly predict the absolute residuals ($p = 0.849$ for self-efficacy; $p = 0.552$ for self-regulation), suggesting the absence of heteroscedasticity. In addition, the autocorrelation test using the Runs Test showed no evidence of residual autocorrelation ($p = 0.542 > 0.05$). Overall, these results confirm that the regression assumptions of normality, linearity, homoscedasticity, and independence of errors were satisfied. Therefore, the data were deemed appropriate for simple and multiple linear regression analyses.

Hypothesis Testing

To examine the predictive effects of self-efficacy and self-regulation on mathematics learning achievement, simple and multiple linear regression analyses were conducted. The summary of regression results is presented in Table 2.

Table 2 Summary of Regression Analysis Results

Predictor	β	t	p	R^2
Self-Efficacy → Achievement	0.394	4.204	<0.001	0.155
Self-Regulation → Achievement	0.361	3.796	<0.001	0.131
Self-Efficacy & Self-Regulation (Simultaneous)	-	-	<0.001	0.167

The results indicate that self-efficacy significantly predicts mathematics learning achievement ($\beta = 0.394$, $p < 0.001$), explaining 15.5% of the variance. This finding suggests that higher levels of students' confidence in their mathematical abilities are associated with better academic performance. Similarly, self-regulation significantly predicts mathematics learning achievement ($\beta = 0.361$, $p < 0.001$), accounting for 13.1% of the variance. Students who effectively regulate their learning processes tend to achieve higher outcomes in mathematics courses.

When analyzed simultaneously, self-efficacy and self-regulation significantly predict mathematics learning achievement ($p < 0.001$), with a combined explanatory power of 16.7%. Although statistically significant, the modest R^2 value indicates that a substantial proportion of achievement variance is influenced by other factors beyond these two psychological variables.

The Effect of Self-Efficacy on Mathematics Learning Achievement

The present findings indicate that self-efficacy significantly predicts mathematics learning achievement among university students. This result is consistent with social cognitive theory, which emphasizes that individuals' beliefs about their capabilities influence their effort, persistence, and academic performance (Bandura, 2001). Students who possess stronger confidence in understanding mathematical concepts and overcoming learning difficulties are more likely to sustain engagement with challenging tasks and achieve better outcomes. This finding is in line with the meta-analysis by Moussa (2023), which identified academic self-efficacy as a reliable predictor of achievement in higher education. Similarly, Schunk & Dibenedetto (2022) highlighted that self-efficacy strengthens motivation and resilience, particularly in cognitively demanding disciplines such as mathematics. Consistent results have also been reported in national studies, including Rezeki et al., (2023), who found a significant relationship between self-efficacy and mathematics learning outcomes. Nevertheless, the explanatory power observed in this study (15.5%) suggests that self-efficacy contributes meaningfully but not dominantly to mathematics achievement. This moderate effect size indicates that while confidence functions as an important motivational driver, academic success in university-level mathematics is shaped by a broader constellation of cognitive, instructional, and contextual factors. The complexity of higher education mathematics likely requires not only strong self-belief but also strategic learning skills and supportive academic environments.

The Effect of Self-Regulation on Mathematics Learning Achievement

Self-regulation was also found to significantly predict mathematics learning achievement. This result is consistent with Zimmerman's (2002) framework of self-regulated learning, which highlights planning, monitoring, and self-evaluation as essential components of effective learning behavior.

The findings support previous research indicating that self-regulation strategies contribute positively to academic performance (Afiyah et al., 2025; Zheng et al., 2021). In mathematics contexts, self-regulation is particularly critical because problem-solving tasks demand sustained attention and structured cognitive engagement. Nevertheless, the effect size (13.1%) indicates that regulatory skills alone are insufficient to substantially enhance achievement. The effectiveness of self-regulation may depend on how well students' strategies align with instructional design, assessment methods, and academic demands. This reinforces the idea that psychological readiness must be complemented by pedagogical structure

The Simultaneous Effect of Self-Efficacy and Self-Regulation

The simultaneous analysis demonstrated that self-efficacy and self-regulation significantly predict mathematics learning achievement, explaining 16.7% of the variance. This finding confirms that motivational beliefs and strategic learning behaviors operate complementarily (Arellano et al., 2019; Garcia & Pintrich, 2022; Lehmann, 2022). Self-efficacy influences students' willingness to engage, while self-regulation determines how that engagement is managed and sustained.

Although the combined effect is statistically significant, the relatively modest explanatory power highlights that mathematics achievement is multidimensional. Beyond internal psychological variables, academic performance is shaped by instructional quality, prior knowledge, cognitive ability, learning environment, and socio-emotional conditions. By explicitly reporting effect magnitude, this study contributes a more balanced interpretation of psychological predictors in higher education mathematics contexts, avoiding overgeneralization based solely on statistical significance.

Beyond confirming the significant roles of self-efficacy and self-regulation, this study contributes theoretically by extending social cognitive theory and self-regulated learning theory into a university-level mathematics education context. While previous research has predominantly focused on primary and secondary education settings, the present findings demonstrate that these psychological constructs remain relevant in higher education, although with moderate explanatory power. By examining both variables simultaneously and emphasizing effect magnitude, this study offers a more balanced and realistic interpretation of psychological predictors of mathematics achievement. The findings suggest that self-efficacy and self-regulation function as supportive motivational and strategic factors rather than dominant determinants of academic success.

From a practical perspective, the results imply that efforts to enhance mathematics learning achievement should integrate motivational strengthening with structured learning strategy development. Increasing students' self-efficacy may involve providing mastery experiences, constructive feedback, and scaffolded problem-solving opportunities. At the same time, self-regulation can be fostered through metacognitive training, guided reflection, goal-setting practices, and structured academic planning. Particularly within mathematics teacher education programs, integrating psychological skill development with pedagogical competence is essential to prepare future educators who are both academically resilient and strategically adaptive.

Nevertheless, several limitations should be acknowledged. The study was conducted within a single institutional context, which may limit the generalizability of the findings. In addition, the use of grade point average as an indicator of learning achievement may not fully capture deeper conceptual understanding or higher-order mathematical reasoning. The research model also included only two psychological variables, whereas academic achievement is likely influenced by a broader range of cognitive, instructional, and socio-emotional factors. Future research is therefore recommended to incorporate additional

predictors such as prior mathematical competence, metacognitive awareness, instructional quality, and learning environment variables. Longitudinal designs may further clarify how self-efficacy and self-regulation evolve over time and influence academic development in mathematics education programs.

CONCLUSION

Based on the findings of this study, the conclusions are as follows: (1) Self-efficacy significantly influences university students' mathematics learning achievement, contributing 15.5% of the variance. Students with stronger confidence in their mathematical abilities tend to achieve better academic outcomes. (2) Self-regulation significantly influences mathematics learning achievement, contributing 13.1% of the variance. Effective planning, monitoring, and evaluation strategies support students' academic performance. (3) Self-efficacy and self-regulation simultaneously influence mathematics learning achievement, with a combined contribution of 16.7%. Although statistically significant, their explanatory power remains moderate, indicating that mathematics achievement is shaped by multiple interacting factors beyond internal psychological variables.

This study has several limitations. First, this study was conducted within a single institutional context, which may limit generalizability. Second, learning achievement was measured using Grade Point Average, which may not fully represent deeper conceptual understanding. Third, the model only included two psychological predictors. Future research is recommended to incorporate additional cognitive, instructional, and environmental variables, as well as employ longitudinal designs to better understand developmental dynamics in mathematics learning.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, AA, NA, and GS; methodology, AA, NA, and GS; formal analysis, AAA, NA, and GS; investigation, AA, NA, and GS; data curation, AA, NA, and GS; writing—original draft preparation, AA, NA, and GS; writing—review and editing, AA, NA, GS, and MI. All authors have read and agreed to the published version of the manuscript.

AI DISCLOSURE STATEMENT

The authors used artificial intelligence (AI)-assisted language tools during the preparation of this manuscript for language refinement, grammar checking, and improving academic writing clarity. After using these tools, the authors carefully reviewed, revised, and edited the content as necessary and took full responsibility for the final content of the publication. The authors declare that all research processes, data analysis, interpretations, and scientific conclusions were conducted independently by the authors without AI-generated research findings or automated scientific decision-making.

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