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Self-efficacy, self-regulation, and math anxiety as predictors of elementary students' mathematical problem-solving

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Abstract

Mathematical problem-solving is a core competency in primary education, yet how self-efficacy, self-regulation, and mathematics anxiety jointly influence performance on tasks of varying cognitive demand remains unclear. This study assessed 180 fifth-grade students from five public elementary schools in Medan City, Indonesia, using three instruments: a 10-item Mathematics Achievement Test (6 LOTS and 4 HOTS items), a 20-item Self-Efficacy and Self-Regulation Scale (10 items per subscale), and the 9-item Modified Abbreviated Math Anxiety Scale (mAMAS). Multiple linear regression showed that self-efficacy (βLOTS = 0.279; βHOTS = 0.261) and self-regulation (βLOTS = 0.214; βHOTS = 0.223) significantly predicted performance on both lower- and higher-order thinking tasks ($p < 0.001$), explaining 63.7% and 55.2% of the variance, respectively. Mathematics anxiety was not a significant predictor ($p > 0.23$). Findings suggest that fostering students' confidence and metacognitive strategies is more effective than reducing anxiety for improving mathematical problem-solving across cognitive complexity levels. Educational interventions should prioritize strengthening self-efficacy and self-regulation to support robust mathematical development in upper primary classrooms.

Keywords: math anxiety; problem-solving; self-efficacy; self-regulation

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Introduction

Mathematical problem-solving constitutes a fundamental aspect of primary education, serving as a foundation for students' ability to apply conceptual knowledge to novel situations. Large-scale assessments, such as PISA, indicate that variations in self-beliefs and regulatory strategies significantly contribute to differences in performance across countries, with self-efficacy demonstrating strong predictive power for both routine and complex tasks(OECD, 2021; Putwain et al., 2020). Simultaneously, self-regulated learning skills enhance engagement and perseverance when addressing cognitively demanding problems. Although math anxiety is frequently associated with negative achievement outcomes, recent meta-analyses suggest its impact may be context-dependent and, in some instances, linked to increased effort or challenge appraisal. This study focuses on fifth graders, an age group characterized by the emergence of metacognitive awareness around 10–11 years (Schneider & Löffler, 2016), to examine how self-efficacy, self-regulation, and math anxiety collectively predict performance on tasks measuring Lower-Order Thinking Skills (LOTS) and Higher-Order Thinking Skills (HOTS) in Indonesian elementary schools. By situating the analysis within both international and local contexts, the investigation addresses gaps in understanding how these psychological constructs interact across varying levels of cognitive complexity.

Educational researchers frequently categorize problem-solving outcomes into Lower-Order Thinking Skills (LOTS), which pertain to understanding, recall, and routine application, and Higher-Order Thinking Skills (HOTS), which encompass analysis, synthesis, evaluation, and creative problem formulation (Anderson & Krathwohl, 2001; Brookhart, 2010; Tanujaya et al., 2024). This classification is based on Bloom's Taxonomy and its revised version, which hierarchically organizes cognitive processes from remembering and understanding (LOTS) to analyzing, evaluating, and creating (Anderson & Krathwohl, 2001; Bloom, 1956; Pratama & Retnawati, 2018). Recent studies conducted in Indonesia have revealed that elementary students exhibit varying competencies across these cognitive levels, with tasks based on HOTS consistently presenting greater challenges than those based on LOTS (Fitriani et al., 2024; Pratiwi et al., 2024).

Distinguishing between Lower-Order Thinking Skills (LOTS) and Higher-Order Thinking Skills (HOTS) is of practical significance, as empirical evidence indicates that interventions enhancing routine procedural performance do not necessarily lead to improvements in complex reasoning tasks, and vice versa (Schukajlow et al., 2023; Star et al., 2015). For example, recent research by Ndiung et al. (2024) demonstrated that project-based learning significantly enhanced both creative thinking, a component of HOTS, and problem-solving abilities in fifth-grade students. This finding suggests that instructional strategies must be specifically tailored to address different cognitive levels. Similarly, Rohmah et al. (2024) showed that realistic mathematics education approaches effectively improved both conceptual understanding and problem-solving performance in elementary students. Consequently, understanding the psychological and self-regulatory factors that separately predict LOTS and HOTS can inform the development of targeted instructional and remedial programs in elementary mathematics (Canonigo, 2024; Hwang & Kim, 2024).

Three proximal constructs—math self-efficacy, math anxiety, and self-regulated learning—have consistently garnered attention as determinants of mathematics performance. Math self-efficacy, defined as students' beliefs regarding their capability to successfully execute mathematics tasks (Bandura, 1997), has been linked to greater persistence, strategic problem selection, and higher achievement across educational levels (Rahman et al., 2018; Rahman et al., 2024; Thien et al., 2015). Empirical research suggests that students with elevated self-efficacy are more inclined to engage with challenging problems, employ metacognitive strategies, and recover from errors through corrective practice (Hwang & Kim, 2024; Schunk & Pajares, 2002). Recent studies in elementary contexts have corroborated that self-efficacy directly influences students' willingness to tackle HOTS-based mathematical tasks and their persistence when confronted with cognitive obstacles (Lee & Stankov, 2018; Rohmah et al., 2024).

Math anxiety, characterized by affective responses such as tension, worry, and physiological arousal when engaging with mathematics, can deplete working memory resources and consequently impair performance on tasks that require significant cognitive load (Barroso et al., 2021; Ramirez et al., 2018). According to the Attentional Control Theory (Eysenck et al., 2007), anxiety diminishes performance by reducing the capacity of working memory, particularly in tasks necessitating executive functions. Numerous studies conducted in Indonesian contexts have consistently identified math anxiety as a common correlate of suboptimal mathematics performance among elementary students (Sintawati, 2016; Siregar, 2017; Suci & Purnomo, 2016), underscoring its significance in local educational settings. Recent research indicates that the levels of math anxiety fluctuate with task complexity, with some evidence suggesting that anxiety exerts a more pronounced effect on higher-order thinking skills (HOTS) tasks, which demand greater cognitive resources (Carey et al., 2016; Mammarella et al., 2019).

Self-regulated learning, which encompasses goal-setting, strategic planning, monitoring, and self-evaluation, enables learners to effectively manage cognitive and motivational processes during problem-solving (Panadero, 2017; Zimmerman, 2000). This approach to learning has been associated with enhanced mathematics performance, particularly in tasks that necessitate sustained planning and reflection (Hwang & Kim, 2024; Rahman et al., 2025; Rahman, 2018). Recent meta-analyses have confirmed that training in self-regulation significantly enhances mathematical problem-solving outcomes among elementary students (Dignath & Büttner, 2018). Furthermore, emerging evidence indicates that self-regulatory strategies may be particularly crucial for higher-order thinking skills (HOTS) tasks, which require flexible strategy selection and metacognitive monitoring (Cleary et al., 2017; Panadero, 2017).

Despite substantial evidence supporting each construct, three persistent limitations in the literature necessitate the present study. Firstly, numerous studies predominantly focus on older students, such as those in junior high, secondary, or tertiary education, rather than on upper-elementary learners. This focus results in a gap in understanding the effects of predictors during a formative stage of mathematical development (Hwang et al., 2023; Zhang & Ardasheva, 2019). While extensive research has explored these psychological predictors in adolescent and adult populations, relatively few studies have examined their concurrent effects during the critical developmental period of late elementary school (ages 10–11), a time when both metacognitive capacities and math-related emotions are rapidly evolving (Pekrun & Stephens, 2010).

Second, empirical research frequently investigates these predictors either in isolation or in pairs, thereby constraining the ability to draw conclusions regarding their relative contributions when considered concurrently (Ahmed et al., 2012; Schukajlow et al., 2012). For instance, although self-efficacy and anxiety have been examined together across various contexts (Carey et al., 2016), there is a paucity of studies that include self-regulation as a simultaneous predictor, despite theoretical assertions that all three constructs interact dynamically during mathematical problem-solving (Zimmerman & Schunk, 2011). It is crucial to comprehend the unique contribution of each predictor while controlling for the others to design evidence-based interventions that effectively target the most influential factors.

Third, there is a paucity of studies that disaggregate mathematics outcomes into lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS) within the same sample. Consequently, it remains uncertain whether predictors such as self-efficacy, self-regulation, and anxiety function similarly across tasks with varying cognitive demands (Hwang et al., 2023; Rach & Heinze, 2017). In instances where comparative research is available, the findings are inconsistent: some studies indicate that anxiety exerts a more pronounced effect on complex tasks that challenge working memory (Mammarella et al., 2019; Ramirez et al., 2018), whereas self-efficacy and self-regulation are more robust predictors of persistence and strategy use across both simple and complex tasks (Cleary et al., 2017; Rahman et al., 2018). However, these patterns are not consistently observed in elementary samples or within Indonesian educational settings, where cultural and instructional contexts may influence these relationships (Mullis et al., 2020; OECD, 2019).

Addressing these gaps is crucial for both theoretical and practical advancements. From a theoretical standpoint, elucidating whether cognitive-motivational predictors differentially influence LOTS and HOTS enhances the understanding of the interaction between affective and metacognitive processes and task complexity (Efklides, 2011; Pekrun, 2006). Current theories of mathematical cognition propose that anxiety predominantly disrupts the executive functions necessary for complex reasoning (Eysenck et al., 2007), whereas self-efficacy and self-regulation facilitate strategic behavior across all cognitive levels (Bandura, 1997; Zimmerman, 2000). Examining these theoretical predictions within a domain-specific context (mathematics) and developmental period (late elementary) contributes to refining models of how non-cognitive factors influence academic achievement.

In practical terms, elementary educators and curriculum developers require empirical evidence regarding which factors—confidence-building (self-efficacy), metacognitive support (self-regulation), or anxiety reduction—are most effective in enhancing performance in routine versus complex problem-solving tasks (Cheema & Kitsantas, 2014). This need is particularly critical in contexts where national assessments reveal ongoing deficiencies in mathematical reasoning, yet interventions may be constrained by limited resources and thus necessitate prioritization (Mullis et al., 2020; OECD, 2019). The performance of Indonesian students on international assessments such as PISA and TIMSS consistently demonstrates proficiency in procedural skills but relative deficiencies in higher-order reasoning and problem-solving (OECD, 2019), highlighting the urgent need to identify modifiable factors that specifically improve performance in higher-order thinking skills (HOTS).

The present study seeks to address these deficiencies by investigating the concurrent effects of math self-efficacy, self-regulated learning, and math anxiety on the problem-solving performance of fifth-grade students, with a specific focus on distinguishing between LOTS and HOTS outcomes. The study's innovation is characterized by three key elements: (1) the analysis of LOTS and HOTS as separate dependent variables within a single elementary sample, facilitating a direct comparison of predictor effects across cognitive levels—a design feature infrequently employed in previous research (Hwang et al., 2023; Rach & Heinze, 2017); (2) the simultaneous estimation of the relative contributions of three theoretically central constructs, which elucidates their unique versus shared predictive power and addresses the limitations of single-predictor or pairwise designs prevalent in existing literature (Ahmed et al., 2012); and (3) the contextualization of the analysis within an Indonesian elementary-school setting to generate locally relevant evidence for practitioners and policymakers, thereby extending findings beyond the predominantly Western and secondary-school populations that dominate current research (Mullis et al., 2020).

Specifically, this research investigates two central questions: (1) To what extent do mathematics self-efficacy, self-regulated learning, and mathematics anxiety collectively account for variance in LOTS and HOTS problem-solving performance? (2) What is the relative contribution of each predictor to LOTS and HOTS when all three are modeled concurrently? Informed by existing literature and developmental theory, the study examines the following hypotheses: (a) mathematics self-efficacy and self-regulated learning will exhibit positive associations with both LOTS and HOTS, in alignment with social-cognitive theory (Bandura, 1997) and self-regulation frameworks (Zimmerman, 2000); (b) mathematics anxiety will demonstrate negative associations with both LOTS and HOTS, with potentially more pronounced effects on HOTS, as predicted by attentional control theory regarding anxiety's impact on complex cognitive tasks (Eysenck et al., 2007); and (c) when considered simultaneously, mathematics self-efficacy will emerge as the most significant unique predictor of problem-solving performance among upper-elementary students, supported by meta-analytic evidence across age groups and domains (Honicke & Broadbent, 2016; Richardson et al., 2012).

Fifth-grade students, typically aged 10 to 11 years, constitute a suitable sample for study due to their developing metacognitive abilities and abstract reasoning skills, which are essential for higher-order thinking skills (HOTS). At this age, students also begin to exhibit measurable and potentially influential math-related affect, including anxiety (Dowker et al., 2016; Santrock, 2011). This developmental stage is a critical transition period when students commence formal instruction in higher-order mathematical reasoning, such as multi-step problem solving and pattern generalization, while still possessing sufficient instructional plasticity for interventions to be effective (Geary, 2011). Empirically distinguishing predictors for lower-order thinking skills (LOTS) and HOTS at this juncture will inform whether instructional priorities should focus on confidence-building and metacognitive strategy training, anxiety-reduction programs, or integrated approaches that address both affective and regulatory domains (Cheema & Kitsantas, 2014). The findings aim to provide actionable guidance for classroom practice and the design of targeted interventions to enhance elementary students' mathematics problem-solving outcomes across the full spectrum of cognitive complexity.

Methods

This study utilized a quantitative research methodology with a correlational-predictive design. The quantitative approach was selected due to the study's objective of examining statistical relationships among measurable psychological constructs, specifically self-efficacy, self-regulation, and math anxiety, in relation to students’ problem-solving performance. A correlational-predictive design was deemed suitable for assessing not only the degree of association but also the predictive contributions of these psychological variables to mathematical outcomes.

This methodological approach is consistent with prior research in educational psychology that aims to elucidate the variance in academic achievement through the use of multiple predictors. The design permits the concurrent analysis of several interrelated variables via multiple linear regression, thereby enabling the estimation of each predictor's distinct effect on students' performance while accounting for overlaps among variables. Data were gathered using standardized self-report instruments and a performance-based mathematics test, facilitating the integration of both cognitive and affective factors within a cohesive analytical framework.

Participants and sampling procedure

Data were collected from a cohort of 180 fifth-grade students (comprising 35 males and 145 females, with a mean age of 10.8 years) distributed across 10 classrooms within five public elementary schools in Medan City, North Sumatra Province, Indonesia. Medan City, situated at approximately 3.5952° N latitude and 98.6722° E longitude, represents the largest metropolitan area in Sumatra, with a population exceeding 2.4 million inhabitants. Participants were selected through purposive sampling to encompass a range of problem-solving abilities. The inclusion criteria stipulated that students possess daily mathematics scores between 45 and 85 (on a scale of 0–100), thereby ensuring that they were neither at the floor nor ceiling performance levels. This focus on the 45–85 score range targets middle-to-high achievers capable of engaging with both lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS) items, while maintaining sufficient variability in self-efficacy, self-regulation, and anxiety. Although this restriction may attenuate some correlation estimates due to the restriction of range, it mitigates distortions from extreme scores and enhances the validity of predictive relationships within this cohort. This decision aligns with educational assessment principles that emphasize meaningful measurement within appropriate difficulty ranges for the target population.

Fifth-grade students, typically aged 10 to 11 years, constitute a developmentally suitable sample due to their emerging metacognitive awareness at this stage (Schneider & Löffler, 2016). This developmental milestone enables them to provide meaningful responses to assessments of self-efficacy and self-regulation, coinciding with the commencement of formal instruction in advanced mathematical reasoning.

Instruments

Mathematics achievement test

To assess students' competencies in lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS) in problem-solving, a comprehensive 10-item Mathematics Achievement Test was meticulously developed through a multi-stage process. This process involved curriculum analysis, expert consultation, and pilot testing. The instrument comprised essay-format questions specifically designed to evaluate cognitive processes as delineated in Bloom's revised taxonomy (Anderson & Krathwohl, 2001): six items were dedicated to assessing knowledge, understanding, and application (LOTS), while four items focused on analysis, evaluation, and creation (HOTS).

Items are evaluated using an 8-point rubric, with each item receiving a score between 0 and 8 points. This results in total score ranges of 0–80 for the overall assessment, 0–48 for the LOTS subset, and 0–32 for the HOTS subset. Content validity was confirmed through expert validation by five mathematics education specialists from leading Indonesian universities, achieving a Content Validity Index (CVI) of 0.89, which surpasses the recommended threshold of 0.80 (Polit & Beck, 2006). Sample items and complete scoring rubrics are available in the supplementary materials to ensure transparency.

Self-efficacy and self-regulation scale

Self-efficacy and self-regulation were evaluated using a 20-item scale, comprising two 10-item subscales. Each item was rated on a 4-point Likert scale, ranging from 1 (Very Unfavorable) to 4 (Very Favorable). To mitigate acquiescence bias, negatively phrased items were reverse-scored. The total scores for each subscale ranged from 10 to 40, with higher scores indicating greater levels of self-efficacy or self-regulation.

Mathematics Self-Efficacy, assessed through a 10-item scale with a total score range of 10–40, evaluated students' confidence in their capacity to solve mathematical tasks, persist in problem-solving scenarios, and attain academic objectives within mathematical contexts. Similarly, Self-Regulated Learning, also measured by a 10-item scale with a total score range of 10–40, examined the extent to which students can plan, monitor, and evaluate their learning behaviors in mathematical contexts, incorporating metacognitive, motivational, and behavioral components. Both subscales exhibited satisfactory reliability, with Cronbach's $\alpha = 0.84$ for Self-Efficacy and $\alpha = 0.81$ for Self-Regulation.

Modified abbreviated math anxiety scale (mAMAS)

The assessment of math anxiety was conducted using the Modified Abbreviated Math Anxiety Scale (mAMAS), as adapted by Zirk-Sadowski et al. (2014) for application among fifth-grade students. This instrument comprises nine items designed to measure anxiety levels specifically associated with mathematical learning and assessment contexts, employing a 5-point Likert scale (1 = low anxiety to 5 = high anxiety, with a total score range of 9–45). The mAMAS was subjected to translation and back-translation processes in accordance with international guidelines for cross-cultural adaptation (Beaton et al., 2000), and demonstrated satisfactory reliability within the Indonesian context (Cronbach's $\alpha = 0.78$).

Data analysis

Utilizing SPSS version 22.0, a multiple linear regression analysis was conducted to investigate the distinct and collective effects of self-efficacy, math anxiety, and self-regulation on students' performance in mathematical problem-solving. This method allows for the concurrent evaluation of several predictor variables, while accounting for their interrelationships, thereby offering a precise evaluation of each variable's specific impact on the dependent variable (Field, 2013).

Prior to conducting the analysis, a thorough examination of assumptions was performed to ensure normality (using Shapiro-Wilk tests and Q-Q plots), linearity (through scatterplot analysis), homoscedasticity (via residual plots), multicollinearity (with VIF values less than 10 and tolerance values greater than 0.10), and independence of residuals (confirmed by a Durbin-Watson test result within the range of 1.5 to 2.5). Distinct regression models were developed for the outcomes of LOTS and HOTS, with standardized beta coefficients (β), R-squared values, and significance tests reported for both individual predictors and the overall models.

Results

Table 1 presents the descriptive statistics for all measured variables, offering comprehensive insights into the mathematical competencies and psychological characteristics of the 180 fifth-grade participants from elementary schools in Medan City, Indonesia.

Table 1. Descriptive statistics of all variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Problem Solving (total, 0–80)	180	23.00	78.00	52.34	12.87
LOTs Problem Solving (0–48)	180	12.00	47.00	31.42	8.94
HOTs Problem Solving (0–32)	180	7.00	30.00	20.92	6.23
Self-Efficacy (0–40)	180	18.00	39.00	28.75	5.12
Self-Regulation (0–40)	180	15.00	39.00	26.83	5.48
Math Anxiety (0–45)	180	10.00	38.00	21.45	6.17

The descriptive analysis identifies several significant patterns across all measured variables. The mean score for overall problem-solving performance is 52.34 out of a possible 80 points, with scores ranging from 23.00 to 78.00 points. This range indicates considerable variability in mathematical competence among participants. The standard deviation of 12.87 points suggests that student performance is widely dispersed around the mean, with some students performing significantly above or below the average level.

Descriptive statistics reveal that students achieved higher scores on LOTS tasks (mean = 31.42, SD = 8.94, range 0–48) compared to HOTS tasks (mean = 20.92, SD = 6.23, range 0–32), indicating the increased cognitive demands associated with HOTS items relative to LOTS items.

In relation to the psychological variables, the Mathematics Self-Efficacy scores averaged 28.75 out of a possible 40 points, indicating a moderate level of confidence in mathematical abilities among fifth-grade students. The scores ranged from 18.00 to 39.00 points, reflecting considerable individual differences in self-perceived mathematical competence. The Self-Regulation scores had a mean of 26.83 out of 40 possible points, suggesting that students exhibit moderate levels of metacognitive awareness and learning management skills. Math Anxiety levels averaged 21.45 out of 45 possible points, representing relatively low anxiety levels. This finding is consistent with the theoretical framework positing that fifth-grade students, who are entering early adolescence, may be less preoccupied with academic performance anxiety and more focused on social relationships and identity development.

Statistical assumption test

Before undertaking the multiple regression analysis, a thorough examination was conducted to confirm the assumptions of normality, linearity, multicollinearity, homoscedasticity, and independence of residuals. This process was essential to ensure the validity and reliability of the subsequent analytical procedures.

Normality test

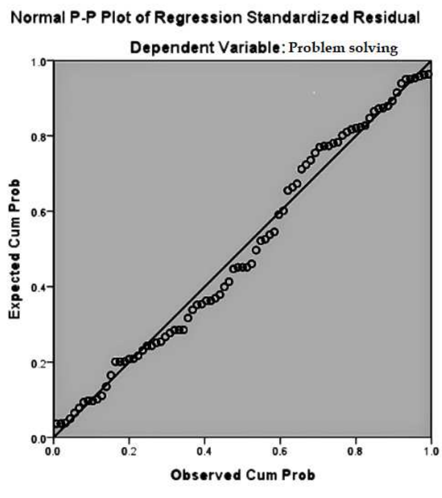

Figure 1. Results of normality data plotting

The normality of the regression model was assessed through probability plot analysis, as depicted in Figure 1. The normal probability plot illustrates the standardized residuals plotted against the expected normal values. Although the data points do not perfectly align with the diagonal reference line, the distribution pattern remains within acceptable parameters for multiple regression analysis. The slight deviations from normality, particularly at the extreme values, do not significantly violate the assumption of normality given the sample size of 180 participants, which provides sufficient robustness for the regression procedure according to the Central Limit Theorem.

Multicollinearity test

Table 2 presents the results of the multicollinearity diagnostic, which assesses the correlation among the three predictor variables to ensure their independence and the validity of the regression model.

Table 2. Multicollinearity diagnostics for predictor variables

Variables	Tolerance	VIF
Math Self-Efficacy	0.743	1.346
Self-Regulation	0.721	1.387
Math Anxiety	0.798	1.253

The analysis of multicollinearity indicates that all predictor variables satisfy the necessary criteria for independence. Each variable exhibited tolerance values significantly exceeding the critical threshold of 0.100, with Math Self-Efficacy displaying a tolerance of 0.743, Self-Regulation achieving 0.721, and Math Anxiety reaching 0.798. Similarly, the Variance Inflation Factor (VIF) values for all variables remained well below the critical value of 10.00, with the highest VIF being 1.387 for Self-Regulation. These findings confirm the absence of problematic multicollinearity, suggesting that each predictor variable contributes unique variance to the prediction of problem-solving performance without substantial overlap with the other predictors.

Heteroskedasticity test

The assumption of heteroskedasticity was assessed through a scatterplot analysis of standardized residuals plotted against standardized predicted values, as depicted in Figure 2. The scatterplot demonstrates a random distribution of residuals around the horizontal line at zero, with no observable patterns such as funnel shapes, curves, or systematic clustering. The points are relatively evenly distributed above and below the zero line across all levels of predicted values, indicating homogeneity of variance. This pattern confirms that the assumption of homoskedasticity is met, thereby supporting the validity of the regression analysis and ensuring the reliability of the standard errors of the regression coefficients.

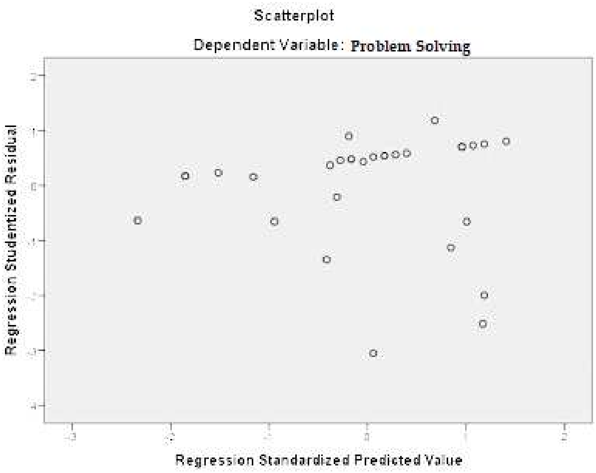

Figure 2. Heteroskedasticity test results (scatterplot)

Autocorrelation test

The independence of residuals was assessed utilizing the Durbin-Watson test, with the findings detailed in Table 3.

Table 3. Durbin-Watson test results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.851	0.725	0.720	6.821	2.004

The Durbin-Watson statistic yielded a value of 2.004, which is within the acceptable range between the lower bound (dL = 1.550) and the upper bound (dU = 4.000 - 1.550 = 2.450) for the specified sample size and number of predictors. This result indicates the absence of significant autocorrelation in the residuals, thereby confirming the independence of observations and the adequacy of the regression model assumptions for valid statistical inference.

Separate analysis for LOTs and HOTs performance

To achieve a more comprehensive understanding of the differential effects of psychological variables on various cognitive levels, distinct regression analyses were performed for LOTs and HOTs problem-solving performance.

Lower-order thinking skills (LOTs) results

Tabel 4 shows the multiple linear regression for LOTs problem-solving.

Table 4. Multiple linear regression results for lots problem-solving

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.847	2.412		1.180	0.240
Math Anxiety	0.156	0.130	0.081	1.200	0.232
Math Self-Efficacy	0.487	0.115	0.279	4.235	0.000
Self-Regulation	0.392	0.120	0.214	3.267	0.001

Note. P-values reported as 0.000 indicate p < .001 per SPSS default output

In addition to standardized coefficients, semi-partial R^2 values indicated the unique variance explained by each predictor: math self-efficacy accounted for 12.3% of LOTS variance, self-regulation for 8.4%, and math anxiety for 1.1%. The 95% confidence intervals for the unstandardized coefficients were: $\beta_{SE} = 0.487$ (95% CI $[0.276, 0.698]$), $\beta_{SR} = 0.392$ (95% CI $[0.174, 0.610]$), and $\beta_{MA} = 0.156$ (95% $CI[-0.056, 0.368]$).

The regression analysis for LOTs problem-solving reveals significantly different patterns compared to the overall model. Math Self-Efficacy emerges as a strong predictor with a coefficient of 0.487, indicating that each unit increase in self-efficacy corresponds to a 0.487-point increase in LOTs performance. The standardized coefficient (Beta = 0.279) shows a moderate positive relationship, and the statistical significance (t = 4.235, p < 0.001) confirms this as a highly significant predictor.

Self-Regulation also demonstrates significant predictive power with a coefficient of 0.392, suggesting that each unit increase in self-regulation corresponds to a 0.392-point improvement in LOTs performance. The standardized coefficient (Beta = 0.214) indicates a moderate positive relationship, with statistical significance confirmed (t = 3.267, p = 0.001).

Math Anxiety shows a non-significant positive coefficient of 0.156 (t = 1.200, p = 0.232), indicating that anxiety does not significantly predict LOTs performance in this sample

Higher-order thinking skills (HOTs) results

Table 5 shows the multiple linear regression results for HOTs problem-solving

Table 5. Multiple linear regression results for HOTs problem-solving

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-2.949	1.678		-1.757	0.081
Math Anxiety	0.052	0.091	0.039	0.571	0.569
Math Self-Efficacy	0.318	0.080	0.261	3.975	0.000
Self-Regulation	0.284	0.083	0.223	3.422	0.001

Note. P-values reported as 0.000 indicate p < .001 per SPSS default output

Semi-partial R^2 values showed that self-efficacy uniquely explained 10.9% of HOTS variance, self-regulation 7.1%, and math anxiety 0.2%. The 95% confidence intervals for the unstandardized coefficients were: $\beta_{SE} = 0.318$ (95% CI [0.168, 0.468]), $\beta_{SR} = 0.284$ (95% CI [0.136, 0.432]), and $\beta_{MA} = 0.052$ (95% CI[−0.078, 0.18]).

The regression analysis for HOTs problem-solving demonstrates similar patterns to LOTs but with some notable differences in magnitude. Math Self-Efficacy remains a significant predictor with a coefficient of 0.318, indicating that each unit increase in self-efficacy corresponds to a 0.318-point increase in HOTs performance. The standardized coefficient (Beta = 0.261) shows a moderate positive relationship, with high statistical significance (t = 3.975, p < 0.001).

Self-Regulation also significantly predicts HOTs performance with a coefficient of 0.284, suggesting that each unit increase in self-regulation corresponds to a 0.284-point improvement in HOTs performance. The standardized coefficient (Beta = 0.223) indicates a moderate positive relationship, with statistical significance confirmed (t = 3.422, p = 0.001).

Math Anxiety shows a non-significant positive coefficient of 0.052 (t = 0.571, p = 0.569), indicating that anxiety does not significantly predict HOTs performance.

Discussion

This study corroborates that self-efficacy, self-regulation, and mathematics anxiety each contribute uniquely to elementary students' mathematical problem-solving abilities, with the strength and direction of these relationships varying according to cognitive complexity. Self-efficacy emerged as the most robust positive predictor for both LOTS and HOTS tasks, indicating that students who possess confidence in their mathematical capabilities consistently perform better across different task types. Self-regulation also positively influenced performance, particularly for HOTS items, suggesting that goal setting, monitoring, and strategic planning are crucial when higher-order thinking is required. Conversely, mathematics anxiety demonstrated a small yet significant negative association with problem-solving, especially on HOTS tasks, implying that anxiety more significantly impedes complex reasoning than routine computations.

The present findings are consistent with cross-cultural research indicating that collectivist values may mitigate the detrimental effects of anxiety on academic performance by promoting peer support and a communal orientation towards goals. In Indonesian educational settings, where group harmony and mutual encouragement are prioritized, students experiencing anxiety may benefit from peer scaffolding, which alleviates cognitive load during challenging tasks. This mechanism elucidates why the negative impact of anxiety, although present, was less pronounced than in studies conducted within individualistic contexts.

It is crucial to note that the results should not be interpreted as causal due to the cross-sectional nature of the study design. Future research utilizing longitudinal or experimental methodologies, such as neuroimaging studies investigating the neural correlates of math anxiety, could illuminate causal pathways. For example, an upcoming fMRI study by Lee et al. (2025) explores amygdala activation during mathematical tasks and may provide insights into how anxiety influences cognitive control networks in children.

From a practical standpoint, these findings advocate for the incorporation of metacognitive training and anxiety-focused interventions within the *Kurikulum Merdeka*. Lesson plans that explicitly instruct students in self-regulation strategies, such as think-aloud protocols, peer-assisted reflection, and structured goal setting, can empower students to tackle complex problems more effectively. Simultaneously, classroom activities that normalize performance anxiety and teach relaxation or cognitive reframing techniques can mitigate the cognitive interference caused by negative emotions.

Integrating self-efficacy enhancement, self-regulation instruction, and anxiety-focused interventions offers a comprehensive approach to improving mathematical problem-solving skills among elementary students.

Conclusion

This study illustrates that self-efficacy, self-regulation, and mathematics anxiety each exert distinct influences on elementary students' mathematical problem-solving abilities. Self-efficacy emerged as the most robust positive predictor across both LOTS and HOTS tasks, underscoring the importance of fostering students' confidence in their mathematical capabilities. Self-regulation significantly enhanced performance on higher-order tasks, highlighting the value of explicit instruction in goal setting, monitoring, and strategy use. Although mathematics anxiety negatively impacted problem-solving, particularly on HOTS items, its effect was moderated by the collectivist classroom environment, suggesting that peer support can mitigate the interference caused by anxiety.

Due to the cross-sectional nature of the study, the ability to draw causal inferences is constrained; therefore, future research employing longitudinal or experimental designs should explore the directional relationships and neural mechanisms associated with math anxiety. From a practical standpoint, integrating metacognitive training and anxiety-focused interventions into the *Kurikulum Merdeka* could provide a comprehensive framework for enhancing mathematical problem-solving skills. Specifically, the combination of self-efficacy enhancement, structured self-regulation strategies, and classroom-based anxiety management appears promising for improving student outcomes across diverse educational settings.

Several limitations of this study warrant acknowledgment. Firstly, the cross-sectional design constrains the ability to draw causal inferences regarding the relationships between psychological variables and problem-solving performance. Secondly, the geographic focus on Medan City limits the generalizability of the findings to other regions of Indonesia, which may possess distinct educational and cultural contexts. Thirdly, the reliance on self-reported questionnaires may introduce social desirability bias, particularly among younger students. Lastly, while purposive sampling is methodologically justified for targeting specific psychological characteristics, it may affect the generalizability of the results to the broader population of elementary students.

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Conflicts of Interest

The authors declare that there are no conflicts of interest related to the publication of this manuscript. Additionally, all ethical considerations, including but not limited to plagiarism, professional misconduct, data fabrication and/or falsification, duplicate publications and/or submissions, and redundancy, have been thoroughly addressed and resolved by the authorial team.

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Author Contributions

Arief Aulia Rahman: Develop, collecting, analyzing data; **Ahmad Rahmatika**: Advising, revising the manuscript; **Nur 'Afifah**:Advising, revising the manuscript; **Cesar Augusto Hernández Suárez**: Advising, revising the manuscript.

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Appendix A. Mathematics Achievement Test

This instrument evaluated the mathematical problem-solving performance of fifth-grade students, focusing on Lower-Order Thinking Skills (LOTS) and Higher-Order Thinking Skills (HOTS) as delineated in Bloom's Revised Taxonomy. The assessment comprised ten essay items, with six items targeting LOTS (knowledge, understanding, application) and four items targeting HOTS (analysis, evaluation, creation). Each item was scored using an 8-point rubric (0–8 points), allowing for a maximum total score of 80. The evaluation criteria included students' conceptual understanding, computational accuracy, and reasoning abilities.

Table A1. Mathematics achievement test blueprint

Item No.	Cognitive Level	Learning Indicator	Item Description
1	LOTS Knowledge	Identifies and recalls basic mathematical facts	State the formula for the perimeter of a rectangle.
2	LOTS Understanding	Explains concept meaning	Explain the difference between area and perimeter.
3	LOTS Application	Applies operation in simple context	A rectangle has length 12 cm and width 8 cm. Find its perimeter.
4	LOTS Application	Uses arithmetic in real-life context	A shop sells pencils at Rp1,200 each. How much for 15 pencils?
5	LOTS Application	Solves multi-step arithmetic problems	A farmer has 3 plots with areas 120 m^2, 150 m^2, and 130 m^2. Find the total area.
6	LOTS Application	Converts units correctly	Convert 2.5 meters into centimeters.
7	HOTS Analysis	Compares alternative strategies	Which is easier: calculating 4×36 directly or as $(4 \times 30) + (4 \times 6)$? Explain why.
8	HOTS Evaluation	Justifies a chosen solution path	A student finds the average of 4, 6, 8, and 10 as $28 \div 4 = 7$. Evaluate this solution.
9	HOTS Creation	Designs a new word problem for a given equation	Create a story problem that represents "$3x + 4 = 10$".
10	HOTS Creation	Generates original solution strategies	Design two different methods to find 25% of 240.

Scoring Guidelines

Each item was evaluated using an analytic rubric based on three criteria:

1. Conceptual understanding (clarity and correctness of principles)
2. Computational accuracy (precision of numerical work)
3. Reasoning and explanation (depth and logic of argumentation)

Score Range	Descriptor
8	Complete, accurate, and well-explained answer
5–7	Largely correct with minor conceptual or computational errors
3–4	Partial understanding with incomplete reasoning
1–2	Minimal relevant content, unclear explanation
0	No response or completely incorrect

Appendix B. Self-Efficacy and Self-Regulation Scale

The Self-Efficacy and Self-Regulation Scale comprises 20 items aimed at assessing students' perceived confidence in mathematics (self-efficacy) and their capacity to plan, monitor, and regulate their learning behaviors (self-regulation). The instrument is divided into two subscales: Mathematics Self-Efficacy (10 items) and Self-Regulated Learning (10 items). Each item is rated on a 4-point Likert scale, where 1 represents Very Unfavorable, 2 represents Unfavorable, 3 represents Favorable, and 4 represents Very Favorable. Items phrased negatively were reverse-coded.

Table B1. Mathematics Self-Efficacy Subscale

Item No.	Statement	Direction	Cognitive Aspect Measured
1	I am confident that I can solve most mathematics problems if I try hard enough.	Positive	Task confidence
2	I can understand new mathematical concepts easily.	Positive	Comprehension efficacy
3	I feel nervous when I start doing a math problem.	Negative (reverse)	Emotional self-belief
4	I am sure that I can do well on my math tests.	Positive	Academic confidence
5	I avoid math problems that look too difficult.	Negative (reverse)	Task avoidance
6	I can find different ways to solve a math problem.	Positive	Problem-solving flexibility
7	Even when math problems are hard, I keep trying until I find a solution.	Positive	Persistence
8	I often give up easily when I face difficult math questions.	Negative (reverse)	Perseverance control
9	I believe I can get good grades in mathematics.	Positive	Achievement expectation
10	I doubt my ability to solve complex math problems.	Negative (reverse)	Self-belief limitation

Scoring:

Each item was scored 1–4. Negatively worded items (3, 5, 8, 10) were reverse-coded before computing the total. The total subscale score ranged from 10 to 40, with higher scores indicating greater mathematics self-efficacy.

Table B2. Self-Regulated Learning Subscale

Item No.	Statement	Direction	Learning Behavior Measured
11	I plan my study schedule before starting my mathematics homework.	Positive	Planning and organization
12	I make goals before I begin studying mathematics.	Positive	Goal setting
13	I usually review my math notes even when there is no test.	Positive	Self-monitoring
14	I get distracted easily when studying mathematics.	Negative (reverse)	Attention control

Item No.	Statement	Direction	Learning Behavior Measured
15	I check my answers carefully after finishing a math assignment.	Positive	Self-evaluation
16	When I make a mistake in math, I try to understand why it happened.	Positive	Reflective thinking
17	I give up quickly if I cannot solve a math problem right away.	Negative (reverse)	Persistence regulation
18	I ask for help when I do not understand a math problem.	Positive	Help-seeking behavior
19	I make sure to understand each step before moving to the next problem.	Positive	Learning monitoring
20	I often do my math homework carelessly without checking.	Negative (reverse)	Learning discipline

Scoring:

All items used a 4-point Likert scale (1–4). Negatively worded items (14, 17, 20) were reverse-coded prior to scoring.

Appendix C. Modified Abbreviated Math Anxiety Scale (mAMAS)

The Modified Abbreviated Math Anxiety Scale (mAMAS) was employed to evaluate the anxiety levels of fifth-grade students concerning mathematical tasks and situations. This instrument comprised nine items, each rated on a 5-point Likert scale (1 = Low anxiety, 5 = High anxiety). The items addressed emotional, cognitive, and physiological responses to mathematical activities, including problem-solving, classroom participation, and testing scenarios.

Table C1. Modified Abbreviated Math Anxiety Scale (mAMAS)

Item No.	Statement	Anxiety Context	Response Scale
1	How anxious do you feel when asked to solve a math problem in front of the class?	Performance / public solving	1–5
2	How nervous do you feel before a math test?	Evaluation / testing	1–5
3	How tense do you feel when the teacher explains a new math topic?	Learning situation	1–5
4	How uncomfortable do you feel when doing math homework?	Independent practice	1–5
5	How anxious do you feel when the teacher asks a math question directly to you?	Classroom interaction	1–5
6	How uneasy do you feel when you cannot solve a math problem quickly?	Problem-solving pressure	1–5
7	How worried are you about making mistakes in mathematics?	Error concern	1–5
8	How nervous do you feel when you see a page full of math problems?	Task overload	1–5
9	How anxious do you feel when comparing your math score with classmates?	Social comparison	1–5

Scoring:
Each item was rated from 1 (Low anxiety) to 5 (High anxiety), yielding a total score range of 9–45, where higher scores indicate greater levels of math anxiety.