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Exploring the Relationship Between Self-Efficacy and Mathematical Critical Thinking Skills Among Vocational High School Students in the Context of Matrix Learning

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Abstract. This study investigates the relationship between students' mathematics self-efficacy and mathematical critical thinking (MCT) performance in the context of vocational high schools. Drawing on Bandura's theory of self-efficacy, the research explores how students' belief in their mathematical abilities predicts their capacity to analyze, evaluate, and reason through mathematical problems, particularly within the topic of matrices. 137 eleventh-grade students from four state vocational schools in Indonesia participated in this study. Data were collected using validated self-efficacy and MCT instruments and analyzed through correlational and regression techniques. Results indicate a strong, positive, and statistically significant correlation between mathematics self-efficacy and MCT ($r = 0.743$, $p < 0.001$), with self-efficacy explaining 55.2% of the variance in MCT scores. This relationship remained robust after controlling for gender and vocational program. Regression analysis confirmed self-efficacy significantly predicted students' MCT performance ($\beta = 0.743$, $p < 0.001$). Additionally, components of self-efficacy—magnitude and strength—were identified as key predictors, while magnitude showed the highest predictive power. Analysis across MCT components revealed that students' self-efficacy beliefs most influenced inference and analytical reasoning. These findings underscore the critical role of self-efficacy in shaping higher-order mathematical thinking and suggest that enhancing students' confidence in mathematics may significantly improve their reasoning and problem-solving abilities. The study provides practical implications for instructional design in vocational education settings, emphasizing the integration of motivational strategies to support students' cognitive performance.

Introduction

As conceptualized by Bandura, self-efficacy refers to an individual's belief in their capacity to execute behaviors necessary to produce specific performance attainments. Within mathematics education, self-efficacy is considered a pivotal psychological construct that influences students' cognitive, emotional, and behavioral engagement. Extensive empirical literature confirms a strong relationship between self-efficacy and mathematics achievement. For instance, Arens et al. (2022) revealed longitudinal reciprocal linkages between mathematics self-efficacy and academic performance, suggesting that enhanced self-efficacy both predicts and is reinforced by successful achievement. In a similar study conducted in the context of online learning, Negara et al. (2021) demonstrated that students with higher mathematics self-efficacy performed better, underscoring the applicability of this construct in digital educational environments. Further, Živković et al. (2023)

emphasized that self-efficacy acts as a positive predictor of performance while simultaneously mitigating the detrimental impact of mathematics anxiety.

Supporting this trend, Clemente et al. (2024), through a systematic review, documented the effectiveness of targeted interventions in improving students' mathematics self-efficacy and, consequently, their learning outcomes. Moreover, emerging research has emphasized the mediating role of self-efficacy in various psychosocial and instructional domains. Yang et al. (2021), for instance, identified academic self-efficacy as a mediator between emotional support from teachers and students' mathematics performance. Similarly, Du et al. (2021) and Hiller et al. (2022) found that self-efficacy interacts dynamically with students' mathematics interest and anxiety, reinforcing its role as a central affective factor in mathematical success. Studies by Mamolo (2022) and Mozahem et al. (2021) further expanded the discourse by showing how demographic variables—such as gender and age—moderate the development of mathematics self-efficacy among students. In addition to students, the role of teacher efficacy is also noteworthy. Özden et al. (2024) found that teachers' self-efficacy in creating digital instructional materials significantly influences pedagogical effectiveness, which may indirectly shape students' confidence and engagement in mathematics learning. These findings converge on the assertion that mathematics self-efficacy is a multifaceted determinant of academic performance, shaped by an interplay of personal, contextual, and instructional variables.

Concurrently, mathematical critical thinking (MCT) has gained significant attention as a core cognitive competency essential for problem-solving in the 21st century. MCT enables learners to interpret, analyze, and evaluate mathematical problems with logic and precision (Sachdeva & Eggen, 2021). Various pedagogical interventions have been developed to promote this skill. Setiana and Purwoko (2021) reported that innovative learning models can effectively enhance students' critical thinking capabilities, especially among senior high school learners. In a complementary meta-analysis, Suparman and Tamur (2021) confirmed the positive impact of problem-based learning in fostering mathematical critical thinking across different instructional settings. Furthermore, Arisoy and Aybek (2021) highlighted that subject-based critical thinking education promotes not only analytical reasoning but also intellectual virtues such as open-mindedness and fair-mindedness.

Within the Indonesian educational context, a bibliometric analysis by Siahaan et al. (2023) revealed increased scholarly attention to MCT development among pre-service mathematics teachers, although it also noted significant gaps in curriculum implementation. Recent innovations integrating digital media into instruction have shown promising results in enhancing MCT. For example, Darmayanti (2022) found that digital comic-based instructional media—infused with character values—positively influenced students' mathematical reasoning, especially when adapted to individual learning styles. Similarly, Zulfikar et al. (2022) demonstrated the effectiveness of the Creative Problem Solving (CPS) model, enhanced with Autograph software, in improving students' capacity to recognize patterns, formulate arguments, and generate logical solutions. These findings suggest that MCT is both teachable and highly responsive to didactic and technological interventions, particularly for vocational high school students who often struggle with abstract and formal reasoning in mathematics.

An emerging line of inquiry explores the interplay between self-efficacy and students' mathematical critical thinking skills. Self-efficacy—defined as students' confidence in their ability to perform specific tasks—has been found to significantly influence their perseverance and cognitive engagement when solving complex mathematical problems (Hari et al., 2018; Nurazizah & Nurjaman, 2018). These studies suggest that students with higher self-efficacy are more capable of generating reasoned solutions and engaging deeply with abstract mathematical concepts. Prajono et al. (2022) further demonstrated that variations in students' self-efficacy levels significantly impact the depth and quality of mathematical critical thinking, especially in aspects of logical reflection and inference-making at the junior high school level. Supporting this, Kurnianto et al. (2019) found that in scientific classroom environments, students with higher self-efficacy showed greater initiative in evaluating their thought processes, a defining trait of critical thinking.

Additional evidence from Meti (2022) and Nabila (2020) emphasized that the integration of inquiry-based or problem-based instructional models with strategies aimed at enhancing students' self-efficacy yields significant improvements in MCT performance, not only in mathematics but also in science disciplines such as thermodynamics. These findings align with conclusions drawn by Suryawan et al. (2023) and Afriansyah et al. (2021), who underscored the interdependence between cognitive skills and affective variables like self-efficacy in the development of mathematical reasoning. Consequently, educators aiming to cultivate MCT should design learning environments that are both intellectually stimulating and psychologically supportive, ensuring that students possess the confidence and strategies necessary to engage deeply with mathematical content.

In light of this evidence, the present study seeks to investigate the relationship between students' self-efficacy and their mathematical critical thinking abilities, particularly in the context of matrix-based instructional tasks among vocational high school students (Sekolah Menengah Kejuruan, SMK). The study aims to explore how students' levels of self-efficacy correlate with the quality of their mathematical reasoning and how specific mathematical contexts—such as the topic of matrices—shape this relationship. The scope is limited to two primary variables: self-efficacy, conceptualized as a motivational construct, and mathematical critical thinking, viewed as a cognitive performance indicator. Practically, the findings are expected to inform the development of more contextualized and effective instructional strategies for vocational education, particularly those that consider students' psychological readiness to engage in higher-order thinking. Theoretically, this research contributes to the growing body of literature on mathematics education in vocational contexts by highlighting the importance of integrating motivational and cognitive factors for meaningful and sustained learning.

Methods

This study employed a quantitative approach with a correlational design to analyze the relationship between students' self-efficacy and mathematical critical thinking (MCT) abilities. The correlational design was selected as it aligned with the research objective of identifying the strength and direction of the relationship between the independent variable (self-efficacy) and the dependent variable (mathematical critical thinking) without manipulating these variables (Creswell & Creswell, 2018). The population comprised 136 eleventh-grade students from State Vocational High Schools (SMK Negeri) distributed across 12 schools in the district during the 2024/2025 academic year. The sampling technique utilized multistage cluster sampling, considering the population's distribution across multiple schools, where the first stage involved random school selection, followed by proportional class selection from each chosen school. Based on Slovin's formula with a 5% error margin, the minimum sample size was determined to be 352 students; however, to anticipate potential dropouts and enhance result validity, the sample was set at 400 students from 8 State Vocational High Schools with a distribution of 50 students per school. Inclusion criteria encompassed eleventh-grade SMK students actively participating in mathematics learning, having completed mathematics subjects for at least two semesters, and willingness to participate in the research by signing informed consent, while exclusion criteria included students currently enrolled in intensive mathematics remedial programs and those with cognitive limitations affecting their ability to complete the research instruments.

The independent variable, mathematics self-efficacy, was defined as students' beliefs in their capacity to complete mathematical tasks of varying difficulty levels, measured using a 5-point Likert scale encompassing three dimensions: magnitude (task difficulty level), strength (strength of belief), and generality (generalization of belief). The dependent variable, Mathematical Critical Thinking (MCT), was defined as students' ability to analyze, evaluate, and construct logical arguments in solving mathematical problems, measured through tests with six indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The Mathematics Self-Efficacy Scale (MSES) instrument for measuring mathematics self-efficacy was adapted from the Mathematics Self-Efficacy Scale developed by Betz & Hackett (1993) and modified to suit the Indonesian SMK context, consisting of 33 items with Cronbach's Alpha reliability of 0.89 based on pilot testing, while construct validity was confirmed through Confirmatory Factor Analysis (CFA) with chi-square/df = 2.14, CFI = 0.95, and RMSEA = 0.06. The Mathematical Critical Thinking Test (MCTT) was developed based on Facione's (2015) taxonomy, comprising 12 essay questions with varying difficulty levels, each designed to measure critical thinking aspects within the SMK mathematics context, with content validity confirmed by an expert panel consisting of 5 mathematics education lecturers and 3 SMK mathematics teachers yielding CVR (Content Validity Ratio) > 0.75 for all items, and instrument reliability tested using the test-retest method with a correlation coefficient of 0.82.

Prior to main data collection, instrument validation was conducted with 60 SMK students outside the research sample, revealing that MSES had 31 valid items ($r > 0.30$) with two items dropped. In contrast, MCTT had 12 valid items with difficulty levels ranging from 0.30 to 0.70 and discrimination power > 0.30. The data collection procedure involved a preparation phase including research permit arrangements with the Education Office and selected schools, coordination with principals and mathematics teachers regarding data collection schedules, and research socialization to students with informed consent completion, followed by an implementation phase where data collection was conducted in two separate sessions with a one-week interval to avoid fatigue effects: Session 1 involved administering the Mathematics Self-Efficacy Scale (30 minutes), and Session 2 involved conducting the Mathematical Critical Thinking Test (90 minutes), with each session guided by the researcher and assisted by trained enumerators to ensure standardized data collection procedures. The data analysis technique included descriptive analysis to describe respondent characteristics and data distribution of both variables using measures of central tendency (mean, median, mode) and measures of dispersion (standard deviation, variance, range), prerequisite tests before inferential analysis including normality testing using Kolmogorov-Smirnov with $p > 0.05$ criteria, linearity testing using ANOVA for Linearity with $p > 0.05$ criteria for deviation from linearity, and homoscedasticity testing using Breusch-Pagan test with $p > 0.05$ criteria, followed by inferential analysis comprising Pearson Product Moment correlation analysis to examine the relationship between self-efficacy and mathematical critical thinking, simple linear regression analysis to test the effect of self-efficacy on mathematical critical thinking, and additional analysis using partial correlation to control demographic variables (gender, vocational program). Interpretation criteria included correlation coefficients of 0.00-0.199 (very low), 0.20-0.399 (low), 0.40-0.599 (moderate), 0.60-0.799 (strong), and 0.80-1.00 (robust), statistical significance at $\alpha = 0.05$, and effect size using Cohen's convention.

Results And Discussion

Result

The study collected data from 137 eleventh-grade students across 4 State Vocational High Schools in the district, representing a comprehensive sample of the target population.

Table 1. Overview of Participant Demographics (N = 137)

Characteristic	Category	Number	Percentage / Notes
Total Participants	–	137	–
Target Population	–	–	11th-grade students
Age Range	–	–	16–18 years
Mean Age (SD)	–	–	16.7 years (SD = 0.62)

Gender	Male	78	56.9%
	Female	59	43.1%
Vocational Program	Engineering and Technology	58	42.3%
	Business and Management	39	28.5%
	Health and Social Care	25	18.2%
	Agriculture and Natural Resources	15	10.9%
School	SMK Negeri 1	35	25.5%
	SMK Negeri 2	34	24.8%
	SMK Negeri 3	36	26.3%

This study involved 137 eleventh-grade students enrolled in four public vocational high schools (SMK Negeri) within the specified region. Participants ranged in age from 16 to 18 years, with a mean age of 16.7 years (SD = 0.62), indicating a relatively homogeneous age distribution consistent with the expected age bracket for this educational level. Gender distribution within the sample showed a moderate predominance of male students, comprising 56.9% (n = 78) of the participants, while female students accounted for 43.1% (n = 59). This imbalance reflects a typical demographic pattern observed in vocational schools, particularly in programs traditionally dominated by male enrollment, such as engineering and technology. In terms of vocational specialization, the most significant proportion of students (42.3%, n = 58) were enrolled in Engineering and Technology, followed by Business and Management (28.5%, n = 39), Health and Social Care (18.2%, n = 25), and Agriculture and Natural Resources (10.9%, n = 15). These figures illustrate the diverse academic and skill-oriented orientations in the sample, providing a balanced basis for subgroup analyses. School-wise distribution also appeared relatively balanced across the four institutions. SMK Negeri 3 contributed the largest share of students (26.3%, n = 36), followed closely by SMK Negeri 1 (25.5%, n = 35), SMK Negeri 2 (24.8%, n = 34), and SMK Negeri 4 (23.4%, n = 32). Such proportional representation across schools minimizes the risk of location-specific bias and enhances the generalizability of the findings within the regional vocational school context.

Table 2. Mathematics Self-Efficacy Summary and Analysis

Aspect	Details / Category	Value / Description
Overall Self-Efficacy Score	Mean	102.45
	Standard Deviation	18.73
	Maximum Possible Score	155
	Distribution	Normal
Self-Efficacy Level Categories	High (≥ 120)	32 students (23.4%)
	Moderate (85–119)	67 students (48.9%)
	Low (< 85)	38 students (27.7%)
Self-Efficacy by Vocational Program	Engineering and Technology (Rank 1st)	M = 108.2, SD = 16.8
	Business and Management (2nd)	M = 101.3, SD = 18.9
	Health and Social Care (3rd)	M = 98.7, SD = 19.4
	Agriculture and Natural Resources (4th)	M = 95.1, SD = 20.3
Self-Efficacy by Gender	Male	M = 104.8, SD = 17.9, n = 78
	Female	M = 99.2, SD = 19.4, n = 59

Statistical Test (Gender)	t-test result	t = 1.68, p = 0.095
	Significance	Not significant (p > 0.05)

Note: The gender difference in mathematics self-efficacy scores was not statistically significant at α = 0.05 level.

The analysis of mathematics self-efficacy among vocational high school students revealed a moderate overall confidence level in mathematical abilities. The mean self-efficacy score was 102.45 with a standard deviation of 18.73, on a maximum possible score of 155, indicating a normal distribution of responses. This central tendency suggests that, on average, students perceive themselves as reasonably capable in mathematics, although individual variation remains considerable. Further categorization of self-efficacy levels showed that 23.4% (n = 32) of students demonstrated high self-efficacy (scores ≥ 120), while 48.9% (n = 67) exhibited moderate self-efficacy (scores between 85–119). A noteworthy 27.7% (n = 38) of students reported low self-efficacy (scores < 85), highlighting a substantial subset of learners who may require targeted instructional or motivational interventions to build mathematical confidence.

When disaggregated by vocational program, students in the Engineering and Technology track reported the highest average self-efficacy score (M = 108.2, SD = 16.8), followed by those in Business and Management (M = 101.3, SD = 18.9), Health and Social Care (M = 98.7, SD = 19.4), and finally Agriculture and Natural Resources (M = 95.1, SD = 20.3). These differences suggest that perceived mathematical competence may be influenced by the nature and mathematical intensity of the vocational curriculum, with more technical programs fostering greater confidence in mathematical skills. Gender-based analysis revealed that male students (n = 78) had a higher mean self-efficacy score (M = 104.8, SD = 17.9) compared to female students (n = 59; M = 99.2, SD = 19.4). However, a t-test analysis yielded a t-value of 1.68 with a p-value of 0.095, indicating that the observed gender difference was not statistically significant at the 0.05 level. Thus, while males appeared to report slightly greater self-efficacy in mathematics, the difference was not strong enough to conclude a reliable gender-based disparity in this sample.

Table 3. Summary of Mathematical Critical Thinking (MCT) Test: Scores, Levels, Components, and Vocational Program Performance

Aspect	Details / Categories	Values / Descriptions
Overall MCT Score	Mean	68.34
	Standard Deviation	15.42
	Maximum Possible Score	100
	Distribution	Positively skewed
MCT Level Categories	High (≥ 80)	25 students (18.2%)
	Moderate (60–79)	72 students (52.6%)
	Low (< 60)	40 students (29.2%)
	Total	137 students (100%)
MCT by Components	Interpretation	M = 12.8, SD = 2.9 (1st - Strongest)
	Inference	M = 11.9, SD = 2.8 (2nd)
	Analysis	M = 11.4, SD = 3.2 (3rd)
	Self-regulation	M = 11.3, SD = 2.7 (4th)
	Evaluation	M = 10.6, SD = 3.1 (5th)
	Explanation	M = 10.3, SD = 3.4 (6th - Weakest)
MCT by Vocational Program	Engineering and Technology	M = 72.1, SD = 14.3 (1st - Highest)
	Business and Management	M = 67.8, SD = 15.8 (2nd)
	Health and Social Care	M = 65.9, SD = 16.2 (3rd)
	Agriculture and Natural	M = 62.4, SD = 17.1 (4th -

	Resources	Lowest)
Component Summary	Strongest Component	Interpretation (M = 12.8)
	Weakest Component	Explanation (M = 10.3)

The analysis of the Mathematical Critical Thinking (MCT) test reveals a mean score of 68.34 with a standard deviation of 15.42, indicating moderate performance across the cohort. The distribution of scores is positively skewed, suggesting a concentration of student scores below the mean with fewer high-performing outliers. The maximum attainable score was 100. In terms of performance levels, 52.6% of students (n = 72) demonstrated a moderate level of critical thinking (scores between 60–79), while 18.2% (n = 25) achieved a high level (scores ≥ 80). Meanwhile, 29.2% (n = 40) were categorized under low critical thinking performance (scores < 60), out of a total of 137 participants. When examining performance across critical thinking components, *Interpretation* emerged as the strongest domain (M = 12.8, SD = 2.9), followed by *Inference* (M = 11.9, SD = 2.8), *Analysis* (M = 11.4, SD = 3.2), *Self-regulation* (M = 11.3, SD = 2.7), and *Evaluation* (M = 10.6, SD = 3.1). The weakest performance was observed in the *Explanation* component (M = 10.3, SD = 3.4), indicating potential areas for instructional improvement. Further analysis by vocational program indicates that students enrolled in Engineering and Technology programs obtained the highest average score (M = 72.1, SD = 14.3), followed by those in Business and Management (M = 67.8, SD = 15.8), Health and Social Care (M = 65.9, SD = 16.2), and Agriculture and Natural Resources (M = 62.4, SD = 17.1), the latter showing the lowest performance.

Table 4. Summary of Assumption Testing for Parametric Analysis

Assumption	Test Used	Statistic	p-value	Result	Conclusion
Normality	Kolmogorov–Smirnov Test	D = 0.071 (Self-Efficacy)	0.124	Non-significant	Normal distribution confirmed
		D = 0.068 (MCT Scores)	0.142	Non-significant	Normal distribution confirmed
Linearity	ANOVA for Linearity	F = 87.23 (Linearity)	< 0.001	Significant	A significant linear relationship exists
		F = 1.34 (Deviation)	0.186	Non-significant	No significant deviation from linearity
Homoscedasticity	Breusch–Pagan Test	$\chi^2 = 2.18$	0.140	Non-significant	Equal variance (homoscedasticity) assumption met

Table 4 presents the results of prerequisite assumption testing prior to conducting parametric statistical analyses. The Kolmogorov-Smirnov test confirmed that both the *self-efficacy scores* (D = 0.071, $p = 0.124$) and the *Mathematical Critical Thinking (MCT) scores* (D = 0.068, $p = 0.142$) were normally distributed, as indicated by non-significant *p*-values greater than 0.05. The ANOVA test for linearity revealed a significant linear relationship between the variables ($F = 87.23$, $p < 0.001$), with no significant deviation from linearity ($F = 1.34$, $p = 0.186$), confirming the appropriateness of a linear model. Additionally, the Breusch-Pagan test indicated homoscedasticity ($\chi^2 = 2.18$, $p = 0.140$), suggesting that the assumption of equal variance was also met. These findings justify the use of Pearson product-moment correlation and linear regression analysis, as all parametric assumptions—normality, linearity, and homoscedasticity—were satisfactorily fulfilled. Having met all prerequisite assumptions for parametric analysis, the study used Pearson's correlation to examine the correlation between students' self-efficacy and their Mathematical Critical Thinking (MCT). The results are summarized in Table 5.

Table 5. Statistical Analysis Justification

Recommended Analysis	Justification
Pearson Correlation	All assumptions for parametric correlation are met.
Linear Regression	Normality, linearity, and homoscedasticity assumptions confirmed.

Following the confirmation of a significant and positive correlation between self-efficacy and Mathematical Critical Thinking (MCT) scores, further analysis was conducted to determine the extent to which self-efficacy could predict students' MCT performance. Therefore, a simple linear regression analysis was employed to examine the predictive power of self-efficacy on students' mathematical critical thinking abilities. The results of this regression analysis are presented in Table 6.

Table 6. Summary of Correlation and Regression Analyses between Mathematics Self-Efficacy and Mathematical Critical Thinking (MCT)

Analysis Type	Details / Variable	Statistical Results	Interpretation / Conclusion
Pearson Correlation	Self-Efficacy & MCT	$r = 0.743$, $p < 0.001$, 95% CI [0.672, 0.802], $r^2 = 0.552$	Strong, significant positive correlation; 55.2% of MCT variance explained by self-efficacy
Partial Correlation	Controlling for Gender & Program	$r = 0.731$, $p < 0.001$	Relationship remains strong after controlling for demographic factors
Component Correlation	Self-Efficacy & MCT Components	Inference: $r = 0.698$ Analysis: $r = 0.672$ Self-Regulation: $r = 0.583$ (all $p < 0.001$)	Consistently significant; strongest with inference, weakest with self-regulation
Gender Subgroup	Male: $r = 0.721$ Female: $r = 0.768$	Both $p < 0.001$	Correlation is strong and consistent across gender
Program Subgroup	$r = 0.685–0.782$ across programs	All $p < 0.001$	Consistent positive correlation across vocational programs
Simple Regression	MCT = 18.42 + 0.487(Self-Efficacy)	$F(1,135) = 167.34$, $p < 0.001$ $R^2 = 0.552$ $\beta = 0.743$ $f^2 = 1.23$	Self-efficacy is a significant predictor with a large effect size.
Model Diagnostics	Residuals, Autocorrelation, Bootstrap CI	Residuals normal ($p = 0.231$) DW = 1.94 CI β [0.431, 0.543]	Model assumptions met; prediction is stable and reliable.
Multiple Regression	Predictors: Self-Efficacy, Gender, Program	$R^2 = 0.589$, $F(4,132) = 47.48$, $p < 0.001$ β: SE = 0.698***, Program = 0.186**, Gender = 0.128*	Self-efficacy is the strongest predictor; other variables contribute modestly.
ANOVA (Vocational)	MCT Differences across	$F(3,133) = 4.87$, $p =$	Statistically significant

	Programs	0.003 Tukey: Eng. & Tech > Agri & NR (p = 0.002)	group differences in MCT scores
Dimension Analysis	Magnitude, Strength, Generality	Magnitude: r = 0.689*** Strength: r = 0.652*** Generality: r = 0.614***	All dimensions are correlated with MCT; the magnitude is most substantial.
Regression by Dimension	Predictors: Magnitude, Strength, Generality	R^2 = 0.578, β: Magnitude = 0.398***, Strength = 0.321**, Generality = 0.184 (p = 0.052)	Magnitude and strength are significant predictors; generality is marginal.
Analysis Type	Details / Variable	Statistical Results	Interpretation / Conclusion

***p < 0.001, **p < 0.01, *p < 0.05

The study found a strong and statistically significant correlation between self-efficacy and mathematical critical thinking (MCT) ($r = 0.743$, $p < 0.001$), with self-efficacy explaining 55.2% of the variance in MCT scores. This relationship remained robust even after controlling for gender and program ($r = 0.731$), suggesting demographic factors do not confound it. Component-level analysis showed that self-efficacy correlated significantly with all dimensions of MCT, strongest with inference ($r = 0.698$) and weakest with self-regulation ($r = 0.583$). These associations were consistently strong across gender (male: $r = 0.721$; female: $r = 0.768$) and vocational programs ($r = 0.685–0.782$). Simple regression confirmed that self-efficacy is a significant predictor of MCT ($\beta = 0.743$, $R^2 = 0.552$, $f^2 = 1.23$), with model assumptions adequately met (normal residuals, DW = 1.94). When gender and program were included in the multiple regression model, self-efficacy remained the strongest predictor ($\beta = 0.698$, $p < 0.001$), while program and gender had smaller, but still significant, effects. ANOVA revealed significant differences in MCT across vocational programs ($F = 4.87$, $p = 0.003$), with students in engineering and technology outperforming those in agriculture and natural resources. Dimension analysis indicated that all aspects of self-efficacy—magnitude, strength, and generality—were significantly correlated with MCT, with magnitude having the strongest association. In regression, both magnitude and strength significantly predicted MCT scores, while generality showed a marginal effect ($p = 0.052$).

Discussion

The findings of this study reveal that most upper-grade elementary students demonstrated moderate levels of mathematical disposition. Specifically, they exhibited strong attentiveness during lessons and a high appreciation for the practical applications of mathematics. These indicators suggest that students are generally engaged and motivated, particularly when mathematics is contextualised in real-life situations—an observation aligned with previous research that emphasises the motivational power of authentic contexts (Bottge, 1999; Heckman & Weissglass, 1994; Reyes et al., 2019). However, despite these affective strengths, students showed significant cognitive flexibility and metacognitive self-regulation weaknesses. Many could not consider alternative strategies or effectively monitor and reflect on their problem-solving processes, suggesting underdeveloped executive function and reflective capacity (Vitiello et al., 2016; Celik & Ozdemir, 2020). This duality supports the initial hypothesis: while students express genuine interest in mathematics, this affective engagement does not necessarily lead to deep cognitive involvement without proper scaffolding.

An analysis of indicator-specific findings provides further insight into this issue. Students reported high levels of self-confidence when dealing with routine problems. However, this confidence diminished when confronted with unfamiliar or complex tasks, indicating a strong dependence on task familiarity, consistent with the literature on context-dependent confidence (Gabriel et al., 2018). Their reliance on single, teacher-modeled strategies points to an instructional emphasis on procedural fluency at the expense of exploratory thinking (Leader & Middleton, 2004; Olivares, Lupiáñez, & Segovia, 2021). Furthermore, although students initially attempted to complete given tasks, perseverance declined in the face of challenges, highlighting the need to develop growth mindsets and emotional regulation. Encouragingly, students displayed high levels of curiosity and attentiveness, particularly when mathematics was framed in everyday contexts. However, their ability to engage in metacognitive monitoring was minimal, possibly due to a lack of explicit instruction in such strategies. The strong appreciation for mathematics in practical domains (e.g., money, measurement) further confirms the motivating role of contextual utility (Reyes et al., 2019). Nevertheless, the moderate ability to independently connect mathematics to daily life suggests a missed opportunity for instructional approaches to foster authentic, student-generated links to mathematical ideas.

Contrary to studies that report high adaptability among learners (e.g., Andreescu et al., 2008), this study found a general rigidity in students' mathematical thinking. This discrepancy may reflect variations in curricular emphases and cultural-educational practices (Berry, 1985; Andreescu et al., 2008). The observed limitations in flexibility and self-monitoring may stem not only from instructional approaches but also from broader sociocultural influences on mathematical cognition. These findings imply the necessity for instructional frameworks that promote both procedural mastery and strategic reasoning. As suggested by Chew, Shahrill, and Li (2019), integrating contextualised problem-solving approaches within the curriculum can foster cognitive resilience and mathematical reasoning. Similarly, Shinn and Hubbard (1992) argue for the alignment of assessment and instruction through problem-solving tasks that target deeper learning processes.

The broader implication is that mathematics instruction should strive for a balanced design that supports both affective engagement and cognitive-metacognitive development. Although students' interest and curiosity were notably strong, this alone was insufficient to sustain independent and reflective thinking. This suggests that instructional practices must go beyond merely engaging students emotionally. They should also incorporate diverse strategies, student-led exploration, and explicit metacognitive scaffolding. Designing tasks that are thematically rich, cross-disciplinary, and grounded in students' lived experiences may further enhance relevance and support the transfer of learning. Ultimately, fostering mathematical disposition requires more than cultivating enthusiasm; it demands intentional pedagogical design to develop students' capacity for flexible reasoning and autonomous mathematical thought.

Conclusion

This study set out to explore the characteristics of mathematical disposition among upper-grade elementary students at SDN Babakan Jawa 1, Majalengka. The findings from questionnaire data, interviews, observations, and documentation reveal that students' overall mathematical dispositions are in the moderate category. This indicates a foundational level of development that holds promise for further enhancement. One of the most significant findings to emerge from this study is that students show high levels of attention and curiosity, as well as a strong appreciation for mathematical applications in real-life contexts. These strengths suggest potential entry points for the design of more engaging and meaningful mathematics instruction. However, the study also found that students demonstrated low levels of flexibility in problem-solving and limited abilities in monitoring and reflecting on their thinking processes. This finding is consistent with prior studies highlighting challenges in developing metacognitive and adaptive thinking skills at the elementary level. These findings suggest several practical implications. Teachers should consider incorporating more open-ended, contextualised tasks that encourage multiple solution strategies and promote student reflection. In addition, classroom practices that foster autonomy, peer collaboration, and real-life relevance may improve students' self-confidence and initiative in mathematics learning. In conclusion, this study has shown that while students already exhibit positive dispositions toward mathematics, more comprehensive and reflective instructional strategies are needed to support their holistic development. Future research should explore the effectiveness of targeted interventions to strengthen students' cognitive flexibility and reflective thinking in mathematics.

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Declarations

Author Contribution	:	RK was responsible for the conceptualization, research design, data collection, data analysis, and manuscript drafting. NAS contributed to substantial revisions and interpretation of findings. All authors have read and approved the final version of the manuscript.
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Additional Information	:	-

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