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Self-Efficacy, Mathematical Reasoning, and Mathematics Anxiety among Junior High Students: A Moderated Mediation Study

Fatin Rohmah Nur Wahidah[*1], Zahra Zakyatunissa[2], Tommy Tanu Wijaya[3]
[1,2] Universitas Muhammadiyah Purwokerto, Indonesia
[3]Beijing Normal University, China
fatinrohmahwahidah@ump.ac.id
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ABSTRACT
Mathematics anxiety is a persistent psychological barrier that negatively affects students' learning processes and academic performance in mathematics. While previous studies have examined psychological and cognitive predictors of mathematics anxiety, limited research has explored their interaction using an integrative moderated mediation framework. Using a cross-sectional design, data were collected from 145 Grade VIII students at an Indonesian public junior high school. The relationships among variables were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that self-efficacy significantly reduces mathematics anxiety and positively predicts mathematical reasoning. Mathematical reasoning also negatively predicts mathematics anxiety and partially mediates the relationship between self-efficacy and anxiety. In addition, self-efficacy moderates the relationship between reasoning and anxiety ($\beta = 0.149$), indicating that reasoning skills are more effective at reducing anxiety when students have greater confidence in their mathematical abilities. Mediation analysis further reveals that mathematical reasoning partially mediates the relationship between self-efficacy and mathematics anxiety. These findings highlight the critical interplay between psychological and cognitive factors in mitigating mathematics anxiety, suggesting that reducing anxiety requires a dual-track approach that strengthens students' mathematical reasoning while simultaneously fostering self-efficacy through confidence-supportive instructional practices such as problem-based and case-based learning.
Keywords: Mathematics Anxiety, Mathematical Reasoning, PLS-SEM, Self-Efficacy.

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Introduction

Mathematics plays a central role in students' cognitive development and serves as a foundational discipline for cultivating logical, analytical, and problem-solving skills. (Abayeva et al., 2024). Through mathematics instruction, students are trained to develop rational, critical, and systematic modes of thinking (Mata-Pereira & Ponte, 2017; Utami et al., 2025). In addition, mathematics education supports students' ability to think logically and creatively in processing information and mastering knowledge across various domains (Lovianova et al., 2022).

Despite its importance, mathematics is frequently perceived by students as an abstract and difficult subject, leading to negative learning experiences and unfavorable attitudes (Aguilar, 2021; Alemany-Arrebola et al., 2025). Many students regard mathematics as a subject to be avoided due to its perceived complexity, which often evokes tension, discomfort, and even fear and may disrupt the teaching–learning process (Wen & Dubé, 2022). When these negative emotional responses persist, they contribute to the emergence of mathematics anxiety, a psychological condition characterized by feelings of tension, apprehension, and worry when engaging with mathematical tasks (Caviola et al., 2021; Luttenberger et al., 2018).

Mathematics anxiety refers to feelings of tension, apprehension, and fear that interfere with mathematical performance (Ashcraft & Moore, 2009; Richardson & Suinn, 1972; Whyte & Anthony, 2012). Mathematics anxiety manifests in various situations, including before and after examinations, quizzes, challenging assignments, basic operations, and everyday applications. Mathematics anxiety has been widely recognized as a significant barrier to mathematics learning because it interferes with cognitive processing, reduces motivation, and negatively affects academic performance and long-term educational choices (Caviola et al., 2021; Khasawneh et al., 2021).

Two key factors in educational psychology that are frequently discussed as contributors to mathematics anxiety are self-efficacy and mathematical reasoning ability. Mathematics anxiety often arises from negative prior experiences, low confidence in completing mathematical tasks, and limited understanding of the application of mathematical concepts. Students who consistently receive low grades or struggle to solve mathematical problems are more likely to develop anxiety toward mathematics.

Self-efficacy refers to individuals' beliefs in their capabilities to organize and execute actions required to achieve specific outcomes (Bandura, 1977). Within the social cognitive framework, self-efficacy plays a central role in shaping how individuals approach challenges, regulate emotions, and persist in the face of difficulties. Bandura conceptualizes self-efficacy through three dimensions: level, which reflects confidence in dealing with varying levels of task difficulty; strength, which indicates the degree of certainty in overcoming obstacles; and generality, which represents beliefs about competence across different contexts. In educational settings, self-efficacy is considered a key psychological factor influencing students' engagement, persistence, and academic performance (Zimmerman, 2000).

Students with high self-efficacy tend to approach academic tasks with greater confidence, persistence, and adaptive emotional regulation. Such beliefs encourage students to engage more actively in learning, maintain motivation when encountering difficulties, and apply effective problem-solving strategies. Students who are confident in their abilities will be more enthusiastic and resilient, even when facing

Department of Mathematics Education, Universitas Muhammadiyah Purwokerto, Purwokerto, Indonesia
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various challenges and obstacles, because they trust their capacity to solve problems and achieve desired goals (Andres, 2020; Meng & Zhang, 2023; Miao, Guo, & Li, 2025). Conversely, students who doubt their abilities are more likely to experience fear, worry, and avoidance when facing challenging tasks, which may increase anxiety (Rodríguez et al., 2020). In the context of mathematics learning, strong self-efficacy beliefs enable students to persist in solving problems, interpret difficulties as part of the learning process, and regulate negative emotions, thereby reducing the likelihood of experiencing mathematics anxiety (Özcan & Gümüş, 2019; Živković et al., 2023).

Another important factor influencing mathematics anxiety is mathematical reasoning (Atoyebi & Atoyebi, 2022; Shimizu, 2022). Mathematical reasoning refers to the cognitive ability to analyze patterns, construct logical arguments, manipulate symbols, and draw valid conclusions when solving mathematical problems. This ability involves processes such as conjecturing, mathematical manipulation, justification, and conclusion drawing (Mofidi et al., 2012; Vebrian et al., 2021). Strong reasoning ability enables students to understand mathematical concepts more deeply and apply them systematically in problem-solving contexts (Medová et al., 2020). Conversely, insufficient reasoning ability often leads students to rely on imitation rather than conceptual understanding, which may increase uncertainty and anxiety when facing mathematical tasks (Habibi et al., 2021; Supriadi & Suherman, 2024).

Students with higher reasoning ability generally understand instructional material more quickly and are more efficient in solving reasoning-based problems (Lai et al., 2015; Zhu et al., 2024). Consequently, mathematical reasoning serves as a protective cognitive factor against mathematics anxiety. Differences in cognitive ability have also been linked to variations in mathematics anxiety, with higher cognitive competence associated with lower anxiety levels (Zeidner, 2007). Strong reasoning ability facilitates the evaluation of mathematical arguments, the development of new ideas, and the identification of appropriate solution strategies, thereby contributing to successful mathematics learning (Mozahem et al., 2020; Zou, 2025). Students with high self-efficacy tend to believe that mathematical problems can be logically analyzed and solved through reasoning processes. Such beliefs strengthen the role of reasoning in reducing mathematics anxiety, whereas low self-efficacy may weaken the protective effect of reasoning (Supriadi & Suherman, 2024; Zhu et al., 2024). Thus, mathematical reasoning is assumed to explain the relationship between self-efficacy and mathematics anxiety partially.

Given the background of the issues described, the researcher is interested in examining the relationships among self-efficacy, mathematical reasoning, and mathematics anxiety among students, particularly junior high school students. The emergence of mathematics anxiety can stem from the development of unpleasant attitudes and perspectives toward mathematics lessons. Anxiety can arise even before the learning process begins, and one of the factors that can play a role is the level of students' self-efficacy. Students with low self-efficacy tend to feel anxious more easily when facing these lessons. In addition, the ability of mathematical reasoning also plays an important role in the emergence of anxiety. Students with insufficient reasoning abilities may find it difficult to understand mathematical concepts, thus making them more prone to stress or fear when confronted with mathematical problems. Conversely, students with strong reasoning abilities are usually able to grasp patterns and solve problems more effectively.

Although previous studies have examined self-efficacy, mathematical reasoning, and mathematics anxiety independently, limited research has investigated their simultaneous direct, mediating, and moderating relationships, particularly at the junior high school level. Examining this moderating mechanism is theoretically important because cognitive ability alone does not guarantee low mathematics anxiety or high performance: students with strong reasoning skills may still feel anxious and underperform if they doubt their capability. Grounded in social cognitive theory, math self-efficacy shapes how effectively students can translate their cognitive resources into performance and regulate anxiety (Bandura, 1977; Pajares & Kranzler, 1995). Understanding how self-efficacy amplifies or attenuates the cognitive benefits of reasoning offers a more comprehensive explanation of individual differences in mathematics anxiety and outcomes. Therefore, this study aims to develop an integrative model explaining how self-efficacy and mathematical reasoning interact to influence mathematics anxiety among junior high school students. Based on the theoretical framework and empirical evidence, this study addresses the following research questions:

1. Does self-efficacy significantly affect mathematics anxiety among students?
2. Does mathematical reasoning significantly affect mathematics anxiety among students?
3. Does self-efficacy significantly affect students' mathematical reasoning?
4. Does self-efficacy moderate the relationship between mathematical reasoning and mathematics anxiety?
5. Does mathematical reasoning mediate the relationship between self-efficacy and mathematics anxiety?.

Methods

Research Design

This study employed a quantitative cross-sectional design to examine the relationships among self-efficacy, mathematical reasoning, and mathematics anxiety. Partial Least

Squares Structural Equation Modeling (PLS-SEM) was used to test the proposed direct, mediating, and moderating effects. PLS-SEM was selected due to its suitability for exploratory models, its robustness to non-normal data distributions, and its ability to simultaneously estimate complex models involving mediation and moderation (Hair et al., 2020).

Participants

The participants were 145 Grade VIII students from SMP Negeri 3 Sumbang, Purwokerto, Central Java, Indonesia (45 males and 100 females). All Grade VIII students enrolled at the school were included in the study using a total sampling technique. To ensure adequate statistical power, an a priori power analysis was conducted using G*Power 3.1 (Faul et al., 2009). Assuming a medium effect size (f^2 = 0.15), a significance level of α = 0.05, and statistical power of 0.80 with two predictors, the minimum required sample size was estimated to be 68 participants. Therefore, the sample size of 145 students in this study exceeds the minimum requirement and is considered sufficient for reliable parameter estimation in PLS-SEM analysis.

Grade VIII level students were selected because students at this stage have acquired foundational mathematical knowledge from previous grades while beginning to engage with more complex mathematical concepts, making them more susceptible to mathematics anxiety. Additionally, students at this level possess sufficient cognitive maturity to meaningfully engage with self-report measures and reasoning-based assessments. This study was approved by the Institutional Review Board of the Faculty of Psychology, Universitas Muhammadiyah Purwokerto, Indonesia (Approval No. C.9-VIII/855-S.Ph/F.Psi/V/2025).

Research Instruments

Data were collected using self-report questionnaires and a mathematical reasoning test. Content validity was established for all scales through expert judgment by lecturers and researchers in mathematics education.

Mathematics Anxiety Scale.

Mathematics anxiety was measured using the *Skala Kecemasan Matematika Siswa* (SKMS) developed by Nurkarim et al., (2024). The scale consists of 25 items assessing physiological, psychological, behavioral, and cognitive symptoms of mathematics anxiety. The instrument demonstrated excellent internal consistency (Cronbach's α = 0.925). All questionnaire items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate stronger levels of the measured construct.

Self-Efficacy Scale

Self-efficacy was measured using the Indonesian version of the General Self-Efficacy Scale (GSES), adapted by Novrianto et al., (2019). The scale consists of 19 items and demonstrated good internal consistency (Cronbach's α = 0.820). The instrument assesses individuals' beliefs in their capability to handle challenges and achieve desired outcomes across situations.

Mathematical Reasoning Test.

Mathematical reasoning was assessed using an essay-based test developed by the authors. The test consisted of eight open-ended items constructed based on the reasoning indicators proposed by Vebrian et al., (2021) dan Mofidi et al., (2012) The indicators included: (a) formulating conjectures, (b) performing mathematical manipulation, (c) constructing proofs and providing logical justifications, and (d) concluding. Each item was scored using a rubric with four performance levels ranging from 1 (incorrect or no response) to 4 (correct and complete response), shown in Table 1. Prior to the main data collection, the mathematical reasoning test was pilot-tested with 40 students from a different junior high school to evaluate item clarity and difficulty level. Feedback from the pilot study was used to refine the wording and scoring rubric of the items.

Table 1. Mathematical Reasoning Ability Assessment Rubric

No.	Indicators	Score	Performance/criteria
(a)	formulating conjectures	1	Cannot make an assumption
		2	Making an incorrect assumption
		3	Making an assumption, but incompletely
		4	Making an assumption correctly and completely
(b)	performing mathematical manipulation	1	Cannot manipulate mathematics
		2	Manipulates mathematics incorrectly
		3	Manipulates mathematics, but not completely
		4	Manipulates mathematics correctly and completely
(c)	constructing proofs and providing logical justifications	1	Cannot construct proof or provide reasoning
		2	Constructs proof and provides reasoning incorrectly
		3	Constructs proof and provides reasoning incompletely.
		4	Constructs proof and provides
(d)	drawing conclusions	1	Cannot conclude from the statements
		2	Concludes statements incorrectly
		3	Concludes statements incompletely
		4	Concludes statements correctly and completely

Department of Mathematics Education, Universitas Muhammadiyah Purwokerto, Purwokerto, Indonesia
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Data Collection Techniques

Data were collected via direct, face-to-face administration in the classroom. Prior to data collection, permission was obtained from the school administration and the teachers. Participants were informed of the study's purpose, and their participation was voluntary. During the data collection session, students were first asked to complete a personal information sheet containing basic demographic data. After that, they were instructed to take the mathematics test designed to measure their mathematical reasoning ability. To minimize scoring bias, student identities were anonymized during grading, and the scoring rubric was strictly applied. Once the test was completed, students proceeded to complete the questionnaire, which included the self-efficacy and mathematics anxiety scales. The entire data collection process was conducted during regular school hours under the supervision of the researchers and classroom teachers to ensure that students clearly understood the instructions and completed all instruments independently. The administration of all instruments required approximately 60-90 minutes.

Data Analysis Techniques

Data analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) following a two-stage approach. In the first stage, the measurement model was evaluated to assess indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Indicator reliability was examined using outer loadings, while internal consistency reliability was assessed using Cronbach's alpha and composite reliability (CR). Convergent validity was evaluated using the average variance extracted (AVE), with values above 0.50 indicating acceptable validity (Fornell & Larcker, 1981). Discriminant validity was assessed using both the Fornell–Larcker criterion and the Heterotrait–Monotrait ratio (HTMT) (Henseler et al, 2015).

In the second stage, the structural model was evaluated to test the hypothesized relationships among constructs. Path coefficients, t-values, and p-values were obtained using a bootstrapping procedure with 5,000 resamples. Effect sizes (f^2), coefficients of determination (R^2), and predictive relevance (Q^2) were also examined to assess the model's explanatory and predictive power. Moderation effects were tested by including an interaction term between self-efficacy and mathematical reasoning. Mediation effects were evaluated using bootstrapped indirect effects and confidence intervals. The analytical procedures followed established guidelines for reporting PLS-SEM results in psychology and education research (Hair, Hult, Ringle, & Sarstedt, 2022).

Result and Discussions

The measurement model was evaluated to ensure the reliability and validity of the latent constructs, namely mathematics anxiety, mathematical reasoning, and self-efficacy. Figure 1 presents the measurement model generated in SmartPLS, illustrating the relationships between the latent constructs and their indicators. The diagram shows the standardized outer loadings for each indicator and the structural paths connecting the constructs. As presented in Table 2, all retained indicators demonstrated satisfactory outer loadings above the recommended threshold of 0.70, except one self-efficacy item (SE9), which exhibited a loading of 0.691. This item was retained as its value was close to the cutoff and its removal did not improve composite reliability or average variance extracted, consistent with prior recommendations (Hair et al., 2013).

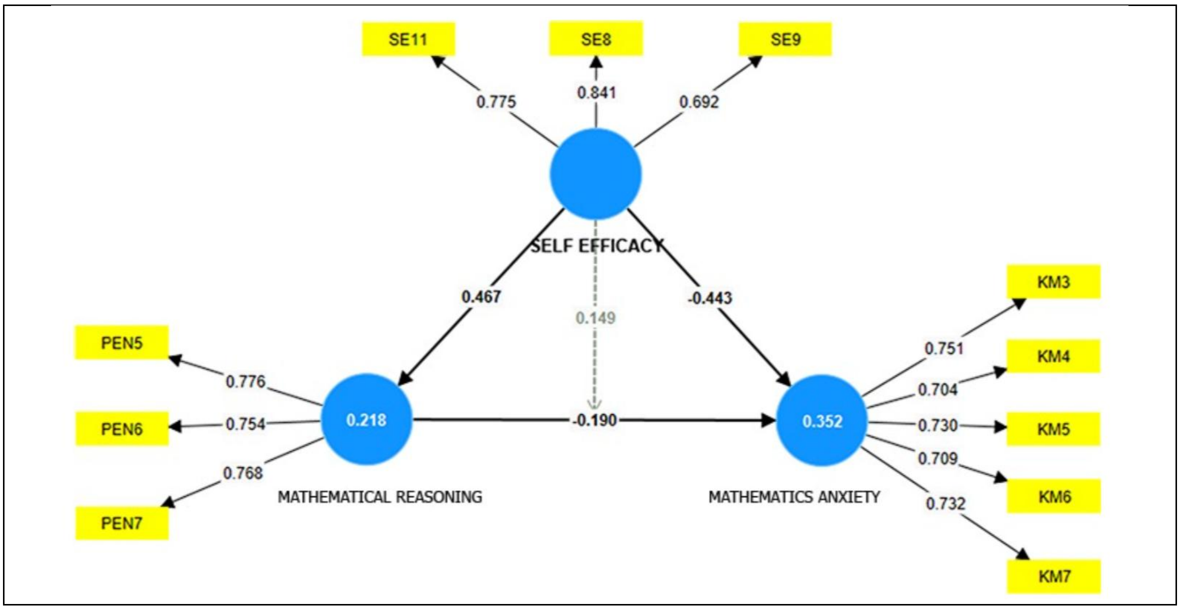

Figure 1. Measurement Model

Internal consistency reliability was supported, with Cronbach's alpha values ranging from 0.651 to 0.775 and composite reliability (CR) values exceeding 0.80 for all constructs, indicating acceptable to good reliability (Hair et al., 2013). Convergent validity was established, as the average variance extracted (AVE) values ranged from 0.526 to 0.595, exceeding the minimum criterion of 0.50 (Fornell & Larcker, 1981). These results indicate that each construct accounted for more than half of the variance of its indicators. Overall, the measurement model demonstrated adequate psychometric properties, supporting its suitability for subsequent structural model analysis in line with best practices in PLS-SEM reporting within psychology and education research (Henseler et al., 2009; Sarstedt et al., 2014).

Department of Mathematics Education, Universitas Muhammadiyah Purwokerto, Purwokerto, Indonesia
p-ISSN 2477-409X, e-ISSN: 2549-9084

Table 2. Measurement Model Evaluation

Variable	Items	Loadings	Cronbach Alpha	CR	AVE
Mathematics Anxiety	KM3	0.751	0.775	0.847	0.526
	KM4	0.704			
	KM5	0.730			
	KM6	0.709			
	KM7	0.732			
Mathematical Reasoning	PEN5	0.776	0.651	0.810	0.587
	PEN6	0.754			
	PEN7	0.768			
Self-Efficacy	SE11	0.775	0.661	0.814	0.595
	SE8	0.841			
	SE9	0.692			

Discriminant validity was assessed using both the Heterotrait–Monotrait ratio (HTMT) and the Fornell–Larcker criterion. As shown in Table 3, all HTMT values were below the conservative threshold of 0.85, indicating satisfactory discriminant validity among mathematics anxiety, mathematical reasoning, and self-efficacy (Henseler et al., 2015). Additionally, the square roots of the AVE values for each construct exceeded the corresponding inter-construct correlations, fulfilling the Fornell–Larcker criterion (Fornell & Larcker, 1981; Hair et al., 2013). Taken together, these findings confirm that the constructs are empirically distinct and suitable for structural modeling.

Table 3. Discriminant Validity

	KM	PEN	SE
Heterotrait-monotrait ratio (HTMT) – Matrix			
KM			
PEN	0.584		
SE	0.750	0.686	
PEN x SE	0.249	0.178	0.148
Fornell-Larcker criterion			
KM	0.725		
PEN	-0.417	0.766	
SE	-0.548	0.467	0.772

Note: **PEN**: Mathematical Reasoning, **KM**: Mathematics Anxiety, **SE**: Self Efficacy

The structural model was assessed to examine the hypothesized direct, mediating, and moderating relationships among the study variables. Bootstrapping with 5,000 resamples was employed to estimate path coefficients, confidence intervals, and significance levels. As reported in Table 4, mathematical reasoning had a significant negative effect on mathematics anxiety ($\beta = -0.190$, $p = .036$, $f^2 = 0.043$, 95% CI [−0.302, −0.006]), suggesting that students with stronger reasoning abilities tend to experience lower levels of mathematics anxiety. Self-efficacy also demonstrated a significant negative effect on mathematics anxiety ($\beta = -0.443$, $p < .001$, $f^2 = 0.236$, 95% CI [−0.549, −0.289]), and a significant positive effect on mathematical reasoning ($\beta = 0.467$, $p < .001$, $f^2 = 0.279$, 95% CI [0.326, 0.572]), indicating that students who believe in their mathematical capabilities tend to perform better in reasoning tasks and feel less anxious when learning mathematics.

The interaction effect between self-efficacy and mathematical reasoning on mathematics anxiety was statistically significant ($\beta = 0.149$, $p = .041$, $f^2 = 0.026$, 95% CI [0.004, 0.286]), indicating a moderating role of self-efficacy in the relationship between reasoning and anxiety. To better understand this interaction, a simple slope analysis was conducted and is presented in Figure 2. The simple slope results show that the negative relationship between mathematical reasoning and mathematics anxiety is strongest among students with low self-efficacy (−1 SD), moderate among students with average self-efficacy, and weakest among students with high self-efficacy (+1 SD). This pattern indicates that improvements in mathematical reasoning lead to a greater reduction in anxiety among students with lower confidence in their mathematical abilities.

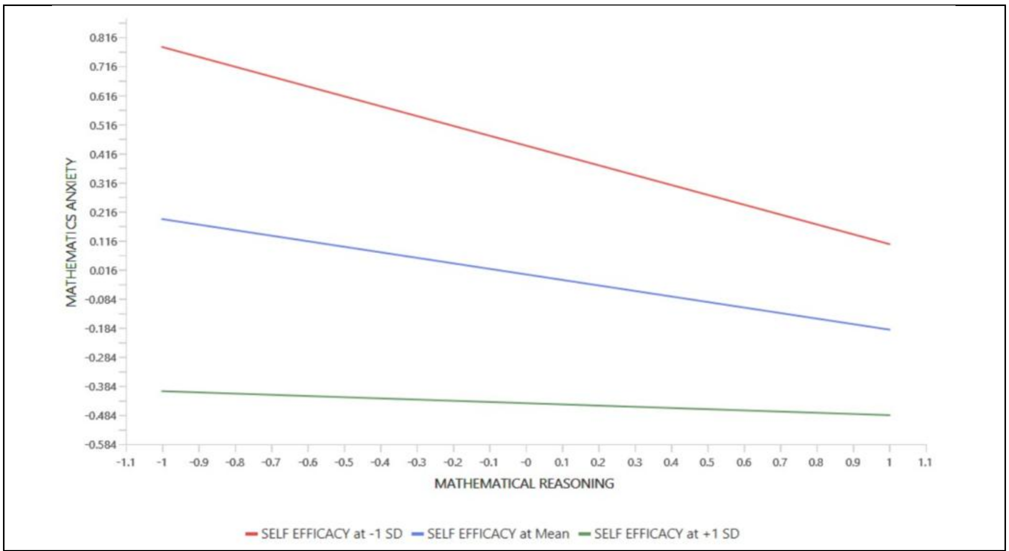

Figure 2. Simple Slope Analysis of the Moderating Effect of Self-efficacy on the Relationship between Mathematical Reasoning and Mathematics Anxiety

The mediation results further clarify the mechanism by which self-efficacy reduces mathematics anxiety. The findings indicate that mathematical reasoning partially mediates the relationship between self-efficacy and mathematics anxiety ($\beta = -0.089$, $p = .044$, 95% CI [−0.150, −0.005]). This suggests that students with higher self-efficacy are more likely to engage in effective reasoning processes when solving mathematical problems. Students with strong self-efficacy are more willing to engage in effortful cognitive activities, explore alternative solution strategies, and persist in problem-solving despite initial failure (Özcan & Gümüş, 2019; Živković et al., 2023). As students become more capable of analyzing relationships, constructing logical arguments, and identifying solution strategies, they experience greater cognitive control over mathematical tasks. This cognitive competence may subsequently reduce feelings of uncertainty and fear that often trigger mathematics anxiety. In this sense, mathematical reasoning serves as an important cognitive pathway through which motivational beliefs such as self-efficacy translate into lower levels of mathematics anxiety. Taken together, these findings suggest that self-efficacy plays a dual role in mathematics anxiety: it promotes reasoning ability that indirectly reduces anxiety, while simultaneously shaping the conditions under which reasoning becomes most effective in alleviating anxiety.

In addition, the model explained 35.2% of the variance in mathematics anxiety (R^2 = 0.352) and 21.8% of the variance in mathematical reasoning (R^2 = 0.218). Predictive relevance was supported, with Q^2 values of 0.268 for mathematics anxiety and 0.198 for mathematical reasoning, indicating adequate out-of-sample predictive capability (Hair et al., 2022). The findings in Table 4 affirm that enhancing self-efficacy plays an important role in reducing mathematics anxiety, both directly and through improved reasoning, and that the interaction between the two is also significant.

Table 4. Hypothesis Test

Path	β	**T statistics**	***P***	f^2	**CI**		**R²**	**Q²**
					LL	**UL**		
SE -> KM	-0.443	6.574	0.000	0.236	-0.549	-0.289	0.352	0.268
PEN -> KM	-0.190	2.099	0.036	0.043	-0.302	-0.006		
SE -> PEN	0.467	7.704	0.000	0.279	0.326	0.572	0.218	0.198
SE x PEN -> KM	0.149	2.039	0.041	0.026	0.004	0.286	n	
SE -> PEN -> KM	-0.089	2.016	0.044	n	-0.150	-0.005	n	

Note. **PEN**: Mathematical Reasoning, **KM**: Mathematics Anxiety, **SE**: Self Efficacy

As an additional analysis, independent samples *t*-tests were conducted to examine gender differences in self-efficacy, mathematical reasoning, and mathematics anxiety. The results are presented in Table 5. The analysis revealed a significant gender difference in self-efficacy, $t(143) = -4.05$, $p < .001$, with a medium-to-large effect size (Cohen's $d = -0.727$), indicating lower self-efficacy among female students. A significant difference was also found in mathematical reasoning, $t(143) = -4.86$, $p < .001$, with a large effect size (Cohen's $d = -0.873$), showing lower reasoning scores among female students. Furthermore, female students reported significantly higher levels of mathematics anxiety than male students, $t(143) = 2.83$, $p = .005$, with a medium effect size (Cohen's $d = 0.508$).

Table 5. Independent sample t-test

	Statistic	df	p	Mean difference	SE difference	Effect Size
Self-Efficacy	-4.05	143	< .001	-6.00	1.482	-0.727
Mathematical Reasoning	-4.86	143	< .001	-2.96	0.609	-0.873
Mathematics Anxiety	2.83	143	0.005	5.85	2.069	0.508

This study aimed to examine the interrelationships among self-efficacy, mathematical reasoning, and mathematics anxiety among junior high school students using a moderated mediation framework. These findings highlight the important interplay between cognitive and motivational factors in shaping students' experiences of mathematics anxiety. While mathematical reasoning generally helps reduce anxiety, its impact varies depending on students' levels of self-efficacy.

Consistent with social cognitive theory, The results confirm that self-efficacy is a central psychological determinant of mathematics anxiety (Bandura, 1977). Students with higher self-efficacy reported significantly lower levels of mathematics anxiety, supporting previous evidence that strong beliefs in one's capabilities facilitate emotional regulation and adaptive coping in challenging academic situations (Jameson et al., 2022; Živković et al., 2023). From a psychological perspective, self-efficacy influences how students appraise mathematical tasks—whether they are perceived as manageable challenges or as threatening demands. When self-efficacy is high, students are more likely to interpret difficulty as part of the learning process rather than as personal failure, thereby reducing anxiety responses.

This finding is in line with prior studies, which explain that self-efficacy plays an important role in influencing mathematics anxiety. When students have high confidence in their ability to understand and solve mathematics problems, they tend not to feel anxious or fearful when facing mathematics lessons. Conversely, low self-efficacy leads students to feel incapable, give up easily, and trigger higher levels of mathematics anxiety. This suggests that self-efficacy has a significant impact on mathematics anxiety, indicating that improving self-efficacy can directly reduce it (Rozgonjuk et al., 2020).

The lower a person's self-confidence in their abilities, the higher the level of anxiety they experience (Živković et al, 2023). Among the three aspects of self-efficacy, the strength aspect, or the conviction in one's own abilities, is the most influential in reducing mathematics anxiety in students. This aspect reflects the extent to which an individual believes they can face and complete tasks. Students with strong beliefs in their abilities tend to be calmer, more confident, and less prone to panic when solving

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math problems (Atoyebi & Atoyebi, 2022; Jameson et al., 2022; Shimizu, 2022). They also demonstrate persistence and are not easily discouraged, even when confronted with difficult problems, thereby reducing the likelihood of experiencing anxiety. Conversely, students with low strength tend to doubt their abilities, are more easily fearful, and experience stress more quickly in academic situations, including in mathematics (Supriadi et al., 2024; Zhu et al., 2024). Therefore, enhancing self-efficacy is expected to improve the management of anxiety.

The significant negative relationship between mathematical reasoning and mathematics anxiety underscores the protective role of cognitive competence. Students with stronger reasoning skills are better equipped to analyze mathematical structures, recognize patterns, and construct logical solution paths, thereby reducing uncertainty during problem-solving (Xu & Dieckmann, 2025). Reduced uncertainty, in turn, diminishes anxiety responses. This finding aligns with prior studies indicating that deficiencies in reasoning ability exacerbate students' vulnerability to mathematics anxiety (Živković et al., 2023).

Importantly, the mediation analysis revealed that mathematical reasoning partially mediated the relationship between self-efficacy and mathematics anxiety. This indicates that self-efficacy reduces anxiety not only by enhancing emotional resilience but also by strengthening cognitive competence. In other words, students who believe in their abilities are more likely to develop effective reasoning skills, which subsequently buffer them against anxiety. This mechanism provides a more nuanced explanation of how affective and cognitive pathways interact in shaping mathematics anxiety (Zou, 2025).

The most novel contribution of this study lies in the moderating role of self-efficacy in the relationship between mathematical reasoning and mathematics anxiety. The significant interaction effect suggests that reasoning skills are most effective in reducing anxiety when accompanied by strong self-efficacy beliefs. Cognitive competence alone may be insufficient to alleviate anxiety if students lack confidence in their abilities. A particularly noteworthy finding is that mathematical reasoning appears to play the strongest anxiety-reducing role among students with low self-efficacy. In other words, reasoning skills may serve as a compensatory mechanism for students who lack confidence in their mathematical abilities. When students with low self-efficacy understand mathematical relationships, construct logical arguments, and successfully solve problems, these cognitive successes may help them overcome feelings of anxiety and uncertainty. The significant interaction effect suggests that reasoning skills are most effective in reducing anxiety when accompanied by strong self-efficacy beliefs. Self-efficacy, therefore, operates as a psychological amplifier that determines whether cognitive resources can be optimally utilized under emotionally demanding conditions (Jameson et al., 2022; Palestro & Jameson, 2020). This finding helps explain inconsistencies in prior research where cognitive ability alone did not consistently predict lower anxiety levels.

The additional gender-based analysis further contextualizes the structural model findings. Female students reported lower self-efficacy and mathematical reasoning, alongside higher mathematics anxiety, compared to male students. From a psychological standpoint, lower self-efficacy may heighten female students' sensitivity to evaluative stress in mathematics-related contexts (Bergqvist, 2024; Rozgonjuk et al., 2020). From an educational perspective, these disparities are more likely attributable to socio-cultural factors—such as gender stereotypes, differential feedback, and classroom dynamics—rather than inherent differences in ability. These findings reinforce the importance of addressing both psychological beliefs and learning environments to reduce gender disparities in mathematics anxiety.

From a social cognitive perspective, lower self-efficacy among female students may increase their vulnerability to anxiety in mathematics-related contexts. According to Bandura's Social Cognitive Theory, self-efficacy shapes how individuals interpret task demands and regulate emotional responses. When students doubt their capabilities, mathematical challenges are more likely to be appraised as threatening, thereby eliciting heightened anxiety. In this context, the lower self-efficacy observed among female students may partially explain their higher levels of mathematics anxiety.

Furthermore, the lower reasoning scores among female students provide additional insight into the cognitive mechanisms underlying gender differences in mathematics anxiety. Reasoning ability serves as a critical cognitive resource, enabling students to process mathematical problems systematically and reduce uncertainty during problem-solving. As demonstrated in the SEM results, reasoning mediates the relationship between self-efficacy and mathematics anxiety. Therefore, gender disparities in reasoning ability may exacerbate the negative emotional impact of low self-efficacy, contributing to elevated anxiety among female students.

Importantly, these findings should not be interpreted as reflecting inherent gender differences in cognitive ability. Rather, they are more plausibly explained by contextual and socio-cultural factors, such as gender stereotypes in mathematics, differential socialization experiences, and variations in instructional support. Prior research has shown that negative stereotypes and reduced encouragement in mathematics can undermine girls' confidence and engagement, ultimately affecting both cognitive performance and emotional well-being.

Taken together, the gender-based differences observed in this study complement the moderated mediation model by illustrating how structural relationships operate differently across groups. The results suggest that interventions aimed at reducing mathematics anxiety should adopt a gender-sensitive approach, with particular emphasis on strengthening self-efficacy and supporting the development of reasoning skills among female students. Enhancing these psychological and cognitive resources may help mitigate gender disparities in mathematics anxiety and promote more equitable learning outcomes.

These results support an integrative perspective in educational psychology, positioning mathematics anxiety as an outcome of dynamic interactions between motivational beliefs and cognitive competence rather than as a purely emotional or skill-based phenomenon. Students who believe in their mathematical capabilities are better equipped to engage in reasoning, manage uncertainty, and regulate negative emotions when facing challenging mathematical tasks.

Taken together, the findings position mathematics anxiety as a product of dynamic interactions between affective beliefs and cognitive skills. For educational practice, this implies that interventions aimed at reducing mathematics anxiety should not focus exclusively on skill acquisition or emotional regulation in isolation. Instead, effective interventions should integrate strategies that simultaneously strengthen students' self-efficacy and promote reasoning-oriented learning experiences. Instructional strategies such as the case method and structured reasoning activities may help students develop deeper mathematical understanding while simultaneously strengthening their confidence. Integrating a case method approach provides a concrete instructional framework where students can collaboratively analyze deeply contextualized mathematical problems, thereby reducing individual anxiety and promoting collective reasoning.

From a psychological perspective, interventions that enhance self-efficacy—such as mastery experiences, constructive feedback, and supportive classroom climates—may play a critical role in mitigating mathematics anxiety. Guidance and counseling programs that integrate self-belief enhancement with anxiety-management strategies may further support students in developing adaptive responses to mathematical challenges. Given the observed gender differences, targeted interventions that support female students' self-efficacy and reasoning development may be particularly important for reducing disparities in mathematics anxiety. Importantly, such efforts should address socio-cultural influences and learning environments rather than attributing differences to inherent ability.

Several limitations should be considered. First, the cross-sectional design precludes causal inferences. Longitudinal or experimental studies are recommended to examine changes in self-efficacy, reasoning, and mathematics anxiety over time. Second, the study was conducted in a single public junior high school, which may limit generalizability. Future research should include more diverse samples across different regions and school contexts. Third, incorporating intervention-based designs could provide stronger evidence for effective strategies to reduce mathematics anxiety.

Conclusion

This study provides empirical evidence that the interplay between affective beliefs and cognitive abilities shapes mathematics anxiety among junior high school students. The findings demonstrate that self-efficacy directly reduces mathematics anxiety and simultaneously enhances mathematical reasoning, which in turn contributes to lower anxiety levels. Mathematical reasoning partially mediates the relationship between self-efficacy and mathematics anxiety. At the same time, self-efficacy also moderates the effect of reasoning on anxiety, highlighting its central role in determining whether cognitive resources can be effectively utilized in emotionally demanding learning contexts. These findings highlight the importance of integrating psychological and cognitive approaches in educational interventions. Instructional practices that simultaneously strengthen students' self-efficacy and reasoning abilities may provide an effective strategy for reducing mathematics anxiety and promoting more positive learning experiences.

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Author's Declaration

Author Contribution	:	**Author 1:** Conceptualization, methodology, formal analysis, writing – original draft preparation; reviewed and approved the final manuscript. **Author 2:** Data collection, data curation, writing – editing; reviewed and approved the final manuscript. **Author 3:** Validation, writing, review, and editing; reviewed and approved the final manuscript.
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Department of Mathematics Education, Universitas Muhammadiyah Purwokerto, Purwokerto, Indonesia
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