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Mathematical Conceptual Understanding as a Predictor of Self-Efficacy Among Fourth-Grade Students

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ABSTRACT

Mathematical conceptual understanding is fundamental to meaningful learning and to the development of students' self-efficacy, an affective factor closely associated with academic success. Despite extensive research on mathematics achievement, limited empirical studies have examined conceptual understanding as a predictor of self-efficacy in non-urban elementary contexts. This study investigated whether mathematical conceptual understanding predicts self-efficacy among fourth-grade students in public elementary schools in Adipala District, Central Java. Employing a quantitative correlational design, 120 students were selected through stratified random sampling. Data were analyzed using Pearson product–moment correlation and simple linear regression. The results revealed a significant positive correlation between conceptual understanding and self-efficacy ($r = 0.544$, $p < .001$). Regression analysis indicated that conceptual understanding significantly predicted self-efficacy ($\beta = 0.507$, $p < .001$), explaining 29.6% of the variance. These findings underscore the importance of concept-oriented instruction in strengthening both cognitive competence and students' confidence in elementary mathematics learning.

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1. INTRODUCTION

Mathematics education emphasizes the importance of conceptual understanding from the early stages of childhood. It functions as a fundamental foundation that supports the development of reasoning skills, analytical thinking, and effective problem-solving abilities (Santos trigo, 2024). This aligns with global educational principles that emphasize not only procedural mastery but also the formation of integrated and meaningful knowledge structures (Thomas et al., 2025). At the elementary level, the quality of learning is particularly crucial because this stage forms the foundation for cognitive patterns, learning attitudes, and students' academic readiness to face challenges in subsequent educational levels (Kim, 2024). Quality primary education not only imparts factual knowledge but also fosters reasoning, critical thinking, problem-solving, and logical decision-making skills in a sustainable manner (Karmila et

al., 2023). Therefore, successful mathematics learning in elementary school becomes a key determinant in developing the cognitive competencies necessary for lifelong learning.

In the formal education system, mathematics occupies a central role as a discipline that significantly contributes to the development of reasoning, logic, and problem-solving abilities. Learning mathematics is not merely a process of transferring procedures or mastering formulas but a systematic mechanism to build foundational conceptual understanding (Santos trigo, 2024). Conceptual understanding, particularly relational understanding, enables students to perceive the relationships between mathematical concepts, comprehend the logical basis of procedures, and apply knowledge across various problem contexts (Utomo, 2020). In contrast, purely procedural or instrumental understanding limits students to algorithmic mastery without the ability to explain or generalize concepts.

Emphasizing relational understanding also closely relates to the principle of learning that promotes knowledge transfer to new situations and the solving of non-routine problems (Orón & Lizasoain, 2023). Students with strong conceptual mastery not only solve routine problems accurately but also reason flexibly, develop alternative strategies, and explain the rationale behind the steps they take (Sofroniou et al., 2025). This process forms a cohesive, integrated, and adaptive knowledge structure, which provides an essential foundation for developing higher-order thinking skills, including critical reasoning, solving complex problems, and making evidence-based decisions (Richland & Zhao, 2026). In this context, mastery of mathematical concepts also serves as a source of mastery experience, which builds students' self-efficacy refers to an individual's confidence in their capacity to organize and carry out actions required to accomplish particular objectives.

Self-efficacy is an affective aspect that plays a crucial role in mathematics learning success. Strong self-belief influences how students face challenges, select learning strategies, maintain effort, and modify their strategies in response to the challenges they face (Zakariya, 2022). Learners who possess strong self-efficacy typically demonstrate persistence, flexibility, and greater creativity when solving problems, while those with low self-efficacy often experience higher levels of anxiety, avoid challenging tasks, and show diminished effort and endurance (Tao et al., 2025). Thus, conceptual mastery and self-efficacy form an interrelated link between cognitive and affective aspects that mutually reinforce one another in learning (Putro & Bernarto, 2024). Students with solid conceptual understanding are not only cognitively competent but also more confident, which, in turn, enhances their ability to face academic challenges effectively (Carcelén-fraile, 2025).

Empirically, students' mathematics learning outcomes in Indonesia still show suboptimal achievement, particularly in reasoning and problem-solving skills (Juandi & Dasari, 2024). Global assessments such as PISA, along with numerous national investigations, show that many primary school students face difficulties in mastering essential mathematical ideas, including fractions, basic computations, and the representation of problems (Boateng et al., 2018). This issue is more pronounced in non-urban areas, including Adipala District, Central Java, where learning environment factors, limited resources, and students' social backgrounds influence their ability to build conceptual understanding and self-efficacy. The gap between students' cognitive capacity and learning demands highlights the need for interventions that simultaneously strengthen conceptual understanding and develop self-efficacy.

Although mathematical conceptual understanding supports flexible knowledge construction (Ayeh, 2025), knowledge transfer, and problem-solving, and self-efficacy determines students' persistence and learning strategies, the predictive influence of conceptual mastery on self-efficacy in non-urban Central Java remains understudied. This empirical gap highlights the importance of conducting context-sensitive research that examines the link between cognitive and affective dimensions in mathematics education, so that the results guide the development of effective and locally relevant teaching strategies for elementary schools in non-urban settings.

Based on this theoretical and empirical foundation this study explores the effect of Mathematical Conceptual Understanding on the self-efficacy of fourth-grade students in Adipala District. Theoretically, it supports the implementation of social cognitive theory proposed by Bandura, particularly emphasizing the role of mastery experiences in non-urban elementary school environments (Amsari et al., 2024).

Practically, the findings support the implementation of Kurikulum Merdeka by strengthening learning that centers on conceptual understanding, which advances academic success while continuously strengthening students' confidence (Wati & Sidoarjo, 2024).

The research question is: to what extent does mathematical conceptual understanding influence the self-efficacy of fourth-grade students in Adipala District? The hypothesis is: there is a significant effect of mathematical conceptual understanding on the self-efficacy of fourth-grade students in Adipala District. The results of this study provide theoretical contributions to the development of Bandura's self-efficacy theory in the context of non-urban elementary education, while also offering practical implications for strengthening concept-based learning in primary schools.

2. METHODS

This research applied a quantitative correlational method to investigate the association between students' mathematical conceptual understanding and their self-efficacy, allowing investigation of naturally occurring relationships without manipulating instructional conditions, which ensured both practicality and ethical appropriateness in elementary classrooms (Cohen et al., 2018). The population consisted of all fourth-grade students aged 9–10 years from four public elementary schools in Adipala District (N = 120), and a stratified random sampling technique with proportional representation ensured balanced participation and minimized sampling bias.

Two instruments were used: a five-item essay test, selected to assess deeper conceptual understanding beyond rote memorization, focusing on analysis and problem-solving, and a self-efficacy questionnaire based on social cognitive theory, consisting of 44 positively and negatively phrased items, which were scored using a four-point Likert scale and were delivered with assistance from the teacher to guarantee students' understanding.

Instrument development followed a systematic procedure (Boateng et al., 2018), including formulation of indicators based on theoretical constructs, item construction, content validation by experts, pilot testing with students not included in the main sample, and evaluation of construct validity (Pearson r = 0.41–0.82, all items valid) and reliability (Cronbach's α= 0.730 for the conceptual understanding test; α = 0.903 for the self-efficacy questionnaire). Ethical approval was obtained from the Adipala District Education Office, school principals, and classroom teachers, with voluntary participation and strict maintenance of student data confidentiality (APA, 2020).

Data were analyzed using SPSS with tests of normality, linearity, Pearson product–moment correlation and simple linear regression were conducted to evaluate the extent to which conceptual understanding predicted self-efficacy R^2, which was reported to explain variance, and effect size was reported alongside regression results using (Jacob, 1988) to strengthen methodological rigor (Lakens, 2013; Ncube et al., 2024). Regression results indicated a significant predictive effect of mathematical conceptual understanding on self-efficacy (β= 0.507, $p < 0.001$), with a moderate explanatory contribution (R^2= 0.296).

3. FINDINGS AND DISCUSSION

3.1 Finding

This section presents the empirical findings derived from a quantitative analysis involving 120 fourth-grade students (N = 120), which was designed to examine both the relationship and the predictive effect of mathematical conceptual understanding on students' self-efficacy with (John & David j, 2018). The results were reported in a systematic and sequential manner aligned with the statistical procedures undertaken, encompassing: (1) rigorous evaluation of instrument quality through validity and reliability testing, (2) verification of statistical assumptions including normality and linearity tests, (3) analysis of the interrelationship between variables using Pearson correlation, and (4) assessment of predictive effects through simple linear regression, integrating regression coefficients and model adequacy testing (F-test). This structured approach was intended to strengthen methodological rigor, enhance clarity in data reporting, and ensure analytical coherence consistent with

the research objectives. All analyses were conducted using IBM SPSS Statistics with the significance level established at $\alpha = 0.05$.

Table 1. Mean Scores of Key Variables across Schools (N = 120)

School	Mathematical Conceptual Understanding (M)	Self-Efficacy (M)
SD Negeri Glempangpasir 01	91.74	136.83
SD Negeri Adipala 01	81.57	135.63
SD Negeri Wlahar 01	80.43	134.32
SD Negeri Karangbenda 01	78.81	130.33

Based on Table 1, descriptive results showed that SD Negeri Glempangpasir 01 had the highest mean scores in mathematical conceptual understanding (M = 91.74) and self-efficacy (M = 136.83), whereas SD Negeri Karangbenda 01 had the lowest scores in mathematical conceptual understanding (M = 78.81) and self-efficacy (M = 130.33). These findings indicated variation across schools and confirmed a positive trend between students' mathematical conceptual understanding and self-efficacy.

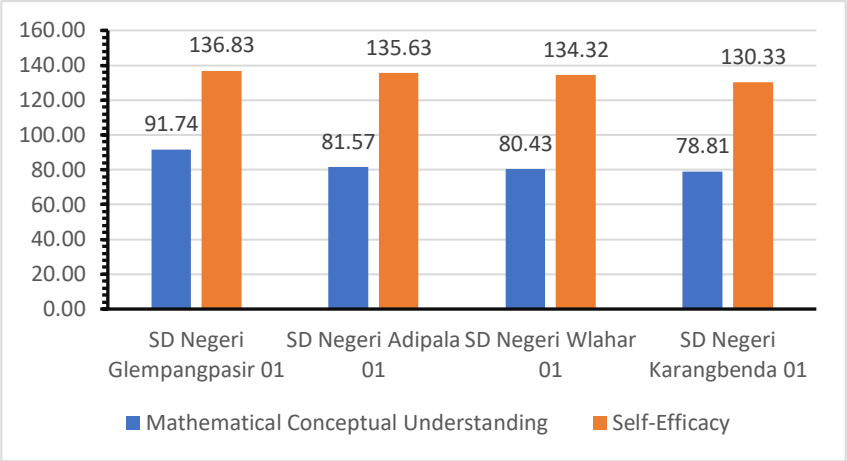

Figure 1. Mean Scores of Mathematical Conceptual Understanding and Self-Efficacy across Schools (N = 120)

Based on Figure 1, a positive pattern was observed in the association between students' mathematical conceptual understanding and their self-efficacy across multiple schools in Adipala. SD Negeri Glempangpasir 01 showed the highest scores in both conceptual understanding (M = 91.74) and self-efficacy (M = 136.83), while SD Negeri Karangbenda 01 had the lowest scores (M = 78.81; M = 130.33). These results indicated variation among schools and supported a positive relationship between conceptual understanding and self-efficacy, consistent with Bandura's mastery experience principle in non-urban school contexts.

Table 2. Quality of Research Instruments

Variable	N of Item	r-value Range	Cronbach's Alpha
Mathematical Conceptual Understanding	5	0.46 – 0.79	0.730
Self-Efficacy	44	0.41 – 0.82	0.903

Based on Table 2, all items in the mathematical conceptual understanding test (5 items) demonstrated item total correlation coefficients ranging between 0.46 and 0.79, whereas the self-efficacy instrument, consisting of 44 items, ranged from 0.41 to 0.82, exceeding the minimum criterion of 0.30.

The Cronbach's Alpha coefficients were 0.730 and 0.903, respectively, indicating good to very high internal consistency. Therefore, both instruments were considered valid and reliable for further analysis.

Table 3. Results of Statistical Assumption Testing

Assumption Test	Method	Sig.	Decision
Normality	Kolmogorov–Smirnov	0.200	Normal
Linearity	ANOVA Linearity	0.117	Linear

Based on Table 3, the Kolmogorov–Smirnov analysis produced a significance level of 0.200 (> 0.05), which indicated that the data followed a normal distribution. In addition, the linearity assessment generated a significance value of 0.117 (> 0.05), demonstrating the presence of a linear association between mathematical conceptual understanding and self-efficacy. Consequently, the prerequisite assumptions for conducting Pearson product–moment correlation and simple linear regression were met.

Table 4. Results of Pearson Correlation Analysis

Variables	r	Sig.	Strength of Relationship
Mathematical Concept Understanding – Self-Efficacy	.544	.000	Moderate to strong

Based on Table 4, a correlation analysis was performed to examine the link between students' mathematical conceptual understanding and their self-efficacy. The Pearson product–moment correlation produced a coefficient of 0.544 with a significance level of 0.000, signifying a statistically significant positive association of moderate magnitude between the variables. This result underscored substantial educational implications for mathematics learning achievement.

Table 5. Results of Simple Linear Regression Analysis

Predictor	r	β	t	p	F	R^2
Mathematical Concept Understanding – Self-Efficacy	0.544	0.507	7.045	< .001	49.626	0.296

Based on Table 5, Pearson product–moment correlation analysis demonstrated a statistically significant positive association between mathematical conceptual understanding and self-efficacy (r = 0.544, p < .001). The simple linear regression model was significant (F = 49.626, p < .001). Mathematical conceptual understanding positively predicted students' self-efficacy (β = 0.507, t = 7.045, p < .001), accounting for 29.6% of the variability in self-efficacy (R^2 = 0.296). Overall, the findings suggested that mathematical conceptual understanding contributed significantly to the development of students' confidence in mathematics learning.

3.2 Discussion

This study provides empirical evidence that mathematical conceptual understanding significantly predicts the self-efficacy of fourth-grade students in Adipala District. Pearson correlation analysis indicated that there was a significant positive relationship between conceptual understanding and self-efficacy (r = 0.544, p < .001). Simple linear regression analysis confirmed that conceptual understanding predicts self-efficacy (β = 0.507, t = 7.045, p < .001), explaining 29.6% of the variance. These results indicate that students with higher conceptual mastery approach mathematical tasks with greater confidence, employ reasoning strategies more effectively, and demonstrate persistence in problem-solving. Unlike procedural memorization, conceptual understanding enables students to interpret mathematical problems meaningfully, transfer knowledge to new contexts, and justify their solution

strategies (Purnomo et al., 2019). This aligns with the principles of the Kurikulum Merdeka, which emphasizes deep conceptual comprehension over procedural proficiency (Melati et al., 2025).

These results are consistent with previous studies that identified a positive association between conceptual understanding and self-efficacy among students in both primary and secondary education (Ahmed, 2025; Azis, 2025; Wijaya et al., 2025). The correlation found in this research (r = 0.544) is somewhat greater than the value previously reported r = 0.468 (Mafugu, 2025), highlighting a potentially stronger effect in non-urban elementary school contexts. This may be due to the greater affective influence of conceptual understanding compared to conventional predictors like test scores (Rozgonjuk et al., 2020). Conceptual understanding directly engages students' cognitive processes, supporting meaningful problem interpretation, comprehension of conceptual interrelationships, and strategic reasoning, rather than merely focusing on numerical achievement (Ncube et al., 2024).

Theoretically, these results support Bandura's social cognitive theory, which emphasizes mastery experiences as a key contributor to the development of self-efficacy (Bandura, 1982). In mathematics learning, genuine conceptual understanding allows students to experience authentic success, reinforcing both cognitive competence and confidence in their abilities (Passiatore et al., 2024; Purnomo et al., 2019). This supports international studies showing moderate positive correlations between conceptual understanding and self-efficacy emphasizing that, in non-urban contexts like Adipala, conceptual mastery may play a more central role due to limited learning resources and reliance on teacher-guided experiences.

The non-urban context of Adipala District is theoretically significant. Environmental constraints including limited classroom facilities, diverse socio-economic backgrounds, and smaller teacher to student ratios necessitate contextualized and individualized instruction (Boz et al., 2025). Teachers' use of scaffolding, one-on-one guidance, and iterative feedback enhances students' engagement with mathematical concepts, creating mastery experiences that increase self-efficacy (Regina et al., 2022). These findings underscore the moderating role of instructional and environmental factors in the cognitive affective relationship, highlighting the importance of context-sensitive approaches in non-urban education.

The novelty of this study lies in its quantitative demonstration that conceptual understanding predicts self-efficacy specifically in non-urban elementary schools, addressing a gap in literature that often emphasizes procedural competence. By linking cognitive understanding with self-efficacy in a localized context (Ho, 2021), the study reinforces Bandura's mastery experience framework and supports the Kurikulum Merdeka's goal of promoting meaningful learning.

Several theoretical and practical implications emerge, Mastery experiences derived from genuine conceptual understanding are critical for fostering self-efficacy (Gei, 2024). The findings also suggest a reciprocal relationship between cognitive competence and affective growth, indicating that interventions targeting conceptual understanding can simultaneously enhance confidence, persistence, and problem-solving resilience. Moreover, tailored instructional strategies in non-urban schools can amplify the effect of conceptual mastery on self-efficacy.

Practically, these results emphasize the importance of concept-based instructional strategies (Prastika & Purwanto, 2020). Teachers implement contextualized tasks, collaborative discussions, and concrete or visual representations to facilitate mastery experiences and deepen understanding (Edson et al., 2025). Feedback addresses both procedural accuracy and conceptual reasoning to build confidence incrementally (Tan et al., 2025). Curriculum and assessment frameworks integrate measures that evaluate students' conceptual understanding, reasoning processes, and flexible application of knowledge. Examples of *Kurikulum Merdeka* implementation include contextualized math projects, pattern-based games, and manipulative exploration to support authentic learning.

Concept-based instruction also promotes positive affective outcomes, reducing learning anxiety, avoidance behaviors, and negative attitudes toward mathematics (Hussein, 2023). Students who develop strong conceptual understanding demonstrate greater perseverance, positive learning attitudes, and resilience when facing academic challenges (Huang & Kou, 2025). This emphasizes the

holistic benefits of concept-focused instruction, where cognitive and affective development reinforce each other (Blanc et al., 2025).

Despite these contributions, this research presents certain limitations, as the sample is confined to fourth-grade students in Adipala, restricting generalizability to other grades or regions. The correlational design precludes causal inference. Future research should consider mixed-methods, longitudinal, or experimental approaches to explore causal mechanisms, track self-efficacy development over time, and examine instructional and environmental moderators more comprehensively.

In summary, this research underscores the crucial influence of mathematical conceptual understanding on the development of self-efficacy among elementary students in non-urban settings. Instruction that emphasizes conceptual understanding, contextualized learning, and personalized support fosters both cognitive skills and confidence, aligning with Bandura's mastery experience theory and the goals of *Kurikulum Merdeka*. These results offer practical guidance for teachers, curriculum designers, and policymakers seeking to enhance comprehensive and sustainable learning outcomes in non-urban elementary education.

4. CONCLUSION

This study offers empirical support that mathematical conceptual understanding serves as a significant predictor of self-efficacy among fourth-grade students in non-urban elementary schools in Adipala District. Students demonstrating stronger conceptual mastery show higher confidence, greater persistence, and more effective problem-solving, highlighting the critical role of deep conceptual learning in fostering both cognitive and affective development. From an educational standpoint, the results emphasize the value of concept-oriented instruction in line with the Merdeka Curriculum, encouraging teachers to apply contextualized tasks, visual and manipulable aids, and scaffolding techniques. Additionally, curriculum developers are recommended to design assessments that measure conceptual understanding, reasoning, and flexible problem-solving to strengthen sustained competence and confidence. The study's limitations include its correlational design, which limits causal conclusions, and a restricted sample size (N = 120 from four schools), which reduces the generalizability of findings to wider or urban populations. Future studies should adopt quasi-experimental designs to investigate the causal impact of concept-focused interventions and utilize mixed-method or longitudinal approaches to examine the progression of self-efficacy and affective processes among students and teachers in non-urban settings.

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