

Research Article

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Exploring the Influence of Self-Efficacy on Mathematical Modeling Ability Middle School Students in Landak Regency, West Kalimantan

Jeliana Intan Permata[✉], Mega Teguh Budiarto[✉], Yusuf Fuad[✉]

Abstract

Background/purpose. Self-efficacy plays a crucial role in enhancing performance in complex tasks such as mathematical modeling, yet its impact remains underexplored. This study examines whether there are influences on students' self-efficacy in modeling.

Materials/methods. The research method employs a quantitative design, utilizing regression analysis. This study involved all eighth-grade students in Landak Regency, West Kalimantan. The sample consisted of 133 students from three randomly selected schools, which were chosen from 18 A-accredited schools. The research instruments consisted of the Mathematical Modeling Test and the Self-Efficacy Questionnaire. Instrument valid using Aiken's V method, with 0.83 ($V \geq 0.4$). All 133 students have to complete two instruments. Scores from both instruments are classified into low, medium, and high categories. A simple linear regression analysis is utilized to examine the hypothesis: "Is there any impact of the self-efficacy (X) against the ability in mathematics modeling (Y)?". Applying SPSS v.26, the regression prerequisite test was met.

Results. The results of relationship between the capabilities of self-efficacy students and the ability students in mathematical modeling ($\text{Sig.} = 0.000 < 0.05$), with a regression equation $Y = -22.150 + 1.213X$, that shows every 1-point increase in self-efficacy is predicted to increase mathematical modeling ability by 1.213 points, obtained by 26.7% of the variance in students' mathematical modeling ability can be explained by their level of self-efficacy. The results analysis shows that students with high self-efficacy successfully completed all modeling phases, whilst low self-efficacy students demonstrated difficulties in formula application and accurate calculations.

Conclusion. These results emphasized the importance of strengthening self-efficacy to enhance mathematical modeling ability.

1. Introduction

Students often struggle with the abstract and complex nature of mathematical concepts, particularly when confronted with open-ended problems that require higher-order thinking and real-world applications. One such context is mathematical modeling, which demands not only procedural fluency but also conceptual understanding, cognitive endurance, and affective regulation. Modeling tasks typically involve interpreting real-world scenarios, identifying relevant variables, and translating them into mathematical representations (Stillman, 2012; Papaevripidou et al., 2014). Studies indicate that incorporating modeling activities in the mathematics classroom enhances students' ability to transfer conceptual understanding into application solutions (Blum & Ferri, 2009; Cevikbas et al., 2021). These tasks challenge students to integrate multiple competencies, making them a valuable yet demanding component of mathematics education.

Among the psychological factors influencing students' success in such tasks, self-efficacy—defined as students' belief in their capacity to organize and execute actions to achieve specific outcomes (Bandura, 1997)—has consistently been identified as a key determinant of academic performance (Pajares & Graham, 1999; Snyder & Lopez, 2002). Empirical studies have shown that students with high self-efficacy tend to persist longer in problem-solving, demonstrate greater resilience in the face of difficulty, and perform better in mathematics (Pajares & Schunk, 2005). Conversely, students with lower mathematical achievement often exhibit diminished confidence in their mathematical competence and reduced self-efficacy (Lee, 2009).

While numerous studies have examined the role of self-efficacy in predicting general academic outcomes—such as test performance, achievement emotions, and motivation (Gottfredson, 2002; Roth et al., 2015; Marsh et al., 2019)—its specific influence within the domain of mathematical modeling, particularly at the middle school level, remains underexplored. This gap is significant, given that mathematical modeling requires sustained engagement, strategic thinking, and emotional regulation—traits closely linked to self-efficacy.

The problem addressed in this study is the limited understanding of how self-efficacy affects students' ability to solve mathematical modeling problems at the junior high school level. Without such insights, instructional strategies may fail to support students' affective needs, especially in tasks that demand complex reasoning and persistence.

Accordingly, the purpose of this research is to examine the effect of students' self-efficacy on their ability to solve mathematical modeling problems. This study aims to investigate whether self-efficacy has a significant impact on students' modeling performance and, if so, to describe the nature of this influence in terms of strategy use, persistence, and accuracy.

To guide this investigation, the following research question is formulated: Does students' self-efficacy influence their ability to solve mathematical modeling problems at the junior high school level? By addressing this question, the study aims to contribute to the development of instructional approaches that integrate cognitive and affective dimensions of mathematical learning. The findings are expected to inform curriculum design and pedagogical interventions that foster both mathematical competence and psychological readiness in students.

2. Literature Review

2.1. Self-Efficacy in Mathematics Learning

Within the framework of social cognitive theory, self-efficacy represents a core construct that refers to an individual's belief in their capability to successfully perform specific tasks (Bandura, 1997). In the context of mathematics education, self-efficacy refers to students' confidence in their ability to solve mathematical problems and achieve academic goals through effort and effective

strategies, rather than relying on innate ability (McShane & Glinow, 2005). Numerous studies have shown that self-efficacy is a robust predictor of students' mathematical performance (Pajares & Graham, 1999; Liu, 2009; Lee, 2009). Students with high self-efficacy demonstrate greater persistence, adaptability, and resilience when solving non-routine problems, while those with low self-efficacy are more likely to avoid challenges, reduce effort, and disengage (Pajares & Schunk, 2005). Moreover, low mathematical achievement is often accompanied by a diminished sense of self-efficacy (Lee, 2009). In mathematical modeling contexts where open-ended and real-world problems must be approached flexibly, self-efficacy becomes particularly influential. Students who believe in their capacity to generate and validate multiple models tend to approach modeling tasks with greater initiative and depth (Czocher et al., 2019; Schukajlow et al., 2019). In this study, self-efficacy in mathematical modeling is defined as students' belief in their ability to execute the stages of the modeling process effectively and to derive meaningful mathematical solutions.

2.2. Mathematical Modeling Ability

Mathematical modeling ability is defined as the capacity to represent real world situations mathematically, construct viable models, and interpret or evaluate those models to propose relevant solutions (Blomhøj & Jensen, 2003; Niss et al., 2007). The modeling process itself typically includes the following stages: understanding, simplifying, mathematizing, working mathematically, interpreting, and validating (Blum & Leiß, 2007). Unlike traditional problem-solving approaches, modeling tasks call for the integration of several mathematical ideas and tools, as well as the capacity to navigate between the problem context and its mathematical representation (Lesh & Zawojewski, 2007). Mathematical modeling problems are inherently complex and demand advanced skills that connect mathematical concepts to real-world phenomena (Dede et al., 2017; Chong et al., 2019; Riyanto et al., 2019). Students must gain a thorough mathematical understanding of these problems before they can effectively address the revealed questions (Kaiser et al., 2006).

A thorough understanding of this ability is inherently connected to the mathematical modeling process itself (Maaß, 2006). Several studies describe the mathematical modeling process as involving the construction, simplification, structuring, mathematization, mathematical work, interpretation, validation, and communication of outcomes (Blum & Ferri, 2009). In this research, the descriptive six-phase model is adopted from Blum & Leiß (2007) as the analytical framework to characterize students' mathematical modeling ability, as shown in Figure 1.

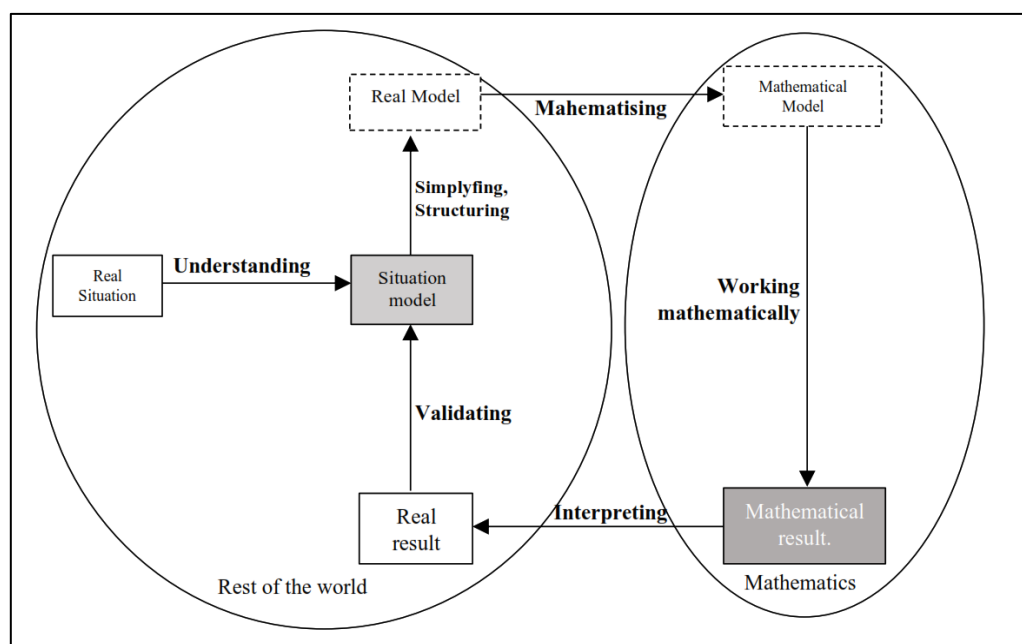


Figure 1. Modelling Proses (Adapted Blum & Leiß: 2007)

3. Methodology

3.1. Study Design

To address the primary research question: “Does students’ self-efficacy influence their ability to solve mathematical modeling problems at the junior high school level?” this study employed a correlational quantitative design using regression analysis to examine the predictive relationship between students’ self-efficacy and their mathematical modeling performance.

3.2. Study Population

The population in this study is all students in grade VIII of junior high schools in Landak Regency, Indonesia. From 104 junior high schools, public and private, 18 junior high schools with the national accreditation A are selected as subpopulations.

3.3. Study Sample

Furthermore, three schools were selected as research sites using purposive sampling based on accreditation status, school type (public and private), and accessibility for data collection. The selected schools include SMP Negeri 1 Ngabang, representing a public school with A-accreditation, and two private schools—SMP St. Benediktus Pahauman and SMP Maniamas Ngabang—both of which also hold A-accreditation and reflect diverse educational settings within the region.

Then, two classes from SMP Negeri 1 Ngabang are randomly chosen from six classes: the class VIIIB (19 girls and 14 boys) and the class VIIIC (13 girls and 17 boys). Whilst at SMP St. Benediktus Pahauman, two classes are randomly chosen from three classes, namely the class VIIIA (12 girls and 9 boys) and the class VIIIB (14 girls and 7 boys), and at SMP Maniamas Ngabang, one class is randomly chosen from two classes, namely the class VIIIA (16 girls and 12 boys).

3.4. Instruments

Two instruments are the Mathematical Modeling Test (MMT), which consists of four essay questions, covering social arithmetic, numbers, and geometry, which aims to measure students' mathematical modeling abilities, and the Self-Efficacy Questionnaire (SEQ), which is adapted and modification from Koyuncu et al. (2017) which is to relevant suit the context of mathematical modeling at the junior high school level. The SEQ utilizes a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). This questionnaire consists of 31 open-ended statements, which measure students' self-efficacy in the mathematical modeling process, including understanding, simplification, mathematization, mathematical problem solving, interpretation, and validation. Two instruments are validated by three associate professors and one mathematics teacher with a master's degree. Applying Aiken's V method, two instruments resulted in a validity value of $V = 0.83 (\geq 0.4)$.

3.5. Data Collection

Being supervised by researchers with the help of one mathematics teacher, all 133 grade VIII students have to complete the MMT in 90 minutes and respond to the SEQ in 45 minutes after a 30-minute break. Students' answers to the MMT are scored and grouped into three levels of ability, namely high ability with $score \geq 80$ (8 boys and 32 girls), medium ability with $65 \leq score < 80$ (11 boys and 21 girls), and low ability with the $score < 65$ (40 boys and 21 girls). Noted that all schools have the KKM (the minimum completion criteria) is 65 (maximum 100). On the other hand, students' responses to the SEQ are scored and grouped into three levels of ability, namely high ability with a $score \geq 80$ (4 boys and 17 girls), medium ability with $65 \leq score < 80$ (25 boys and 40 girls), and low ability with the $score < 65$ (30 boys and 17 girls).

3.6. Data Analysis

Applying SPSS v.26, the regression prerequisite tests were conducted, specifically examining the normality assumption for self-efficacy (Sig. = 0.100) and mathematical modeling ability (Sig. = 0.200), as well as heteroscedasticity (Sig. = 0.052), all of which were met (Sig. > 0.05). So, the prerequisites for the regression test were met. Before regression analysis, ordinal data from students' SEQ responses were converted to an interval scale used the Successive Interval Method. A simple linear regression analysis is utilized to examine the hypothesis: "Is there any significant impact of the capabilities of self-efficacy students (X) against the ability students in mathematics modeling (Y)?"

To complement and deepen the quantitative findings, a description analysis was conducted on students' written responses and interview data. Two students from the sample research were selected as research subjects based on the following criteria: one representing the high consistency (HS) and the other representing the low consistency (LS) category, characteristics of students' answers to explore students' mathematical modeling abilities based on written answers, and the research subjects were voluntary participants. By this, semi-structured interviews might provide an in-depth description of the pattern of solving mathematical modeling problems. Although a medium consistency category was identified, this study focuses solely on students from the high and low categories to highlight the contrasting patterns in mathematical modeling abilities. These two categories were chosen to provide a clearer depiction of the spectrum of student performance and to better capture the range of challenges and strategies observed. The selected students also voluntarily participated in interviews. Through these semi-structured interviews, the study aimed to gain an in-depth understanding of students' problem-solving patterns in mathematical modeling

4. Results

4.1. Mathematical Modeling Ability and Self-Efficacy Score

Table 1 displays data on student's mathematical modelling ability and self-efficacy based on the data collection results.

Table 1. Data on Students' Mathematical Modelling Ability & Self-Efficacy

Statistic	MMA	SE
n	133	133
Mean	62.19	69.53
Standard deviation	19.28	10
Highest student score	100	90.96
Lowest student score	25	35
High category (Score ≥ 80)	40	21
Medium category ($65 \leq \text{Score} < 80$)	32	65
Low category (Score < 65)	61	47

Table 1 shows that the mean score for MMA was 62.19 (Standard Deviation = 19.28), indicating a medium level of students' mathematical modeling ability. In contrast, the mean SE score was 69.53 (standard deviation = 10), suggesting a relatively high level of self-efficacy. The highest score in MMA reached 100, while the lowest was 25, showing a wide range of modeling competence. For SE, scores range from 35 to 90.96, indicating less variability compared to MMA. For MMA, 40 students (30.1%)

were in the high category, 32 students (24.1%) in the medium category, and 61 students (45.9%) in the low category. For SE, the distribution was notably different: only 21 students (15.8%) were in the high category, while the majority, 65 students (48.8%), fell into the medium category, and 47 students (35.3%) were in the low category.

These results suggest that while students generally report moderate levels of self-efficacy, their actual performance in mathematical modeling is more polarized, with nearly half falling into the low category. The discrepancy between self-perceived (SE) and actual performance (MMA) suggests the need for further investigation into how self-efficacy aligns with or diverges from students' demonstrated problem-solving abilities. It also highlights the importance of teaching strategies that not only build self-efficacy but also reinforce modeling competency.

Based on the data score the MMA has a validity score of 0.83 (valid), a reliability coefficient of 0.73 (reliable), a difficulty level value of 0.49 (easy category), and a discriminatory power of 0.62 (good category), whilst SE has a validity score of 0.87 (valid) and a reliability coefficient of 0.916 (reliable). Two instruments are therefore valid and reliable for measuring students' mathematical modeling abilities and self-efficacy in this research.

4.2. The Influence of Self-Efficacy on the Mathematical Modeling Ability of Students

Based on Table 1, this research aims to examine the hypothesis: "Is there any significant impact of self-efficacy (X) on the ability of students in mathematics modeling (Y)?" using a simple linear regression analysis. Applying SPSS v.26, the regression prerequisite test was met with a (Sig. > 0.05), conducted normality assumption for self-efficacy (Sig. 0.100) and mathematical modeling ability (Sig. 0.200), heteroscedasticity (Sig. 0.052).

The results of the relationship between the capabilities of self-efficacy students and the ability in mathematical modeling (Sig. = 0.000 < 0.05), with a regression equation $Y = -22.150 + 1.213X$, the equation is interpreted, intercept (-22.150) is the predicted value of mathematical modeling ability in the linear model, the regression equation represents the relationship between X and Y accurately. The regression coefficient (1.213) shows that every 1-point increase in self-efficacy is predicted to increase mathematical modeling ability by 1.213 points. In other words, there is a positive linear relationship between self-efficacy and modeling ability.

Based on the regression analysis, the adjusted R^2 value is 0.267. This suggests that 26.7% of the variance in students' mathematical modeling ability can be attributed to their level of self-efficacy. Although this indicates a moderate effect size, it also implies that other factors, such as prior mathematical knowledge, problem-solving strategies, or teaching context, may also play a role in shaping students' modeling performance. Nevertheless, the results confirm that self-efficacy is a significant predictor and support the stereotype that students' beliefs about their own abilities significantly influence their engagement and success in complex mathematical problems.

4.3. Description of Students' Mathematical Modeling Process: Analysis Based on Self-Efficacy

Following the regression analysis, which revealed a significant relationship between self-efficacy and students' mathematical modeling ability, a detailed analysis of students' responses on each modeling test was conducted. This description aimed to complement the statistical findings by uncovering the specific patterns, strategies, and errors exhibited by students across different levels of self-efficacy. All students who showed consistency in the high and low self-efficacy categories are purposively selected to illustrate a more detailed analysis. By this, semi-structured interviews might provide an in-depth description of the pattern of solving mathematical modeling problems. The research subject in solving problem number 2, which involves a geometric concept inspired by Talawang, a local ethnic war protector. Problem 2 is an open-ended problem that allows students to

choose their own Talawang dimensions. The results of the analysis showed that 40 high-category students were able to answer the question correctly, while no low-category students were able to do so.

The results of the answers and interviews with students in the HS are presented as follows.

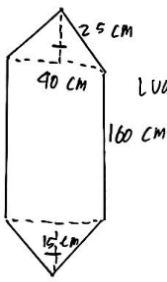
Dik : Panjang Talawang = 1 m ≤ D 2 m Lebar Talawang = 0,5 m Max tinggi Ujung Talawang ke alas = 15 cm Dit : Luas Talawang = ? 	Translation in English. Given: Length of Talawang = 1 m ≤ D 2 m Width of Talawang = 0.5 m maximum Height of Talawang tip to base = 15 cm Find: Area of Talawang Translation in English: Area Talawang
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Figure 2. Understanding and Simplifying Process

Figure 2, HS demonstrated comprehension by clearly identifying the given notification and the questions based on the problem statement and successfully simplified the problem by creating a design sketch of the Talawang based on the chosen dimensions.

$L\Delta \text{ dan } 2 = \frac{1}{2} \times a \times t$ $= \frac{1}{2} \times 40 \text{ cm} \times 15 \text{ cm}$ $= 20 \text{ cm} \times 15 \text{ cm}$ $= 300 \text{ cm}^2 \times 2$ $= 600 \text{ cm}^2$ $= 6 \text{ m}^2$ $LUAS \text{ Talawang} = L\Delta \text{ dan } 2 + L\square = 6 + 64 = 70 \text{ m}^2$	Translation in English: $L\Delta_{1 \text{ and } 2} = \frac{1}{2} \times a \times t$ $= \frac{1}{2} \times 40 \text{ cm} \times 15 \text{ cm}$ $= 20 \text{ cm} \times 15 \text{ cm}$ $= 300 \text{ cm}^2 \times 2$ $= 600 \text{ cm}^2$ $= 6 \text{ m}^2$ Area Talawang $= L\Delta_{1 \text{ and } 2} + L\square$ $= 6 + 64 = 70 \text{ m}^2$	$L\square = p \times l$ $= 160 \times 40$ $= 6400 \text{ cm}^2$ $= 64 \text{ m}^2$
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Figure 3. Mathematizing Process and Working Mathematically

Figure 3: HS wrote the equations to calculate the geometric shapes comprising the Talawang, as well as the equation for determining the area of the Talawang, and was able to record the calculations performed and obtain the correct mathematical solution.

$LUAS \text{ Talawang} = L\Delta \text{ dan } 2 + L\square = 6 + 64 = 70 \text{ m}^2$ Jadi, luas Talawang 70 m²	Translation in English: $\text{Area Talawang} = L\Delta_{1 \text{ and } 2} + L\square$ $= 6 + 64 = 70 \text{ m}^2$ So, area Talawang 70 m²
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Figure 4. Interpreting Process

Figure 4, HS successfully wrote a conclusion consistent with the context of the question and accurately interpreted the mathematical solution derived. During the interview, the student explained the question as a problem related to the Talawang at home, described the simplification process, particularly in calculating its area, and justified using equations as a problem-solving strategy and correctly solved the problem, linked the result to its context, and confirmed its accuracy after rechecking the modeling process. The mathematical modeling process is illustrated in Figure 5, which is adopted from Pirie-Kieren (1989).

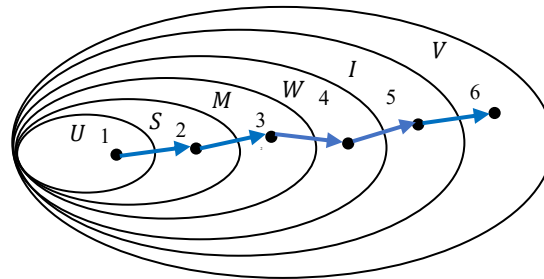


Figure 5. The Modeling Process Conducted by HS

Figure 5 describes the modeling process by students in the high category. The results of this analysis support the results of the regression test that has been carried out; there is an influence of student self-efficacy on mathematical modeling ability. As seen, students with high self-efficacy capability are able to carry out the entire mathematical modeling process.

The results of the answers and interviews with students in the LS are presented as follows.

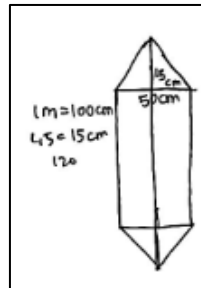


Figure 6. Simplifying Process

Figure 6, LS did not record the given notification or the question requirements. Instead, the written response directly included a diagram created during the simplification process, successfully creating a drawing as a simplification step in the problem-solving procedure. The dimensions shown in the drawing accurately correspond to the notification provided in the question.

	Translation in English:
$L_1 = 100 \text{ m}$ $L_2 = \frac{1}{2} \times a \cdot t$ $= \frac{1}{2} \times 50 \times 15$ $= 375 \text{ cm}$ $L_3 = \frac{1}{2} \times a \cdot t$ $= \frac{1}{2} \times 50 \times 15$ $L_{\text{talawang}} = L_{\text{Parsagi, Panian}} + L_1 + L_2$ $= 3500 + 375 + 375$ $= 9911$	$L_1 = \text{rectangle area} = p \times l$ $= 70 \times 50$ $= 3500 \text{ cm}^2$ $L_2 = \frac{1}{2} \times a \cdot t$ $= \frac{1}{2} \times 50 \times 15$ $L_{\text{talawang}} = L_{\text{rectangle}} + L_1 + L_2$ $= 3500 + 375 + 375$ $= 9911$

Figure 7. Mathematizing and Working Mathematically Process

Figure 7, LS was inconsistent in using symbols, for example in the formula for the area of a triangle, $L_2 = \frac{1}{2} \times a \cdot t$. LS made calculation errors. The section in the table reveals that the student was unable to complete the mathematical process to determine the total area of Talawang and did not provide a written answer at the interpretation level. During the interview, LS demonstrated their understanding through a drawing, recalling a Talawang at home to aid comprehension, and explained sketched it based on chosen dimensions but struggled with multiplication and addition, and acknowledged potential inaccuracies in the drawing and in identifying the geometric shapes and formula used to calculate its area.

Based on data answers written and interviews, the mathematical modeling process carried out is presented in Figure 8, which is adopted from Pirie-Kieren (1989).

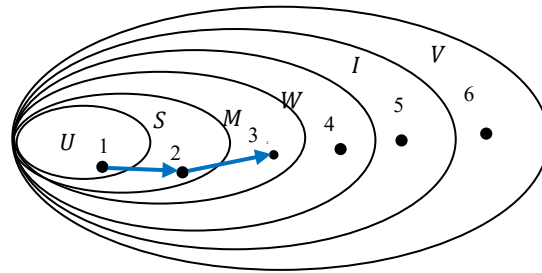


Figure 8. The Modeling Process Conducted by LS

Figure 8 presents the modeling process carried out by students with low categories. The results of this analysis support the findings of the regression test that was carried out; there is a significant influence of student self-efficacy on mathematical modeling abilities. As seen, students with low self-efficacy abilities are limited in carrying out several mathematical modeling processes.

5. Discussion

The results emphasize that self-efficacy forms as a significant predictor of students' mathematical modeling ability, aligning with previous research that positions self-efficacy as a critical mediating factor between academic performance and problem-solving behavior (Honick & Broadbent, 2016; Holenstein et al., 2021). Consistent with social cognitive theory, students' beliefs about their own capabilities influence not only strategies they adopt when solving problems, but also their persistence, effort, and resilience when engaged in cognitively demanding tasks such as mathematical modeling (Bandura, 1997).

Quantitative analysis revealed a statistically significant positive effect of self-efficacy on modeling performance, particularly students classified as having high self-efficacy (HS). These students demonstrated the ability to engage fully with each modeling process-understanding, simplifying, mathematizing, working mathematically, interpreting, and validating-and produced structurally sound, contextually relevant models. In contrast, students with low self-efficacy (LS) often display initial comprehension of contextual problems, particularly when the context was familiar or culturally resonant (Orey & Rosa, 2018), but encountered challenges in mathematizing and validating their solutions. This limitation appears to stem not from a conceptual misunderstanding, but from a reduced confidence in applying formulas and procedures accurately.

Student with high self-efficacy were also more likely to exhibit metacognitive awareness, regulate their cognitive processes, and respond adaptively to challenges (Stillman, 2011). This was reinforced through written responses and interview data, where HS students were found to justify assumptions, revise models, and validate solutions independently-practices less frequently observed in the LS group. These findings support prior studies indicating that mathematical modeling

instruction has the dual capacity to strengthen both problem-solving skills and affective dispositions such as self-efficacy (Kohen et al., 2019; Schukajlow et al., 2019; Omar et al., 2024).

Importantly, students with learning difficulties or histories of low achievement tend to exhibit reduced self-efficacy, which in turn undermines their willingness to persevere through multi-step problem-solving tasks (Jungert & Anderson, 2013; Larsen & Jang, 2022). This study contributes to the literature by demonstrating that self-efficacy not only influences overall modeling performance but also shapes how students engage with each stage of the modeling process. The integration of regression analysis, written response evaluation, and interview findings revealed a consistent pattern: students in the high self-efficacy category demonstrated a more complete and coherent modeling cycle, successfully navigating all six stages, from understanding the problem to validating, often with strategic reflection and self-monitoring. In contrast, students in the low self-efficacy category tended to struggle early in the process, particularly in mathematizing and validating stages, and often exhibited fragmented or incomplete modeling attempts.

These results extend previous research by offering a stage-specific interpretation of how self-efficacy manifests in mathematical modeling behavior. Rather than viewing self-efficacy as a general trait, this study highlights its dynamic role in guiding students' decisions, persistence, and cognitive regulation throughout the modeling process. This nuanced understanding underscores the need for instructional designs that explicitly support the development of self-efficacy at each stage of modeling.

Furthermore, the empirical validity and reliability of the modeling instruments used in this study strengthen the credibility of the observed performance differences. The inability of some students, particularly those with low self-efficacy, to complete the modeling process cannot be attributed to flaws in the assessment tools, but rather to psychological and instructional factors. It is essential to recognize that self-efficacy is not merely an observable skill but an internal belief influencing students' application of knowledge (Snyder & Lopez, 2002).

In light of these findings, interventions aimed at enhancing self-efficacy, such as structured feedback, culturally relevant modeling contexts, and gradual scaffolding, may yield significant benefits for students' modeling proficiency and overall mathematical development (Siegle & McCoach, 2007; Schukajlow et al., 2019). Future research should explore self-efficacy not merely as an independent variable, but as a moderating construct that influences how students navigate and respond to each stage of the modeling process.

6. Conclusion

The results demonstrate that self-efficacy has a significant influence on students' mathematical modeling ability, as evidenced by the regression analysis. Students with higher self-efficacy are more confident in approaching and solving modelling-based mathematical problems, demonstrating greater persistence and optimism. They successfully complete all stages of the modelling process. Conversely, students with lower self-efficacy tend to struggle, particularly when applying formulas and performing calculations, despite engaging in the initial phases of problem-solving.

These patterns are further supported by the empirical validity and reliability of the instruments used to assess mathematical modeling ability. The instruments were rigorously tested and confirmed to be both valid and reliable, ensuring that the observed differences in students' modeling performance were not artifacts of measurement error. Therefore, the inability of some students, particularly those with low self-efficacy, to complete the modeling process cannot be attributed to flaws in the assessment tools. Rather, it highlights the influence of other factors, with self-efficacy emerging as a crucial determinant.

These results suggest that, while self-efficacy plays a significant role, other factors, such as instruction quality, access to learning resources, and environmental support, may also contribute to students' mathematical modeling abilities. Strengthening self-efficacy through targeted interventions could further enhance their problem-solving skills in mathematical modelling. The future research should explore targeted instructional strategies and interventions aimed at strengthening self-efficacy, particularly among students who struggle with complex mathematical tasks.

Based on the findings, it is recommended that educators implement modeling-based tasks with structured feedback to build students' confidence and persistence. Schools should provide targeted interventions such as peer mentoring and problem-solving workshops to strengthen self-efficacy, especially among students who struggle with complex mathematical tasks. Curriculum designers and policymakers are encouraged to integrate affective components into mathematics instruction, while teacher training programs should equip educators with strategies to foster self-efficacy in diverse learners.

6.1. Limitations and Suggestions for Future Research

Despite demonstrating a significant influence of self-efficacy on students' mathematical modeling ability, this study acknowledges several limitations that warrant consideration. First, the analysis focused solely on self-efficacy without accounting for other contributing factors such as instructional quality, access to learning resources, or socio-emotional support, which may also shape students' modeling performance. Second, the sample was limited to three schools within a specific region, potentially constraining the generalizability of the findings. Third, While the modeling instruments used were empirically validated and shown to be reliable, the study did not incorporate qualitative methods that could provide deeper insights into students' cognitive and affective experiences during problem-solving. Future research should explore multi-factorial models that integrate both psychological and contextual variables, employ qualitative approaches to capture students' modeling strategies and reflections, and design targeted interventions to strengthen self-efficacy, particularly among students who struggle with complex mathematical tasks.

7. Suggestion

The implications of this research suggest the importance of enhancing the teaching of mathematical modeling in schools through a structured STEM-based approach that considers students' mathematical modeling abilities and self-efficacy. Further research with larger and more diverse samples could strengthen the generalizability of these findings. Teachers are advised to design effective learning programs or pedagogical approaches designed to enhance students' self-efficacy and its impact on their mathematical modeling competencies. Scaffolding-based learning interventions, such as formative scaffolding, are recommended to improve basic numeracy literacy, which serves as an important foundation for supporting more complex mathematical modeling processes.

Declarations

Author Contributions. Jeliana Intan Permata is responsible for creating articles and instruments, collecting research data, and overseeing the overall research. Mega Teguh Budiarto focuses on analyzing the collected research data, while Yusuf Fuad contributes to article creation, assists in data analysis, validates the instruments, and oversees the overall research. All authors have read and approved the published on the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

Ethical Approval. This study was reviewed and approved by the Institutional Review Board of Universitas Negeri Surabaya, Indonesia, under protocol number (letter number:

B/23583/UN38.3/LT.02.02/2023). All procedures followed the ethical standards of the institution. Informed consent was obtained from all participants prior to data collection.

Data Availability Statement. The data supporting the findings of this study are available upon request from the first author. The data are not publicly available due to privacy or ethical restrictions.

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