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Metacognitive skills in low self-efficacy students: A case study of junior high school students in the using of the Pythagorean theorem

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Abstract

Metacognitive skills are increasingly acknowledged as a decisive determinant of mathematical proficiency, as they enable students to plan, monitor, and evaluate their cognitive strategies in problem-solving. However, empirical studies rarely focus on how these skills are exhibited by students with low self-efficacy, a population particularly vulnerable to persistent underachievement in mathematics. Addressing this gap, the present study provides novel insights into the metacognitive functioning of low self-efficacy students when engaging with problem-solving tasks, specifically in the context of the Pythagorean Theorem. The study aimed to describe the manifestation of metacognitive skills among junior high school students with low self-efficacy and analyze their problem-solving strategies and underlying thought processes. Employing a descriptive qualitative design, participants were identified as low self-efficacy students using a standardized questionnaire. Data were obtained from self-efficacy questionnaires, problem-solving tasks, and semi-structured interviews, and subsequently analyzed through metacognitive indicators embedded within Polya's problem-solving framework. Findings indicate that while low self-efficacy students exhibited consistent awareness and evaluative monitoring, their regulatory skills were less developed, particularly in the reviewing stage of problem-solving. Although planning and assessment strategies were evident, frequent errors required iterative adjustments before arriving at correct solutions. These results highlight the intertwined relationship between metacognition and affective-motivational factors, suggesting that mathematics instruction should explicitly integrate self-efficacy enhancement with metacognitive training. The study contributes to advancing the theoretical discourse on mathematics learning and offers practical implications for designing instructional models that accommodate learners with diverse motivational profiles.

Keywords: Metacognitive Skills, Problem Solving, Pythagorean Theorem, Self-Efficacy

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Mathematics represents a fundamental mode of human thought, encompassing ideas, processes, and reasoning. It is not merely a collection of numbers and formulas but rather a product of abstraction, systematic reasoning, and cognitive organization developed to make sense of the world. Mathematics arises from the human need to represent, interpret, and solve problems through logical structures and patterns, making it a manifestation of human cognition that is expressed through concepts, methodologies, and reasoning processes.

As a field of study, mathematics education is dedicated to cultivating logical reasoning and mathematical understanding (Situngkir & Dewi, 2022). Positioned at the intersection of multiple theoretical and practical domains, it plays a central role in advancing both the comprehension of mathematical concepts and the effectiveness of teaching practices. The importance of mathematics education extends across all levels of society—from primary to higher education—given that a solid mathematical foundation is essential for intellectual and professional development (Gjone, 1998). Scholars emphasize that mathematics education enhances cognitive function, logical reasoning, and problem-solving abilities (Sikdar, 2024). It is therefore integral to fostering critical thinking, analytical skills, and the capacity to approach complex problems with informed decision-making (Agbata et al., 2024).

From this perspective, mathematics education can be regarded as essential for equipping learners with fundamental life skills. Accordingly, mathematics should be taught in a systematic and meaningful way across all levels of formal education, beginning as early as preschool. For example, in kindergarten, children are introduced to basic concepts such as numbers, patterns, and shapes through developmentally appropriate activities. More than the transmission of knowledge, mathematics instruction is intended to stimulate cognitive processes by encouraging students to reason, reflect, and engage in critical and logical problem solving.

Mathematics instruction is inherently linked to students' thinking processes, in which critical and logical reasoning play a central role in problem solving. However, many students struggle to analyze and regulate their thinking, which in turn limits their ability to solve problems effectively (Clivaz & Miyakawa, 2020). Metacognition, understood as an individual's awareness and regulation of their own thinking processes, is therefore crucial in the context of mathematical learning. Pathuddin et al. (2019) conceptualize metacognition as "thinking about thinking," encompassing the interaction of three key components: (1) knowledge of one's cognitive processes, (2) self-regulation, and (3) beliefs and intuition.

A growing body of research has established that metacognitive skills are central to successful learning (Abdelshiheed et al., 2023). Strengthening these skills should thus be a priority in mathematics education to promote independent, reflective, and self-regulated learners. Beyond metacognition, both cognitive and non-cognitive factors shape mathematics achievement. Non-cognitive factors include economic, social, and cultural status (ESCS), resilience, life satisfaction, emotions (e.g., pride, fear, sadness, happiness), and gender, while metacognition serves as the central cognitive factor (Wutsqa et al., 2024). Specifically, metacognitive processes support learning by enabling students to evaluate task demands, mobilize relevant knowledge and skills, plan strategies, monitor progress, and adjust approaches when necessary (Joshi et al., 2022).

Several studies highlight the benefits of integrating metacognitive knowledge into mathematics instruction. Pathuddin et al. (2018) found that engaging students' metacognitive knowledge enhances awareness of existing cognitive resources during problem solving. Students with strong metacognitive abilities are generally more adept at understanding problems, analyzing relevant information, and devising appropriate strategies for implementation. Similarly, Güner and Erbay (2021) report that metacognitive skills significantly improve problem-solving success by helping learners select effective strategies and evaluate their outcomes. Pathuddin and Bennu (2021) further observe that students with advanced mathematical talent rely on metacognition to solve contextual problems, as awareness of cognitive processes fosters deeper and more rational understanding. These findings align with Subba et al. (2025), who argue that metacognitive skills are indispensable for problem-solving, and with Henra et al. (2024), who note the growing recognition of metacognitive activities in mathematics education research.

Taken together, these studies suggest that metacognition is a critical indicator of students' problem-solving proficiency and a mechanism for regulating cognitive processes during learning and reasoning. Consequently, assessing metacognitive skills through problem-solving tasks is essential for understanding and fostering students' mathematical competence.

Mathematical problem solving is widely regarded as a central component of learning mathematics (Pathuddin et al., 2018) and has remained a longstanding focus of mathematics education research (Gözde, 2020). Students, however, vary considerably in their ability to understand and solve mathematical problems. One factor consistently linked to these differences is mathematics self-efficacy, defined as students' beliefs in their capacity to successfully complete mathematical tasks. Several studies have demonstrated that mathematics self-efficacy is a strong predictor of performance, often measured through test scores or course grades (Zakariya, 2022). Similarly, Švecová (2024) found that mathematical anxiety, closely tied to self-efficacy, significantly affects students' academic achievement, problem-solving success, and emotional regulation—outcomes that can be enhanced through stronger self-efficacy. Jameson et al. (2022) likewise highlight that students' confidence in their ability to solve mathematical problems is directly linked to their self-efficacy, a view supported by Shimizu (2022), who identifies self-efficacy as one of the primary determinants of mathematical problem-solving ability. This conclusion is reinforced by Ningsih et al. (2023), who report a reciprocal relationship between self-efficacy and mathematical problem solving, suggesting that students' beliefs about their knowledge shape both their problem-solving behaviors and their ability to select effective strategies.

The literature further indicates a close connection between self-efficacy and metacognitive abilities. Metacognitive skills—defined as awareness and regulation of one's cognitive processes—are positively influenced by self-efficacy (Bozgün & Pekdoğan, 2018). Students with higher self-efficacy tend to display greater metacognitive awareness, leading to improved learning strategies and enhanced problem-solving performance. This relationship has been confirmed by Meher et al. (2024), who demonstrate a mutual influence between metacognitive skills and self-efficacy, as well as by Duratun and Maryani (2023), who identify a significant positive correlation between the two. Nevertheless, this relationship is not always straightforward. Prakoso et al. (2025) report that in certain contexts, elevated self-efficacy may negatively affect critical thinking, even though metacognition continues to exert a positive influence. These findings underscore the complexity of the relationship between self-efficacy and metacognitive skills, suggesting that their interaction is highly context dependent.

Given these dynamics, further research is needed to explore how self-efficacy and metacognition interact in mathematics learning environments, where students' confidence and self-regulation strongly shape outcomes. In particular, it is essential to investigate how students with low self-efficacy develop metacognitive skills during mathematical problem solving. This study responds to that need by examining the development of metacognitive skills among students with low self-efficacy in the context of solving problems involving the Pythagorean theorem.

The Pythagorean Theorem is a fundamental competency taught to eighth-grade students in junior high school mathematics, falling within the geometry curriculum, specifically under the topic of right-angled triangles. Students are expected to understand, apply, and solve problems involving this theorem across a variety of contexts, including real-world or contextual problems. Mastery of this material requires not only proficiency in arithmetic procedures but also higher-order thinking skills, particularly the ability to regulate and monitor one's cognitive processes, or metacognition. The application of the Pythagorean Theorem in contextual problems demands an understanding of spatial relationships, the ability to model problems as right-angled triangles, and the selection of appropriate and efficient solution strategies.

Interviews with junior high school mathematics teachers reveal that many students encounter difficulties in solving problems related to the Pythagorean Theorem. These challenges extend beyond the use of formulas to include understanding the concept of the hypotenuse, translating verbal problem statements into visual or geometric representations, and identifying suitable solution strategies. Adhitama et al. (2018) reported that students particularly struggle to determine the length of the hypotenuse, especially when problems involve algebraic manipulations or verbal expression of mathematical ideas. Similarly, Taamneh et al. (2024) found that students frequently commit conceptual, procedural, and computational errors when working with Pythagorean problems. More broadly, student achievement in geometry and measurement tends to lag behind performance in other mathematical domains, a trend confirmed by international assessments. For instance, the Programme for International Student Assessment (PISA) indicated that Indonesian students scored lowest in geometry (OECD, 2019), and the Trends in International Mathematics and Science Study (TIMSS) reported similar findings regarding geometry and measurement compared to number and algebra tasks (Mullis et al., 2019).

The interviews also highlighted notable differences in students' use of metacognitive strategies—planning, monitoring, and evaluating—during problem solving. While some students manage their thinking processes effectively, others demonstrate limited skill in employing these strategies. Teachers observed that these differences may be related to students' levels of self-efficacy. Students with high self-efficacy tend to demonstrate greater confidence in applying the Pythagorean Theorem and employ more effective metacognitive strategies, whereas students with low self-efficacy often exhibit uncertainty and struggle to develop and implement appropriate strategies. These observations align with PISA findings, which indicate that metacognitive awareness and self-efficacy significantly enhance mathematical literacy and performance (OECD, 2019). Research further shows that metacognitive regulation—including planning, monitoring, and evaluation—is critical for improving students' academic performance in mathematics (Callan et al., 2016), and that students with higher self-efficacy use more complex and effective metacognitive strategies than their lower-efficacy peers (Magno, 2010).

Based on these considerations, the present study focuses on junior high school students' metacognition in solving problems involving the Pythagorean Theorem in relation to their self-efficacy. Specifically, it aims to investigate how students organize and regulate their thinking processes and how their beliefs about their own abilities influence their use of metacognitive strategies. Although prior research has examined metacognition and self-efficacy separately, few studies have explored the relationship between these constructs in the context of geometry problem solving, particularly at the junior high school level. This study seeks to fill this gap and provide a foundation for further research on the interplay between metacognitive skills and self-efficacy across different mathematical contexts.

METHODS

Research Design

This study employed a descriptive research design using a qualitative approach. Descriptive qualitative research generates data in the form of words, either written or spoken, providing a detailed overview of the phenomenon under investigation. In this study, the approach was used to describe and analyze students' metacognitive skills in solving problems involving the Pythagorean Theorem, with a particular focus on differences in self-efficacy. Selecting participants with varying self-efficacy levels allowed the study to capture rich insights into how these beliefs influence students' problem-solving strategies and metacognitive processes.

Participants

The participants in this study were junior high school students. Initial selection was based on responses to a self-efficacy questionnaire adapted from Bandura (1977). A total of 32 students completed the questionnaire, and classification according to Schwarzer and Jerusalem (1995) identified four students with low self-efficacy. Participants were further selected based on willingness to participate, teacher recommendations, and effective verbal communication skills. These four students subsequently served as the primary subjects for the study.

Research Instruments

This study employed two types of instruments: the researcher as the main instrument, and supporting instruments including a self-efficacy questionnaire, a mathematics problem-solving test, and an interview guide. In qualitative research, the researcher plays a central role in data collection and interpretation, ensuring direct engagement with participants and their cognitive processes.

The self-efficacy questionnaire, consisting of 35 statements rated on a Likert scale, was designed to assess students' beliefs in their capabilities. The questionnaire included both positively and negatively worded items to ensure reliable measurement. Results of this assessment served as the basis for classifying participants by self-efficacy level.

Students' metacognitive skills were assessed through a mathematics problem-solving test focused on the Pythagorean Theorem. The test was validated by a lecturer in the Mathematics Education Study Program and a junior high school mathematics teacher, ensuring both content and construct validity. Construct validation confirmed that the problem statements were unambiguous, appropriately bounded for the Pythagorean Theorem content, and clearly comprehensible to students. Content validation ensured that the problems were aligned with participants' ability levels.

The mathematics problem-solving test comprised a single item designed to evaluate key aspects of students' metacognitive skills. Specifically, the test assessed students' understanding of the Pythagorean Theorem, their ability to formulate and implement a problem-solving plan, and their capacity to review and verify solutions using alternative approaches. An example of the test item is provided in Figure 1. The problem-solving test served as the primary instrument for collecting data on students' metacognitive processes.

An airplane flies from airport A 200 miles east and lands at airport B. From airport B the airplane continues its flight south. After traveling 120 miles, suddenly bad weather occurs which requires the airplane to turn west for 360 miles and then land at airport C.

a. From the illustration, describe the route of the plane from airport A to airport C.
b. Determine the distance between airport A and airport C.

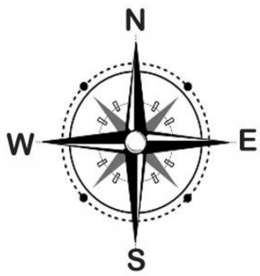

Figure 1. Problem solving test

Data Validity Check

The credibility of the data collected from problem-solving tests and in-depth interviews was ensured through multiple strategies, including member checking, prolonged observation, and peer discussions. Member checking, in particular, allows participants to verify the accuracy and consistency of the findings against their experiences, thereby enhancing the trustworthiness of qualitative research outcomes (Birt et al., 2016). This participant-involved verification process strengthens the reliability and credibility of the study's findings.

Data Analysis Technique

Data analysis followed the qualitative model proposed by Miles et al. (2014), which involves three interrelated stages: data condensation, data display, and conclusion drawing/verification. Student responses and behaviors were classified according to indicators of metacognitive skills derived from Polya's problem-solving framework, which consists of four steps. This approach provides a systematic and structured means of evaluating students' planning, monitoring, and evaluation skills, aligning with the study's focus on cognitive regulation during problem solving in the context of the Pythagorean Theorem.

Furthermore, data condensation involved summarizing, focusing, and selecting relevant information while discarding extraneous details. Special emphasis was placed on metacognitive skill indicators observed during interviews and problem-solving activities. Condensed data were organized and presented in narrative form, providing concise descriptions of students' metacognitive processes, particularly among those with low self-efficacy.

Table 1. Indicators of metacognitive skills in solving problems using the Pythagorean theorem

No.	Polya's Steps	Metacognitive Aspects	Indicator
1	Understanding the problem	Awareness	Students are aware of what is known and what is asked in the problem (UA)
		Regulation	Students determine the strategy to understand the problem (UR)
		Evaluation	Students assess the adequacy of information to solve the problem (UE)
2	Devising a plan	Awareness	Students are aware of the steps needed to solve the problem (DA)
		Regulation	Students determine the solution steps to be used (DR)
		Evaluation	Students assess the effectiveness of the planned steps (DE)
3	Carrying out the plan	Awareness	Students are aware of what actions to take (CA)
		Regulation	Students plan subsequent steps during problem solving (CR)
		Evaluation	Students check their answers and appropriateness of steps (CE)
4	Looking back	Awareness	Students recognize the importance of reviewing results (LA)
		Regulation	Students consider alternative strategies (LR)
		Evaluation	Students assess the correctness of the obtained solutions (LE)

Notes: Adapted from Polya (1945) and Hermin et al. (2025).

Finally, interpretation of the data involved synthesizing results from student work, interview transcripts, and participant confirmations. In the final stage, the researcher drew conclusions based on observed patterns and aligned these findings with the study's theoretical framework. Student performance in solving Pythagorean Theorem problems was evaluated using metacognitive indicators mapped onto Polya's four-step problem-solving model, as summarized in Table 1. These indicators assess students' awareness, regulation, and evaluation across each problem-solving phase.

RESULTS AND DISCUSSION

The data collection process commenced after identifying students who met the predetermined research criteria, specifically those exhibiting low self-efficacy (LSE). These students were selected as the research participants. Subsequently, data concerning their metacognitive skills were gathered through test-based interviews with the selected participants. The analysis employed metacognitive indicators aligned with Polya's problem-solving framework, which consists of four sequential steps: (1) understanding the problem, (2) devising a plan, (3) executing the plan, and (4) reviewing or rechecking the solution. In this study, the analysis of metacognitive skills in mathematics was contextualized within the framework of low self-efficacy. Problem-solving tests focused on students' application of the Pythagorean theorem were evaluated using metacognitive indicators derived from Polya's four-step problem-solving model, which has been validated as specific to metacognitive processes in problem-solving.

Understanding the Problem

The written test results indicated that LSE participants exhibited difficulties in the "understanding the problem" stage, as they often did not explicitly record the given information or the problem requirements. To gain deeper insight, follow-up interviews were conducted with LSE participants to clarify their reasoning during this stage. Table 2 presents excerpts from these interviews, illustrating participants' responses in the context of understanding the problem.

Table 2. LSE subject interview excerpt on understanding the problem

Interview Code	Conversation	Indicator Code
PA – 01	Do you understand the question?	
LSE – 02	Yes, I understand.	UA
PA – 03	What information do you know from this question?	
LSE – 04	It means?	UA
PA – 05	According to you, what do you know from this question?	
LSE – 06	Pythagoras' formula.	UA
PA – 07	Do you mean to find the answer using the Pythagorean formula?	
LSE – 08	Yes.	UA
PA – 09	Oh, that's the part of the work steps. When you read this question, what information do you get, for example, how far is it from here to here?	
LSE – 10	From airport A, 200 miles east to airport B, then continue south 120 miles; bad weather requires turning west for 360 miles, then landing at airport C.	UR
PA – 11	What is asked in the question?	
LSE – 12	Determine the route and calculate the distance.	UR
PA – 13	Do you think the information provided is sufficient to solve the problem?	
LSE – 14	Yes, it is sufficient.	UE

Analysis of the interview transcripts indicates that LSE participants initially struggled to articulate the information provided in the test problems. However, with targeted questioning, participants were able to identify and restate the relevant information, including the distances between airports and the requirement to determine the route and total distance. Despite this progress, participants tended to reproduce the problem statement verbatim rather than summarizing or interpreting it independently, suggesting partial engagement with the metacognitive process at the understanding stage.

Devising a Plan

To investigate the stage of devising a problem-solving plan, researchers conducted interviews with LSE participants to obtain detailed information regarding their strategic approach. Table 3 presents excerpts from these interviews, highlighting participants' responses during the planning stage.

Table 3. LSE subject interview excerpt on devising a plan

Interview Code	Conversation	Indicator Code
PA – 15	What strategies or steps will you use to solve this problem?	
LSE – 16	First create the route, make an illustration, then determine the distance.	DA, DR
PA – 17	When you illustrate the route, can you immediately determine the distance asked?	
LSE – 18	There's still something I'm looking for.	DA, DR
PA – 19	Please explain what we should look for first.	
LSE – 20	(LSE subject falls silent)	DA, DR
PA – 21	Why did you cross this out?	
LSE – 22	This is wrong	DE
PA – 23	Please explain what is wrong.	
LSE – 24	I initially thought everything should be added, but it turns out the Pythagorean formula is used.	DE

Analysis of the interview data indicates that LSE participants exhibited limited ability to fully articulate the steps of their problem-solving plan. While the participant identified initial steps, such as creating a route and illustrating it before calculating the distance, they were unable to explain in detail how to determine the specific distance required by the problem. This suggests a partial understanding of the planning process, with the participant relying on tentative reasoning and trial-and-error strategies rather than a fully developed metacognitive plan.

Carrying Out the Plan

The written test results of the LSE participant during the stage of implementing the problem-solving plan are presented in Figure 2. Analysis of Figure 2 indicates that the LSE participant's initial strategy involved representing the flight route as a line diagram forming a trapezoid, annotating the lengths of each segment. Subsequently, the participant drew a diagonal to create a right triangle, intending to apply the Pythagorean theorem to determine the distance from airport A to airport C. However, errors were observed in the application of the Pythagorean theorem, including failing to correctly isolate AC before taking the square root. The test sheet also contained multiple scribbles, reflecting uncertainty during the problem-solving process.

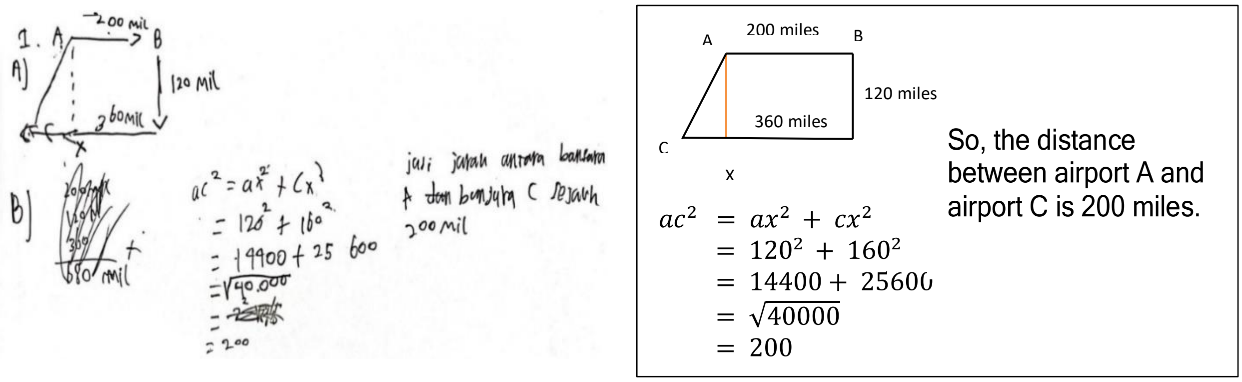

Figure 2. Results of the LSE participant's written test in carrying out the plan

To gain further insight into the participant's reasoning, follow-up interviews were conducted. Table 4 presents excerpts from these interviews, illustrating the participant's explanations during the implementation stage.

Table 4. LSE subject interview excerpts on carrying out the plan

Interview Code	Conversation	Indicator Code
PA – 25	Please explain how you approached this problem.	
LSE – 26	First, create a route from airport A to B heading east for 200 miles, then from B heading south for 120 miles; due to bad weather, the plane turns west for 360 miles.	CA, CR
PA – 27	After illustrating the route, what steps did you take next?	
LSE – 28	Draw a line to form a triangle.	CR
PA – 29	What type of triangle is that?	
LSE – 30	(LSE subject falls silent)	CR
PA – 31	Why did you create the triangle?	
LSE – 32	To determine the distance from A to C using Pythagoras.	CR
PA – 33	What did you do after that?	
LSE – 34	To find the distance from A to C, use the formula $AX^2 + CX^2$	CR
PA – 35	What does x represent?	
LSE – 36	The distance from airport A to C.	
PA – 37	What next?	
LSE – 38	Apply the Pythagorean theorem.	CR
PA – 39	Please show which sides are AC, AX, and CX.	
LSE – 40	AC is this line, AX is 120 miles, CX is 160 miles (students point to the pictures).	CR
PA – 41	How do you know AX is 120?	
LSE – 42	Because it matches the distance shown in the diagram (student points to the picture).	CR
PA – 43	How did you determine CX is 160?	
LSE – 44	By subtracting 200 from 360.	CR
PA – 45	Why subtract 200 from 360?	
LSE – 46	Because 200 is shorter than 360.	CR
PA – 47	Please explain the Pythagorean calculation again.	
LSE – 48	$AC^2 = AX^2 + CX^2$, so $120^2 + 160^2$, the result is 14,400 + 25,600, after that we find the square root of 40,000 which is 200.	CR

PA – 49	Why take the square root of 40,000?	
LSE – 50	(LSE subject falls silent)	CR
PA – 51	Do you feel confident in your solution?	
LSE – 52	Yes.	CE
PA – 53	What is the conclusion?	
LSE – 54	The distance from airport A to C is 200 miles.	CE

Analysis of the interview data shows that the participant initially constructed a route diagram in the form of a trapezoid and subsequently drew a triangle to apply the Pythagorean theorem. The participant correctly identified the base and height of the triangle but was unable to explain why the square root of 40,000 was taken to find AC. Additionally, the participant initially attempted to sum all side lengths, reflecting a partial understanding of the correct mathematical procedure. These observations indicate that, while the participant engaged in the implementation stage, errors and incomplete conceptual understanding affected the accuracy of the problem-solving process.

Looking Back

The written test results of the LSE participant during the looking back stage are presented in Figure 3.

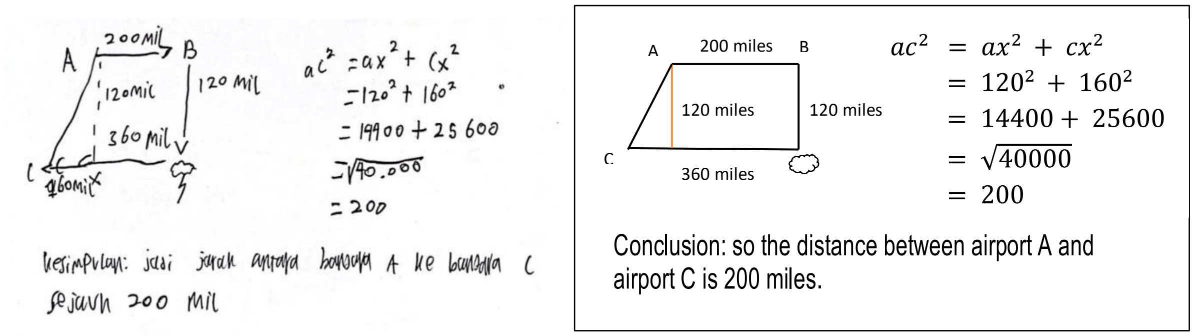

Figure 3. Written test results in the looking back stage

Analysis of Figure 3 indicates that, during the rechecking stage, the LSE participant did not recognize an error in the previous solution process, specifically failing to rewrite AC without the square after taking the square root of 40,000. Additionally, the participant did not attempt alternative strategies or methods to verify the solution. Furthermore, to gain further insight, follow-up interviews were conducted. Table 5 presents excerpts from these interviews, illustrating the participant's approach during the looking back stage.

Table 5. LSE subject interview excerpt on looking back

Interview Code	Conversation	Indicator Code
PA – 51	Please try another method and double-check your steps and calculations.	
LSE – 52	(Participant reworks the problem)	LA
PA – 53	Is the method you used the same as before?	
LSE – 54	Yes, because I do not know any other methods.	LR
PA – 55	Were there any mistakes in your previous work?	
LSE – 56	No.	LR
PA – 57	What is the conclusion of your answer?	
LSE – 58	The distance from airport A to C is 200 miles.	LE

The interview data indicate that the participant rechecked the solution but did not detect minor errors in the earlier calculations. The participant repeated the previous steps and obtained results consistent with the initial attempt. This suggests that the participant was unable to consider alternative strategies to verify the correctness of the solution. Nevertheless, the participant was able to draw a conclusion from the problem-solving process.

Based on the analysis, the metacognitive abilities of subject LSE in solving mathematical problems involving the Pythagorean theorem were assessed. The findings indicate that LSE demonstrated proficiency in two out of three metacognitive components across the four stages of Polya's problem-solving framework.

At the understanding the problem stage, LSE exhibited metacognitive awareness by consciously engaging in the thinking process and interpreting the question. However, LSE showed limited regulatory skills in thoroughly analyzing the information given and identifying what was required. LSE did demonstrate evaluative skills by re-examining his understanding and deciding on subsequent steps after comprehending the problem. Furthermore, during the planning stage, LSE displayed metacognitive awareness by recognizing that the available information was sufficient to address the problem. Regulatory skills were also evident, as LSE attempted to design a problem-solving strategy using the given information, despite initially making errors in determining the correct steps. Additionally, evaluative skills were observed as LSE reviewed his plan, specifically in selecting appropriate formulas for problem-solving.

In the implementation stage, LSE applied metacognitive awareness by recalling the solution steps based on the chosen formulas. Regulatory skills were evident in connecting the information obtained during the problem comprehension stage with the planned solution steps. However, LSE did not demonstrate evaluative skills at this stage, as he did not draw a final conclusion from the obtained results. Finally, at the re-examination stage, LSE showed metacognitive awareness by reviewing the results. Evaluation skills were also evident in verifying the correctness of the solution steps. Nonetheless, regulatory skills were limited, as LSE did not explore alternative strategies to confirm the accuracy of the answer.

These findings are consistent with prior research. Ridlo and Lutfiya (2017) reported that students with low self-efficacy often spend excessive time on tasks due to repeated attempts, reflecting less effective metacognitive strategies and resulting in inefficient problem-solving compared to peers with high self-efficacy. Similarly, Tchounwou et al. (2023) highlighted that enhanced metacognitive skills positively influence students' confidence in their academic abilities. Students with low self-efficacy may identify relevant information but often fail to focus on the core problem, leading to suboptimal planning of solution strategies. Conversely, Anggraini et al. (2024) demonstrated that students with high self-efficacy exhibited superior metacognitive skills—including awareness, regulation, and evaluation—thereby supporting more effective problem-solving. However, this study has limitations, including a small sample size and a focus on Pythagorean theorem problems within a single school context, which limits the generalizability of the results. Future research should involve larger, more diverse samples, varied levels of self-efficacy, and broader mathematical content to further explore the relationship between metacognition and self-efficacy across different student populations.

CONCLUSION

This study investigated the metacognitive processes of students with low self-efficacy during mathematics problem-solving across the stages of understanding the problem, designing a plan, implementing the plan, and reexamining the solution. The results indicate that low self-efficacy students consistently demonstrated metacognitive skills in the aspects of awareness and evaluation throughout the problem-solving process, while regulation was notably absent during the reexamination stage. This pattern suggests that low self-efficacy students engage in selective metacognitive control, which manifests in repeated errors and adjustments before arriving at a correct solution. Consequently, self-efficacy appears to influence not only the correctness of the final result but also the efficiency and systematicity of the entire problem-solving process. These findings corroborate and extend prior research, which highlighted that higher self-efficacy is associated with more confident, fluent problem-solving and the strategic use of metacognitive skills, whereas lower self-efficacy is linked to hesitation, prolonged cognitive processing, and error-prone approaches.

Despite the insights gained, this study presents certain limitations that must be acknowledged. The sample was limited to students characterized by low self-efficacy, which constrains the generalizability of the findings to broader populations encompassing moderate and high self-efficacy levels. Additionally, the research focused on a specific set of mathematics problems, which may not fully capture the variability of metacognitive engagement across different mathematical domains or levels of complexity. Furthermore, the observational and qualitative nature of metacognitive assessment may introduce subjective interpretation, suggesting that future studies could benefit from integrating quantitative metrics or experimental designs to validate and extend these findings.

Finally, several recommendations emerge for both educational practice and future research. Practically, educators are encouraged to design mathematics instruction that explicitly integrates strategies for enhancing self-efficacy and fostering all dimensions of metacognition, such as scaffolding, reflective feedback, and structured problem-solving exercises. At a policy level, the findings underscore the importance of curricula that balance cognitive and affective development, preparing students for complex, real-world problem-solving. For future research, studies should expand to include participants across the full spectrum of self-efficacy levels and examine diverse mathematical topics, including advanced algebra and geometry. Experimental interventions aimed at improving self-efficacy and metacognitive skills would provide further evidence of causal relationships, ultimately contributing to a deeper understanding of how these psychological and cognitive factors interact to influence student performance in mathematics.

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Additional Information	:	Additional information is available for this paper.

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