

Metacognitive Blindness in Mathematical Problem-Solving: An Analysis of Junior High School Students on Function Relations

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Abstract: This research is based on the importance of mathematical problem-solving skills as a fundamental competency that students must master. However, PISA results show that Indonesian junior high school students' problem-solving skills remain relatively low. One suspected factor contributing to low problem-solving skills is metacognitive failure in the form of metacognitive blindness, a condition in which students are unaware of mistakes in the problem-solving process. This study aims to analyze junior high school students' problem-solving ability in function relations material, examined in the context of metacognitive blindness. The research used a qualitative, descriptive approach. The study subjects were grade VIII junior high school students selected using purposive sampling. Data collection was carried out through problem-solving ability tests, structured interviews, and documentation. Problem-solving skills were analyzed based on Polya's four steps: understanding the problem, planning the solution, executing the solution plan, and re-examining the results obtained. Metacognitive blindness is identified through three types of red flags, according to Goos: lack of progress, error detection, and anomalous results in each problem-solving phase. The findings reveal that all five subjects experienced metacognitive blindness, with error detection being the most dominant red flag. Students demonstrated procedural competence without metacognitive awareness, as evidenced by Faizan, who achieved the highest score (58) yet remained unable to detect anomalous results. The study concludes that metacognitive blindness significantly contributes to low problem-solving performance, and this condition persists even when students work on structured, routine problems. These findings imply that explicit metacognitive scaffolding should be implemented across all achievement levels, not only for low-performing students, as procedural fluency can develop independently of metacognitive competence.

Keywords: problem-solving ability, metacognitive blindness, function relations, polya steps, red flag goos.

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■ INTRODUCTION

Mathematics plays a significant role in daily life as a foundation for learning other disciplines. Mathematics also serves as a major pillar in advancing technology and modern knowledge, equipping individuals with strong skills in abstraction, problem analysis, and logical reasoning (Siswanto & Meiliasari, 2024). In the 21st century, the goal of learning mathematics is that students are expected to have the

characteristics of the 4Cs, namely Communication, Collaboration, Critical Thinking and Problem Solving, and Creativity and Innovation (Septikasari & Frasandy, 2018 in Siswanto & Meiliasari, 2024), where problem-solving skills are one of the key skills that must be mastered. Mathematical problem-solving ability is an individual's ability to solve mathematical problems, measured using Polya's four steps: understanding the problem, planning

the solution, implementing the solution plan, and re-examining the results obtained (Siswanto & Meiliasari, 2024).

However, students' problem-solving skills in the field are still relatively low. Based on the 2022 PISA results, Indonesian students obtained an average mathematics score of 366, still far below the OECD average of 472 (OECD, 2023). This condition indicates that Indonesian students continue to face significant challenges in solving non-routine or high-level problems. One contributing factor is that Indonesian students are more accustomed to low-level routine problems rather than problems that require higher-order thinking skills (Mullis et al., 2020). To strengthen the empirical justification for selecting SMPN 4 Cirebon City as the research site, a preliminary observation was conducted prior to data collection. The observation involved a review of students' mathematics test results from the previous semester and informal discussions with the mathematics teacher. The teacher reported that approximately 65% of students in grade VIII scored below the minimum mastery criterion (KKM) of 75 on function relations material, with common errors including incorrect algebraic manipulation, failure to construct mathematical models from word problems, and inability to check the reasonableness of answers. Furthermore, during preliminary problem-solving exercises, the researcher observed that students rarely re-examined their work, and when prompted to reflect on their solutions, they expressed confidence in incorrect answers. This pattern suggests that students at SMPN 4 Cirebon City show difficulties consistent with metacognitive failure, specifically an inability to recognize obstacles, errors, and anomalous results during problem-solving. These preliminary findings provide a strong empirical basis for investigating metacognitive blindness in this specific school context. Problem-solving activities as a form of high-level thinking are closely related

to metacognition. Problem-solving is not sufficient if students have only mathematical knowledge; it must be accompanied by the ability to monitor and organize that knowledge. Unfortunately, metacognitive processes cannot always run optimally. Students cannot always use the knowledge they possess optimally, which can result in metacognitive failure.

One type of metacognitive failure that can occur in problem solving is metacognitive blindness. This occurs when students are unaware of errors in the problem-solving process, identified through three types of red flags according to Goos (2002) in Faradiba et al. (2019). These include lack of progress (obstacles in the problem-solving process), error detection (errors in the problem-solving process), and anomalous results (unusual or strange results in problem solving). Faradiba et al. (2019) found that students can experience metacognitive blindness during problem solving, with the dominant red flag being error detection. This occurs because students do not pay attention to problem details, so they miss important information and see problems only on the surface based on the words they read.

Based on this description, this study focuses on analyzing problem-solving abilities in function-relation material through junior high school students' metacognitive blindness. This focus matters because relations and functions are among the junior high school mathematics topics that require conceptual understanding and strong problem-solving skills. However, evidence shows that many students still struggle to translate problems into mathematical models and solve linear function problems (Valentine et al., 2024).

Based on this background, this study examines how metacognitive blindness affects junior high school students' thinking process in solving function-relation problems (Faradiba et al., 2019). More specifically, the formulation of the problem in this study can be described as

follows: first, how the problem-solving ability of junior high school students in the material of function relations is based on the Polya steps; second, how the metacognitive blindness profile experienced by junior high school students in solving problems in function relations material is reviewed based on indicators of Red Flag from Goos; and third, how the problem-solving ability of junior high school students in the material of function relations is reviewed from metacognitive blindness (Polya, 1973).

In line with the problem formulation, this study aims to analyze junior high school students' problem-solving ability in the material of function relations through the lens of metacognitive blindness. In particular, the purpose of this study is to describe the problem-solving ability of junior high school students in function relations material based on Polya steps, describe the metacognitive blindness profile experienced by junior high school students in solving problems in function relations material based on indicators of Red Flag from Goos, as well as analyze the problem-solving abilities of junior high school students in the material of function relations reviewed from metacognitive blindness.

■ METHOD

Research Design

This study uses a qualitative approach with a descriptive research design. The qualitative approach was chosen because this study aims to describe and analyze students' mathematical problem-solving abilities in depth, as viewed through metacognitive blindness, on function relations material. The qualitative approach allows researchers to understand phenomena holistically and deeply by collecting data rich in contextual information (Faradiba et al., 2019; Ikhwan et al., 2023). This research uses a case study design to explore in depth how metacognitive blindness occurs when junior high school students solve mathematical problems on function relations material. This research was carried out in one of

the Junior High Schools (SMP), namely SMPN 4 Cirebon City, in the even semester of the 2023–2024 academic year, with the consideration that the school has diverse student characteristics in mathematical abilities and has never conducted similar research related to metacognitive blindness in mathematical problem solving.

Research Subjects

This study employed a qualitative approach with a descriptive research design. A qualitative approach was selected because the research aims to describe and deeply analyze students' mathematical problem-solving abilities specifically regarding the concept of relations and functions through the lens of "metacognitive blindness." This approach enables a holistic, in-depth understanding of the phenomenon by gathering data rich in contextual information (Faradiba et al., 2019; Ikhwan et al., 2023). This case study design explored how metacognitive blindness manifests during the mathematical problem-solving process among junior high school students learning relations and functions. The study was conducted at SMPN 4 Cirebon City during the even semester of the 2023–2024 academic year; this site was chosen because the student body exhibits diverse mathematical abilities, and no prior research on metacognitive blindness in mathematical problem-solving had been conducted there. Subject selection began with a discussion with a mathematics teacher at the school, leading to the selection of a class deemed highly suitable for the study. This class consisted of 36 students who first took a test based on Goos's "red flag" indicators. Following the results of this initial test, five students exhibiting the highest levels of metacognitive blindness (operationally defined as those with the lowest scores on Test 1, as low scores indicate difficulty detecting and addressing red flags) were selected to take a second test based on Polya's problem-solving framework; these five students were also interviewed to supplement the data.

Clarification on the scoring categorization: The scoring rubric (0–33 = high metacognitive blindness; 34–66 = moderate; 67–100 = low) was developed after data collection to aid interpretation. However, the selection of subjects was based on relative ranking among the 36 students on Test 1, not on absolute score categories. The five students selected Kenzie, Fani, Viana, Faizan, and Zainab were those who demonstrated the most severe metacognitive blindness relative to their peers, as indicated by their low scores, qualitatively poor solutions, and interview responses showing a lack of awareness of difficulties, errors, and anomalies. Although their scores on Test 2 later fell into the moderate category (36–58), this does not invalidate their selection because: (1) the categorization rubric was an interpretative tool developed after subject selection, not a selection criterion; and (2) relative ranking among peers remains a valid basis for purposive sampling in qualitative research. The subsequent improvement in some students' scores (particularly Viana) strengthens the finding by showing that even when students perform

better on structured problems, metacognitive blindness persists, as evidenced by their inability to detect errors and anomalies in their work.

Research Instruments

The instruments used in this study consisted of primary and supporting instruments; the researcher served as the primary instrument (human instrument), playing a role in planning, data collection, data analysis, data interpretation, and drawing conclusions. Supporting instruments included a test based on Goos's "red flag" indicators, a problem-solving ability test based on Polya's framework, interview guidelines, and documentation. Prior to collecting data at the school, the researcher submitted a formal request to conduct the study and obtained permission to collect data on underage students and to interview them. The researcher explained the research procedure to both the school authorities and the students before data collection began. For the first test based on Goos's "red flag" indicators, the researcher prepared three problems; one of them is presented here:

No	Questions	Answers	Score	Red flag Type
1.	The function $f(x) = 3x + 5$ represents the volume of water (in liters) in a tank after x minutes of filling. This function applies from the time the tank is empty until it is full at the 10-minute mark. A student is asked to find the time when the water volume reaches 50 liters. He writes: $3x+5=50$ $\Rightarrow 3x = 45$ $\Rightarrow x = 15$ He answered: "A volume of 50 liters is reached at the 15th minute." Is the student's answer correct? If incorrect, provide the correct answer.	Wrong. (5) The student's answer is invalid because $x = 15$ lies outside the domain of the function. (5) Domain of a function: $0 \leq x \leq 10$ (valid only until the 10th minute). (5) Maximum volume at $x=10$ $f(x)=3x+5$ (2) $: f(10) = 3(10)+5$ (3) $= 30 + 5$ (3) $= 35$ liter. (2t) The 50-liter volume was never reached. (5)	30	Difficulty understanding the context The student overlooked the information that the function applies only up to the 10th minute and that the maximum volume is 35 liters. They remained convinced they understood the problem and answered $x = 15$, even though the volume never reaches 50 liters.

The second test based on Polya's problem-solving framework was designed to measure students' ability to solve mathematical problems regarding relations and functions using open-ended questions; it consisted of two problems, one of which is shown here:

No	Question	Answer	core
1.	A ride-hailing company sets its fares as follows: Initial fare (base fare) = Rp7,000 Fare per kilometer = Rp3,500 The total fare is expressed by the function $T(x) = 3,500x + 7,000$, where x is the distance traveled in km. A customer wants to travel 12 km but only has Rp50,000. Question: Is the customer's money sufficient? If not, what is the maximum distance the customer can travel with Rp50,000?	Step 1: Understanding the Problem Given: Fare function: $T(x) = 3,500x + 7,000$ x = distance (km) Customer's money = Rp50,000 Planned distance = 12 km (5) Question: Is the money sufficient for 12 km? If not, what is the maximum x? (2) Step 2: Formulating a Plan Calculate $T(12)$ to determine the fare for 12 km. Compare it with Rp50,000. If it is insufficient, solve the equation $3,500x + 7,000 = 50,000$ to find the maximum x. (3) Step 3: Executing the Plan Calculating the fare for 12 km: $T(12) = 3,500(12) + 7,000$ $= 42,000 + 7,000 = 49,000$ Customer's money Rp50,000 > Rp49,000 → sufficient; there is even Rp1,000 left over. (5) Calculating the maximum distance: $3,500x + 7,000 = 50,000$ $3,500x = 50,000 - 7,000$ $3,500x = 43,000$ $= \frac{43,000}{3,500} = 12,285$ $= 12,28 \text{ km}$ (5) Step 4: Double-checking $T(12) = 49,000$ → correct. $T(12,28) = 3,500(12,28) + 7,000$ $= 42,980 + 7,000$ $= 49,980$ (still less than 50,000). (3) If $X = 12.3$ $T(12.3) = 43,050 + 7,000 = 50,050$ (exceeds the limit). (2) So, the maximum distance is approximately 12.28 km. (2) Final answer: Funds are sufficient for 12 km; maximum distance = 12.28 km. (3)	30

Developing these tests involved creating a test blueprint, drafting questions, validating them, and establishing scoring guidelines.

Instrument Validation

The validation process of the problem-solving ability test instrument in this study was carried out through two stages, namely the preparation of a question grid containing indicators of problem-solving ability based on Polya's steps and indicators of metacognitive blindness based on three types of red flags from Goos, followed by content and construct validation conducted by three validators, namely two expert lecturers in the field of mathematics education and one experienced junior high school mathematics teacher. The validators assessed the suitability of the questions with the indicators, the clarity of the sentence formulations, the accuracy of language use, and the suitability of the material for the ability level of grade VIII students. Based on the three validators' assessment results, all items were generally declared feasible for use as research instruments. However, there were several notes for improvement given, including improvements to sentence wording on several questions to make them more communicative and easily understood by students, adjustment of the context of the questions to be more relevant to students' daily lives so that students can more easily understand the situations presented in the questions, as well as the addition of clearer work instructions on the question sheets so that students are not confused in writing the required solution steps. After improvements were made based on the suggestions and input from the validators, all items consisting of 5 essay questions, namely 3 questions for the first test based on Goos' red flags and 2 questions for the second test based on Polya's steps, were declared to have met the criteria of content and construct validity, so that the test instrument was declared qualitatively valid and feasible to be used to collect research data.

The interview guidelines used were structured interviews that aimed to explore deeper information about the problem-solving process carried out by students to identify the existence of metacognitive blindness based on red flag indicators from Goos (2002), which include lack of progress (LP), error detection (ED), and anomalous results (AR) in each phase of problem solving, where interview questions were designed to reveal students' awareness of difficulties, errors, or anomalies encountered during the problem-solving process. Student answer sheets were used to analyze students' problem-solving process and identify indications of metacognitive blindness, and audio/video recordings during the interview process were used to ensure data accuracy.

Data Collection Techniques

Data collection in this study involved several stages: problem-solving ability tests, structured interviews, and document analysis. Students completed the problem-solving ability test individually, working on the provided questions without cooperating with friends; the results were used to identify students' problem-solving abilities and select research subjects.

Specifically, the test instrument consists of two types of tests administered sequentially:

First Test (Test 1): This test consists of 3 essay questions based on three types of red flags according to Goos (2002): lack of progress (LP), error detection (ED), and anomalous results (AR). Each question was constructed to trigger specific metacognitive failures, so that students' difficulties in detecting obstacles, errors, or anomalies in the problem-solving process could be identified. This test is more difficult because it requires students not only to solve the problems but also to be aware of their own thinking processes. The questions were designed to be non-routine and require a deeper understanding of concepts, making them more challenging. The first test was

given to all selected students to initially identify their metacognitive blindness profile.

Second Test (Test 2): This test consists of 2 essay questions based on Polya's four problem-solving steps (1973): understanding the problem, planning the solution, implementing the solution plan, and re-examining the results obtained. The questions in this test are less difficult than those in the first test because they are more routine and structured according to Polya's clear problem-solving stages. This test aims to measure students' problem-solving abilities in a more guided and procedural way.

The sequential administration of these two tests served a specific purpose. The first test (red flag-based questions) was given earlier because

it is more complex and challenging and was designed to explore students' metacognitive awareness. The second test (Polya-based questions) was given afterward at a lower difficulty level to observe whether students who struggled on the first test performed better on the second. This design allowed the researcher to compare students' performance across different problem-solving demands and to see whether difficulties in metacognitive monitoring (as indicated by red flags) persist even when the problem-solving task is more structured and routine.

Based on the results in Table 1, students' scores on the second test did not always improve significantly compared to the first test. While all

Table1. Students' scores in test 1 and 2

Subject	Test 1 Score	Test 2 Score	Score Difference	Red Flag Type
Kenzie	28	36	+8	Lack of progress
Fani	31	36	+5	Error detection
Viana	20	54	+34	Error detection
Faizan	40	58	+18	Anomalous result
Zainab	30	38	+8	Anomalous result

subjects showed some improvement, the gains varied considerably: Viana demonstrated the largest improvement (+34 points), while Fani showed the smallest (+5 points). Notably, even with the more structured questions in Test 2, students' scores remained relatively low, with the highest score being 58 (Faizan). This pattern indicates that metacognitive blindness persists and affects problem-solving performance regardless of question type. The modest improvements suggest that providing more structured, routine problems alone is insufficient to overcome metacognitive blindness; explicit interventions targeting metacognitive awareness are needed.

Structured interviews were conducted after students completed both individual problem-solving tests, using interview guidelines prepared to explore the thinking process, awareness of difficulties, errors, and results obtained during

problem solving; the interviews were recorded using a voice recorder to facilitate transcription and data analysis. Document analysis involved collecting student answer sheets from both tests to examine the problem-solving steps taken and identify potential metacognitive blindness based on red flag indicators.

Data Analysis Techniques

Data analysis in this study used Miles and Huberman's (1994) interactive analysis model, which consists of three main components: data reduction, data presentation, and conclusion drawing. The operational implementation of each stage is described as follows.

Data Reduction

Data reduction was carried out through four sequential sub-stages. First, all interview

recordings from the five research subjects (Kenzie, Fani, Viana, Faizan, and Zainab) were transcribed verbatim, written exactly as spoken, including hesitations, pauses, and non-standard expressions. The transcription produced nine questions per subject covering problem-solving processes, strategies, difficulties, and re-examination procedures, yielding 45 question-answer pairs across all subjects.

Second, open coding was conducted by reading each transcript repeatedly. Every statement or sentence relevant to the problem-solving process was given a preliminary code or label. The coding focused on expressions indicating awareness or unawareness of difficulties; awareness or unawareness of errors in calculations or procedures; awareness or unawareness of strange or unreasonable results; strategies used to solve problems; and re-examination processes performed. For example, when Kenzie stated, "*Mm... there isn't any, it's fine,*" in response to whether there were confusing parts in the problem, this was coded as "unaware-of-difficulty." When Fani stated, "*I can't, I only know that one way,*" regarding alternative solution methods, this was coded as "limited-strategy." When Viana admitted, "*Formula from what's in the brain, just like making up a formula,*" regarding her solution strategy, this was coded as "unplanned-strategy." When Faizan said, "*Formula... I don't know. Confused,*" regarding his planning, this was coded as "confusion-in-planning." When Zainab stated, "*It makes sense,*" regarding her answer even though the calculation was not systematic, this was coded as "accepts-anomaly." Through this process, a total of 54 initial codes were generated from all five transcripts.

Third, axial coding was performed by grouping codes that had similar meanings into broader categories. This process involved comparing codes and identifying recurring patterns across subjects. This categorization process yielded three main categories. The first

category was "unrecognized obstacles", which combined codes such as unaware-of-difficulty, confusion in planning, difficulty realized post hoc, and superficial checking. This category indicated that students experienced obstacles but did not recognize them as significant problems during problem-solving. The second category was "undetected errors", which combined codes such as difficulty in procedural step, unplanned-strategy, limited strategy, dependence on others, and calculation-mistake. This category indicated that students made procedural, calculation, or strategic errors but did not detect them during the process. The third category was "accepted anomalies", which combined codes such as accepts anomaly, reasonable unreasonable results, no rechecking, and false confidence. This category indicated that students obtained strange or unreasonable results but accepted them without question.

Fourth, selective coding was conducted to map the three categories to Goos' (2002) three types of red flags that indicate metacognitive blindness. The category "unrecognized obstacles" was mapped to lack of progress (LP), which refers to students experiencing obstacles in the problem-solving process but being unaware of their existence. The category "undetected errors" was mapped to error detection (ED), which refers to students making mistakes in the problem-solving process but being unaware of them. The category "accepted anomalies" was mapped to anomalous results (AR), which refers to students obtaining unusual or strange results but being unaware of their peculiarities.

Each subject was then grouped based on the dominant red flag that emerged from their test answers and interview transcripts. This grouping was determined by calculating the frequency of codes belonging to each category for each subject. Kenzie was classified under lack of progress because approximately 65% of his codes reflected unrecognized obstacles, such as stating there were no confusing parts while

simultaneously expressing confusion in the calculation process. Fani and Viana were classified under error detection because approximately 60% and 55% of their codes, respectively, reflected undetected errors, such as Fani's admission that she only knew one way of solving and Viana's use of an unplanned strategy without realizing the potential for error. Faizan and Zainab were classified under anomalous results because approximately 58% and 62% of their codes, respectively, reflected accepted anomalies, such as Zainab's statement that her answer made sense even though her calculation was not systematic. This grouping was further validated by comparing the patterns of students' written answers on Test 1 and Test 2 with their interview responses, ensuring consistency between what students wrote and what they said during the interviews.

Data Presentation

The reduced data were presented as narrative descriptions for each subject, accompanied by direct quotations from interview transcripts and excerpts from students' test answers. The presentation followed Polya's four problem-solving steps: understanding the problem, planning the solution, implementing the solution plan, and re-examining the results, so that readers could trace how each subject experienced red flags at specific stages. The data presentation format for each subject included a brief profile of the subject (name, Test 1 score, and Test 2 score), findings at each Polya step supported by direct quotations from interview transcripts with codes indicated in parentheses, excerpts from students' written test answers, and the researcher's interpretation linking findings to red flag indicators, as well as a summary of the subject's metacognitive blindness profile.

Conclusion Drawing

Conclusions were drawn continuously throughout the study, with initial conclusions being

temporary and subject to change if no strong evidence emerged. After all data were collected and analyzed, final conclusions were verified through several strategies. Member checking was conducted by re-confirming interpretation results back to the subjects to ensure the accuracy of meaning. For example, when a subject was classified as having unrecognized obstacles, the researcher asked follow-up questions such as, "When you said there was no confusing part, did you really mean there was no difficulty at all, or did you not realize it at the time?" Source triangulation was performed by comparing test data from Test 1 and Test 2 with interview data to see the consistency of findings. For instance, Kenzie's written answer showed calculation errors, and the interview confirmed that he did not recognize these as obstacles during the process. Technique triangulation was carried out by comparing test results, interviews, and documentation data to ensure the consistency of findings. Peer debriefing was also conducted by discussing coding results and interpretations with fellow researchers to reduce subjective bias and ensure the codes and categories emerged from the data, not the researcher's assumptions.

Conclusions were drawn continuously during the study, where the initial conclusion was temporary and would change if no strong evidence was found, so that the conclusion in this study was in the form of a description of students' problem-solving abilities on function relation material based on Polya's steps, metacognitive blindness profiles experienced by students based on red flag indicators from Goos, and analysis of problem-solving abilities reviewed from metacognitive blindness.

Data Validity

To ensure data validity, this study used source triangulation and technique triangulation. Source triangulation was carried out by comparing test results data from Test 1 and Test 2 as well as interview results from several

research subjects. In contrast, technique triangulation involved comparing test results, interviews, and documentation data to ensure consistent findings. In addition, member checking was carried out by re-verifying interview results with research subjects to ensure the researcher's interpretation aligned with the subjects' intentions.

■ RESULT AND DISCUSSION

Problem-Solving Ability Based on Polya's Steps

The comparison between Test 1 and Test 2 provides an initial overview of changes in

students' performance across the two problem-solving demands. Test 1 was designed around Goos' red-flag indicators, whereas Test 2 used more structured problems based on Polya's four stages. The paired visualization below makes the direction and magnitude of change for each student visible. Figure 1 replaces the former static score table as the primary visual summary.

The results are organized according to the three research questions: (1) students' mathematical problem-solving ability based on Polya's four stages, (2) students' metacognitive blindness profile based on Goos' red flags, and

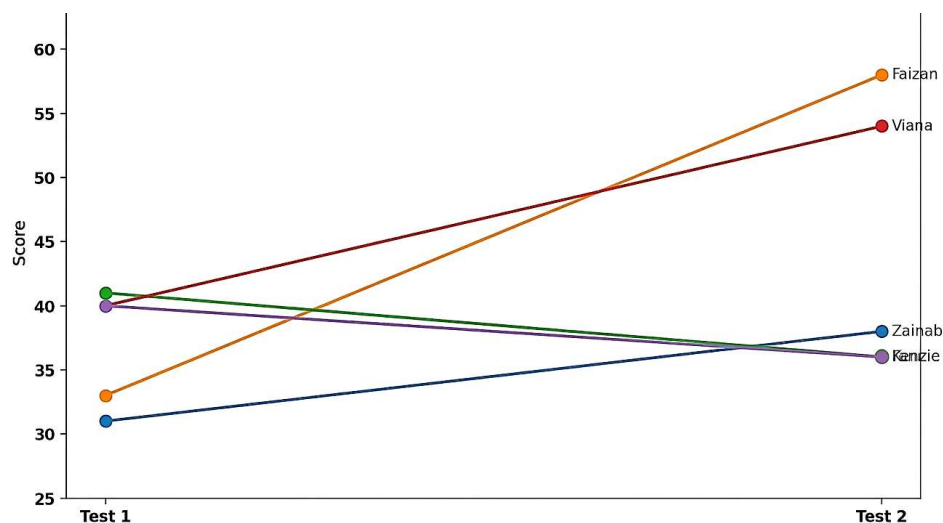


Figure 1. Paired scatter plot of students' test 1 and test 2 scores

(3) the relationship between problem-solving ability and metacognitive blindness. The following sections present the findings and discussion in this order.

Understanding the problem

Most students identified important information in the function-relation problems. Kenzie, Fani, Viana, and Faizan identified key numerical information, while Zainab identified only part of the relevant information. This indicates that context comprehension was generally adequate, but incomplete identification of known and

unknown information remained a weakness for some students.

Implementing the solution

During implementation, Kenzie and Fani showed calculation or procedural difficulties that they did not fully recognize. A critical finding emerged from Fani's work: although she arrived at a correct final answer for question number 2, a closer examination of her solution revealed a procedural error in algebraic manipulation. Specifically, when transposing the constant term across the equals sign, Fani failed to change its

sign properly, yet this error went completely undetected throughout her solution process. This pattern of undetected procedural errors, even when the final answer is correct, clearly reflects metacognitive blindness in error detection (ED), where students perform mathematical operations mechanically without evaluating the validity of their intermediate steps. Fani's case illustrates a dissociation between procedural execution and metacognitive monitoring: students may arrive at correct answers through flawed processes without recognizing the errors. Similarly, Kenzie experienced confusion in algebraic manipulation but did not recognize this confusion as a significant obstacle requiring intervention.

Re-examining the results

All subjects reported some form of checking, but the re-examination was generally superficial. Kenzie checked formulas and numbers without recognizing the effect of her difficulty on the final result; Faizan checked his answer without questioning an anomalous result; and Zainab reread and recalculated without recognizing the implausibility of the outcome. Thus, verification was present as an activity but not always as effective metacognitive monitoring.

Metacognitive Blindness Profile Based on Goos' Red Flags

The qualitative findings were mapped across the four Polya stages to show how the three Goos

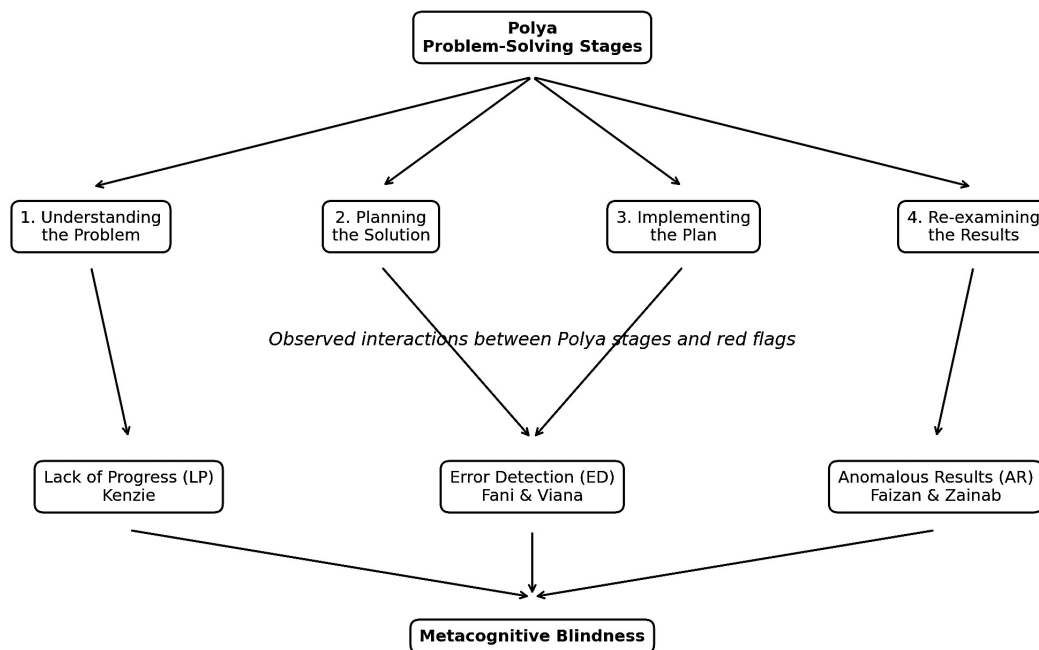


Figure 2. Concept map of polya's problem-solving stages and metacognitive blindness red flags

red flags appeared in students' work. Lack of Progress (LP) was associated with unrecognized obstacles, Error Detection (ED) with unrecognized procedural or strategic errors, and Anomalous Results (AR) with acceptance of unusual outcomes without adequate evaluation.

Based on interviews with the five research subjects, the following profiles describe each subject by the type of red flag experienced. To

provide context for the scores mentioned, the maximum theoretical score for each test is 100. Furthermore, to help readers interpret the position of each student's score, the following categorization was used: scores in the range of 67–100 indicate a low level of metacognitive blindness, scores in the range of 34–66 indicate a moderate level of metacognitive blindness, and scores in the range of 0–33 indicate a high level

of metacognitive blindness. This categorization allows readers to understand that students with higher scores demonstrate better problem-solving abilities and lower metacognitive blindness, while students with lower scores exhibit more severe metacognitive blindness.

Based on the data from the second test results, students were grouped based on the type of red flag experienced in accordance with the metacognitive blindness indicator from Goos (2002) in Faradiba et al. (2019), which included three types of red flags, namely lack of progress (LP), error detection (ED), and anomalous results (AR). The grouping was carried out by analyzing students' answer sheets and interview results for five students who were selected as research subjects, namely Kenzie, Fani, Viana, Faizan, and Zainab, who represented the problem-solving ability category.

Profile of students with red flag Lack of Progress (LP)

The subject identified as experiencing a lack of progress (LP) was Kenzie. Based on the second test results, Kenzie scored 36 out of a maximum of 100. This score falls into the moderate category of metacognitive blindness (34–66), indicating that Kenzie experienced a moderate level of metacognitive blindness in the problem-solving process.

Findings on the problem understanding step

Kenzie is able to identify important information in the problem well. In question number 1, Kenzie mentioned that the initial fare is IDR 7,000 and the tariff per kilometer is IDR 3,500 with a distance of 12 kilometers. This shows that Kenzie is able to understand the problem well.

Findings on settlement planning and implementation steps

Kenzie uses the formula of the function $T(x) = 3500x + 7000$ and substitutes $x = 12$.

However, Kenzie did not realize that there were obstacles in the calculation process. In question number 2, Kenzie wrote down the initial formula correctly:

$$N = \frac{2H + 3U + 5A}{10}$$

However, when substituting values, Kenzie was confused about moving variable fields. Kenzie expressed her confusion in the part, "*the 5A should be divided first.*" Kenzie does not fully realize this obstacle as a significant problem in the problem-solving process

Findings on the re-examination step

Kenzie re-examined by checking the formulas and numbers used. However, Kenzie did not realize that the obstacles experienced during the calculation process actually affected the accuracy of the final answer.

Student Profile with Red Flag Error Detection (ED)

The subjects identified as having error detection were Fani and Viana.

Fani Subject

Based on the second test results, Fani scored 36. Fani showed a good ability to understand the problem, but made a mistake in the calculation process and was unaware of the error.

1. Findings on the problem understanding step

Fani is able to identify important information in the question well. In question number 1, Fani mentioned the initial fare of IDR 7,000, the tariff per kilometer of IDR 3,500, and the distance of 12 kilometers. In question number 2, Fani identified the weighted average formula and correctly noted the known values for the daily score (80) and mid-semester exam score (70), as well as the unknown final semester exam score.

2. Findings on settlement planning and implementation steps

Fani correctly applied the given formulas for both problems and arrived at the correct final answers. For question number 1, she appropriately substituted the distance value into the linear function and correctly determined that the fare of IDR 49,000 was within the available budget of IDR 50,000. For question number 2, she successfully manipulated the algebraic expression and obtained the correct value. However, a closer examination of Fani's solution reveals a critical metacognitive failure: she made a procedural error when transposing the constant term across the equals sign, yet she failed to detect it throughout her solution process. This undetected error is particularly significant because Fani's approach to problem-solving was characterized by surface-level engagement with procedures rather than deep conceptual understanding of algebraic operations. Her admission that she only knew one way to solve the problem and could not provide an alternative method further confirms that her problem-solving strategy relied on rote procedural execution without meaningful monitoring of each step. This pattern of undetected procedural errors, even when the final answer is correct, clearly reflects metacognitive blindness in error detection (ED), where students perform mathematical operations mechanically without evaluating the validity of their intermediate steps. Fani's case illustrates that students may arrive at correct answers through flawed processes without realizing the errors, highlighting the need for instructional interventions that develop students' ability to monitor and evaluate their own solution procedures.

3. Findings on the Re-Examination Step

Fani re-examined by checking the calculations. However, Fani did not realize that there was a mistake in the process of moving the section that she did. Fani admitted that she knew

only one way to solve it and could not solve it another way.

Viana subject

Based on the results of the second test, Viana scored 54. Viana showed improvement compared to the first test. However, Viana still made mistakes in the problem-solving process.

1. Findings on the problem understanding step

Viana understands the problem quite well. Viana said it was about discussing online taxi fares and whether there was enough money.

2. Findings on settlement planning and implementation steps

Viana uses a self-made formula, which is not necessarily correct. Viana admitted that the strategy was "a formula from what is in the brain, just like making a formula." This shows that Viana does not have a thorough strategic plan.

Viana stated that if she was confused, she would ask a friend. This shows that Viana does not have an alternative strategy to overcome the difficulties faced.

Student profiles with red flag Anomalous Results (AR)

The subjects who were identified with anomalous results were Faizan and Zainab.

Subject of faizan

Based on the second test results, Faizan scored 58. Faizan showed improved ability compared to the first test.

1. Findings on the problem understanding step

Faizan is able to identify important information in the question. In question number 1, Faizan mentioned the initial fare of Rp7,000, the tariff per kilometer of Rp3,500, and the function $T(x) = 3500x + 7000$, with x being the distance traveled in kilometers.

2. Findings on settlement planning and implementation steps

Faizan correctly applied the appropriate formulas for both problems. However, when asked about his solution strategy during the interview, Faizan appeared confused when articulating his planning process. This seeming contradiction being able to select and apply the correct formulas while simultaneously expressing confusion about strategy can be explained by distinguishing between procedural knowledge and metacognitive knowledge. Faizan possessed procedural knowledge, as evidenced by his ability to correctly substitute values and perform arithmetic operations to obtain the final answers. However, he lacked metacognitive knowledge, as he could not verbally articulate his reasoning, explain why he chose particular formulas, or describe a coherent solution plan. This pattern is consistent with the characteristics of metacognitive blindness, where students are able to execute procedural tasks correctly but are unaware of or unable to monitor their own cognitive processes. Faizan's confusion was not about which formula to use; he clearly knew the correct formulas, but rather how to explain or plan his approach. Further confirming this interpretation, Faizan's re-examination was superficial, as he simply stated he checked the answer without describing any specific checking strategy. Additionally, his admission that he could not solve the problems using an alternative method indicates that his approach relied on rote procedural execution rather than conceptual understanding. This case illustrates that even when students achieve relatively high scores (Faizan obtained 58 out of 100, the highest among the five subjects), they may still experience metacognitive blindness, particularly in the form of anomalous results (AR), as Faizan did not detect the strangeness in his answers and considered them to be appropriate without questioning their reasonableness. This finding suggests that producing correct answers

does not necessarily guarantee metacognitive awareness, highlighting the need for instructional strategies that develop students' ability to monitor, evaluate, and articulate their thinking processes.

3. Findings on the re-examination step

Faizan checked the answer again but did not notice the strangeness in the results. Faizan considered the answer consistent with the question's context.

Subject of zainab

Based on the second test results, Zainab scored 38. Zainab showed low problem-solving ability.

1. Findings on the problem understanding step

Zainab was able to identify some important information in the question, but it was not complete. Zainab mentioned the tariff, tariff price per kilometer, initial tariff, and total tariff.

2. Findings on settlement planning and implementation steps

Zainab used a strategy of substituting numbers into the formula. However, her calculations were not systematic, and the resulting values were numerically unreasonable. When asked about her strategy, Zainab expressed confidence in her answer, indicating that she did not detect the mathematical inconsistencies in her work. This failure to recognize unreasonable results clearly reflects anomalous results (AR), where students produce unusual or strange outcomes but accept them as valid without adequate evaluation. Zainab's case exemplifies how the absence of systematic calculation procedures, combined with a lack of metacognitive monitoring, leads students to accept answers that are conceptually or numerically nonsensical. Her inability to detect the implausibility of her results suggests that she lacks

both the procedural skills and the evaluative habits necessary for effective problem-solving.

3. Findings on the re-examination step

Zainab re-examined it by re-reading and counting again. However, Zainab was not aware of the strangeness in the results she obtained.

Relationship Between Problem-Solving Ability and Metacognitive Blindness

The findings confirm that junior high school students at SMPN 4 Cirebon City experienced various types of metacognitive blindness: lack of progress (LP), error detection (ED), and anomalous results (AR) in solving function relations problems, aligning with Faradiba et al. (2019) and Maliana et al. (2025), who identified similar red flags in students' problem-solving processes. However, this study extends beyond merely confirming Goos' framework by revealing a dissociation between procedural competence and metacognitive awareness: students like Faizan achieved relatively high scores (58) yet remained unaware of anomalous results, challenging the assumption that higher mathematical achievement necessarily correlates with stronger metacognitive skills. This finding both supports and complicates international research on metacognitive interventions. On one hand, it reinforces meta-analytic evidence that explicit metacognitive instruction, particularly through reflective prompts and scaffolding, significantly improves problem-solving outcomes, as students do not naturally develop monitoring skills through routine practice alone. On the other hand, it challenges intervention studies that focus primarily on achievement outcomes without examining process awareness, suggesting that procedural fluency can develop independently of metacognitive competence. This dissociation is consistent with Yanti and Alvira (2026), who found metacognitive failure persists across educational levels, and Ng (2010), who linked learning culture to red flag detection.

Furthermore, as Schoenfeld (1992) noted, and as routine-based instruction in Indonesian classrooms reinforced, students' beliefs about mathematics as memorization of formulas may create conditions conducive to metacognitive blindness. These findings imply that metacognitive scaffolding should be implemented across all achievement levels, not only for low-performing students, and that future comparative studies across instructional contexts are needed to examine how learning cultures shape metacognitive development. This pattern is also consistent with recent research showing that metacognitive instruction and metacognitive strategies are associated with improved mathematics performance and problem solving (Hidayata et al., 2025; Hunaifi & Juandi, 2023).

Problem-Solving capabilities based on polya steps

Based on the analysis of test and interview results, students' problem-solving ability in function-relationship materials remains relatively low. This is evident from the second test results, which show that the average student score remains below 60. This result aligns with previous research findings that Indonesian students' problem-solving ability is still relatively low, based on PISA results.

In the problem-understanding step, most students can identify important information in the problem quite well. However, some students, like Zainab, still struggle to fully write down what they know and what they ask. This difficulty aligns with the finding that students often write down incomplete information from the questions.

In the solution planning step, students like Viana demonstrated a tendency to use unplanned strategies, as she admitted to using a formula derived "from what I remember, just like making up a formula" rather than systematically considering which approach would be appropriate for the problem. This phenomenon

can be traced to the habitual learning practices that pervade mathematics instruction in Indonesian classrooms. As noted in the introduction, Indonesian students are predominantly exposed to low-level routine problems that emphasize procedural execution and rote memorization of formulas, rather than problems that require strategic planning and conceptual understanding (Siswanto & Meiliasari, 2024; OECD, 2023). This routine-based learning environment conditions students to view problem-solving as recalling and applying memorized formulas, rather than as a process that requires careful planning and evaluation of available strategies. Consequently, when students encounter problems that are not identical to those they have practiced, they resort to guessing or selecting formulas based on surface-level similarities, a behavior Viana exemplified when she said her strategy was simply “*from what’s in the brain,*” without any justification for its appropriateness. This reliance on memorized patterns reflects a deeper issue: students have never been trained to ask themselves questions such as “What is this problem asking? What strategies might work? Why does this formula apply here?” In other words, they lack the metacognitive habit of planning, monitoring, and evaluating their own solution processes. This lack of metacognitive training stems directly from routine-based instruction, which prioritizes procedural fluency over strategic thinking. As a result, students like Viana cannot articulate a coherent solution plan and instead rely on trial and error or peer assistance, as she stated, “*If I’m confused, I’ll ask a friend,*” further confirming that they lack independent strategic planning skills. This finding aligns with previous research (Garofalo & Lester, 1985; Schoenfeld, 2014), which emphasizes that students’ difficulty planning solutions often stems from unfamiliarity with the thinking required to solve non-routine problems. Thus, the tendency to guess formulas

is not merely a lack of ability, but a manifestation of a learning culture that has failed to cultivate strategic and metacognitive competencies.

During the implementation step of the completion plan, students like Kenzie and Fani make calculation errors. This error occurs because students are not thorough and do not pay attention to the details of the process they should follow.

In the re-examination step, all students were admitted to re-examination. However, the examination remains superficial and not in-depth. This shows that students do not yet have strong metacognitive awareness when checking the correctness of their answers.

Metacognitive blindness profile based on goos’ red flags

Based on the analysis results, students showed three types of red flags indicating metacognitive blindness: lack of progress, error detection, and anomalous results.

1. Red flag: lack of progress (LP)

Kenzie’s subject showed a lack of progress because he encountered obstacles in the problem-solving process but was not aware of them. This obstacle occurs during calculations and when transferring variable fields. Kenzie did not realize the obstacle she was experiencing was a red flag that should have made her stop the process or go back to the previous step. Previous research has found that lack of progress is one type of red flag that students often experience in solving math problems.

2. Red flag error detection (ED)

Fani and Viana experienced error detection because they made mistakes in the problem-solving process but were unaware of them. Fani made a mistake while moving the section, while Viana used an inappropriate strategy without careful planning. This type of red flag is the most

dominant in metacognitive blindness, in line with the findings of Faradiba et al. (2019), which state that the dominant red flag is error detection, which occurs because students do not pay attention to the details of the problem, so they lose a lot of important information. Students see problems only on the surface, based on the words they read.

3. Red flag anomalous results (AR)

Faizan and Zainab experienced anomalous results because they obtained unusual results but were not aware of their strangeness. Faizan is not aware of the peculiarity of the result because he does not fully understand the function used. At the same time, Zainab is not aware of the peculiarity of the result because the calculation made is not systematic. This red flag aligns with the finding that students are often unaware of the peculiarities of the results they obtain because they do not fully understand the concept.

Analysis of the Relationship Between Problem-Solving Ability and Metacognitive Blindness

Based on the results, problem-solving skills and metacognitive blindness are closely related. Students who experience metacognitive blindness tend to have lower problem-solving skills than those who do not. Recent evidence likewise reports a close connection between metacognitive skills and mathematical problem-solving performance, including work using Polya-aligned tasks and studies of Indonesian junior high school learners (Zhao & Saleh, 2025; Wibawa et al., 2025; Kusaka & Ndiokubwayo, 2022).

Students who experience error detection (Fani and Viana) do not realize mistakes in the problem-solving process, which leads to wrong answers. This aligns with research showing that metacognitive failure can lead to errors in mathematical problem-solving.

Students who experienced anomalous results (Faizan and Zainab) showed that the inability to detect the strangeness of the results

led to an inability to evaluate the correctness of the answers. This aligns with research showing that metacognitive blindness occurs when metacognitive activity fails to lead students to detect their mistakes.

Students who experience a lack of progress (Kenzie) show that obstacles in the problem-solving process are not realized, causing confusion and an inability to continue the problem-solving process. This aligns with research showing that students often fail to recognize red flags in the form of obstacles, so they continue the process without realizing the problem.

Taken together, the findings show that metacognitive blindness does not occur at a single point in the solution process. LP was most visible when students encountered obstacles but did not recognize them; ED appeared when students did not monitor procedural or strategic errors; and AR appeared when students accepted unusual results without evaluating their reasonableness. The paired score visualization further shows that the structured Test 2 did not produce uniform gains for all students, supporting the interpretation that procedural guidance alone may not be sufficient when students lack monitoring and evaluation skills.

■ CONCLUSION

Based on the results of the problem-solving ability tests and interviews with grade VIII students of SMPN 4 Cirebon City, several conclusions can be drawn. First, students' problem-solving skills in function relations material remain relatively low, with the average score on the second test below 60, indicating significant challenges in applying Polya's four problem-solving steps effectively. Second, all research subjects were identified as experiencing metacognitive blindness, manifesting in three types of red flags according to Goos: Kenzie experienced lack of progress (LP), Fani and Viana experienced error detection (ED), and Faizan and

Zainab experienced anomalous results (AR). Third, metacognitive blindness is closely linked to low problem-solving skills: students' inability to detect obstacles, errors, or anomalies during the problem-solving process is a primary factor contributing to their low performance. Notably, even students who achieved relatively higher scores (such as Faizan with 58) exhibited metacognitive blindness, confirming that procedural competence does not guarantee metacognitive awareness.

Practical Implications for Classroom Instruction

To address the specific patterns of metacognitive blindness identified in this study, instructional interventions must directly respond to the red flags each subject experienced. The findings reveal distinct profiles: Kenzie experienced unrecognized obstacles (LP); Fani and Viana made undetected procedural and strategic errors (ED); and Faizan and Zainab failed to detect anomalous results (AR). Below are targeted scaffolding strategies designed to address each type of red flag, derived directly from the empirical findings.

Addressing lack of progress (LP) - kenzie's case

Kenzie struggled with algebraic manipulation but did not recognize these obstacles as significant problems requiring intervention. This suggests that students need explicit training in obstacle recognition. Recommended Scaffolding: "Stop and Reflect" checkpoints: Teachers should design problems with embedded prompts at critical junctures, such as "Stop: Are you stuck? What is confusing you right now?" This forces students to pause and recognize obstacles rather than proceeding blindly.

Visual progress tracking: Provide students with a checklist of potential obstacles (e.g., "*I don't know which formula to use,*" "*I'm confused about moving variables,*" "*My*

answer doesn't make sense") and ask them to check any that apply during problem-solving.

Think-aloud pair work: Pair students and have them verbalize their thinking, with the partner identifying and flagging any moments of confusion. This externalizes the monitoring process that Kenzie lacked.

Addressing error detection (ED) - fani and viana's cases

Fani made a procedural error in algebraic manipulation (transposing constants without changing signs) but did not detect it, even though she achieved a correct final answer. Viana used unplanned, self-generated strategies without evaluating their appropriateness. Both demonstrate that procedural execution can occur without metacognitive monitoring. Recommended Scaffolding: Error analysis exercises: Provide students with solved problems containing deliberate errors (similar to Fani's sign error) and ask them to identify and correct the mistakes. This builds the habit of active error detection. Alternative solution generation: Require students to solve problems using at least two different methods. Fani's admission that she could not solve using an alternative method indicates this skill needs explicit development. Viana's unplanned strategy suggests the need for structured planning templates.

Step-by-step verification: Before calculating, ask students to write a complete solution plan (what they will do, why, and what to watch out for). This addresses Viana's lack of strategic planning and Fani's reliance on rote execution.

Addressing anomalous results (AR) - faizan and zainab's cases

Faizan achieved the highest score but could not articulate his strategy and failed to detect the reasonableness of his results. Zainab accepted implausible answers because her calculations

were not systematic. Both failed to evaluate the conceptual appropriateness of their answers. Recommended Scaffolding: Reasonableness checks: Before finalizing answers, require students to estimate what a reasonable answer should be (e.g., “Based on the context, should the answer be more or less than...? Is it realistic? Why?”). This targets Faizan’s failure to question his results and Zainab’s acceptance of anomalies.

Contextual grounding: Always have students relate their answers to the problem context. For example, “If x represents kilometers, and you found $x = 12.28$, does that make sense given the situation?” This prevents the detachment from context that both Faizan and Zainab exhibited. Peer review with justification: After solving, students exchange work and must explain each step to their peer. If they cannot justify a step, the peer flags it for discussion. This externalizes the missing evaluation process.

General recommendations based on cross-cutting findings:

1. Explicit metacognitive instruction for all achievement levels

A key finding is that higher achievement does not guarantee metacognitive awareness. Faizan achieved the highest score yet experienced anomalous results. Therefore, metacognitive scaffolding should not be reserved only for low-performing students. Teachers should implement structured metacognitive questioning protocols that are integrated into daily instruction, using Polya’s four steps as a framework: “What does the problem ask? What strategy will I use? Is my solution correct? How can I verify my answer?”

2. Gradual fading of scaffolding

Viana’s substantial improvement (from 20 to 54) on structured problems shows that students can benefit from explicit scaffolding. However, the persistence of metacognitive blindness across all subjects suggests that scaffolding should be

gradually faded to promote independence. Begin with highly structured problems with embedded prompts, then progressively remove supports as students demonstrate improved monitoring skills.

3. Integration of metacognitive reflection into assessment

Teachers should incorporate metacognitive reflection journals into formative assessment. Students can be asked to document their solution process, identify difficulties, explain why they chose certain strategies, and reflect on how they could improve. This practice directly addresses the lack of awareness that characterizes metacognitive blindness.

■ DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

In preparing this manuscript, the author utilized ChatGPT (OpenAI) as a supporting tool for language editing, proofreading, and enhancing the clarity and coherence of the written content. All AI-assisted content was carefully reviewed, revised, and validated by the author to ensure its accuracy and consistency with the research. The author retains full responsibility for the originality, accuracy, interpretation, and conclusions of this manuscript.

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