

Critical Thinking of Senior High School Students in Solving Mathematical Problems Reviewed from Adversity Quotient and Gender

Nur Aulia Jadidah^{1*}, Dwi Juniati¹, Siti Khabibah²

^{1,2}Department of Mathematics, State University of Surabaya, Surabaya, Indonesia

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*Corresponding author:

nuraulia.23013@mhs.unesa.ac.id

Abstract: Critical thinking is one of the important 21st century skills to be developed in mathematics learning because it helps students analyse information, evaluate arguments, and make logical decisions. Factors that influence students' critical thinking include adversity quotient and gender. This study aims to describe high school students' critical thinking in solving mathematical problems in terms of adversity quotient (AQ) and gender. This study uses a qualitative approach with a descriptive research type. The subjects of this study were two 10th-grade students at MAN 7 Jombang who were selected based on their adversity quotient category (climber) and gender (masculine males and feminine females) with equivalent mathematical abilities. Data collection was carried out through problem-solving assignments and interviews. The data were analysed using the Miles and Huberman model, which includes data reduction, data presentation, and conclusion drawing, and were validated through time triangulation. The criteria for critical thinking were analysed using the six FRISCO elements from Ennis, which include: Focus, Reason, Inference, Situation, Clarity, and Overview. The problem-solving process was analysed based on Polya's four steps, namely understanding the problem, planning the solution, implementing the solution plan, and reviewing. The results suggest that students with a climber type of Adversity Quotient (AQ), both male and female, tended to demonstrate more consistent and well-developed critical thinking across the stages of mathematical problem solving, including understanding the problem, planning the solution, carrying out the solution, and reviewing the results. These students generally showed an ability to provide logical reasoning, connect given information with prior knowledge, and review their solutions more thoroughly. In terms of gender, differences in students' critical thinking are not substantial; however, female students tend to be more meticulous in documenting procedures and reviewing results, while male students tend to show stronger strategic reasoning.

INTRODUCTION

21st-century skills, which include communication, critical thinking, creativity, and collaboration, are essential competencies for facing global challenges and changes. The Centre for Curriculum Redesign (CCR) emphasises the importance of mastering the '4Cs', including critical thinking skills, as one of the competencies that students must acquire in order to be prepared for the demands of the 21st century (Bialik & Fadel, 2015). Supporting this view, Wang & Abdullah (2024) noted in their systematic review that critical thinking is often inadequately fostered through conventional mathematics instruction, underscoring the need for research that examines how individual factors, such as adversity quotient and

gender, shape students' critical thinking processes. However, despite growing recognition of these individual factors, limited attention has been given to how adversity quotient and gender jointly influence students' critical thinking skills in the context of mathematical problem solving, particularly within the Indonesian education setting.

Critical thinking is a fundamental skill in the thinking process for analysing arguments, developing logical thinking patterns, and evaluating to produce conclusions based on relevant facts (Dhayanti et al., 2018). According to Ennis (2011), the ideal critical thinker is an individual who has the ability to clarify ideas, carefully examine and evaluate the basis of a viewpoint, and draw judicious conclusions based on the available reasons or evidence. Thus, critical thinking is not only concerned with cognitive aspects, but also underpins an individual's ability to make sensible and responsible judgements. Ennis (1996) further identifies six interrelated elements of critical thinking, often abbreviated as FRISCO – Focus, Reason, Inference, Situation, Clarity, and Overview – which together guide individuals through a systematic process of identifying the core problem, constructing sound arguments, drawing logical conclusions, considering contextual factors, communicating ideas clearly, and reflectively evaluating the overall reasoning process. Based on this, by developing critical thinking, students not only learn to solve problems, but also train themselves to think rationally and structurally, which is very useful in daily life and further learning. This is reinforced by Monteleone et al. (2023), who conceptualised critical mathematical thinking as a domain-specific capability that emerges early and can be identified through how students question, justify, and evaluate their mathematical reasoning, rather than through generic reasoning skills alone. According to Chasanah (2019), in mathematics learning, what is more important is not the final result, but how students think in understanding and solving problems. Thus, critical thinking skills not only support academic achievement, but also equip students with rational thinking skills that are useful in real life.

In mathematics education, critical thinking is necessary to understand mathematical concepts in depth, apply them in problem solving, and relate the results of problem solving to real-life situations. Although it has been stated that critical thinking is one of the skills that needs to be developed, in reality, students' critical thinking skills in Indonesia are relatively low and inadequate. This is evidenced by the findings of a study by Benyamin et al. (2021), which showed that 14 out of 31 students had low critical thinking skills. This finding is supported by the results of the 2022 Programme for International Student Assessment (PISA), which shows that Indonesia's average score in mathematical literacy is below the OECD average (OECD, 2023). One of the causes of these low scores is students' lack of familiarity with mathematical problems that require critical thinking skills (Kusaeri & Aditomo, 2019). This shows that the low achievement of Indonesian students may be due to a lack of understanding in solving problems that require critical thinking skills.

Evidence of students' limited critical thinking skills is also shown by research conducted by Sugiarti et al. (2023), their findings indicate that students with high mathematical ability were generally able to fulfil all critical thinking indicators, whereas students with moderate

and low mathematical ability experienced difficulties in analysing problems, selecting appropriate strategies, and drawing conclusions. These findings suggest that critical thinking skills are closely related to students' ability to process mathematical information systematically. This systematic process aligns with Polya's framework of problem solving, which consists of four stages – understanding the problem, devising a plan, carrying out the plan, and looking back – through which students progressively identify what is known and unknown, formulate an appropriate strategy, implement it carefully, and finally verify the correctness and completeness of their solution (Polya, 2004). Accordingly, the difficulties faced by students with moderate and low mathematical ability in analysing problems, selecting strategies, and drawing conclusions, as found by Sugiarti et al. (2023), can be understood as reflecting weaknesses in specific stages of Polya's problem-solving process, thereby reinforcing the close relationship between critical thinking and structured mathematical problem solving.

Students' responses to difficulties in mathematics also vary, which is related to intelligence in facing challenges known as Adversity Quotient (AQ). Paul G. Stoltz introduced the Adversity Quotient (AQ) and argued that AQ is an individual's intelligence when facing and overcoming challenges and can be a measure of how resilient a person is in facing difficulties (Stoltz, 2000). AQ is generally classified into three types: quitter, camper, and climber. A study by Manazila et al. (2022) found that “climber” students demonstrated high perseverance, strategic exploration, and the ability to seek alternative solutions, whereas “quitter” students tended to give up quickly and struggled to continue their thought process when encountering obstacles. Another study conducted by Agus & Purnama (2022) showed that camper-type students tend to be heterogeneous and do not exhibit consistent response patterns. These differences in characteristics indicate that AQ plays a significant role in determining how students think when solving mathematical problems. Therefore, the analysis and findings of this study are limited to exploring the critical thinking processes of climber-type students during mathematical problem solving.

In addition to AQ, gender is also thought to influence students' critical thinking in the context of solving mathematical problems. Gender reflects socio-cultural differences in tasks, responsibilities, and personality that can shape students' thinking and learning strategies (Puspitawati, 2012). Girls and boys are often raised with different expectations and habits from an early age due to socio-cultural reasons. This is based on how parents treat their children; boys are trained to be strong, independent, and assertive (masculine traits), while girls are taught to be gentle, loving, and expressive (feminine traits) (Leaper, 2014). Gender-related development occurs very early, such as recognising gender differences, using gender labels, and beginning to form stereotypes. Children begin to form a basic understanding of gender roles through social interaction and learning experiences (Mesman & Groeneveld, 2018). Therefore, education plays an important role in shaping children's views on gender in a healthy and equitable manner.

In mathematics, several studies have mentioned that male students tend to be more confident in solving complex problems, while female students show greater accuracy and

perseverance. Several studies have examined the relationship between gender and students' critical thinking skills in mathematics; however, the findings remain inconclusive. Prameswari & Ismail (2023) found differences in critical thinking processes between male and female students when solving contextual mathematical problems. Male students tended to be more active in identifying various solution methods and exploring alternative strategies, whereas female students demonstrated greater thoroughness in interpreting problem information and explaining solution procedures. On a larger international scale, Ding (2026) analysed TIMSS 2023 data from 47 education systems and found that gender differences in academic resilience were most pronounced in mathematics, with disadvantaged boys more frequently reaching high international achievement benchmarks than girls, although this pattern was not uniform across countries. These findings suggest that gender may influence how students process information and approach mathematical problem solving, even when they work on similar tasks. However, the results of studies on the relationship between gender and critical thinking skills in mathematics still show varying findings, so it is important to conduct further research, especially in the context of AQ, which also plays a major role in mediating students' responses to challenges. These contrasting findings indicate that the relationship between gender and critical thinking is still open to further investigation. Based on the above description, the researcher is interested in conducting a study entitled "Critical Thinking of Senior High School Students in Solving Mathematical Problems Reviewed from Adversity Quotient and Gender".

METHOD

This study was conducted using a qualitative approach with a descriptive research type. Through this approach, the research results not only show the students' final answers, but also describe the students' process in solving problems, the strategies used, and how students make decisions during the problem-solving process. This study was conducted at Madrasah Aliyah Negeri (MAN) 7 Jombang. The subjects of this study were two 10th grade students at MAN 7 Jombang, who were first classified based on their gender (one masculine male student and one female student with a climber type adversity quotient).

Subject selection was based on the results of the adversity quotient questionnaire and gender questionnaire. In this study, to classify students into climber types, the researchers adopted a validated adversity quotient questionnaire from (Sudarman, 2010). In addition, the questionnaire used to obtain gender difference data was from the Bem Sex Role Inventory (Bem, 1974). The Bem Sex Role Inventory is a measurement instrument that identifies individuals in masculine, feminine, or androgynous groups.

The Mathematical Problem-Solving Test (TPM) was developed by the researcher to investigate students' critical thinking processes when solving mathematical problems. The instrument consisted of one open-ended mathematical problem designed to elicit students' reasoning, analysis, evaluation, and decision-making during problem solving. The problems were constructed based on the indicators of critical thinking and the stages of mathematical problem solving. The use of Polya's four-step framework as an analytical lens

is further supported by Dookurong et al. (2025), whose systematic review confirmed that Polya's problem-solving strategy consistently strengthens critical thinking when used to structure the analysis of students' reasoning processes.

To ensure content validity, the TPM was reviewed by two mathematics education lecturers with expertise in mathematical thinking and assessment. The experts evaluated the relevance, clarity, and appropriateness of the problems in measuring students' critical thinking skills. Revisions were made based on their suggestions regarding wording, problem context, and alignment with the research objectives. After the validation process, the TPM was administered to the selected participants. Students' written responses were then analyzed using the critical thinking indicators in mathematical problem solving, and follow-up interviews were conducted to obtain a deeper understanding of their thinking processes. The critical thinking indicators in problem solving are shown in Table 1 below (Syam et al., 2018).

Table 1. Critical thinking indicators in problem solving

Criteria for Critical Thinking	Understanding the problem	Devising a plan	Carrying out the plan	Looking back
Focus	Identify the core of the problem by reading repeatedly, underlining the question or writing down the core of the problem in the form of points, pictures, charts, or others.	Determine the strategy chosen to solve the problem.	Apply solution steps by performing calculations to solve problems systematically.	Review the key points to consider when solving the problem.
Reason	Provide reasons that form the basis for identifying the core of the problem.	Provide reasons for choosing the strategy to solve the problem.	Provide reasons for applying these steps to the calculations.	Provide logical reasons why the answer should be reviewed.
Inference	Make logical conclusions based on several reasons for identifying the core of the problem by writing down what is known and asked in the question.	Draw logical conclusions based on several reasons for choosing the strategy.	Draw logical conclusions based on the results of the calculations performed.	Draw a final conclusion based on the calculation results or check whether the results are logical in the context of the problem.
Situation	Analyse the problem in the question by understanding all the information contained in the question	Combining the information and concepts learned to design a solution	Ensure that the calculation process is appropriate to the context of the problem and applies the correct mathematical rules.	Re-examine whether there are other more efficient or easier ways to solve the problem
Clarity	Clarify the terms, symbols, or concepts used in understanding the problem	Clarify the terms, symbols, or concepts used when planning the steps to solve the problem	Clarify the terms, symbols, or concepts used in implementing the solution steps	Clarify the terms, symbols, and concepts used in re-examining the solution to the problem

Overview	Reviewing the important information contained in the question as a whole	Reviewing the strategy and steps chosen to solve the problem	Reviewing the calculation results to ensure there are no calculation errors	Re-examine all activities that have been carried out (from identifying the core of the problem to making a final conclusion)
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In addition, interviews were conducted with research subjects to confirm answers and complete the necessary data. The data analysis process in this study used the Miles and Huberman model, which consists of three stages: data reduction, data presentation, and conclusion drawing or verification (Sugiyono, 2020).

RESULT AND DISCUSSION

Results

The results of the adversity quotient questionnaire, gender questionnaire, and TKM revealed two subjects with the AQ climber type (masculine male and feminine female), as well as equivalent mathematical abilities, as described in the following Table 2.

Table 2. Research Subjects

No	Student's Initials	Adversity Quotient	Gender	Code	TKM Score
1	OIA	Climber	Maskulin	SL	85
2	RKY	Climber	Feminin	SP	85

Labeling and Research Data Code

The data was obtained from TPM results and interviews with research subjects. The interviews were recorded and transcribed. The transcripts of each research subject's interview were labelled to facilitate the data reduction process. The following is an explanation of the use of these codes.

1. The first letter, "S" denotes the research subject, and "P" denotes the researcher/interviewer.
2. The second letter, "L" denotes male, and "P" denotes female.
3. The third letter, "U" indicates the stage of understanding the problem, "D" indicates the stage of devising a plan, "C" indicates the stage of carrying out the plan, and "B" indicates the stage of looking back.
4. The first and second numbers indicate the sequence of interview activities.
5. The fifth letter, "F" stands for focus, "R" stands for reason, "I" stands for inference, "S" stands for situation, "C" stands for clarity, and "O" stands for overview.
6. The third number, "1" stands for the stage of understanding the problem, "2" stands for the stage of planning the solution, "3" stands for the stage of implementing the solution, and "4" stands for the stage of reviewing.

Example:

1. SLU01 means male subject at the problem understanding stage and is in sequence 1 in the interview transcript.

2. PLU01 means the interviewer for the male subject at the stage of understanding the problem and is in sequence 1 in the interview transcript.
3. F1 means focus at the stage of understanding the problem and R3 means reason at the stage of implementing the solution.

Critical Thinking of Male Students with Climber-Type Understanding the problem

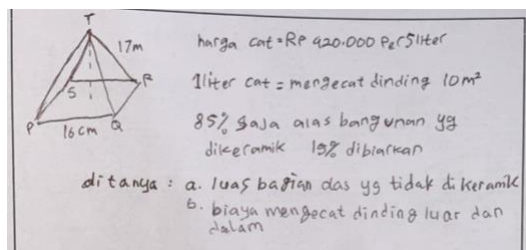


Figure 1. SL's Answer to the Step Understanding the Problem

PLU01 : "How do you understand the problem?"

SLU01 : "I read it first, then I write down the important information contained in the problem." (F1)

PLU02 : "Why do you write that this information is known and asked in the problem?"

SLU02 : "Based on the information contained in the question, I write it down as known, and I write down what is asked according to the question." (R1)

PLU03 : "How do you ensure that what you write is clear and easy to understand?"

SLU03 : "I double-check from the beginning to make sure that what I write is consistent with the information in the question and can be understood clearly." (C1) (O1)

Based on the results of the TPM and interview transcript at the step understanding problem, it can be explained that SL first reads the information contained in the problem, then writes down the important information in the form of points (*focus*). Next, SL writes down what is known from the problem using their own words, namely that the price of paint is Rp 420.000 per 5 litres, 1 litre of paint can be used to paint a wall area of $10m^2$, and writes that only 85% of the building's floor is tiled and 15% is left bare (*inference*). Then, SL wrote down the questions according to the information in the problem using their own words, namely the area of the base that is not tiled and the cost of painting the exterior and interior walls (*inference*). In addition, SL also wrote down what was known from the problem by drawing a square pyramid and writing down the known side lengths, namely the 16m square base and the 17m sloping sides of the triangle (*focus*). SL revealed that the reason he wrote down what was known from the problem was because it was in accordance with the information contained in the question and wrote down what was asked in accordance with the questions contained in the question (*reason*). SL clarified the terms/symbols used when understanding the problem, such as clearly expressing what was known and stated in the problem (*clarity*). SL ensured that every term/symbol written was clear and understandable (*clarity*) by double-checking the information contained in the problem from the beginning (*overview*). Based on this, it can be explained that SL understands all the information contained in the question (*situation*).

Devising a plan

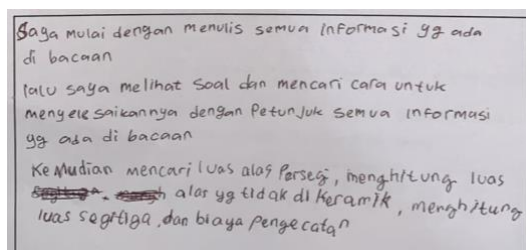


Figure 2. SL's Answer to the Step Devising a Plan

PLD04 : "On the solution sheet, you wrote down the steps to solve the problem. Can you explain why you used those steps or strategies?"

SLD04 : "So, first I wrote down all the information in the reading, then I looked for a way to solve the problem using the clues from the information. Then I started looking for the area of the base, the area of the base that was not tiled, calculating the area of the triangle and the cost of painting it." (R2)

PLD05 : "On the solution sheet, you did not write down the formula you might use to solve the problem. How do you ensure that the steps you take are appropriate for solving the problem?"

SLD05 : "Before doing the calculations, I write down the formula first to see if it is appropriate or not." (R2)

PLD06 : "Based on the steps you have written down to solve the problem, do you combine the available information with the concepts you have learned?"

SLD06 : "Yes, I wrote down the steps according to the concepts I had learned previously and the information contained in the reading." (S2)

PLD07 : "How do you ensure that what you write is clear and easy to understand?"

SLD07 : "I write it down in simple language and clear steps so that it is easy to follow." (C2)

PLD08 : "Before starting the calculation, do you double-check all the steps you will use?"

SLD08 : "No, I just calculate the answer right away."

Based on the results of the TPM and interview transcripts at the step devising a plan, it can be explained that SL revealed the plan to be carried out in solving the problem by writing down the steps to be taken, namely starting by writing down all the information contained in the reading, finding ways to solve the problem based on the instructions and information contained in the reading, then finding the area of the square base, calculating the area of the base that is not tiled, calculating the area of the triangle, and calculating the cost of painting (*focus*)(*inference*). Furthermore, SL explains the reasons for using the steps or strategies written down to solve the problem (*reason*). However, SL does not write down the formulas that will be used to solve the problem. This is because SL writes down the formulas to be used directly during the calculation process. Furthermore, SL reveals that he combines the information contained in the problem with concepts that he has learned previously, which are written in the solution, although not in detail (*situation*). SL clarifies the terms used in planning the solution when revealing the reasons for using the solution steps (*clarity*). In addition, SL also ensures that every term/symbol written is clear and understandable by writing it in simple language and clear steps so that it is easy to follow (*clarity*). However, SL does not double-check the steps to be used to solve the problem before starting the calculation.

Carrying out the plan

a. luas alas = 5×5
 $= 16 \times 16 = 256 \text{ m}^2$
 85% dikeramik
 15% tidak dikeramik
 $\frac{256 \times 85}{100} = 217.6$
 $256 - 217.6 = 38.4 \approx 39 \text{ m}^2$

b. biaya pengecatan 25.000 Per m^2 dan harga total untuk mengecat seluruh bagian luar dalam
 $T = \sqrt{17^2 - 8^2}$
 $= \sqrt{289 - 64}$
 $= \sqrt{225}$
 $= 15$
 Luas segitiga = $\frac{1}{2} \times a \times t$
 $= \frac{1}{2} \times 16 \times 15 = 120 \text{ m}^2$
 $960 = 96$
 $\frac{96}{10} = 9.6$
 $\frac{9.6}{5} = 1.92 \approx 2$
 biaya cat = $20 \times 420.000 = 8.400.000$

Figure 3. SL's Answer to the Step Carrying Out a Plan

- PLC09 : "On your answer sheet, after finding the area of the base, what did you mean by writing $\frac{256}{100} \times 85$? Then why did you subtract the result from 256?"
- SLC09 : "So that's to find the area of the base that is not tiled. First, I find the area that is tiled, which is 85%, then I multiply it by 256 to get 217. Then I subtract 256 from 217 to get 39, so 39 m^2 is the area of the base that is not tiled." (R3)
- PLC10 : "In your solution, what does $T = \sqrt{17^2 - 8^2}$ mean? Why did you use that method?"
- SLC10 : "I used the Pythagorean theorem to find the height of the triangle, sis. So T means the height of the triangle obtained from the Pythagorean theorem." (R3)
- PLC11 : "Then, after finding the area of the triangle, why did you write $120 \times 8 = 960 \text{ m}^2$? What does that mean?"
- SLC11 : "That's the area of the triangle multiplied by 8. 8 is the outer and inner walls, so the total area of the walls that need to be painted is 960 m^2 " (S3)
- PLC12 : "Then, what does $\frac{960}{10} = 96$ mean? Then why is it $\frac{96}{5} = 19.2$?"
- SLC12 : "I divided by 10 because 1 liter of paint is used to paint 10 m^2 wall, then from 96 liters I divided by 5 because the price of paint is per 5 liters, so the paint that needs to be bought is 20 cans. I rounded it up because 20 is also a multiple of 5." (S3)
- PLC13 : "Does your calculation answer the question?"
- SLC13 : "Yes, sis." (R3)
- PLC11 : "Then how much is the total cost needed to paint the entire wall?"
- SLC11 : "The cost of the paint is 8.400.000." (C3)
- PLC12 : "Don't you need to calculate the cost of painting the walls?"
- SLC12 : "Oh yes, I forgot to calculate that, so the total cost should be added to the cost of painting the walls." (I3)
- PLC13 : "So, did you double-check your calculations thoroughly?"
- SLC13 : "Yes, I double-checked my calculations, although I wasn't very thorough." (O3)

Based on the results of the solution and interview transcript at the step carrying out the plan, it can be explained that SL wrote down the formula for finding the area of a triangle and the area of a square before starting the calculation. SL calculated the area of the square using the formula $L = s \times s$, resulting in an area of 256 m^2 (focus). Next, SL calculated the area of the un-tiled base by calculating 85% multiplied by 256 m^2 , resulting in 217. This result was then subtracted from the area of the square, namely $256 - 217 = 39$, resulting in the area of the un-tiled base being 39 m^2 (reason)(inference). SL uses the Pythagorean theorem to determine the height of the triangle in order to calculate the area of the triangle (reason). After obtaining the height of the triangle, which is 15m, and the base of the triangle, which is 16m, SLCL calculates the area of the triangle using the formula $L = \frac{1}{2} \times a \times t$, resulting in an area of 120 m^2 (situation).

Then, SL multiplied the area of the square by the number of wall sections that needed to be painted, which was $120 \times 8 = 960 \text{ m}^2$, resulting in a total wall area that needed to be painted of 960 m^2 (*reason*)(*situation*). SL divides 960 m^2 by 10 because 1 litre of paint can be used to paint 10 m^2 , so 96 litres of paint are needed. Then, SL divides 96 by 5 because the paint is sold in 5-litre containers, so 20 containers of paint need to be purchased (rounded up from 19.2) (*reason*)(*situation*). After determining the amount of paint needed, SL calculated the cost of the paint based on the amount needed, which is $20 \times 420.000 = 8.400.000$ (*focus*). In addition, SL also stated that the total cost of painting the walls was obtained from the cost of the paint needed plus the cost of the painting service (*inference*). However, SL forgot to write this conclusion on the answer sheet. SL explained that arrows were provided on the answer sheet so that the answers could be read in order because SL wrote the answers in a non-sequential manner (*reason*). In addition, SL clarified the terms/symbols/concepts used when solving the problem, such as when explaining the reasons for using the formula and the calculation process (*clarity*). Based on this, it can be explained that SL ensured that all terms/symbols used in the calculation were correct by double-checking the calculation results (*clarity*)(*overview*).

Looking back

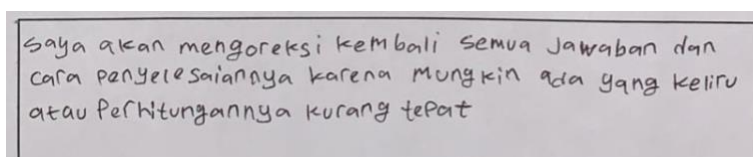


Figure 4. SL's Answer to the Step Looking Back

PLB17 : "After completing the calculations, why is it necessary to double-check all the calculations? Do you check only the calculations or the entire sheet?"

SLB17 : "I double-check the entire sheet to make sure my answers are correct before submitting it." (R4)
(O4)

PLB18 : "What are the important points you pay attention to when double-checking?"

SLB18 : "All the information on my answer sheet, such as the steps, calculations, and what is known and asked." (F4)
(C4)

PLB19 : "What is your final conclusion based on the calculations you did?"

SLB19 : "The area of the floor that is not tiled is 39 m^2 , and the total cost to paint all the walls is 8.400.000 plus the painting service fee." (I4)

PLB20 : "Did you also check if there was another more efficient/easier way to solve the problem?"

SLB20 : "No." (S4)

Based on the results of the completion and interview transcripts at the step looking back, it can be stated that SL wrote that it would re-correct all answers and solutions because there may be errors or inaccuracies in the calculations (*reason*). Furthermore, SL revealed that he reviewed all answers before submitting them to ensure they were correct (*overview*). In addition, when reviewing the solutions, SL checked several important points, namely all the information contained in the solution sheet, such as the steps, calculations, and what was known and asked (*focus*)(*clarity*). SL also revealed the final conclusion based on the results of their calculations, namely that the area of the base that was not tiled was 39 m^2 and the total cost of painting the entire wall was Rp 8.400.000 plus the painting service fee (*inference*). However, SL did not recheck whether there was a more efficient/easier way to solve the problem.

Critical Thinking of Female Students with Climber-Type

Understanding the problem

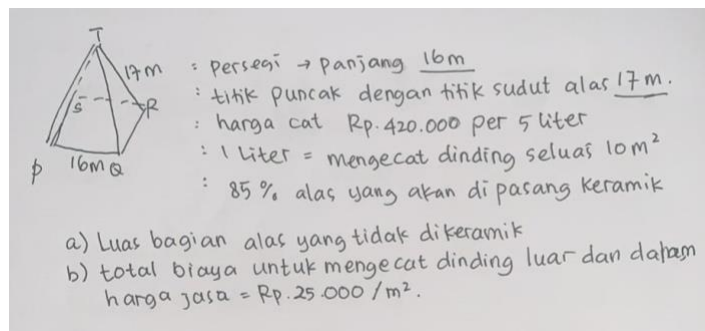


Figure 5. SP's Answer to the Step Understanding the Problem

PPU01 : "How do you understand the problem?"

SPI01 : "I read the whole thing while looking at the pictures and writing down important information contained in the problem." (F1)

PPU02 : "Why did you write that this information is known and asked in the problem?"

SPI02 : "I wrote down what is known based on the information contained in the question, and I wrote down what is asked based on what needs to be found in the calculation." (R1)

PPU03 : "How do you ensure that what you write is clear and easy to understand?"

SPI03 : "I ensure that my writing is clear by rereading and double-checking what I have written to see if there are any sentences that are unclear." (C1)
(O1)

Based on the results of the completion and interview transcripts at the step understanding the problem, it can be explained that SP reads all the information contained in the problem while observing the image, then writes down the important information contained in the problem in the form of points (*focus*). Next, SP writes down what is known from the problem using their own words, namely that the length of the side of the square is 16m, the distance between the apex and the base corner is 17m, the price of paint is Rp 420.000 per 5 litres, 1 litre of paint can be used to paint a wall area of 10 m^2 , and 85% of the building base will be tiled (*inference*). Then, SP wrote down the questions according to the information in the problem using their own words, namely the area of the base that is not tiled and the total cost of painting the exterior and interior walls at a service price of Rp 25.000 per m^2 (*inference*). In addition, SP also wrote down what was known from the problem by drawing a square pyramid and writing down the known side lengths, namely the 16m square base and the 17m sloping side of the triangle (*focus*). SP revealed that the reason he wrote down what he knew about the problem was based on the information contained in the question and wrote down what was asked based on what needed to be found in the calculation (*reason*). Furthermore, SP ensured that every term/symbol written was clear and understandable by rereading and double-checking what was written to see if there were any inappropriate sentences (*clarity*)(*overview*). In addition, SP clarified the terms/symbols used when understanding the problem, such as clearly expressing what was known and stated in the problem (*clarity*). Based on this, it can be explained that SP understood all the information contained in the question (*situation*).

Devising a plan

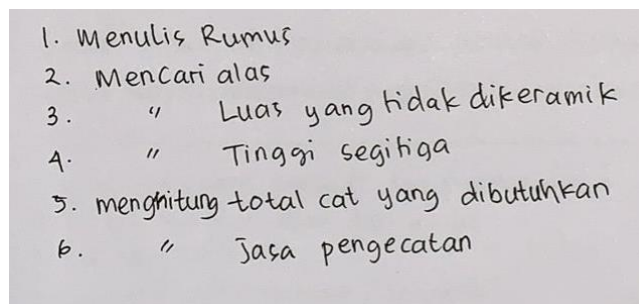


Figure 6. SP's Answer to the Step Devising a Plan

PPD04 : "On the solution sheet, you wrote down the steps to solve the problem. Can you explain why you chose to use those steps or strategies?"

SPD04 : "First, I wrote down the necessary formulas so I wouldn't forget them. Then, I calculated the area of the base using the formula for the area of a square so I could determine the area of the base that was not tiled. Then I will calculate the height of the triangle so that I can determine the area of the triangle to find the area of the wall to be painted, then calculate the total paint needed and the cost of painting services." (R2)

PPD05 : "Based on the steps you have written to solve the problem, did you combine the available information with the concepts you have learned?"

SPD05 : "Yes, I wrote down the steps according to the available information and what was asked in the question." (S2)

PPD06 : "How do you ensure that what you write is clear and easy to understand?"

SPD06 : "I wrote down the steps in sequence and used simple and clear language so that it would be easy to understand." (C2)

PPD07 : "Before starting the calculations, did you double-check all the steps you were going to use?"

SPD07 : "Yes, I double-checked by reading the steps again." (O2)

Based on the results of the solution and interview transcript at the step devising a plan, it can be explained that SP revealed the plan to be carried out in solving the problem by writing down the steps to be taken, namely writing the formula, finding the base, finding the un-tiled area, finding the height of the triangle, calculating the total paint required, and calculating the painting service (*focus*)(*inference*). Furthermore, SP revealed the reasons for using the steps or strategies that had been written down to solve the problem, such as finding the base area using the area formula for a square and calculating the height of the triangle to find the area of the wall to be painted (*reason*). Next, SP reveals that he combines the information contained in the problem with concepts that he has learned previously (*situation*). SP clarifies the terms used when planning the steps to solve the problem, such as revealing the reasons for the strategies used in solving the problem (*clarity*). In addition, SP ensures that every term/symbol written is clear and understandable by writing down the steps in sequence and using simple and clear language (*clarity*). SP also double-checks the steps to be used to solve the problem before starting the calculations (*overview*).

Carrying out the plan

Handwritten mathematical work showing calculations for area and height of a triangle, and cost of painting.

1. rumus alas = $s \times s$
 2. rumus $\Delta = \frac{1}{2} a t$
 3. Tinggi $\Delta = \sqrt{ab^2 + bc^2}$

1. L. alas = $s \times s$
 $= 16 \times 16$
 $= 256$

* luas yg tdk ditertimb
 $= \frac{15}{100} \times 256 = \frac{3840}{100} = 38,4 \text{ m}^2$

2. Luas $\Delta = \frac{1}{2} a t$
 $= \frac{1}{2} \times 16 \times 15$
 $= 8 \times 15 = 120$

* Tinggi $\Delta = \sqrt{17^2 - 8^2}$
 $= \sqrt{289 - 64}$
 $= \sqrt{225} = 15$

$= L \Delta \times 8$
 $= 120 \times 8$
 $= 960 \text{ m}^2$

* 5 liter cat 420.000
 $\frac{960}{10} : 5 = 19,2 \rightarrow 20$

* Cat yang dibutuhkan
 $= 20 \times 420.000$
 $= 8.400.000$

* jasa = L dinding $\times 25.000$
 $= 960 \times 25.000$
 $= 24.000.000$

* Total
 $= 8.400.000 + 24.000.000$
 $= 32.400.000$

Figure 7. SP's Answer to the Step Carrying Out a Plan

PPC08 : "On your answer sheet, there is a formula for the height of a triangle. Why did you use that formula?"

SPC08 : "To calculate the height of the triangle before finding the area of the triangle." (R3)

PPC09 : "Can you explain the meaning of the formula $\Delta = \sqrt{ab^2 + bc^2}$ and height $\Delta = \sqrt{17^2 - 8^2}$?"

SPC09 : "The formula Δ uses Pythagoras, right? Usually the formula is $ac = \sqrt{ab^2 + bc^2}$, o find the height of a triangle, subtract the base of the triangle from the hypotenuse. The 17 is the hypotenuse and the 8 is the base of the right triangle." (R3)

PPC10 : "Where do you get the base of a right triangle?"

SPC10 : "From the base of the triangle or the base of the square divided by 2." (S3)

PPC11 : "Then, what do you mean by calculating $120 \times 8 = 960 \text{ m}^2$?"

SPC11 : "So, the wall area is calculated from the area of the triangle multiplied by the number of wall sides that need to be painted. 120 is the area of the triangle and 8 is the number of outer and inner wall sides that need to be painted." (S3) (R3)

PPC12 : "On your answer sheet, why did you divide 960 by 10 and then divide the result by 5 again?"

SPC12 : "So, the area of the wall that needs to be painted is 960 m^2 , then divided by 10 m^2 o get 96, then I divide by 5 because we know that the price of paint is for 5 liters." (S3) (R3) (C3)

PPC13 : "Why divide by 10 m^2 and why round it up to 20 liters?"

SPC13 : "Because each liter is used to paint 10 m^2 , and it's rounded up to a multiple of 5 because the paint price is per 5 liters." (C3)

PPC14 : "How do you make sure your answer is correct?"

SPC14 : "I double-check the calculations, starting from verifying the formula to the final total cost." (O3)

Based on the results of the resolution and interview transcripts at the step carrying out the plan, it can be explained that SP wrote down the formulas to be used before starting the calculations, namely the formula for the area of a square $L = s \times s$, the formula for the area of a triangle $L = \frac{1}{2} \times a \times t$, and the formula for height $\Delta = \sqrt{ab^2 + bc^2}$. Next, SP calculated the area of the square using the formula $L = s \times s$, resulting in an area of 256 m^2 (focus). Next, it calculates the area of the un-tiled base by multiplying 15% by 256, resulting in $38,4 \text{ m}^2$ (inference). Then, based on its calculations, SP uses the Pythagorean theorem to determine the height of the triangle in order to calculate the area of the triangle (reason). SP also explains that to find the height of a triangle, one must subtract the sloping side of the triangle from the base of the triangle (reason). After obtaining the height of the triangle,

which is 15m, and the base of the triangle, which is 16m, SP calculates the area of the triangle using the formula $L = \frac{1}{2} \times a \times t$, resulting in an area of 120 m^2 (*situation*).

Next, SP multiplies the area of the square by the number of wall sections that need to be painted, which is $120 \times 8 = 960 \text{ m}^2$, resulting in a total wall area that needs to be painted of 960 m^2 (*reason*)(*situation*). SP divides 96 litres by 5 because the price of paint is per 5 litres, resulting in 19.2 litres of paint required, which is then rounded up to 20 litres because the price of paint available is per 5 litres (*reason*)(*situation*). After determining the amount of paint that needs to be purchased, SP calculates the cost of paint according to the amount needed, which is $20 \times 420.000 = 8.400.000$, then calculates the painting service cost, which is $960 \times 25.000 = 24.000.000$. Based on these calculations, the total painting cost is $8.400.000 + 24.000.000 = 32.400.000$ (*focus*)(*inference*). In addition, SP clarifies the terms/symbols/concepts used when solving problems, such as when explaining the reasons for using formulas and calculation processes (*clarity*). Based on this, it can be explained that SP ensures that all terms/symbols used in the calculations are correct by rechecking the calculation results, starting from checking the formula to the final total cost (*clarity*)(*overview*).

Looking back

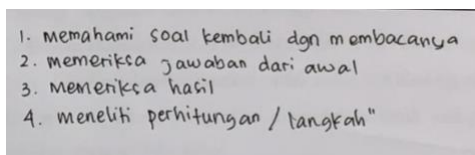


Figure 8. SP's Answer to the Step Looking Back

PPB15 : "After completing the calculations, why is it necessary to double-check all the calculations? Do you check only the calculations or the entire work?"

SPB15 : "I double-check the entire work to ensure my answers are correct before submitting them." (R4)
(O4)

PPB16 : "What are the important points you pay attention to when double-checking?"

SPB16 : "The information given and asked, the steps, the use of formulas, and the calculations." (F4)
(C4)

PPB17 : "What is the final conclusion based on the calculations you did?"

SPB17 : "The area of the floor that is not tiled is $38,4 \text{ m}^2$ and the total cost to paint all the walls is $32.400.000$." (I4)

PPB18 : "Did you also check if there was another more efficient/easier way to solve the problem?"

SPB18 : "No." (S4)

Based on the results of the review and interview transcript at the review stage, it can be explained that SP wrote down four steps taken during the review, namely understanding the question again by reading it, checking the answers from the beginning, checking the results, and examining the calculations/steps (*overview*). Furthermore, SP revealed that he checked the entire answer before submitting it to see if it was correct or not (*reason*). In addition, when checking his solution, SP checked several important points, namely the information known and asked, the steps, the use of formulas, and the calculations (*focus*) (*clarity*). SP also revealed the final conclusion based on the results of his calculations, namely, the area of the base that was not tiled was $38,4 \text{ m}^2$ and the total cost of painting the entire wall was $32.400.000$ (*inference*). However, SP did not recheck whether there was a more efficient/easier way to solve the problem.

Discussion

Critical Thinking of Male Students with Climber-Type

Understanding the problem

Male climber-type students demonstrated focus by identifying important information, rewriting it in their own words, and representing the problem visually. This finding is consistent with Selan et al. (2023), who reported that climber students tend to identify the core of a problem and restate information independently. Similarly, Prameswari & Ismail (2023) found that students with strong critical thinking skills were able to distinguish known and unknown information before proceeding to solution strategies. These findings indicate that male climber students possess strong interpretative skills, allowing them to construct an accurate understanding of the problem.

Students also demonstrated reason and inference by explaining why specific information was relevant and by restating the problem using their own language. This supports Hidayat & Sariningsih (2018), who found that climber students tend to validate information before making decisions. Furthermore, students demonstrated situation, clarity, and overview by identifying the context of the problem, using appropriate mathematical terms and units, and reviewing the information before moving to the next stage. This behaviour reflects metacognitive awareness in ensuring that the information used is accurate and relevant.

Devising a plan

At the planning stage, male climber students determined solution strategies before performing calculations and provided logical reasons for their choices. They were able to connect information from the problem with relevant mathematical concepts and formulate appropriate solution steps. This is in line with Waisman et al. (2025), who found that students with greater mathematical expertise were more capable of strategic, non-routine problem solving, supporting the idea that strong planning ability reflects a deeper, more flexible engagement with mathematical strategies rather than mere procedural knowledge. This finding is consistent with Veola & Faiziyah (2023), who reported that climber students systematically organise solution procedures based on the information obtained. Students with this type tend to consider several alternative strategies before choosing the most efficient and rational method.

Furthermore, students demonstrate inference by drawing preliminary conclusions about the solution steps to be applied. These preliminary conclusions are drawn based on the information contained in the question and the strategies that have been selected previously. According to Halpern & Butle (2019), drawing preliminary conclusions is part of critical reasoning because it allows students to predict the results of the planned steps before implementing them. In addition, they expressed their plans clearly and systematically. However, they did not re-evaluate the planned strategy before beginning calculations, indicating that the overview criterion was not fully demonstrated at this stage.

Carrying out the plan

Male climber students implemented their solution plans systematically and consistently. They applied relevant formulas, justified the procedures used, and maintained the selected strategy throughout the solution process. This finding supports Hidayat & Sariningsih (2018), who found that climber students tend to ensure that each procedure is logically justified. The student's behaviour at this stage shows that they tend to be persistent, do not rush to change strategies, and are committed to following the plan that has been made until completion.

Students also demonstrated inference by drawing conclusions from intermediate calculations and demonstrated situation by adjusting mathematical procedures to the problem context. These findings are in line with Prameswari & Ismail (2023), who reported that students with strong critical thinking skills are able to select appropriate strategies, perform accurate calculations, and justify their procedures. This is consistent with Makowski et al. (2026), who found that female students tend to rely more on algorithmic, step-by-step computation strategies, whereas male students more often use flexible or invented strategies, a pattern that persists from adolescence into adulthood. Furthermore, students reviewed their calculations and checked each step before proceeding, indicating strong metacognitive regulation and persistence. Astiantari et al. (2022) emphasise that students with climber-type AQ have a strong drive to complete tasks thoroughly by paying attention to the process, not just the results. This is evident when climber male students carry out their completion plans: they perform calculations systematically, recheck each step before continuing, and maintain consistency between the plan and its implementation.

Looking back

At the verification stage, male climber students reviewed calculations, procedures, and conclusions to ensure consistency between the solution and the problem requirements. They provided logical reasons for rechecking their work and evaluated whether the final answer was reasonable. This finding is consistent with Prameswari & Ismail (2023), who found that students with strong critical thinking skills formulate conclusions that are consistent with both mathematical results and problem contexts. The ability to generate appropriate conclusions indicates that students successfully connect interpretation, analysis, and evaluation processes into a coherent reasoning structure. This shows that students not only check the answers numerically, but also ensure that the conclusions drawn are consistent with the context of the problem.

However, students did not consider alternative strategies that might have been more efficient. They focused on verifying the correctness of the chosen solution rather than evaluating its effectiveness. Brookfield (2012) states that evaluating alternative strategies is part of metacognition in critical thinking, which is the ability to assess the strategies used and consider other approaches. Nevertheless, students reviewed the entire problem-solving process and ensured that their reasoning, notation, and conclusions were clear and accurate, reflecting the persistence characteristic of climber students.

Overall, the findings of this study indicate that male climber-type students demonstrated critical thinking characteristics across all stages of Polya's problem-solving process. These findings support the results of Prameswari & Ismail (2023), which showed that students with strong critical thinking skills were able to fulfil the indicators of interpretation, analysis, evaluation, and inference. Furthermore, the persistence shown by climber-type students throughout the problem-solving process strengthens previous findings that students with higher resilience tend to maintain logical reasoning and continue seeking solutions when encountering difficulties. Therefore, the combination of strong critical thinking skills and high adversity quotient appears to contribute positively to successful mathematical problem solving.

Critical Thinking of Female Students with Climber-Type

Understanding the problem

Female climber-type students demonstrated focus by identifying important information, recording it in bullet points, and representing the problem visually. This finding is consistent with Selan et al. (2023), who reported that climber students are able to identify essential information and restate it in their own words. Similarly, Sugiarti et al. (2023) found that students with strong critical thinking skills could distinguish known and unknown information and organise it systematically before solving the problem. These findings indicate that female climber students possess strong interpretative abilities and tend to ensure a complete understanding of the problem before proceeding to the next stage.

Students also demonstrated reason and inference by explaining the relevance of the information identified and restating the problem using their own language. This supports Hidayat & Sariningsih (2018), who found that climber students tend to reflect carefully before making decisions. Furthermore, students demonstrated situation, clarity, and overview by identifying the problem context, using clear mathematical terms and symbols, and reviewing the information obtained. This behaviour indicates metacognitive awareness in ensuring the completeness and accuracy of problem interpretation.

Devising a plan

At the planning stage, female climber students determined solution strategies before performing calculations and provided logical explanations for their choices. They connected the information contained in the problem with relevant mathematical concepts and arranged solution procedures systematically. This finding is in line with Veola & Faiziyah (2023), who reported that climber students are able to organise solution steps based on relevant mathematical concepts.

Students also demonstrated inference by predicting the steps required to solve the problem and demonstrated situation by integrating prior knowledge with the problem context. In addition, they reviewed their plans before beginning calculations, indicating the presence of overview. This finding suggests that female climber students tend to evaluate the suitability of their strategies before implementation. However, minor inconsistencies in

the use of mathematical terminology were still observed. In line with this, climber-type students showed strengths that included perseverance and self-evaluation, which supported the process of reviewing their solution plans (Gunawan et al., 2023). This action showed that climber-type female students did not just make plans, but also evaluated those plans to ensure their suitability and completeness.

Carrying out the plan

Female climber students implemented their solution plans systematically and consistently. They applied relevant formulas, completed calculations sequentially, and maintained the chosen strategy throughout the solution process. This finding supports Santrock (2014), who stated that female students tend to approach mathematical tasks carefully and systematically.

Students also demonstrated reason by explaining the rationale behind the formulas and procedures used. This finding is consistent with Hidayat & Sariningsih (2018), who found that climber students tend to evaluate the appropriateness of the procedures they apply. Furthermore, students demonstrated inference by drawing logical conclusions from intermediate calculations and demonstrated situation by adjusting mathematical procedures to the problem context. These findings are supported by Prameswari & Ismail (2023), who reported that students with strong critical thinking skills are able to formulate conclusions that are consistent with mathematical evidence obtained during problem solving.

In addition, students demonstrated clarity by using appropriate symbols, units, and mathematical notation. They also reviewed calculations, formulas, and solution steps to ensure accuracy, reflecting the persistence and thoroughness commonly associated with climber students. In line with this, Rahmawati (2022) revealed that climber-type female students are more stable in maintaining the steps for solving problems even when faced with several challenges. Based on this, female climber-type students carry out the steps to solve the problem with perseverance and resilience in facing challenges while solving the problem.

Looking back

At the verification stage, female climber students reviewed the entire solution process, including calculations, procedures, and conclusions. They provided logical reasons for rechecking their work and ensured that the final answer was consistent with the problem context. This behaviour reflects a reflective and careful approach to problem solving. Students also demonstrated inference by evaluating whether the conclusions obtained were reasonable and supported by the available evidence. This finding is consistent with Sugiarti et al. (2023), who found that students with strong critical thinking skills are able to formulate conclusions that align with both mathematical results and problem requirements.

However, similar to male climber students, female climber students did not evaluate alternative solution strategies that might have been more efficient. They focused on

verifying the correctness of the chosen strategy rather than comparing it with other possible approaches. Nevertheless, students reviewed the entire problem-solving process and ensured that their reasoning and conclusions were accurate and understandable, reflecting the persistence and self-evaluation characteristics of climber students.

Overall, female climber-type students demonstrated critical thinking characteristics throughout all stages of Polya's problem-solving process. These findings are consistent with those of Sugiarti et al. (2023), who found that students with strong critical thinking skills were generally able to fulfil the indicators of interpretation, analysis, evaluation, and inference. Furthermore, the tendency of female climber-type students to carefully review information, evaluate procedures, and ensure the consistency of their conclusions reflects the persistence and resilience that characterise individuals with high adversity quotient. Therefore, the findings suggest that critical thinking and adversity quotient interact positively in supporting successful mathematical problem solving.

CONCLUSION AND SUGGESTIONS

Critical Thinking of Male Students with Climber-Type

The male climber student demonstrated critical thinking throughout all stages of mathematical problem solving. In understanding the problem, he carefully identified relevant information, restated known and unknown elements in his own words, and reviewed the information before proceeding. In devising a plan, he selected appropriate strategies and provided logical reasons for their use, although he tended to move directly to the implementation stage without re-evaluating the planned strategy. During carrying out the plan, he consistently followed the selected strategy, justified the use of mathematical concepts and formulas, and reviewed calculation results to ensure accuracy. In looking back, he rechecked procedures, calculations, and conclusions; however, he did not consider alternative strategies that might have been more efficient. These findings suggest that the male climber student exhibited persistence, logical reasoning, and careful verification during problem solving.

Critical Thinking of Female Students with Climber-Type

The female climber student also demonstrated critical thinking throughout all stages of mathematical problem solving. In understanding the problem, she carefully identified and organized relevant information using her own words and verified its accuracy before proceeding. In devising a plan, she selected appropriate solution strategies, provided logical justifications, and reviewed the planned steps before implementation. During carrying out the plan, she applied mathematical procedures systematically, explained the reasons for using specific formulas and concepts, and carefully checked each stage of the calculation process. In looking back, she reviewed the solution process and final answers to ensure correctness. However, similar to the male climber student, she did not evaluate or compare alternative solution strategies. These findings suggest that the female climber student

demonstrated careful, systematic, and reflective thinking during mathematical problem solving.

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