JRPM, 2024, *9*(2), 156-167
JRPM (Jurnal Review Pembelajaran Matematika)
http://jurnalftk.uinsa.ac.id/index.php/jrpm

Analyses of Meta-Cognition of Middle School Students Based on Gender Differences in Solving Flat-Rectangular Space Problems

Ikrar[1], Muhammad Hajarul Aswad A[2*], Muhammad Ihsan[3]

[1,2,3]IAIN Palopo, Kota Palopo, Sulawesi Selatan, Indonesia
***Corresponding Author:** muh_hajarul_aswad@iainpalopo.ac.id

ARTICLE INFO

Article history:
Received 14 Oct 2024
Revised 25 Dec 2024
Accepted 30 Dec 2024

Keywords:
Flat-Sided Geometric; Gender; Metacognition; Problem Solving.

ABSTRACT

Students with well-developed metacognition tend to excel in problem-solving. This study examines the metacognitive skills of junior high school (MTs) students in solving three-dimensional geometric problems, focusing on gender differences. The analysis involves three stages of metacognition: planning, monitoring, and evaluation. Using a qualitative descriptive approach, the study selected three male and three female students from 35 ninth-grade students. Data were gathered through mathematics learning outcome documents, metacognitive essay tests, and interview guidelines. The results reveal that male students face challenges across all three metacognitive stages when solving geometric problems, whereas female students encounter difficulties primarily at the evaluation stage. These findings highlight the need for targeted interventions to strengthen metacognitive skills, particularly in problem-solving contexts, while addressing gender-specific challenges.

How to cite:
Ikrar., Aswad, M. H., & Ihsan, M. (2024). Analyses of Meta-Cognition of Middle School Students Based on Gender Differences in Solving Flat-Rectangular Space Problems. *JRPM (Jurnal Review Pembelajaran Matematika)*, *9*(2), pp. 156-167.

INTRODUCTION

To solve mathematical problems, students must continue to practice during learning activities in class. This is because problem solving is the core of fundamental skills in the learning process (Annisa et al., 2021). To solve mathematical problems, efficient steps are required, which is important to ensure that the problem-solving process is clear. Mayasari (2019) revealed that five aspects of mathematical ability are necessary for students to be able to solve mathematical problems, namely, a special understanding of mathematical concepts, mathematical algorithm skills, mathematical process skills, a positive attitude towards mathematics, and finally, metacognitive skills.

ISSN 2503–1384 (*online*)
DOI: https://doi.org/10.15642/jrpm.2024.9.2.156-167

Metacognition is the ability to reflect on, understand, and control cognitive processes (Maor et al., 2023). Metacognition can also be translated as the process of understanding and monitoring one's thinking activity (Nurhayati & Kusaeri, 2024) and making a significant contribution to students (Putri et al., 2024). Furthermore, Gunstone & Mitchell (2005) stated that meta-cognitive knowledge refers to knowledge about the characteristics and process of learning, learning characteristics, and effective learning strategies. Students who know their meta-cognition can develop their problem-solving abilities.

Students' ability to solve problems is influenced by their metacognition level (Suryani et al., 2023). Weak metacognition is one of the causes of students' poor understanding of concepts (Taufik & Vandita, 2023). Mathematical problem-solving can be done by students through maximum effort according to correct solution procedures and appropriate strategies (Putri et al., 2024; Wahyuni, 2023).

Several studies have been conducted on the relationship between students' meta-cognition and their problem-solving abilities. Hasybi & Munandar (2021) analyzed the mathematical meta-cognition of male and female students. The results showed that female students had three meta-cognitive abilities, namely planning, monitoring, and evaluation, while male students were still lacking in monitoring and evaluation. Zulfikar (2019) analyzed the meta-cognition of students with high, medium, and low abilities, focusing on awareness, cognition, planning, and checking back. The results showed that students' metacognitive ability was good, where they had good planning and checked back against the results obtained in solving mathematical problems. Taufik et al. (2022) analyzed the meta-cognition of two female students with cognitive learning styles of reflective and impulsive. The results showed that students with a cognitive learning style met all three stages of metacognition and were classified as *reflective use*, while students with an impulsive cognitive learning style were still not maximal in planning and evaluation and were classified as *aware use*.

The three studies mentioned earlier have successfully analyzed student meta-cognition. Hasybi & Munandar (2021) only considered gender as the subject variable, Zulfikar (2019) analyzed meta-cognition using four indicators, namely awareness, cognitive, planning, and checking back, and Taufik et al. (2022) analyzed meta-cognition among female students only based on their learning styles. In contrast, this study analyzed meta-cognition among students based on both gender and mathematical ability. Based on this, this study aims to describe the metacognition of male and female students in mathematical problem-solving, with the expectation that it will provide benefits for teachers in offering appropriate responses as follow-up actions to address students' character differences.

RESEARCH METHODS

This study is qualitative descriptive research focused on the metacognitive abilities of male and female students in solving flat rectangular space problems. The indicators of metacognitive ability used in this study are consistent with Sihotang et al. (2024) and Erlin & Fitriani (2019). The stages of metacognition, problem-solving steps, and their indicators can be seen in Table 1.

Table 1. The Metacognition Steps, Problem Solving, and Indicators

The Metacognition Steps	The Problem-Solving Steps	Indicators
Planning	Understanding the problem	Students can write what they know and what is asked in the question.
	Planning	Students can determine the solution plan to be used.
Monitoring	Implementing the plan	Students are already able to use the plan that has been made to solve the problem.
		Students can explain the steps of the solution correctly.
Evaluation	Checking Back	Students can evaluate the answers that have been solved by checking whether the calculations are correct and the results are accurate.

The study was conducted at MTs Negeri Palopo in South Sulawesi, with preliminary analysis of daily homework scores and Mid-Term Test scores to obtain students with high, medium, and low mathematics abilities. Categorization was done using standard deviation score ranges. From this, data reduction was performed, resulting in a selection of 6 students out of a population of 35, consisting of 3 males and 3 females, each representing their respective categories within the male and female groups. The identification of the research subjects is presented in Table 2.

Table 2. Initial Identification of Students' Mathematical Abilities

No	Initial Subjects	Gender	Mathematical Abilities	Code
1	USMK	P	High	SP1
2	NAZ	P	Medium	SP2
3	UMA	P	Low	SP3
4	MDAP	L	High	SL1
5	FW	L	Medium	SL2
6	DF	L	Low	SL3

The selected subjects were then given a meta-cognitive test in the form of essay questions. The metacognition test used consisted of one HOTS essay question that had been validated by two validators, namely a lecturer and a subject teacher.

In addition to the metacognition test, another instrument used was the interview sheet. The interview sheet contained open-ended questions to obtain more detailed information about the difficulties encountered by students in answering the metacognition test. Data collection through the metacognition test and interviews was conducted in person with each respondent.

RESULTS AND DISCUSSION

Metacognition, problem-solving, and the indicators used are presented as shown in Table 1. The metacognitive processes of male and female students were then described separately. To ensure the consistency of the obtained data, a technique triangulation was conducted between the test results and interview data. Triangulation aims to ensure the credibility of the research findings (Mekarisce, 2020), where technique triangulation is employed to verify data accuracy from the same source using different methods (Nurfajriani et al, 2024).

Metacognition of Female Students with High Mathematical Ability (SP1)

In the planning stage, SP1 wrote down information about what was known and what was asked in the problem, but it was incomplete as it did not clearly state what was known from the given problem. SP1 was unable to solve the problem and the final result is still incorrect. This reinforces that students who rush when solving problems tend to overlook important information in the question, leading to an inability to answer the questions correctly (Bungawati, 2024; Nabiila & Listiyani, 2024; Nufus et al., 2022). See Figure 1.

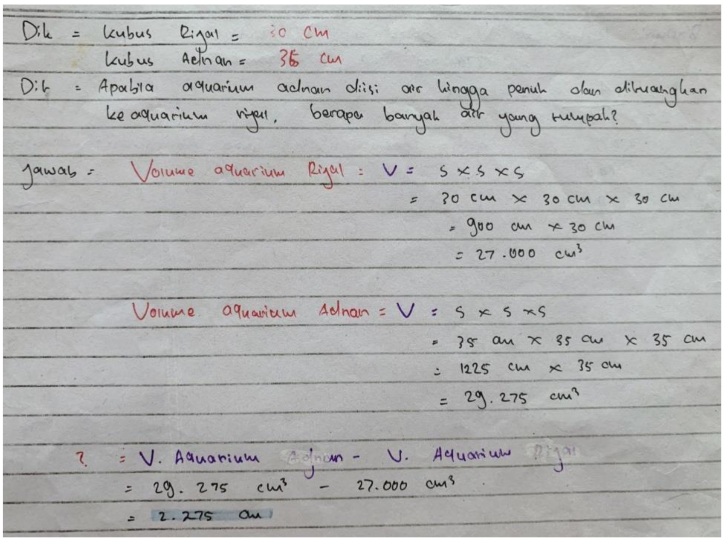


Figure 1. The result of SP1

The reason SP1 did not write the plan in full was confirmed through a direct interview. The interview results showed that SP1 understood the problem well, including the information known from the question. SP1 did not write it on the answer sheet because they wanted to solve the problem quickly and had already determined a plan to address the given question.

Metacognition of Female Students with Moderate Mathematical Ability (SP2)

In the planning stage, SP2 did not write down information about what was known and what was asked in the problem. However, SP2 was able to correctly solve the problem by first writing down the formula to be used. See Figure 2.

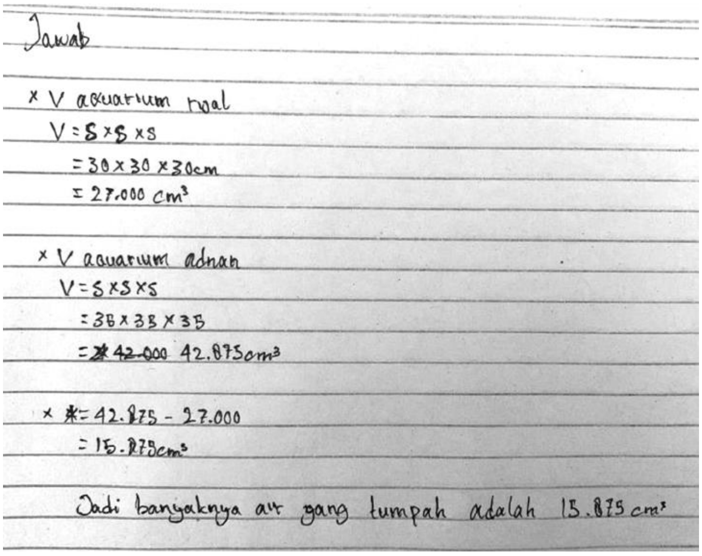

Jawab
× V aquarium rival
V = S × S × S
= 30 × 30 × 30cm
= 27.000 cm³
× V aquarium adnan
V = S × S × S
= 35 × 35 × 35
= ~~42.000~~ 42.875cm³
× = 42.875 - 27.000
= 15.875cm³
Jadi banyaknya air yang tumpah adalah 15.875 cm³

Figure 2. The result of SP2

The reason SP1 did not write the plan in full was confirmed through a direct interview. The interview results indicated that SP2 actually understood the problem well, including the information known and asked in the question. SP2 did not clearly write it on the answer sheet but rather on the correction sheet. In this case, SP2 had essentially been able to understand the problem and develop a good plan for solving the problem.

Metacognition of Female Students with Low Mathematical Ability (SP3)

In the planning stage, SP3 wrote down what was known but did not include what was asked in the question. SP3 wrote down the formula to be used to solve the problem, but the formula written used incorrect notation. See Figure 3.

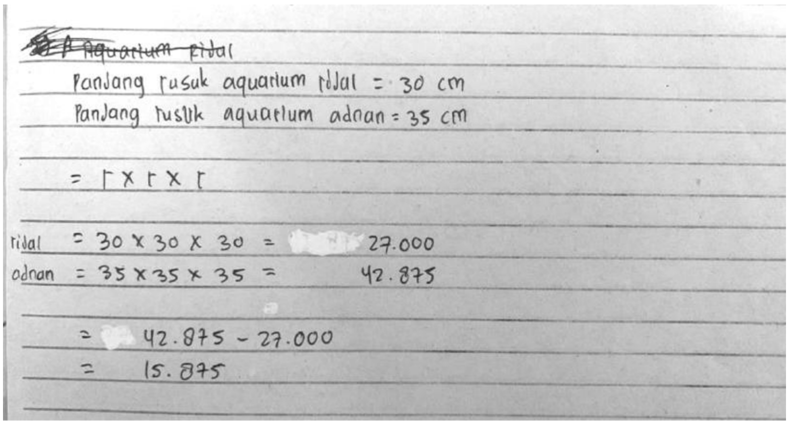


Figure 3. The result of SP3

The interview with SP3 revealed that, in essence, SP3 understood what was known and what was asked in the problem but did not write it down on the answer sheet. SP3 had also been able to develop a correct plan to solve the problem. The notation "r" written was a misinterpretation of the notation for the side length, which should have been denoted by "s." This is categorized by Suri et al. (2024) as careless errors, which are mistakes caused by students' negligence.

Female students have been able to apply problem solving steps. This is evident from their ability in each stage of meta-cognition that has been carried out, although, in the evaluation stage, female students are still less thorough in their process, resulting in an incorrect final answer, as can be seen in Figure 1. However, through an interview, the female student had indeed carried out all the steps of problem-solving and felt certain with the answer given. This result needs to be discussed further because, based on Cunningham et al. (2017) and Nurhayati & Kusaeri (2024), students with high meta-cognitive ability have a focus and understanding of the material that is good and effective, and therefore can minimize mistakes in the process of solving mathematical problems.

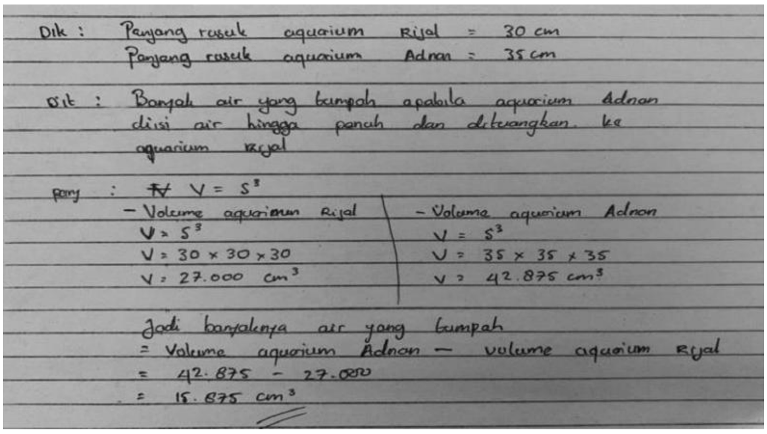
Metacognition of female students for the planning, monitoring, and evaluation can be seen in Table 3.

Table 3. Metacognition and Problem-Solving Steps in Female Students

The Metacognition Steps	The Problem-Solving Steps	Indicators	Subject		
			SP1	SP2	SP3
Planning	Understanding the problem	Students can write what they know and what is asked in the question.	Students can write what they know and what is asked in the question.	Students are unable to write what they know and what is asked in the question.	Students are only able to write what they know in the question.
	Planning	Students can determine the solution plan to be used.	Students can determine the solution plan to be used.	Students can determine the solution plan to be used.	Students are less able to determine the solution plan.
Monitoring	Implementing the Plan	Students are already able to use the plan that has been made to solve the problem.	Students are already able to use the plan that has been made to solve the problem.	Students are already able to use the plan that has been made to solve the problem.	Students are less able to use the plan that has been made to solve the problem, as indicated by the incomplete steps of the solution written.
		Students can explain the steps of the solution correctly.	Students can explain the steps of the solution, although there are still errors in the final calculation.	Students can explain the steps of the solution correctly.	Students cannot explain the steps of the solution correctly, as indicated by the incorrect use of formulas.
Evaluation	Checking Back	Students can evaluate the answers that have been solved by checking whether the calculations are correct and the results are accurate.	Students can check their answers again, but they are not aware that there is an incomplete calculation, resulting in an incorrect final result.	Students can get their answers again and the answer is already correct.	Students can check their answers again, but they are not aware of the mistake in determining the formula used.

Metacognition of Male Students with High Mathematical Ability (SL1)

SL1 wrote down information about what was known and what was asked in the problem, but it was incomplete as it did not clearly state what was known from the given problem. However, SL1 was able to solve the problem by first writing down the formula to be used. See Figure 4.



Dik : Panjang rusuk aquarium Rijal = 30 cm
Panjang rusuk aquarium Adnan = 35 cm

Dit : Banyak air yang tumpah apabila aquarium Adnan diisi air hingga penuh dan dituangkan ke aquarium Rijal

Peny : $V = s^3$

- Volume aquarium Rijal
$V = s^3$
$V = 30 \times 30 \times 30$
$V = 27.000\ cm^3$

- Volume aquarium Adnan
$V = s^3$
$V = 35 \times 35 \times 35$
$V = 42.875\ cm^3$

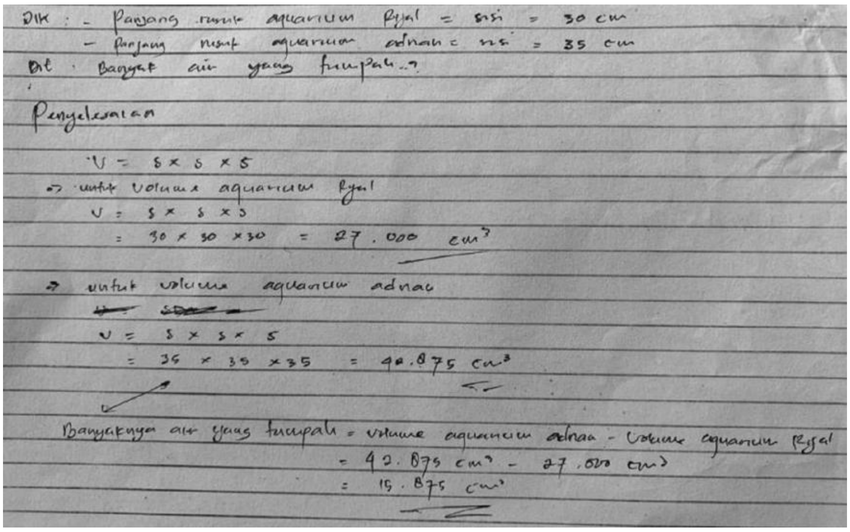
Jadi banyaknya air yang tumpah
= Volume aquarium Adnan − volume aquarium Rijal
= 42.875 − 27.000
= $15.875\ cm^3$

Figure 4. The result of SL1

The interview with SL1 revealed that SL1 understood what was known and what was asked about the problem, even though it was not written down on the answer sheet. SL1 had also been able to develop a correct plan to solve the problem.

Metacognition of Male Students with Moderate Mathematical Ability (SL2)

SL2 did not encounter any difficulties in answering the question. SL2 wrote down information about what was known and what was asked in the problem. SL2 also successfully answered the question correctly by first writing down the formula to be used. See Figure 5.



Dik : - Panjang rusuk aquarium Rijal = sisi = 30 cm
- Panjang rusuk aquarium adnan = sisi = 35 cm

Dit : Banyak air yang tumpah..?

Penyelesaian

$V = s \times s \times s$

→ untuk volume aquarium Rijal
$V = s \times s \times s$
$= 30 \times 30 \times 30 = 27.000\ cm^3$

→ untuk volume aquarium adnan
$V = s \times s \times s$
$= 35 \times 35 \times 35 = 42.875\ cm^3$

Banyaknya air yang tumpah = volume aquarium adnan − volume aquarium Rijal
$= 42.875\ cm^3 - 27.000\ cm^3$
$= 15.875\ cm^3$

Figure 5. The result of SL2

Confirmation with SL2 was also conducted through an interview. The interview results indicated that SL2 had been able to understand the problem well and was able to determine the plan to be used to solve the problem correctly.

Metacognition of Male Students with Low Mathematical Ability (SL3)

SL3 appeared to have difficulty solving the problem. SL3 was unable to write down what was known and what was asked in the problem. SL3 also could not write down the formula to be used, making it impossible to solve the problem correctly. See Figure 6.

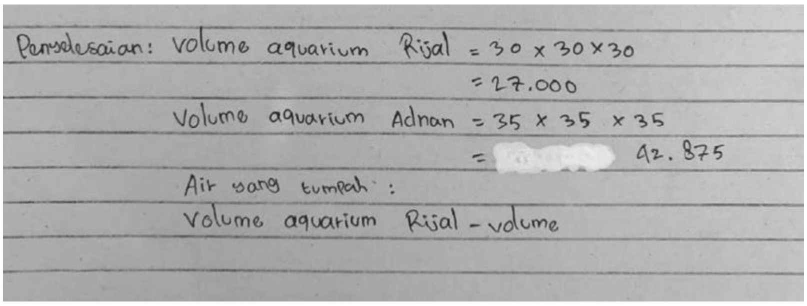


Figure 6. The result of SL3

The test results of SL3 were clarified through an interview. From the interview, it was found that SL3 was indeed unable to understand the problem presented in the question properly. SL3 was also unable to determine a plan to solve the problem, which led to an incorrect answer to the question.

There are still male students who are unable to apply the problem solving step. This is evident from the mathematical ability of male students who have low mathematical ability, struggling at every stage of problem solving. Those students do not understand the material provided in the question, so they are unable to solve each question well, as seen in Figure 2. The interview results also strengthen this finding. This result is consistent with previous research (Nurhayati & Kusaeri, 2024).

Male students' metacognition for the planning, monitoring, and evaluation can be seen in Table 4.

Table 4. Metacognition and Problem-Solving Steps in Male Students

Metacognition Steps	Problem-Solving Steps	Indicator	Subject		
			SL1	SL2	SL3
Planning	Understanding the problem	Students can write what they know and what is asked in the question.	Students can write what they know and what is asked in the question.	Students can write what they know and what is asked in the question.	Students are unable to write what they know in the question.
	Planning	Students can determine the solution plan to be used.	Students can the solution plan to be used.	Students can the solution plan to be used.	Students are unable to determine the solution plan.
Monitoring	Implementing the Plan	Students are already able to use a plan that has been made to solve the problem.	Students are already able to use a plan that has been made to solve the problem.	Students are already able to use a plan that has been made to solve the problem.	Students are unable to use the plan that has been made to solve the problem.

Metacognition Steps	Problem-Solving Steps	Indicator	Subject		
			SL1	SL2	SL3
		Students can explain the solution correctly.	Students can explain the solution correctly.	Students can explain the steps of the solution correctly.	Students are unable to correctly explain the steps for solving the problem.
Evaluation	Checking Back	Students can evaluate the answers that have been solved by checking whether the calculations are correct and the results are accurate.	Students can re-evaluate the answers that have been solved.	Students can re-evaluate the answers that have been solved.	Students are unable to re-evaluate the answers that have been solved.

CONCLUSION AND SUGGESTIONS

This study has shown how the students' metacognition varies based on gender in solving flat-plane geometric problems. The problem-solving steps have been described based on existing indicators, with three metacognitive stages starting from planning, monitoring, and evaluation. There are still male students who are unable to solve flat plane geometric problems for three metacognitive stages because they lack understanding of the material in the problem. On the other hand, female students only have a problem at the evaluation stage. This study can be improved by increasing the number of subjects for each mathematics ability category, which in this study only took one person for each gender in each mathematics ability category. The use of standardized instruments such as *The Motivated Strategies for Learning Questionnaire* can be done to perfect this study.

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