SIGMA: JURNAL PENDIDIKAN MATEMATIKA
Volume 17 Nomor 2, Halaman 608 - 624
p-ISSN: 2085-3610, e-ISSN: 2746-7503
https://journal.unismuh.ac.id/index.php/sigma

ANALYSIS OF CRITICAL THINKING SKILLS IN SOLVING HOTS TYPE PROBLEMS REVIEWED FROM STUDENTS' METACOGNITIVE AWARENESS

Farizah Nur Amaliyah[1)], Noer Hidayah [2)], Dwi Shinta Rahayu[3)]
[1,2,3]Tadris Matematika, Fakultas Tarbiyah, UIN Syekh Wasil, Jalan Sunan Ampel No. 7 Kediri, 64129, Indonesia

✉ *noer_hid@iainkediri.ac.id*

ARTICLE INFO

Article History:
Received: 29/08/2025
Revised: 21/10/2025
Accepted: 10/12/2025

ABSTRAK

Kemampuan berpikir kritis merupakan salah satu kompetensi abad ke-21 yang perlu dikembangkan pada peserta didik. Rendahnya kemampuan berpikir kritis siswa dalam menyelesaikan soal Higher Order Thinking Skills (HOTS) pada materi Sistem Persamaan Linear Dua Variabel (SPLDV) menjadi permasalahan yang perlu dikaji lebih mendalam. Penelitian ini bertujuan untuk menganalisis kemampuan berpikir kritis siswa dalam menyelesaikan soal HOTS ditinjau dari tingkat kesadaran metakognitif. Penelitian ini menggunakan desain deskriptif kualitatif dengan subjek sebanyak 31 siswa kelas VIII-A MTs Sunan Gunung Jati. Data dikumpulkan melalui angket kesadaran metakognitif, tes HOTS, dan pedoman wawancara. Data dianalisis dengan mengelompokkan siswa berdasarkan kategori kesadaran metakognitif tinggi, sedang, dan rendah. Hasil penelitian menunjukkan bahwa siswa dengan kesadaran metakognitif tinggi dan sedang memenuhi seluruh indikator berpikir kritis, yaitu interpretasi, analisis, evaluasi, dan inferensi. Siswa dengan kesadaran metakognitif rendah hanya memenuhi indikator interpretasi dan analisis. Penelitian ini memberikan wawasan baru mengenai hubungan antara kesadaran metakognitif dan kemampuan berpikir kritis pada pembelajaran SPLDV di tingkat MTs yang masih jarang diteliti. Temuan penelitian ini memiliki implikasi praktis yang kuat, yakni guru matematika disarankan mengintegrasikan strategi metakognitif dalam model pembelajaran untuk meningkatkan kemampuan berpikir kritis siswa secara sistematis.

Kata kunci: *HOTS; Kemampuan Berpikir Kritis; Kesadaran Metakognitif.*

ABSTRACT

Critical thinking ability is one of the essential 21st-century competencies that must be developed in students. The low level of students' critical thinking skills in solving Higher Order Thinking Skills (HOTS) problems on the Two-Variable Linear Equation System (TVLES) material is an issue that requires further investigation. This study aims to analyze students' critical thinking skills in solving HOTS problems based on their level of metacognitive awareness. This research employed a descriptive qualitative design involving 31 students of class VIII-A at MTs Sunan Gunung Jati. Data were collected through a metacognitive awareness questionnaire, a HOTS test, and interview guidelines. Students were categorized into high, moderate, and low levels of metacognitive awareness for data analysis. The results show that students with high and moderate metacognitive awareness met all critical thinking indicators: interpretation, analysis, evaluation, and inference, and those with low metacognitive awareness fulfilled only interpretation and analysis indicators. This study provides new insights into the relationship between metacognitive awareness and critical thinking skills in learning TVLES at the junior secondary level, an area rarely explored in previous studies. The findings have strong practical implications, suggesting that mathematics teachers should integrate metacognitive strategy training Learning models to systematically foster students' metacognitive awareness and enhance their critical thinking skills.

Keywords: Critical Thinking Skills; HOTS; Metacognitive Awareness.

Cara Menulis Sitasi: Amaliyah, F, N., Hidayah, N., & Rahayu, D, S. (2025). Analysis of Critical Thinking Skills in Solving HOTS Type Problems Reviewed from Students' Metacognitive Awareness. *SIGMA: Jurnal Pendidikan Matematika, 17 (2),* 608-624. https://doi.org/10.26618/6shsyg26

Introduction

Entering the 21st century, Indonesia is faced with an era of information disruption marked by rapid digitalization in various aspects of life. This transformation presents new challenges in the world of education because technology and information are now the foundation of modern human activities. For this reason, individuals are required to master 21st century skills to be able to adapt and compete in the midst of rapid change (Apriliani et al., 2021). One of the main competencies is the 4C skills, namely collaboration, communication, creativity, and critical thinking (Wulansari & Sunarya, 2023). Of the four, critical thinking skills are very important because they help individuals solve complex problems in daily life.

Critical thinking can be understood as a logical reasoning process to solve problems, gain understanding, and evaluate various opinions in order to make valid decisions (Abdullah, 2013; Ennis, 2011; Vijayaratnam, 2009). In mathematics learning, critical thinking has a central role to help students in analyzing, evaluating alternative solutions, and drawing the right conclusions (Maulidiya & Nurlaelah, 2019). This ability is closely related to the Higher Order Thinking Skills (HOTS) in Bloom's Taxonomy, namely analysis, evaluation, and creation (Susilowati & Sumaji, 2020).

An important instrument to measure critical thinking skills is the HOTS question. The HOTS questions test the cognitive levels of C4 (analysis), C5 (evaluation), and C6 (creation) (Nafiati, 2021). These questions are designed to stimulate problem-solving, requiring students to connect, evaluate, and come up with new solutions. In mathematics, HOTS problems are very relevant because students are not only asked to calculate but also interpret contextual problems that are non-routine (Kamila, 2020).

However, in reality, many students still struggle with solving HOTS questions. Previous studies consistently highlight several underlying causes of these difficulties, including limited conceptual understanding, weak mastery of prerequisite concepts, low critical thinking skills, and lack of experience in solving non-routine problems (Permatasari et al., 2015; Ernawati & Sutiarso, 2020; Mella et al., 2023; Hastiwi & Budiharti, 2018). Students are also often confused by complex question instructions, which leads them to answer without fully comprehending the given information (Nuraini & Julianto (2022). These findings indicate that the challenge is not merely technical but involves both cognitive and metacognitive factors that affect students' ability to engage with higher-order thinking tasks.

One of the important factors that affect students' critical thinking skills in working on HOTS questions is metacognitive awareness. Flavell, (1979) defines metacognitive awareness as an individual's awareness of monitoring, evaluating, and controlling their own thinking strategies. In mathematics learning, this awareness helps students examine the thinking process, formulate strategies, and evaluate the resulting solutions (Wahdah et al., 2016b, Hidayah & Nabila, 2022). Jianto et al. (2020) even refer to metacognition as a person's ability to review, monitor, and monitor the solution process in problem solving.

Metacognitive awareness is closely related to critical thinking. Metacognitive helps individuals monitor thought processes, identify weaknesses, and then correct them in order to make more informed decisions (Shintawati et al., 2023). In the context of solving HOTS questions, metacognition facilitates students to examine strategies, correct answers, and reconsider the completion steps.

A number of previous studies have raised the relationship between metacognitive awareness and critical thinking. Faiziyah & Priyambodho (2022) found that the higher the students' metacognitive awareness, the better their critical thinking skills in solving HOTS questions. Students with high metacognition tend to be able to meet indicators of critical thinking skills such as interpretation, analysis, and evaluation, although there are still weaknesses at the inference stage.

However, there are still limitations to previous research. For example, Faiziyah & Priyambodho (2022) do not specifically discuss the use of HOTS questions in certain materials with varied test instruments to explore more deeply students' critical thinking patterns. Related studies have also not examined how metacognitive awareness actually affects critical thinking skills in certain contextual mathematical materials, such as the Two-Variable Linear Equation System (SPLDV).

In fact, SPLDV is one of the materials that is closely related to daily life and has great potential to be used to test critical thinking skills. Research by Shafira et al. (2023) shows that students' critical thinking skills in solving HOTS problems in SPLDV are still very low. On average, students have not been able to meet the four indicators of critical thinking (interpretation, analysis, evaluation, and inference).

The reality on the ground reinforces these findings. Based on the results of the researcher's interview with the eighth grade mathematics teacher at MTs Sunan Gunung Jati, there has never been a measurement of students' metacognitive awareness, including its relationship with the ability to think critically in solving HOTS problems. Teachers even have to repeat explanations many times so that students understand the material, and in working on problems, students still need intensive guidance.

Although several previous studies have examined the relationship between metacognitive awareness and critical thinking skills in solving HOTS problems, most of them remain general and do not focus on specific mathematical content. Research by Faiziyah & Priyambodho (2022) confirmed that metacognitive awareness positively affects students' critical thinking skills, but the analysis of critical thinking indicators was not explored in detail. Furthermore, these studies predominantly employed a quantitative approach, emphasizing statistical correlations rather than exploring students' thinking processes in depth. In contrast, this study adopts a qualitative approach to provide a richer and more comprehensive description of how students with different levels of metacognitive awareness engage in solving HOTS problems, particularly within the Two-Variable Linear Equation System (SPLDV) context, a mathematical concept closely related to students' daily experiences and highly suitable for testing critical thinking skills.

This study addresses this gap by focusing on the relationship between metacognitive awareness and students' critical thinking skills in solving HOTS questions specifically designed for SPLDV material. The HOTS test instrument in this research was developed to measure critical thinking indicators such as Interpretation (understanding the problem), Analysis (analyzing information), Evaluation (collecting and evaluating information), and inference (drawing conclusions which produce solutions based on the analysis carried out).

This targeted approach ensures that the findings provide a more nuanced understanding of how metacognitive awareness supports students' higher-order thinking within a concrete mathematical context.

In addition to contributing to the scientific literature in mathematics education, this study offers practical implications for classroom practice. By mapping students' profiles of metacognitive awareness and critical thinking in solving SPLDV HOTS questions—particularly at MTs Sunan Gunung Jati, where no similar research has been conducted—teachers can design more effective learning strategies. These strategies can simultaneously foster students' metacognitive regulation and critical thinking skills, helping them to approach non-routine problems more strategically and meaningfully

With this research, it is hoped that a more comprehensive picture can be obtained of how metacognitive awareness affects the ability to think critically in solving HOTS problems in SPLDV materials, as well as provide important input for teachers in designing learning that is able to stimulate both aspects simultaneously.

METHODS

This study employed a qualitative descriptive design. The purpose of the researcher is to describe the ability to think critically in solving HOTS type problems in more depth and specifically which is reviewed from the student's metacognitive awareness.

This research was conducted at MTs Sunan Gunung Jati, precisely on Jalan PGA No. 5, Gurah, Gurah District, Kediri Regency, East Java 64181. The research time was carried out in the even semester of the 2024/2025 academic year. The subjects chosen in this study were all students from class VIII-A. Next, the researcher selected 6 students to be interviewed using the purposive sampling technique, which represented 3 levels of metacognitive awareness based on the most scores in each category.

This study employed a qualitative descriptive design with four main procedures: preparation, implementation, data analysis, and reporting. In the preparation stage, research instruments were developed, including a metacognitive awareness questionnaire, a set of Higher-Order Thinking Skills (HOTS) test on the Two-Variable Linear Equation System (SPLDV), and interview guidelines. All instruments underwent expert validation to ensure content validity, clarity, and relevance to the indicators of metacognitive awareness and critical thinking.

The metacognitive awareness questionnaire was developed based on the following blueprint.

Table 1. Blueprint of the Metacognitive Awareness Questionnaire

No	Aspect	Indicator	Item Numbers
Metacognitive Awareness Knowledge			
1	Declarative Knowledge	1) Factual knowledge that students need before they are able to process or employ critical thinking related to a topic 2) Knowledge of students' skills, intelligence, and abilities.	3, 4, 5 (+) 1 (–)
2	Procedural Knowledge	Application of knowledge in executing procedures.	6, 7 (+)
3	Conditional Knowledge	1) Application of knowledge about why and when to use a procedure, skill, or strategy.	8, 9, 10 (+)

		2) Selecting important information to be used in problem solving.	
Metacognitive Awareness Skills			
1	Planning Skills	1) Recognizing the objectives of a given problem. 2) Identifying which skills and resources should be engaged to solve the problem. 3) Determining the amount of time allocated for problem solving. 4) Integrating and selecting information from various sources.	11, 12, 16, 19 (+)
2	Monitoring Skills	1) Considering the accuracy of collected data. 2) Identifying sources of error in the obtained data. 3) Choosing an alternative strategy when the initial strategy does not work. 4) Monitoring one's progress and providing self-feedback.	13, 14, 15, 17, 18 (+)
3	Evaluation Skills	Assessing the effectiveness of the strategies used in solving the given problem.	2 (+)

A test item to measure students' Higher-Order Thinking Skills (HOTS) were developed based on the following blueprint.

Table 2. Blueprint of HOTS Test Items

Indicator	**Test Item**
Cognitive Level : C6 (Creating) Action Verb: Constructing Given a contextual problem involving food purchases at a café, students are able to: 1. Solve a system of two-variable linear equations using elimination and substitution. 2. Construct another problem with the same solution.	At a café, Dika buys 2 sandwiches and 3 iced teas for IDR 35,000, while Sari buys 3 sandwiches and 2 iced teas for IDR 40,000. Determine the price of one sandwich and one iced tea. Then, create a different word problem with the same solution and provide the answer.

During the implementation stage, the validated instruments were administered to 31 students in Grade VIII. Students first completed the metacognitive awareness questionnaire, followed by the HOTS test. Based on the questionnaire results, students were categorized into three levels of metacognitive awareness: high, moderate, and low. Six students, two from each category, were then selected as interview subjects to obtain deeper insights into their critical thinking processes when solving the HOTS questions.

The data analysis stage involved three steps: data reduction, data presentation, and conclusion drawing/verification. Students' written responses were analysed to identify indicators of critical thinking, namely interpretation, analysis, evaluation, and inference. Interview transcripts were coded thematically to triangulate the findings from the written tests. The results were then synthesized to describe patterns of critical thinking skills across different levels of metacognitive awareness. The final stage consisted of systematically compiling the research findings into a comprehensive report.

RESULTS

The research began with the administration of a metacognitive awareness questionnaire to all students. The distribution of students across the categories of metacognitive awareness is presented in Table 3.

Table 3. Table Results of Student Metacognitive Awareness Questionnaire

Metacognitive Awareness Categories	Many Students	Percentage
High	6	19%
Moderate	17	55%
Low	8	26%
Number of Students	31	100%

The results on Table 1 show that out of 31 students, 6 students (19%) demonstrated high metacognitive awareness, 17 students (55%) demonstrated moderate metacognitive awareness, and 8 students (26%) demonstrated low metacognitive awareness. These findings indicate that the majority of students in class VIII-A possess a moderate level of metacognitive awareness.

Subsequently, Six students were selected as research subjects, representing each category of metacognitive awareness (two students from each category). The categorization of these subjects is presented in Table 4.

Table 4. Table Categorization of Students' Metacognitive Awareness Subjects

Metacognitive Awareness Categories	Code
High	S1
High	S2
Moderate	S3
Moderate	S4
Low	S5
Low	S6

In each category of metacognitive awareness level, students' critical thinking in solving Higher Order Thinking Skills (HOTS) problem were analyzed as follows.

Table 5. Students' Critical Thinking Ability

Metacognition Category	Subject	Aspects of Students' Critical Thinking Ability				
		Interpretation	Analysis	Evaluation	Inference	Creation
High	S1	√	√	√	√	√
	S2	√	√	√	√	√
Moderate	S3	√	√	√	√	√
	S4	√	√	√	√	√
Low	S5	√	√	X	X	X
	S6	√	√	X	X	X

Table 5 above can be described as follows.

a. Student responses with high metacognitive skills (S1).

Students with high metacognitive skills (S1 and S2) demonstrated comprehensive critical thinking abilities across all four aspects, namely interpretation, analysis, evaluation, and inference. Their problem-solving performance reflected a highly developed level of critical thinking, reaching C6 (Creating) according to Bloom's taxonomy, as evidenced by the systematic reasoning process they employed.

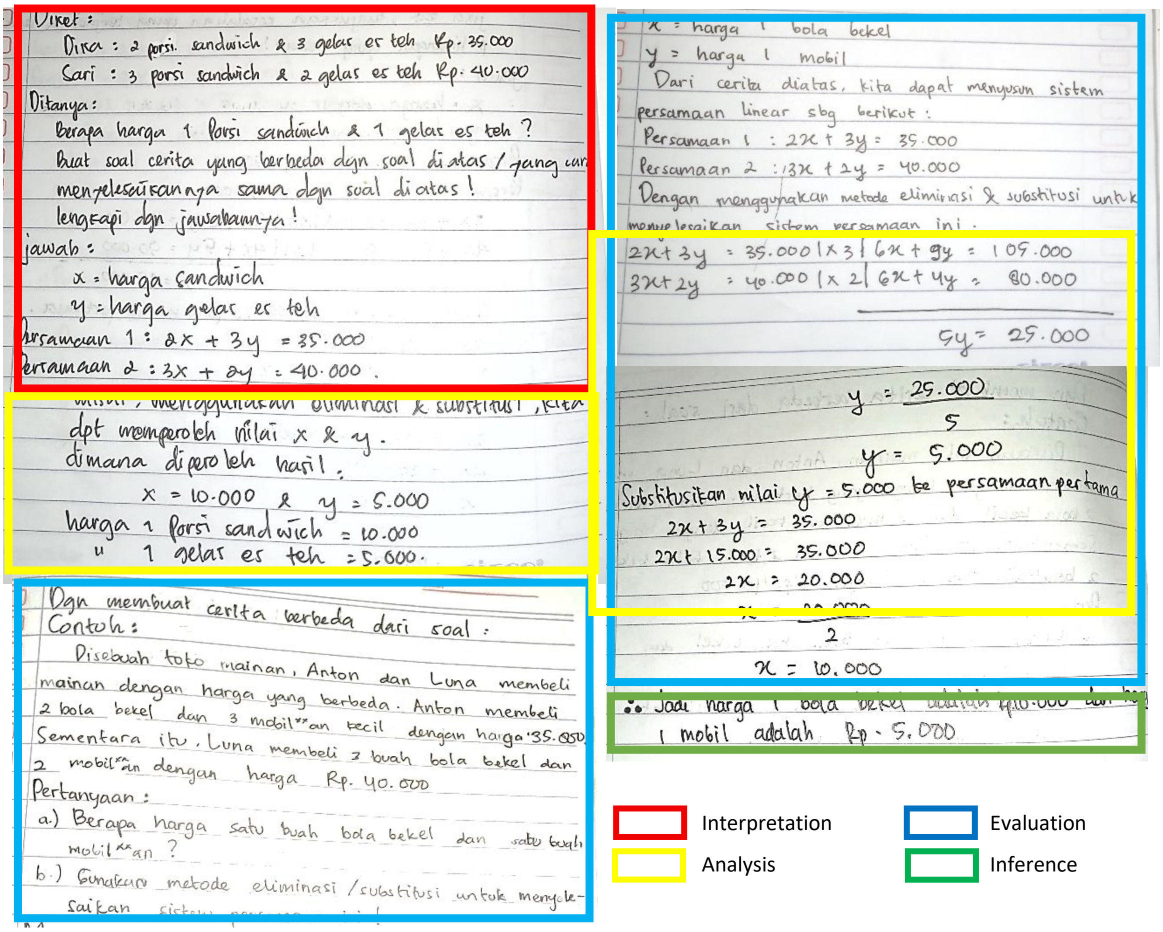

Figure 1. Student S1's Response to a HOTS Question at C6 (Creating) Level

Figure 1 illustrates that (1) the student demonstrated accurate interpretation by formulating the story narrative into two correct linear equations; (2) the student conducted a strong analysis by selecting efficient elimination and substitution strategies; and (3) the student achieved the highest levels of inference and evaluation, not only by obtaining the correct numerical solution but, more importantly, by creating a new word problem in a completely different context (from food to toys) while maintaining the same mathematical structure ($2x + 3y = 35{,}000$ and $3x + 2y = 40{,}000$). This clearly indicates that the student had mastered and was able to reconstruct the concept of systems of linear equations in two variables (SPLDV) at the deepest level of understanding.

The following excerpt from the interview between Researcher (R) and Student (S1) supports the conclusion above:

R : "Did you understand the question well?"
S1 :"Yes. At first, when I read the problem, I didn't understand it, so I read it several times until I finally understood what it meant."

This statement indicates that S1 engaged in a self-checking process to ensure comprehension of the problem through repeated reading. Such activity demonstrates metacognitive awareness during the interpretation phase, ensuring a correct understanding of the problem context before moving on to the problem-solving stage.

Furthermore, S1 exhibited reflective ability in the inference indicator, as shown in the following dialogue:

S1: "Yes, I'm sure. I have rechecked it."
R : "How did you check it?"
S1: "By reviewing my answer and substituting the values of x and y back into the equations to see whether the results were consistent."

This excerpt shows that S1 not only solved the problem but also conducted an evaluative process by verifying the correctness of the substituted variable values in the equations.

b. Student responses with moderate metacognitive skills (S3)

Table 3 shows that students with moderate metacognitive skills demonstrated mastery of all aspects of critical thinking, interpretation, analysis, evaluation, inference, and creation when solving a HOTS problem at the C6 (Creating) level. Figure 2 illustrates that S3's problem-solving process reflected accurate and systematic reasoning at the C6 level. The student accurately interpreted the problem by formulating it as a system of linear equations in two variables (2x + 3y = 35,000 and 3x + 2y = 40,000).

Afterward, the student carried out a precise analysis by selecting the elimination and substitution methods efficiently to find the solution x = 10,000 and y = 5,000. The student demonstrated deep inference and evaluation by applying these solutions back to both problem contexts. Hence, it can be concluded that S3 did not merely solve a routine problem but successfully organized and reconstructed the core mathematical structure of the system of linear equations in two variables (SPLDV) as a universal and transferable model.

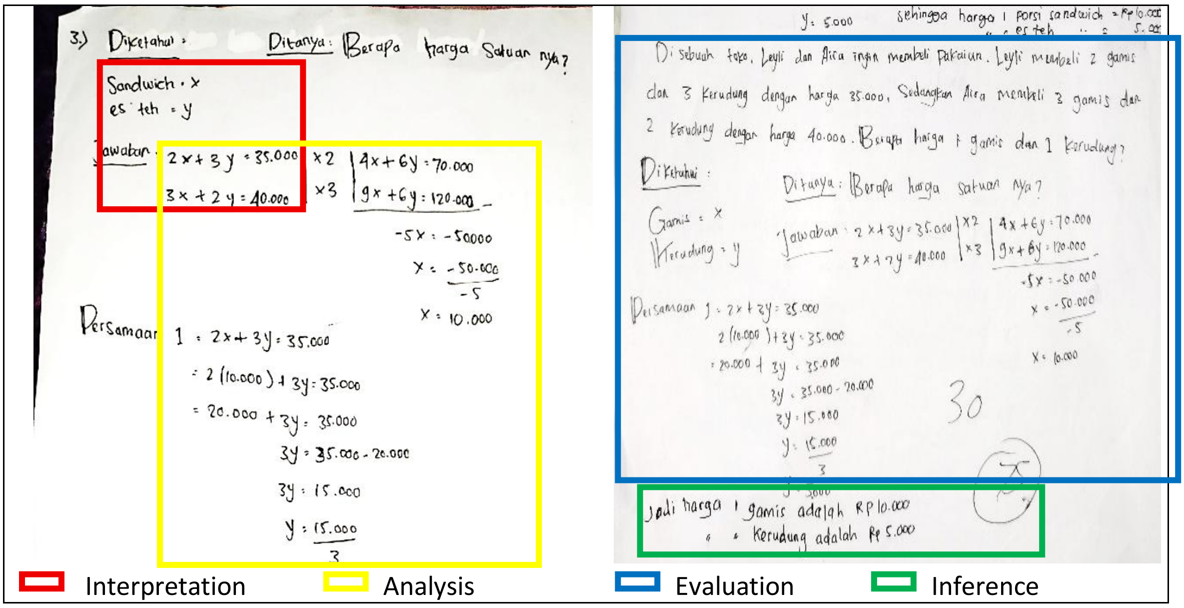

Figure 2. Student's Response in Solving a HOTS Problem

The student's thought process in solving the HOTS problem is supported by the following interview excerpt with student S3:

R : "Explain how you solved question number 3."
S3 : "So, I represented the price of one sandwich as x and the price of one glass of iced tea as y. The first equation is 2x + 3y = 35,000, and the second equation is 3x + 2y = 40,000. Then, I multiplied the first equation by 3 to get 6x + 9y = 105,000, and the second equation by 2 to get 6x + 4y = 80,000. After subtracting them, I found that y = 5,000. I substituted this value into the first equation and obtained x = 10,000. So, the price of one sandwich is Rp10,000, and the price of one glass of iced tea is Rp5,000."
R : "Are you confident with your answer?"
S3 : "Yes, I am. I rechecked my answer by substituting the results into the equations, and the results matched."
R : "Did you find it difficult to create another similar problem?"
S3 : "No, I didn't."

This interview excerpt indicates that S3 demonstrated a systematic and reflective reasoning process throughout problem-solving. The student not only applied the correct algebraic procedures but also engaged in self-monitoring by verifying the solution through substitution, ensuring its accuracy. Furthermore, S3's ability to generate similar problems independently shows transfer of learning and the presence of creative reasoning, both of which are hallmarks of higher-level metacognitive regulation and critical thinking.

b. Responses from Students with Low Metacognition (S6)

Students with low metacognitive awareness were also able to solve the problem correctly. Figure 3 shows that the student demonstrated adequate skills in interpretation and analysis**,** as evidenced by the ability to identify the problem presented in the question and determine the correct solution. However, the student did not exhibit the ability to construct a new word problem that applied the concept of a system of linear equations in two variables (SPLDV). This indicates that although the student understood the procedural aspect of the problem-solving process, the creative and reflective components of metacognitive regulation, such as transferring knowledge to new contexts or generating novel problem situations, were still lacking.

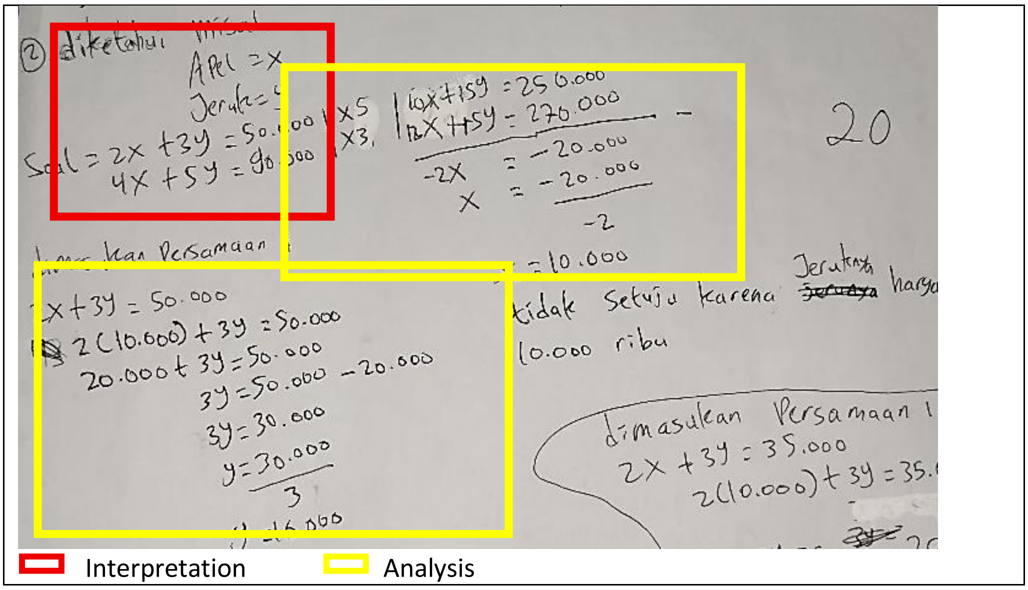

Figure 3. Student S6's Response to the HOTS Problem

The conclusion above is supported by the following interview excerpts with student S6, conducted to confirm their thought process:

R : "May I ask, please explain in your own words what is known and what is being asked in question number 3?"

S6 : "It is known that the sandwich is represented by x and the iced tea by y. The question asks for the price of one sandwich and one glass of iced tea."

R : "What are your next steps in solving the problem?"

S6 : "I created mathematical equations. Equation 1: 2x + 3y = 35,000 multiplied by 3 gives 6x + 9y = 105,000, and Equation 2: 3x + 2y = 40,000 multiplied by 2 gives 6x + 4y = 80,000. Subtracting them results in y = 5,000, which is then substituted into the first equation to get x = 10,000. So, the price of one sandwich is Rp10,000 and one glass of iced tea is Rp5,000."

R : "Are you confident that your answer is correct? Did you check your answer again?"

S6: "Actually, I'm not sure. I didn't check my answer again."

R : "Did you experience any difficulties while solving the problem?"

S6: "Yes, I had some trouble with the calculations and with creating the problem. I found it confusing to make a real-world context."

Based on the interview results, it can be concluded that although student S6 was able to understand and solve the problem, they did not engage in an evaluative process and experienced difficulty creating a new word problem related to the SPLDV topic. This indicates that the creative aspect of critical thinking, particularly the ability to apply mathematical concepts to real-world contexts, had not yet developed.

The relationship between students' critical thinking abilities and metacognitive awareness can be illustrated in the following table.

Table 6. Analysis of Students' Critical Thinking Skills in Terms of Metacognitive Awareness

Metacognitive Level	**Aspect**	**Critical Thinking Indicators**				**Creating Activity (C6)**
		Interpretation	**Analysis**	**Inference**	**Evaluation**	
High Metacognition	Evidence	Clearly states known and unknown information in a logical sequence	Transforms the story text into two linear equations	Determines the values of *x* and *y* using logical mathematical methods	Reviews the results, writes final conclusions, and tests understanding by creating a new problem	Presents a new problem consistent with the SPLDV concept
	Analysis	Demonstrates the ability to understand information meaningfully and distinguish relevant data from the context	Demonstrates the ability to identify causal relationships between variables in the problem	Draws accurate conclusions based on computational evidence	Strongly indicates the ability to assess the reasonableness of results and reexamine concepts	Understands the SPLDV concept contextually
Moderate Metacognition	Evidence	Correctly defines variables	Forms two equations and applies the elimination method	Draws conclusions for *x* and *y* values	"I disagree because the price should be 10,000"	Constructs a new problem related to SPLDV
	Analysis	Understands the context and translates verbal information into mathematical form	Identifies relationships among data and organizes logical information	Demonstrates mathematical inference skills based on given data	Reflective critical thinking, students do not accept results passively but evaluate their validity	Shows contextual understanding of SPLDV
Low Metacognition	Evidence	Understands the context and assigns variables correctly	Forms two linear equations from the problem	Performs elimination and concludes variable values	No rechecking or verification process is observed	Fails to create a new problem related to SPLDV

Metacognitive Level	Aspect	Critical Thinking Indicators				Creating Activity (C6)
		Interpretation	Analysis	Inference	Evaluation	
	Analysis	Ability to comprehend and translate information into symbolic form indicates adequate interpretation	Identifies relationships among pieces of information and converts them into mathematical models	Demonstrates logical reasoning in drawing conclusions from data relationships	Evaluation skills are still limited, no justification of whether the results are reasonable	Lacks contextual understanding of SPLDV concepts

Based on Table 6, it can be seen that students' critical thinking skills show a pattern that aligns with their level of metacognitive awareness. The higher the metacognitive awareness, the more complex and reflective the thought processes demonstrated, characterized by the ability to reassess work results and create new, relevant problems. Conversely, students with low metacognitive awareness tend to only carry out procedural steps without in-depth evaluation of the solutions obtained. This pattern indicates a positive relationship between metacognitive regulation and the depth of critical thinking in solving HOTS problems in the SPLDV material, which is then discussed further in the discussion section.

DISCUSSION

The findings reveal that students with high and moderate metacognitive abilities tend to meet critical thinking indicators, particularly in performing repeated reviews during the interpretation stage and rechecking during the inference stage. This reflects self-monitoring and self-evaluation, two core components of metacognitive skills (Flavell, 1979). These highlight the close relationship between metacognitive skills and critical thinking. Individuals with metacognitive awareness can identify what they understand, adjust strategies when necessary, and reflect on the effectiveness of their approaches (Firmansyah et al., 2022). These findings are consistent with previous studies stating that individuals with well-developed metacognitive skills are more capable of judgment and reflection, two essential components of critical thinking (Ku & Ho, 2010; Akbay et al., 2018).

On the other hands, it was revealed that subject with low metacognitive awareness tends skip the evaluative process and experiences difficulty creating a new word problem related to the topic. These findings align with the research of Wilujeng et al. (2023), which found that students with low metacognitive awareness can describe and identify information needed to solve problems but often fail to evaluate their answers, an essential component of critical thinking. Similarly, Suryaningtyas and Setyaningrum (2020) stated that students with low metacognitive awareness tend not to recheck their answers to ensure their accuracy.

The results of this study indicate a relationship between metacognitive awareness and critical thinking skills. These findings reinforce the results of previous research conducted by Albab et al. (2020), which emphasized that metacognition plays a crucial role in enhancing critical thinking, as it serves as a regulatory mechanism for one's cognitive processes.

Metacognitive knowledge, which involves awareness of what, how, and when to use specific thinking strategies, encourages individuals to consciously plan, monitor, and evaluate their own thought processes (Rivas et al., 2022; Varveris et al., 2023). In complex problem-solving, metacognition enables students to critically assess the strategies they employ, identify cognitive errors, and improve the quality of their decision-making (Toraman et al., 2020).

Metacognition is one of the key factors influencing students' academic success (Chytrỳ et al., 2020**).** Integrating metacognition into mathematics instruction can help students develop a deeper understanding of mathematical concepts and problem-solving strategies. Mathematics learning, therefore, should not only emphasize procedural mastery or formula application but also foster metacognitive awareness, students' consciousness of their own thinking and learning processes (Amin & Sukestiyarno, 2015**).** Instructional strategies designed to cultivate students' metacognitive skills have been shown to significantly improve both learning outcomes and critical thinking abilities (Macabecha et al., 2024; Hutabarat et al., 2019; Serenia et al., 2023**).** Hence, metacognitive skills must be intentionally nurtured through systematic classroom activities.

Metacognition can be enhanced and refined through a variety of learning activities, including (1) *Thinking aloud* while solving problems, individually or collaboratively; (2) Monitoring one's comprehension during group problem-solving discussions; (3) Developing reflective habits by reviewing and rethinking problem-solving processes; (4) Using online resources to seek relevant information for assignments or problem contexts; (5) Reflecting on one's own thinking and continuously monitoring comprehension during problem-solving; (6) Attempting to solve problems independently before sharing solutions with peers or teachers to verify correctness; (7) Engaging in error analysis by identifying and discussing mistakes in the solution process (Tachie, 2019**).**

Teachers can apply the Cooperative Learning Method to improve metacognitive awareness (Erdoğan & Şengül, 2017**).** Social interaction and group collaboration provide effective contexts for eliciting and strengthening metacognitive reflection. Fitriyani & Duran Corebima (2015) revealed that implementing learning models such as Problem-Based Learning (PBL) and guided inquiry significantly enhances students' metacognitive awareness and critical thinking skills. Other effective strategies include (1) Journaling or reflective writing**,** where students regularly document their learning experiences, strategies used, difficulties encountered, and possible improvements; (2) Think-Pair-Share, where students first think independently, then discuss with a partner, and finally share with the whole class encouraging reflection and peer teaching; (3) Peer feedback**,** where students provide constructive comments on their peers' strategies and problem-solving approaches; and (4) Self-assessment or checklists**,** allowing students to evaluate their strategies, understanding, and areas for improvement using established rubrics **(**Ajayi, 2024**).**

In designing learning evaluations, it is essential to consider two key dimensions: the knowledge dimension**,** which includes factual, conceptual, procedural, and metacognitive aspects; and the cognitive process dimension, which encompasses stages from *remembering* to *creating*, forming the foundation for the development of learning indicators and assessment blueprints**.**

CONCLUSIONS

The findings of this study emphasize that metacognitive awareness plays a significant role in shaping students' critical thinking skills when solving mathematics problems based on Higher Order Thinking Skills (HOTS). Mathematics instruction should therefore be intentionally designed to stimulate students' metacognitive awareness as a pathway to strengthening their critical thinking abilities. Teachers are expected not only to guide students toward obtaining correct answers but also to help them become aware of their thinking processes through activities such as self-questioning, error analysis, and self-evaluation. Practically, these results can serve as a reference for curriculum developers, mathematics education lecturers, and teachers in designing formative assessments that assess not only learning outcomes but also the awareness of students' cognitive processes. The implementation of metacognitive-based interventions is expected to foster a reflective, adaptive, and creative learning culture, supporting the attainment of 21st-century educational goals that emphasize higher-order thinking skills.

This study, however, has certain limitations. It only explores metacognitive awareness as a determinant of students' critical thinking skills, without considering other potential influencing factors. External aspects such as learning environment, teacher support, and students' intrinsic motivation were not included in the analysis but may play an essential role in the effectiveness of metacognitive strategies. Therefore, future studies are recommended to expand this research by integrating these variables to produce more comprehensive and meaningful conclusions.

REFERENCE

Abdullah, I. H. (2013). Berpikir kritis matematik. *Delta-Pi: Jurnal Matematika dan Pendidikan Matematika*, 2(1), 66–75. https://doi.org/10.33387/dpi.v2i1.100

Ajayi, J. (2024). Metacognitive strategies in the classroom: Introduction to metacognitive strategies in the classroom. *Improving Teaching and Learning in Science and Mathematics*, 190–200.

Akbay, T., Akbay, L., & Gülsoy, V. G. B. (2017). Causal effect of two predominant factors on critical thinking disposition. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, (45), 88-104. https://doi.org/10.21764/maeuefd.349581

Albab, U., Budiyono, & Indriati, D. (2020). Metacognition skills and higher order thinking skills (HOTS) in mathematics. *Journal of Physics: Conference Series*, 1613 (1). https://doi.org/10.1088/1742-6596/1613/1/012017

Amin, I., & Sukestiyarno, P. Y. L. (2015). Analysis metacognitive skills on learning mathematics in high school. *International Journal of Education and Research*, 3 (3), 213–222.

Apriliani, E. A., Afandi, & Marlina, R. (2021). Memberdayakan keterampilan berpikir kritis di era abad 21. *Prosiding Seminar Nasional Fakultas Keguruan dan Ilmu Pendidikan Universitas Tanjungpura Pontianak* , 1045–1052.

Chytrý, V., Říčan, J., Eisenmann, P., & Medová, J. (2020). Metacognitive knowledge and mathematical intelligence—Two significant factors influencing school performance. *Mathematics*, 8 (6), 969. https://doi.org/10.3390/math8060969

Ennis, R. H. (2011). Inquiry: Critical thinking across the disciplines. *Philosophy Documentation Center*, 26 (2), 15–17.

Erdoğan, F., & Şengül, S. (2017). The effect of cooperative learning method enhanced with metacognitive strategies on students' metacognitive skills in math course. *Egitim ve Bilim, 42 (192),* 263–301. https://doi.org/10.15390/eb.2017.6492

Ernawati, & Sutiarso, S. (2020). Analisis kesulitan menyelesaikan soal matematika kategori higher order thinking skills menurut tahapan Polya. *Jurnal Penelitian Pembelajaran Matematika*, 13 (2), 178–195.

Faiziyah, N., & Priyambodho, B. L. (2022). Analisis kemampuan berpikir kritis dalam menyelesaikan soal HOTS ditinjau dari metakognisi siswa. *Aksioma: Jurnal Program Studi Pendidikan Matematika*, 11 (4), 2823–2834. https://doi.org/10.24127/ajpm.v11i4.5918

Fitriyani, R., & Duran Corebima, A. (2015). Pengaruh strategi pembelajaran problem based learning dan inkuiri terbimbing terhadap keterampilan metakognitif, berpikir kritis, dan hasil belajar kognitif siswa SMA. *Jurnal Pendidikan Sains,* 3 (4), 186–200.

Firmansyah, F. F., Sa'dijah, C., Subanji, S., & Qohar, A. (2022). Characterizations of students' metacognition in solving geometry problems through positioning group work. *TEM Journal,* 11 (3), 1391–1398.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, 34 (10), 906–911. https://doi.org/10.1037/0003-066x.34.10.906

Hastiwi, L., & Budiharti. (2018). Identifikasi kesulitan dalam menyelesaikan soal cerita pada mata pelajaran matematika kelas V SDN Sinduadi Timur Mlati Sleman. *Jurnal PGSD Indonesia,* 4 (1), 93–97.

Hidayah, N., & Nabila, N. (2022). Analisis kemampuan metakognisi ditinjau dari pemecahan masalah matematis siswa pada materi Teorema Phytagoras. *Journal of Authentic Research on Mathematics Education (JARME*), 4 (1), 57–65.

Hutabarat, M., Caswita, C., & Suharsono, S. (2019). Development learning design based on metacognitive strategies oriented to critical thinking skills. *International Journal of Trends in Mathematics Education Research,* 2 (3), 120–123. https://doi.org/10.33122/ijtmer.v2i3.73

Jianto, L., Anita, A., & Boisandi, B. (2020). Pengaruh penerapan lembar kerja siswa berbasis inkuiri terbimbing terhadap kemampuan metakognisi siswa pada materi Hukum II Newton. *Radiasi: Jurnal Berkala Pendidikan Fisika*, 13 (2), 61–64. https://doi.org/10.37729/radiasi.v13i2.295

Kamila, A. (2020). Analisis kemampuan siswa SMP dalam menyelesaikan soal HOTS matematika materi sistem persamaan linear dua variabel. *Jurnal Pendidikan Matematika*, 1 (22), 119–126.

Ku, K. Y. L., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and Learning,* 5 (3), 251–267. https://doi.org/10.1007/s11409-010-9060-6

Macabecha, E., Tangcogo, K. E., Sawit, M. R., & Ucang, J. T. (2024). Metacognitive strategy on students' mathematics self-efficacy and critical thinking skills. *International*

Journal of Applied Science and Research, 7(1), 25–33. https://doi.org/10.56293/ijasr.2024.5704

Maulidiya, M., & Nurlaelah, E. (2019). The effect of problem-based learning on critical thinking ability in mathematics education. *Journal of Physics: Conference Series, 1157* (4). https://doi.org/10.1088/1742-6596/1157/4/042063

Mella, P. D., Putra, A., & Anggraini, R. S. (2023). Analisis kesulitan siswa dalam menyelesaikan soal higher order thinking skills (HOTS) pada materi bentuk aljabar. *Jurnal Ilmiah Pendidikan Matematika Al Qalasadi*, 7 (2), 171–179. https://doi.org/10.32505/qalasadi.v7i2.7308

Nafiati, D. A. (2021). Revisi taksonomi Bloom: Kognitif, afektif, dan psikomotorik. *Humanika*, 21 (2), 151–172. https://doi.org/10.21831/hum.v21i2.29252

Nuraini, T., & Julianto. (2022). Analisis faktor penyebab kesulitan siswa sekolah dasar kelas IV dalam menyelesaikan soal HOTS pada mata pelajaran IPA. *Jurnal Pendidikan Guru Sekolah Dasar,* 10 (1), 60–74.

Permatasari, D. A. B., Setiawan, B. T., & Kristiana, I. A. (2015). Analisis kesulitan siswa dalam menyelesaikan soal materi aljabar siswa kelas VIII SMP Negeri 2 Bangil. *Kadikma,* 6 (2), 119–130.

Rivas, S. F., Saiz, C., & Ossa, C. (2022). Metacognitive strategies and development of critical thinking in higher education. *Frontiers in Psychology*, 13, 913219. https://doi.org/10.3389/fpsyg.2022.913219

Sercenia, J. C., & Prudente, M. S. (2023). Effectiveness of the metacognitive-based pedagogical intervention on mathematics achievement: A meta-analysis. *International Journal of Instruction*, 16 (4), 561–578. https://doi.org/10.29333/iji.2023.16432a

Shafira, A., Muchtadi, M., & Nurmaningsih, N. (2023). Analisis kemampuan berpikir kritis siswa dalam menyelesaikan soal higher order thinking skill (HOTS). *Journal of Comprehensive Science (JCS),* 2 (6), 1884–1888. https://doi.org/10.59188/jcs.v2i6.414

Shintawati, A., Atmojo, I. R. W., & Ardiansyah, R. (2023). Pengaruh kesadaran metakognisi terhadap kemampuan berpikir kritis mahasiswa PGSD UNS Surakarta. *Didaktika Dwija Indria, 11* (3), 1–6. https://doi.org/10.20961/ddi.v11i3.76819

Suryaningtyas, S., & Setyaningrum, W. (2020). Analisis kemampuan metakognitif siswa SMA kelas XI program IPA dalam pemecahan masalah matematika. *Jurnal Riset Pendidikan Matematika*, 7 (1), 74–87. https://doi.org/10.21831/jrpm.v7i1.16049

Susilowati, Y., & Sumaji, S. (2020). Interseksi berpikir kritis dengan high order thinking skill (HOTS) berdasarkan taksonomi Bloom. *Jurnal Silogisme: Kajian Ilmu Matematika dan Pembelajarannya*, 5 (2), 62–70. https://doi.org/10.24269/silogisme.v5i2.2850

Tachie, S. A. (2019). Meta-cognitive skills and strategies application: How this helps learners in mathematics problem-solving. *Eurasia Journal of Mathematics, Science and Technology Education,* 15 (5), em1695. https://doi.org/10.29333/ejmste/105364

Toraman, Ç., Orakcı, Ş., & Aktan, O. (2020). Analysis of the relationships between mathematics achievement, reflective thinking of problem-solving and metacognitive awareness. *International Journal of Progressive Education*, 16 (2), 72–90. https://doi.org/10.29329/ijpe.2020.241.6

Varveris, D., Saltas, V., & Tsiantos, V. (2023). Exploring the role of metacognition in measuring students' critical thinking and knowledge in mathematics: A comparative study of regression and neural networks. *Knowledge,* 3 (3), 333–348. https://doi.org/10.3390/knowledge3030023

Vijayaratnam. (2009). Cooperative learning and critical thinking. In *Secondary Schools and Cooperative Learnin*g (pp. 67–92).

Wahdah, N. F., Jufri, A. W., & Zulkifli, L. (2016). Jurnal Belajar Sebagai Sarana Pengembangan Kemampuan Metakognisi Siswa. *Jurnal Pijar Mipa*, *11*(1), 70–74. https://doi.org/10.29303/jpm.v11i1.65

Wulansari, K., & Sunarya, Y. (2023). Keterampilan 4C (critical thinking, creativity, communication, dan collaborative) guru Bahasa Indonesia SMA dalam pembelajaran abad 21 di era industri 4.0. *Jurnal Basicedu*, 7 (3), 1667–1674. https://doi.org/10.31004/basicedu.v7i3.5360