Jurnal Riset Pendidikan dan Inovasi Pembelajaran Matematika
JRPIPM. 2026 (Vol. 10, no. 2, 246-267)
ISSN: 2581-0480 (electronic)
URL: journal.unesa.ac.id/index.php/jrpipm

Students' Critical Thinking in Solving Mathematical Literacy Problems Based on Mathematical Ability

Saniaturochmah[1]*, Susanah[2], Lestariningsih Lestariningsih[3]

[1*]Universitas Negeri Surabaya, 25030785028@mhs.unesa.ac.id
[2] Universitas Negeri Surabaya, susanah@unesa.ac.id
[3] Universitas Negeri Surabaya, lestariningsih@unesa.ac.id

Submitted: 17 July 2026; Revised: 30 July 2026; Accepted: 24 August 2026

ABSTRACT

Critical thinking helps students analyze information, reason logically, and develop appropriate solutions. However, difficulties still arise when students are confronted with complex problems, particularly those involving mathematical literacy. This study aimed to describe students' critical thinking in solving mathematical literacy problems based on mathematical ability. Critical thinking was examined using Facione's indicators: interpretation, analysis, inference, evaluation, explanation, and self-regulation. A descriptive qualitative approach was used with three students involving high, moderate, and low mathematical ability, classified using scores from a five-item essay Mathematical Ability Test. The data were obtained from students' written solutions to mathematical literacy problem-solving tasks and from tasks-based interviews. Data credibility was established through time triangulation by administering two equivalent problem-solving tasks and conducting tasks-based interviews in two sessions at different times, then comparing the data from both sessions to examine their consistency. The results showed that the student with high mathematical ability demonstrated critical thinking indicators, namely interpretation, analysis, inference, explanation, evaluation, and self-regulation. The student with moderate mathematical ability demonstrated interpretation, analysis, inference, explanation, evaluation, and self-regulation; however, the reasoning, use of evidence, and evaluation of procedures were still expressed in a simple manner. The student with low mathematical ability demonstrated interpretation and analysis in the steps that were understood, while explanation, evaluation, and self-regulation appeared to a limited extent. Inference was not evident because the problem-solving process remained incomplete.

Keywords: *critical thinking, mathematical literacy, mathematical ability*, *problem solving*

Berpikir Kritis Siswa dalam Memecahkan Masalah Literasi Matematis Ditinjau dari Kemampuan Matematika

ABSTRAK

Berpikir kritis membantu siswa dalam mengkaji informasi, menggunakan penalaran logis, dan mengembangkan solusi yang sesuai. Meskipun demikian, siswa masih menghadapi kesulitan ketika menyelesaikan permasalahan kompleks, terutama

yang berkaitan dengan literasi matematis. Penelitian ini bertujuan untuk mendeskripsikan berpikir kritis siswa dalam memecahkan masalah literasi matematis ditinjau dari kemampuan matematika Kerangka berpikir kritis yang digunakan mengacu pada indikator Facione, yaitu interpretasi, analisis, inferensi, evaluasi, eksplanasi, dan regulasi diri. Pendekatan kualitatif deskriptif digunakan dengan melibatkan tiga siswa yang diklasifkasikan ke dalam kategori kemampuan matematika tinggi, sedang, dan rendah berdasarkan hasil Tes Kemampuan Matematika berupa lima soal uraian. Data diperoleh dari hasil tertulis siswa dalam menyelesaikan tugas pemecahan masalah literasi matematis dan wawancara berbasis tugas. Kredibilitas data diperoleh melalui triangulasi waktu, yang dilakukan dalam dua sesi berbeda menggunakan tugas pemecahan masalah yang setara dan wawancara berbasis tugas, kemudian data dibandingkan untuk menilai konsistensinya. Hasil penelitian menunjukan bahwa siswa dengan kemampuan matematika tinggi menunjukkan indikator berpikir kritis interpretasi, analisis, inferensi, eksplanasi, evaluasi, dan regulasi diri pada tahap pemecahan masalah. Siswa dengan kemampuan matematika sedang menunjukkan interpretasi, analisis, inferensi, eksplanasi, evaluasi, dan regulasi diri, tetapi alasan, penggunaan bukti, dan penilaian terhadap prosedur masih disampaikan secara sederhana. Siswa dengan kemampuan matematika rendah menunjukkan interpretasi dan analisis pada langkah-langkah yang telah dipahami, sedangkan eksplanasi, evaluasi, dan regulasi diri tampak secara terbatas. Inferensi belum tampak karena proses pemecahan masalah belum diselesaikan.

Kata Kunci: *Berpikir kritis, literasi matematis, pemecahan masalah, kemampuan matematika*

How to cite: Saniaturochmah, Susanah, & Lestariningsih. (2026). Students' Critical Thinking in Solving Mathematical Literacy Problems Based on Mathematical Ability. *Jurnal Riset Pendidikan dan Inovasi Pembelajaran Matematika (JRPIPM)*, *10*(2), 246-267. https://doi.org/10.26740/jrpipm.v10n2.p246-267

License

 This work is licensed under a Creative Commons Attribution 4.0 International License.

1. Introduction

Developments in science and technology have reshaped the goals of education in the twenty-first century. Education is no longer focused solely on subject-matter mastery, but also on strengthening students' reasoning, critical thinking, and problem-solving skills. This orientation reflects the increasing emphasis on higher-order thinking in learning (Haq & Prasetiyo, 2025). In line with this direction, the learning process is expected to foster students' critical thinking, problem-solving competence, and adaptability (Kemendikbud, 2019). Therefore, students should be prepared not only to acquire disciplinary knowledge but also to use it when interpreting everyday situations and addressing problems they encounter (Insani et al., 2025).

Thinking is inseparable from learning because it enables students to explore ideas, raise questions, and seek alternative solutions (Slavin, 2018). In mathematics education, thinking processes help students view mathematics not merely as a collection of formulas to be memorized but as a means of solving problems (Ismaimuza, 2025). Critical thinking is included as one of the eight Graduate Profile dimensions in Ministerial Regulation No. 10 of 2025. One of these dimensions is critical thinking, a key higher-order thinking competency that needs to

be deliberately fostered through appropriate instructional practices (Santos-Meneses & Drugova, 2023).

Developing students' critical thinking is an important objective of mathematics education (Rejeki et al., 2021). It helps individuals organize their reasoning and approach problems in a systematic manner (Santoso et al., 2025). Six core skills characterize critical thinking as a process of deliberate and reflective judgment, such as interpretation, analysis, inference, evaluation, explanation, and self-regulation (Facione & Gittens, 2016). Accordingly, students' thinking should not be assessed solely from the correctness of their final answers, but also from the processes through which they construct, justify, evaluate, and refine their solutions.

Critical thinking supports students in solving problems logically, examining information, and making rational decisions (Kurnia & Caswita, 2020; Siswono, 2018). It also enables them to consider alternative solutions and organize their reasoning systematically (Rahmasari et al., 2025). Such demands become challenging in non-routine problems, with which many students still have limited experience (Setiana et al., 2021). These difficulties become more evident when students encounter mathematical literacy problems, which require them to understand contexts, select relevant information, and apply mathematical concepts meaningfully (Rahmawati, 2022).

Mathematical literacy concerns the use and interpretation of mathematics in situations connected with the real world (Pratama, 2020). Solving mathematical literacy problems involves more than performing calculations; it requires students to interpret contextual information, determine relevant data, select appropriate strategies, justify procedures, and draw reasonable conclusions. These processes are closely related to critical thinking because students need to analyze information, evaluate the appropriateness of strategies, use evidence, and reflect on their solutions. A positive contribution of mathematical critical thinking to mathematical literacy was reported by Haeruman et al. (2024). Similarly, Tandililing et al. (2025) reported that students' mathematical literacy performance in geometry was significantly associated with their critical thinking skills. Therefore, critical thinking supports students in formulating, applying, and interpreting mathematics meaningfully, while mathematical literacy problems provide a context in which critical thinking can be demonstrated and developed. Moreover, success in solving such problems depends on reasoning and understanding relationships among concepts rather than merely performing calculations accurately (Niss, 2015).

The PISA framework organizes mathematical literacy into the domains of quantity such as change and relationships; uncertainty and data; and space and shape (OECD, 2013). Geometry, which is included in the space and shape domain, is closely related to real-life objects and activities (Malasari et al., 2017). It requires students to interpret visual information, read maps and diagrams, determine positions, and analyze shapes and structures. However, students still experience difficulties in interpreting geometry problems, planning solution steps, and connecting concepts with appropriate mathematical procedures (Nabila & Aminah, 2025). These difficulties make geometry-based literacy problems a relevant setting for examining how critical thinking unfolds during problem solving.

Students' critical thinking in solving mathematical literacy problems may vary according to their mathematical ability. Prior literature relates mathematical ability to how students examine a problem and consider possible solutions (Sumarmo et al., 2018), as well as to the quality of thinking used in non-routine and contextual situations (Hendriana et al., 2017). Accordingly, students at different levels of mathematical ability may differ in how they interpret information, choose strategies, carry out procedures, and formulate conclusions (Rejeki et al., 2021). Since mathematical literacy involves applying mathematical ideas to situations encountered in everyday life (OECD, 2019), examining how students arrive at a solution is as important as considering the final answer.

Several studies have explored students' critical thinking in the context of solving mathematics problems. In numeracy problems from the Minimum Competency Assessment, (Rohim & Rofiki, 2024) identified interpretation, analysis, and evaluation in students' work. Their study, however, did not compare students across mathematical-ability levels or trace critical thinking indicators throughout successive problem-solving stages. Harahap et al. (2024) investigated critical thinking by considering students' initial mathematical ability, although the tasks employed were not specifically situated within mathematical literacy. Mathematical literacy problems, in contrast, involve interpreting everyday contexts, identifying relevant information, linking mathematical ideas, providing justification for procedures, and assessing solutions.

Consequently, there is still limited understanding of how students with varying mathematical abilities exhibit critical thinking at different points in solving mathematical literacy problems. Earlier studies have also provided insufficient detail regarding the indicators that emerge within each problem-solving stage and the ways in which their characteristics vary among students with high, moderate, and low mathematical ability. To fill this gap, the present study uses Facione's framework as an analytical lens and Polya's stages as the structure for tracing students' problem-solving processes. Facione's indicators characterize the critical thinking activities demonstrated by students, while Polya's stages provide the sequence for examining those activities. This integration enables a stage-by-stage description of interpretation, analysis, inference, evaluation, explanation, and self-regulation and provides insight into the depth and continuity of students' critical thinking throughout the problem-solving process.

By examining students' critical thinking at each stage of problem solving, this study is expected to enrich theoretical understanding of how such thinking varies across levels of mathematical ability. The findings may also offer practical guidance for teachers in designing mathematical literacy tasks and adjusting instructional support to students' critical thinking characteristics. Accordingly, this study describes the critical thinking of students with high, moderate, and low mathematical abilities across Polya's four problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and looking back.

2. Research Method

This study employed a descriptive qualitative approach to obtain an in-depth description of students' critical thinking in solving mathematical literacy problems based on their mathematical ability. The study was conducted with students at SMP Sepuluh Nopember Sidoarjo. The researcher served as the primary research instrument, while the supporting instruments consisted of a Mathematical Ability Test (MAT), mathematical literacy Problem-Solving Tasks (PST), and a semi-structured interview guide. Prior to data collection, the supporting instruments underwent content validation by three mathematics education experts. The validation focused on the alignment of each instrument with the research objectives, mathematical content, critical thinking indicators, problem-solving stages, language clarity, and suitability for Grade IX students. The validators also examined the equivalence of PST 1 and PST 2 in terms of mathematical concepts, level of difficulty, problem structure, and cognitive demands. Their suggestions were used to revise the wording of several questions, clarify the information presented in the tasks, and refine the interview prompts. After revision, the instruments were considered appropriate for data collection.

The MAT consisted of five essay questions covering mathematical content previously learned by the participants. It was accompanied by an indicator grid, scoring guidelines, and an answer key to ensure consistency in assessing students' mathematical ability. The PST consisted of two equivalent mathematical literacy problems involving real-world contexts,

geometric transformations, and distance determination. The tasks were designed to elicit students' critical thinking activities across Polya's four problem-solving stages. The semi-structured interview guide, derived from Facione's indicators, was used to probe reasoning that could not be fully inferred from the students' written work.

The MAT used to determine students' mathematical ability and classify them into high, moderate, and low categories. The classification followed Arikunto's (2013) criteria: scores ranging from 80 to 100 were categorized as high mathematical ability, scores ranging from 60 to below 80 as moderate mathematical ability, and scores below 60 as low mathematical ability. Participant selection was conducted purposively to obtain information-rich cases from each mathematical ability category. One participant from each category was chosen by considering the MAT results, commitment to complete all stages of the study, and ability to communicate reasoning during problem solving. The ability to articulate mathematical thinking was essential because task-based interviews were used to explore critical thinking processes that were not fully evident in the written responses. The three selected participants were therefore intended to provide detailed and contrasting qualitative cases rather than statistical representation of all students in their respective categories. The participants' data are presented in Table 1.

Table 1. Research Participants

Initials	Score	Category	Code
LIB	93	High	ST
JAK	70	Moderate	SS
NPE	35	Low	SR

The research data consisted of students' written responses and task-based interview transcripts. Data were collected by asking each participant to complete the PST independently, followed by semi-structured interviews to explore thinking processes that were not evident in the written responses. Data credibility was established through time triangulation by comparing the consistency of the participants' written responses and task-based interview results collected in two sessions at different times. The data collection involved PST 1 and PST 2, which were designed to be equivalent in terms of mathematical content. Both tasks involved a sequence of geometric transformations and required the participants to determine the distance between the initial and final positions. After consistent critical thinking activities were identified across the two tasks, the data from PST 1 were used as the primary data for analysis, while the data from PST 2 served to confirm the consistency and credibility of the findings.

Analysis followed the interactive components of data condensation, data display, and conclusion drawing/verification described by Miles et al. (2014). During data condensation, the students' written responses and task-based interview transcripts were reviewed, selected, and coded according to Facione's critical thinking indicators and sub-indicators within Polya's four problem-solving stages. Data that were relevant to the students' critical thinking activities were grouped according to the stages of understanding the problem, devising a plan, carrying out the plan, and looking back. During data display, the condensed data were organized in the form of written-response figures, interview excerpts, tables, and narrative descriptions for each participant. Conclusion drawing and verification were conducted by identifying the critical thinking characteristics of students with high, moderate, and low mathematical abilities and continuously checking the conclusions against the written responses, interview transcripts, and time-triangulation results.

Students' critical thinking was described using Facione & Gittens six indicators: interpretation, analysis, inference, evaluation, explanation, and self-regulation. Each indicator was further elaborated into relevant sub-indicators to identify the critical thinking activities

demonstrated by the students. The indicators and sub-indicators used in this study are presented in Table 2.

Table 2. Critical Thinking Indicators

Indicators	Sub-indicator
Interpretation	1) Categorization: Classifying information according to specific criteria.
	2) Decode Significance: Elaborating the significance or important meaning contained in information.
	3) Clarify Meaning: Clarifying the meaning of information.
Analysis	1) Examine Ideas: Examining or reviewing the ideas contained in information.
	2) Identify Arguments: Identifying the arguments presented in a statement.
	3) Identify Reasons and Claims: Identifying the reasons and claims used to support an argument.
Inference	1) Query Evidence: Identifying relevant evidence to support the drawing of a conclusion.
	2) Conjecture Alternatives: Formulating various possibilities or alternative conjectures that may occur.
	3) Draw Conclusions: Drawing conclusions based on evidence.
Evaluation	1) Assess Credibility of Claims: Assessing the credibility of sources and the accuracy and truthfulness of claims based on context.
	2) Assess Quality of Arguments: Assessing the quality of arguments by examining the reasons, assumptions, and evidence.
Explanation	1) State Results: Stating or communicating the results obtained.
	2) Justifying Procedures: Providing reasons or explanations for the procedures used.
	3) Present Arguments: Presenting arguments that support the results or reasoning provided.
Self-Regulation	1) Self-Examination: Monitoring or observing the thinking process being carried out.
	2) Self-Correction: Correcting errors identified in the reasoning process or in the results obtained.

During analysis, evidence for these indicators and sub-indicators was traced within the four problem-solving stages proposed by Polya: understanding the problem, devising a plan, carrying out the plan, and looking back.

3. Result and Discussion

3.1 Research Result

The results draw on participants' written work together with the corresponding task-based interviews. Evidence was coded with Facione's indicators and sub-indicators and then organized according to the four stages of Polya's problem-solving process.

3.1.1 Critical Thinking of the High Mathematical Ability Participant (ST) in Solving Mathematical Literacy Problems

The student with high mathematical ability (ST) demonstrated all critical thinking indicators and successfully solved the problem. The activities shown were appropriate and supported by clear reasons, relevant evidence, and coherent relationships between each step of the solution.

3.1.1.1 ST's Critical Thinking in Understanding the Problem

At the understanding-the-problem stage, interpretation was demonstrated through categorization, decoding significance, and clarifying meaning. In the written response, ST

wrote the known and required information, placed the locations on the coordinate plane, and constructed a sequential illustration of the journey.

English Version:
Given:
A (−10,−1): Starting point at the Airport
B (−3,5): Paris Van Java
C (−5,5): Zoo
D (4,5): Creative Market
E (7,−5): Kiara Artha Park
F (−8,−8): Festival Citylink
G (−4,−4): Braga Citywalk
Asked:
- What is the distance between the final position and the starting position?
- What transformations were used?



Figure 1. ST's Written Response at the Understanding-the-Problem Stage

This finding was supported by the following evidence from ST's interview:

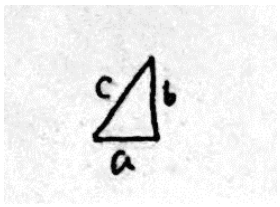
ST *"I illustrated the journey step by step, starting from the airport, to make the information easier to understand."*

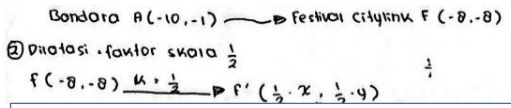
ST *"All the information was important because the starting point and each step were needed to determine the subsequent results."*

The evidence shows that ST demonstrated categorization by writing the known and required information and identifying the airport as the starting point. Clarifying meaning was evident when ST determined the coordinates of each location and explained that the illustration was created to make the sequence of the journey easier to follow. Decoding significance was demonstrated when ST identified the important information and described each movement step based on the illustration.

3.1.1.2 ST's Critical Thinking in Devising a Plan

At the devising-a-plan stage, ST demonstrated analysis through examining ideas. ST determined the initial point at each step based on the result of the preceding transformation. ST also formed a triangle by drawing a line between the initial and final positions, and then identified the hypotenuse as the distance to be determined.





English Version:
Bandara $A(-10,-1) - - \rightarrow$ Festival Citylink $F(-8,-8)$
2) Dilation: scale factor $\frac{1}{2}$
$F(-8,-8) \xrightarrow{k=\frac{1}{2}} F'(\frac{1}{2}x, \frac{1}{2y})$

Figure 2. ST's written response at the devising-a-plan stage

This finding was supported by the following evidence from ST's interview:

ST *"I drew the diagonal line directly ... in the end, I made a diagonal line that formed a triangle."*

ST *"I used the diagonal line to determine Rafa's distance."*

ST *"If the first step is incorrect, the following steps will also be incorrect because each step depends on the result of the previous one."*

These statements show that ST examined two important relationships. First, the result of one transformation became the initial point of the next transformation, so the steps had to be

completed sequentially. Second, the initial and final positions could be connected to form the hypotenuse of a right triangle as the basis for determining the distance. ST's plan connected geometric transformations with the Pythagorean theorem according to the purpose of each step.

3.1.1.3 ST's Critical Thinking in Carrying Out the Plan

At the carrying-out-the-plan stage, ST demonstrated interpretation, analysis, inference, and explanation. Interpretation reappeared when ST interpreted directions as signs in translation vectors and interpreted rotation in the illustration. Analysis was evident when ST determined transformations based on the characteristics of each movement and identified the reasons for using signs, a scale factor, a center of rotation.

English Version:

Answer:

1) Translation: 2 units east and 7 units south

$A(-10,-1) \xrightarrow{T(2,-7)} A'(x+a, y+b)$

$(-10+2, (-1)+(-7))$

$(-8,-8)$

Airport $A(-10,-1)$ → Citylink Festival $F(-8,-8)$

2) Dilatation : scale factor $\frac{1}{2}$

$F(-8,-8) \xrightarrow{k=\frac{1}{2}} F'\left(\frac{1}{2}x, \frac{1}{2}y\right)$

$\left(\frac{1}{2}(-8), \frac{1}{2}(-8_\right)$

$(-4,-4)$

Citylink Festival $F(-8,-8)$ → Braga Citywalk $G(-4,-4)$

3) Translation: 11 units east and 1 units south

$G(-4,-4) \xrightarrow{T(11,-1)} G'(x+a, y+b)$

$(-4+11, (-1)+(-4)$

$(7,-5)$

Braga Citywalk G$(-4,-4)$ → Kiara Artha Park $E(7,-5)$

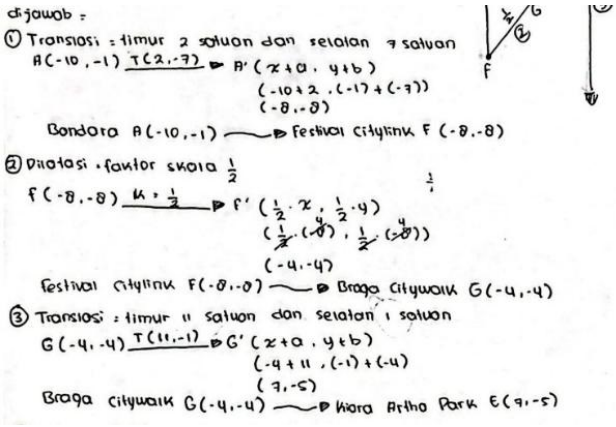


Figure 3. ST's written response at the carrying-out-the-plan stage

This finding was supported by the following evidence from ST's interview:

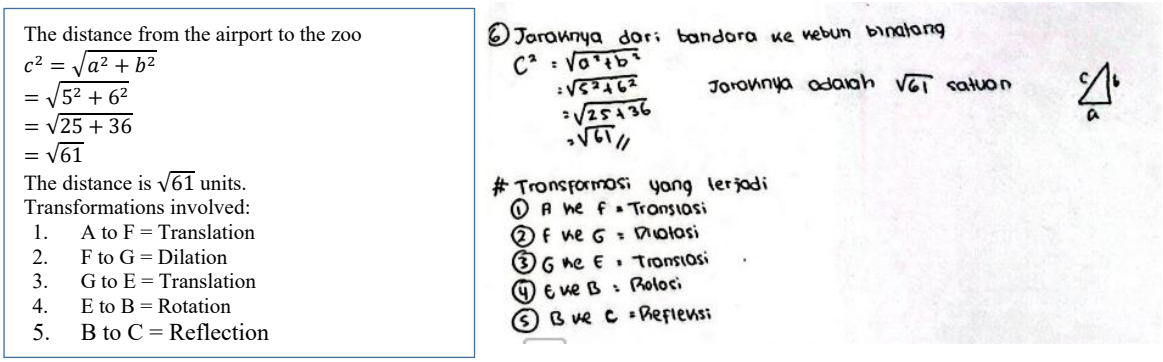
ST *"The problem says that he only moves 2 units and 7 units. Moving means shifting, so I used translation because translation is just a shift."*

ST *"Why dilation? After leaving the festival, the problem says that Rafa travels toward Gedung Sate along a straight route. However, because of the traffic jam, he can complete only half of the journey. Since it is half, the scale factor is one-half. Dilation involves multiplication or division."*

ST *"Eleven units east means moving to the right. Moving right is positive. Then one unit south means moving downward, and moving downward is negative."*

At the carrying-out-the-plan stage, ST demonstrated interpretation by clarifying the meanings of east and south to determine the positive and negative signs of the translation components. Analysis was evident through identifying arguments by selecting translation because a shift occurred, dilation because only half of the journey was completed. The participant then identified reasons and claims by connecting the information in the problem with transformation rules, including positive and negative signs, the scale factor $\frac{1}{2}$, the angle and direction of rotation.

ST also demonstrated inference when verifying and determining the solution based on the evidence obtained.



The distance from the airport to the zoo
$c^2 = \sqrt{a^2 + b^2}$
$= \sqrt{5^2 + 6^2}$
$= \sqrt{25 + 36}$
$= \sqrt{61}$
The distance is $\sqrt{61}$ units.
Transformations involved:
1. A to F = Translation
2. F to G = Dilation
3. G to E = Translation
4. E to B = Rotation
5. B to C = Reflection

⑥ Jarakmya dari bandara ke kebun binatang
$C^2 = \sqrt{a^2+b^2}$
$= \sqrt{5^2+6^2}$
$= \sqrt{25+36}$
$= \sqrt{61}$ //
Jarakmya adalah $\sqrt{61}$ satuan

Transformasi yang terjadi
① A ke F = Translasi
② F ke G = Dilatasi
③ G ke E = Translasi
④ E ke B = Rotasi
⑤ B ke C = Refleksi

Figure 4. ST's written response at the carrying-out-the-plan stage

This finding was supported by the following evidence from ST's interview:

ST *"Since the diagonal side belongs to the triangle, I determined a and b from the grid units below. Each square represents one unit so a is five units and b is six units."*

ST *"I succeeded. After calculating, I found that the final distance was $\sqrt{61}$ units."*

Inference was evident through the use of evidence and the formulation of a conclusion. ST relied on the grid units shown in the illustration to establish the two side lengths as 5 and 6 units. Based on these results, the participant concluded that the final distance was $\sqrt{61}$ units. This shows that the participant used visual evidence and calculation results to support the conclusion, providing a clear basis that was consistent with the solution procedure.

After drawing a conclusion based on the evidence obtained, ST demonstrated explanation by describing the results, procedures, and reasons used in the solution.

ST *"In conclusion, the geometric transformations were translation, dilation, another translation, rotation, and reflection. The final distance was $\sqrt{\mathbf{61}}$ units."*

ST *"I used transformations. A transformation moves from point A to point B, point C, and so on. I used transformations because they seemed to fit the problem best."*

ST *"I used the theorem because I understand the Pythagorean theorem better. I used it because it was easier for me, and it could also be used to find the distance, which was the hypotenuse."*

ST *"I considered this the most appropriate method because I first determined which method and formula best suited the problem. After understanding it, I thought transformations were the most appropriate."*

Explanation was demonstrated through stating results, justifying procedures, and presenting arguments. The participant stated the final result in the form of the sequence of transformations used and the final distance. Procedural justification was shown when the participant chose geometric transformations to represent the movement between locations and applied the Pythagorean theorem to calculate the required distance. The participant then presented the

argument that both methods were the most appropriate because they matched the characteristics of the problem and facilitated determination of the result.

3.1.1.4 ST's Critical Thinking in Looking-Back

At the looking-back stage, ST demonstrated evaluation and self-regulation. Evaluation was evident when ST assessed that the response had addressed the two requirements of the problem: the types of transformations and the distance to the final position. This assessment was based on consistency with the problem, illustration, formulas, sequence of steps, and calculation results

ST *"The problem requires the distance from the final position back to the starting point. The distance has been found ... and the transformations are translation, dilation, another translation, rotation, and reflection."*

ST *"I checked it again. If the calculation is wrong, the point in the illustration will also be different."*

ST *"There was an error in number four, the rotation step ... after calculating and understanding it again, I corrected it."*

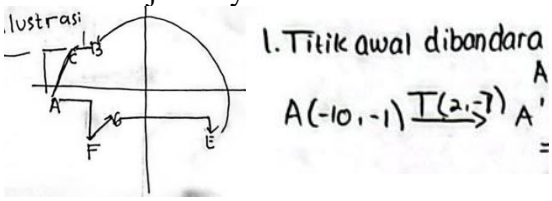
ST assessed claims by matching the results with the questions and assessed arguments by checking the formulas, calculations, illustration, and sequence of transformations. Self-examination was carried out because ST understood that an error in the calculation would also change the position in the illustration. Self-correction was evident when ST found an error in the rotation step and corrected the point that had been written.

3.1.2 Critical Thinking of the Moderate Mathematical Ability Participant (SS) in Solving Mathematical Literacy Problems

The student with moderate mathematical ability (SS) demonstrated six critical thinking indicators, although some activities were less developed and conjecturing alternatives was not evident.

3.1.2.1 SS's Critical Thinking in Understanding the Problem

At the understanding-the-problem stage, SS demonstrated interpretation through categorization, decoding significance, and clarifying meaning. The written response showed the initial point, movement information, the question asked, the coordinates of the locations, and an illustration of the journey.



English Version:
Starting point at the Airport
$A(-10,-1) \xrightarrow{T(2,-7)} A'$

Figure 5. SS's Written Response at the Understanding-the-Problem Stage

This finding was supported by the following evidence from SS's interview:

SS *"The initial point is at the airport ... Rafa moves 2 units east and 7 units south ... in the final step, he crosses a straight vertical road toward a location at the same distance."*

SS *"All of the information is important and can be used to answer the question."*

SS *"Paris Van Java is located at (4,5), where 4 represents the x-coordinate and 5 represents the y-coordinate."*

SS categorized the initial point and the information requested, described the sequence of movements, and clarified the locations using coordinate pairs. However, when asked to decode the significance of the information, SS stated that all information was important without elaborating on how each piece of information affected the subsequent step. Interpretation was evident, but the decoding of significance was less detailed.

3.1.2.2 SS's Critical Thinking in Devising a Plan

At the devising-a-plan stage, SS demonstrated analysis through the activity of examining ideas. SS planned to use the hypotenuse of a triangle to determine the distance and recognized the relationship between the endpoint of one step and the starting point of the subsequent step.

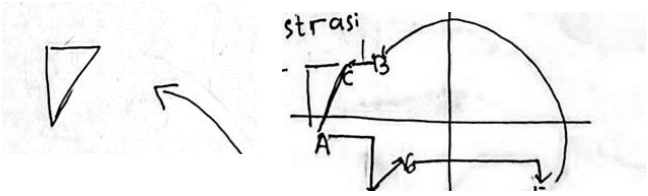


Figure 6. SS's Written Response at the Devising-a-Plan Stage

This finding was supported by the following evidence from SS's interview:

SS *"The illustration contains a triangle, which is intended to find the distance, Miss."*

SS *"There is a relationship among all the steps through their initial and final points."*

SS identified the main idea that the distance could be found through the hypotenuse and that each step was connected through the initial and final points. Nevertheless, the description of the relationship among the steps remained brief. SS did not state that an error in one step would affect the overall result.

3.1.2.3 SS's Critical Thinking in Carrying Out the Plan

At the carrying-out-the-plan stage, SS demonstrated interpretation, analysis, inference, and explanation. Interpretation was evident when SS interpreted the directions and the curved line in the illustration. Analysis emerged through determining the types of transformations and the reasons for using their elements.

English Version:

1) Starting point in Airport

$A(-10,-1) \xrightarrow{T(2,-7)} A'(x+a, y+b)$

$(-10+2, -1+(-7))$

$(-8,-8)$ Festival Citylink

2) From Festival Citylink

$F(-8,-8) \xrightarrow{k=\frac{1}{2}} F'(kx, ky)$

$\left(\frac{1}{2}(-8), \frac{1}{2}(-8)\right)$

$(-4,-4)$) Braga Citywalk

3) From Braga Citywalk

$G(-4,-4) \xrightarrow{T(11,-1)} G'(x+a, y+b)$

$(-4+11, -4+-1)$

$(7,-5)$ Kiara Artha Park

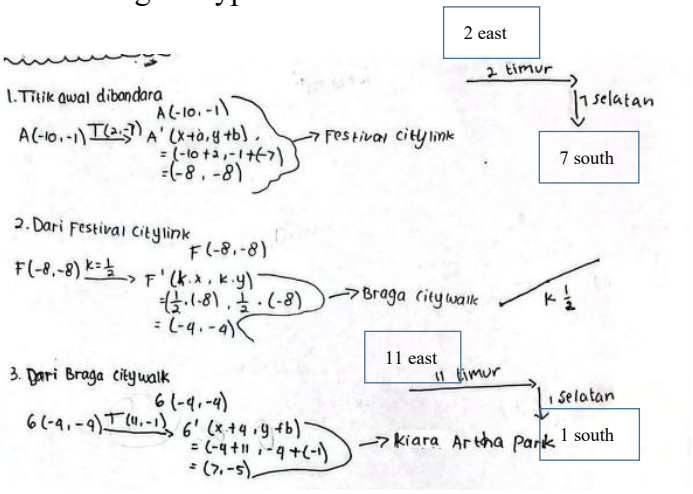


Figure 7. SS's written response at the carrying-out-the-plan stage

This finding was supported by the following evidence from SS's interview:

SS *"Because Rafa shifts 2 units east and 7 units south, I used translation, Miss."*
SS *"Dilation, because the scale factor is one-half, Miss."*
SS *"The scale factor is the value used for multiplication, Miss."*
SS *"Eleven is positive, so it means moving right or east. Negative one means moving downward or south, so it is negative."*
SS *"Let me illustrate it, Miss. There is a point, next a mirror line, also there is image. The distnce from the point to the mirror line is the same as the distance from the mirror line to its image."*

At the carrying-out-the-plan stage, SS demonstrated interpretation by clarifying the meanings of east and south to determine the positive and negative signs in the translation. Analysis was evident through identifying arguments by selecting translation because a shift occurred, dilation because the scale factor was one-half. SS then identified reasons and claims by describing the different translation components, explaining the use of positive and negative signs, identifying Gedung Sate as the center of rotation, and identifying the line of reflection because the point and its image were equidistant from that line. This shows that SS connected the information in the problem with transformation rules, although the reasons provided were still simple and were largely based on the direct characteristics of each transformation.

SS also demonstrated inference when verifying and determining the solution based on the evidence obtained.

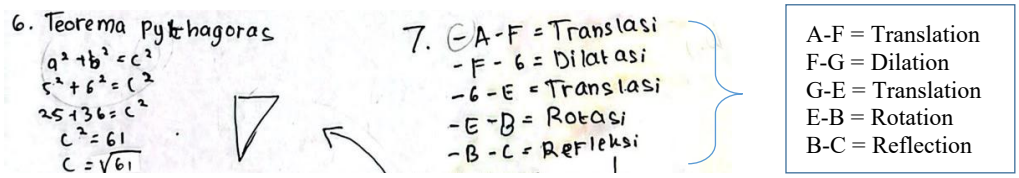


Figure 8. SS's written response at the carrying-out-the-plan stage

This finding was supported by the following evidence from SS's interview:

P *"Apart from geometric transformations, did you think of any other method?"*
SS *"No."*
P *"What conclusion did you draw from all your work on this problem?"*
SS *"The conclusion is that the movements involve translation, dilation, another translation, rotation, and reflection."*
P *"What was the question asking?"*
SS *"The distance from Rafa's final position to the initial position."*
P *"Have you found the answer?"*
SS *"Yes."*

Within the inference indicator, conjecturing alternatives was not evident because SS stated that no other method besides geometric transformations had been considered. However, drawing a conclusion was evident when SS summarized the sequence of transformations used translation, dilation, translation, rotation, and reflection and stated that the distance from the final position to the initial position had been obtained. The conclusion was directed toward the solution result, but remained brief because SS did not restate the distance value or the evidence supporting it.

After drawing a conclusion based on the evidence obtained, SS demonstrated explanation by describing the results, procedures, and reasons used in the solution. This was supported by the following interview evidence:

P *"Why did you choose the Pythagorean theorem to find the distance between the two positions?"*
SS *"Because the illustration forms a right triangle, Miss, and the distance is its hypotenuse."*

Explanation was demonstrated through justifying procedures, stating results, and presenting arguments. Procedural justification was shown when SS selected the Pythagorean theorem because the initial and final positions formed a right triangle and the distance sought was its hypotenuse. SS stated the results by giving the sequence of transformations used and confirming that the final distance had been obtained. In addition, SS presented arguments through the reasons for using translation, dilation, rotation, and reflection in each movement. This shows that SS communicated results and reasons supporting the solution procedure, although still in a simple manner.

3.1.2.4 SS's Critical Thinking in Looking Back

At the looking-back stage, SS demonstrated evaluation and self-regulation. SS assessed that the response had answered the question because it had been checked and matched against the problem. This checking also resulted in a correction to a step that had previously been inaccurate.

P *"From all of this, do you think you have been able to draw a conclusion or answer all the questions?"*
SS *"Yes, Miss."*
P *"Are you confident in your answer?"*
SS *"Yes, I am confident."*
P *"Are you also confident that your answer addresses all the questions?"*
SS *"Yes, because I checked it again and matched it with the problem, Miss."*
P *"Was there an incorrect step that you later corrected?"*
SS *"Yes, Miss, in number 2".*
P *"Please explain".*
SS *"I initially thought it was translation, but the movement did not fit translation. The distance was only half, so I used dilation instead, Miss."*

At the looking-back stage, SS demonstrated evaluation and self-regulation. Evaluation was evident through assessing claims when SS expressed confidence in the answer obtained. Assessing arguments was evident when SS judged that the solution had answered all questions after matching it again with the information in the problem. Self-regulation was demonstrated through self-examination by rechecking the consistency of the answer and through self-correction when SS recognized an error in the second step.

3.1.3 Critical Thinking of the Low Mathematical Ability Participant (SR) in Solving Mathematical Literacy Problems

The student with low mathematical ability demonstrated critical thinking activities in the parts of the problem that were understood. Interpretation and analysis were evident in several

initial steps, while explanation, evaluation, and self-regulation appeared to a limited extent; inference was not evident.

3.1.3.1 SR's Critical Thinking in Understanding the Problem

At the understanding-the-problem stage, SR demonstrated interpretation by categorizing some relevant information and clarifying its meaning, although the significance of the information was only partially decoded.

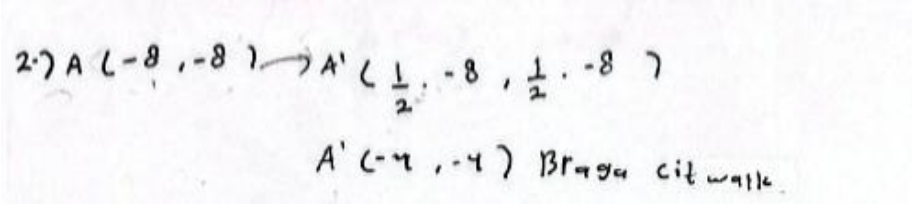


Figure 9. SR's written response at the understanding-the-problem stage

This finding was supported by the following evidence from SR's interview:

SR *"It started from the airport to Festival Citylink ... after Kiara, I did not know what to do and forgot the method."*

SR *"He moved two units east and seven units south ... half of the journey ... turned 180° ... and moved to the opposite side."*

SR *"I counted the grid squares from point 0 to Braga ... so the coordinates were (−4, −4)."*

SR *"The question asks for the distance. It says to determine the distance from Rafa's final position to his initial position at the international airport."*

SR identified important cues in the problem by stating the initial point and the information requested and by connecting the illustration with coordinates. However, the information was not categorized completely. SR described the journey only as far as Kiara Artha and then stated that the method for continuing was not understood. This shows that SR recognized the information but had not connected all of it into a complete problem structure.

3.1.3.2 SR's Critical Thinking in Devising a Plan

At the devising-a-plan stage, SR demonstrated analysis through examining ideas. SR understood that the final result of one step was used as the initial point of the next step. However, SR had not planned how to determine the distance from the final position to the initial position.

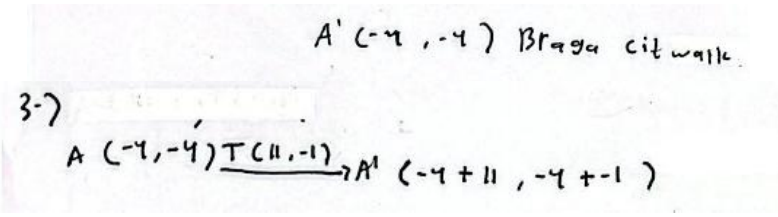


Figure 10. SR's written response at the devising-a-plan stage

This finding was supported by the following evidence from SR's interview:

SR *"(−4, −4), from the final result of the second step."*

SR *"There is a relationship because each final result becomes the initial point of the next step."*

These statements show that SR understood the sequential nature of the transformation series. This understanding is important because an error in the initial point would affect all subsequent results. Nevertheless, SR's plan did not cover the entire solution because neither a hypotenuse representation nor the Pythagorean theorem was proposed for determining the distance.

3.1.3.3 SR's Critical Thinking in Carrying Out the Plan

At the carrying-out-the-plan stage, SR demonstrated interpretation, analysis, and explanation to a limited extent. SR interpreted directions to determine signs, selected several transformations based on words or movement characteristics, and provided simple reasons. However, the execution stopped at the rotation step, so the final position and distance were not obtained.

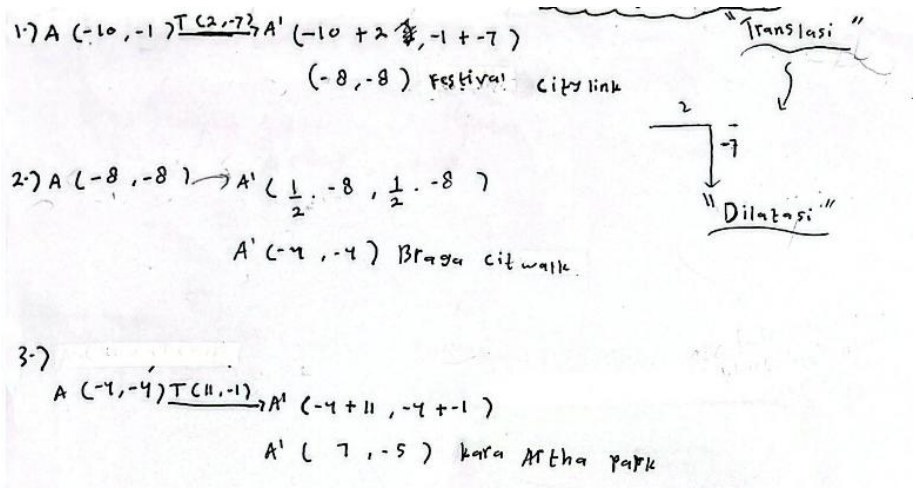


Figure 11. SR's written response at the carrying-out-the-plan stage

This finding was supported by the following evidence from SR's interview:

SR *"Because he shifts or moves, translation is used."*
SR *"East is positive and south is negative. Therefore, (11, −1) is written because south is negative."*
SR *"Rafa completed only half of the distance ... so the result was (−4, −4)."*
SR *"Because there is a 180° counterclockwise turn."*
SR *"Because the illustration shows that the center is (0,0)."*
SR *"It is not complete. I am confused about the method ... I still cannot remember it and remain confused."*

At the carrying-out-the-plan stage, SR demonstrated interpretation by clarifying that east corresponded to a positive direction and south to a negative direction when determining signs in the translation. Analysis was evident through identifying arguments by selecting translation because a shift occurred, dilation because only half of the journey was completed, and rotation because there was a 180° counterclockwise turn. SR then identified reasons and claims by connecting the directions of movement with positive and negative signs and by setting the point (0,0) as the center of rotation based on the illustration. However, inference was not evident because SR could not complete the rotation step and had not reached a conclusion.

After demonstrating interpretation in making sense of the directions of movement and analysis in determining and stating reasons for the use of transformations, SR did not demonstrate inference because the solution was incomplete. Nevertheless, SR demonstrated

limited explanation by describing the procedures and reasons for the steps that had been completed. This was supported by the following interview evidence:

P *"Why did you decide to use this method to solve the problem?"*
SR *"Because that is the method, Miss."*
P *The initial point is (7, 5). Why is the result point still blank here?*
SR *"It is not complete because I am confused about the method. Even after trying to remember it, I still forgot and remained confused."*
P *"Does that mean you have been able to draw a conclusion from your work?"*
SR *"Not yet."*
P *"Have you successfully determined the distance here?"*
SR *"Not yet."*

SR demonstrated explanation to a limited extent. Procedural justification was shown when SR stated that coordinates were used because this was the procedure that was understood, although the reason provided did not explain its mathematical basis. Stating results was not evident because SR could not determine the image point, draw a conclusion, or obtain the final distance. Presenting arguments was evident to a limited extent through the reasons for using transformations in the steps that had been completed, but these arguments did not cover the entire solution.

3.1.3.4 SR's Critical Thinking in Looking Back

At the looking-back stage, SR demonstrated evaluation and self-regulation to a limited extent. SR expressed confidence in the parts that had been completed but acknowledged that the conclusion and distance had not been obtained. The basis for this confidence was limited to adding the initial point and the translation vector and did not include checking the entire procedure.

P *"Are you confident in your answer?"*
SR *"Yes."*
P *"Does that mean you have been able to draw a conclusion from your work?"*
SR *"Not yet."*
P *"How did you determine whether your answer was correct? What did you do?"*
SR *"Because I am confident in the answer."*
P *"How did you convince yourself that your answer was consistent with what you had done?"*
SR *"Because the initial point and the translation were added, so I was confident in the answer."*
P *"Why did you not complete this problem? What made it difficult, and in which part?"*
SR *"The result point. I am confused about how to describe it".*
P *"Was there anything you corrected while working on it?"*
SR *"In the third step, the initial point should have been (−4, −4), but I wrote (−3, −3)."*

At the looking-back stage, SR demonstrated evaluation and self-regulation to a limited extent. Assessing claims was evident when SR expressed confidence in the answer despite being unable to draw a conclusion. Assessing arguments was evident when SR judged that the translation step was correct because the initial point had been added to the translation vector. Self-regulation was evident through self-examination when SR recognized difficulty in

determining the image point and through self-correction when an error in writing the initial point in the third step was identified and corrected from (−3, −3) to (−4, −4).

3.2 Discussion

The results revealed differences in the critical thinking characteristics of students with high, moderate, and low mathematical ability when solving mathematical literacy problems. These differences were evident not only in the indicators that emerged, but also in the depth of the reasons, the connections among steps, and the completeness of the solution. The discussion was based on the critical thinking patterns consistently identified across the two data collection sessions. Although PST 1 and PST 2 used different problem contexts, both tasks involved equivalent mathematical content and problem-solving demands. The comparison of the two sessions showed consistent critical thinking characteristics for each student. Therefore, PST 1 was used as the primary basis for the discussion, while PST 2 confirmed the consistency of the findings.

3.2.1 Critical Thinking of Students with High Mathematical Ability

The student with high mathematical ability demonstrated six critical thinking indicators across the four problem-solving stages. At the understanding stage, the participant identified important information, interpreted the illustration, and clarified the position of each location using coordinates. These activities are consistent with Facione & Gittens interpretation indicator, which involves understanding and expressing the meaning of information.

At the devising-a-plan stage, the participant demonstrated analysis by examining the relationships among steps. The participant recognized that each transformed point became the starting point for the next movement and also planned to determine the required distance with the Pythagorean theorem. This activity is consistent with Polya's (2004) view that devising a plan involves connecting information and determining an appropriate solution strategy.

At the carrying-out-the-plan stage, the participant demonstrated interpretation, analysis, inference, and explanation. The participant interpreted the directions of movement, determined and justified the use of each transformation, used illustrations and calculations as evidence, drew a conclusion, and described the procedures and solution results. The ability to connect geometric transformations with the Pythagorean theorem supports Niss's (2015) view that mathematical literacy requires reasoning and an understanding of relationships among concepts.

At the looking-back stage, the student with high mathematical ability demonstrated evaluation and self-regulation by assessing the consistency of the results, rechecking the calculations, and correcting identified errors. These activities indicate that the student did not merely focus on obtaining the final answer but also monitored the accuracy and coherence of the entire solution process. These activities suggest that the participant did more than verify the final answer; the accuracy and coherence of the solution process were also examined. This pattern is consistent with the findings of Harahap et al. (2024) and Jaelani et al. (2023), who reported stronger critical thinking activities among students with higher mathematical ability. These findings also reflect the student's organized mathematical knowledge in connecting geometric transformations, coordinate representations, and the Pythagorean theorem. These conceptual connections supported the student in evaluating intermediate results and identifying errors. The rechecking and correction activities also reflected metacognitive regulation because the student actively monitored and revised the solution process.

A similar pattern was identified across the two data collection sessions. In both tasks, the student demonstrated critical thinking in the steps that were understood but experienced difficulty when an unfamiliar procedure was encountered. Consequently, the solution remained incomplete and inference was not evident. The consistency of this pattern confirms the student's critical thinking characteristics when solving equivalent mathematical literacy problems.

3.2.2 Critical Thinking of Students with Moderate Mathematical Ability

The student with moderate mathematical ability demonstrated all six critical thinking indicators, although some activities were less developed and conjecturing alternatives was not evident. At the understanding-the-problem stage, the participant identified important information, determined what was asked, and used an illustration to understand the sequence of the journey. However, the role of each piece of information was interpreted only in a simple manner.

At the devising-a-plan stage, the participant understood the relationships among steps and planned to use geometric transformations and the Pythagorean theorem. When carrying out the plan, the participant determined the types of transformations based on the characteristics stated in the problem, such as a shift for translation, half of the journey for dilation, a turn for rotation, and a position on the opposite side for reflection. The participant also explained the use of the Pythagorean theorem because the initial and final positions formed a right triangle. Inference was evident when the participant concluded the sequence of transformations used and stated that the final distance had been obtained. Explanation was evident through communicating the results, the reason for using the Pythagorean theorem, and the reasons for selecting each transformation. At the looking-back stage, the participant assessed that the response had answered the problem, matched the response against the problem, and corrected an error in which translation had initially been used for a movement that should have been represented by dilation.

Despite reaching the solution, the moderate-ability participant generally gave shorter reasons and less developed assessments than the high-ability participant; some explanations became visible only after additional interview prompts. This is in line with Jaelani et al. (2023), who reported that students with moderate mathematical ability can display critical thinking indicators while providing explanations and evaluations that are less elaborate than those of high-ability students

The results from the two sessions also showed a consistent pattern. The student completed both tasks and demonstrated the six critical thinking indicators, although the reasons, use of evidence, and evaluation of procedures remained relatively simple. This pattern confirms that the student's critical thinking characteristics were similar across the two equivalent tasks.

3.2.3 Critical Thinking of Students with Low Mathematical Ability

Students with low mathematical ability demonstrated critical thinking activities in the steps they understood. At the understanding-the-problem stage, the participant stated the initial position, movement information, and the question asked. The participant also interpreted east and south when determining signs in the coordinates. However, the participant did not fully describe the role of all information in the solution.

At the devising-a-plan stage, the participant understood that the final result of one step became the initial point of the next. This demonstrated analysis of the relationships among steps. Nevertheless, the solution plan did not cover all stages because the participant could not determine the procedure for the rotation step and the subsequent transformation.

When carrying out the plan, the participant identified translation because a shift occurred, dilation because only half of the journey was completed, and rotation because there was a 180° turn. The participant also connected the directions of movement with positive and negative signs and identified the point (0, 0) as the center of rotation. However, the participant could not apply the rotation rule, so the solution stopped and inference was not evident. Explanation appeared only to a limited extent through reasons for the procedures used in the steps that were understood.

At the looking-back stage, the participant demonstrated limited evaluation by assessing the accuracy of the translation step that had been completed. Self-regulation was evident when the participant recognized difficulty in determining the image point and corrected an error in writing the initial point. This shows that self-regulation can still emerge even when the solution is incomplete.

This result aligns with Harahap et al. (2024), who found that students with low mathematical ability do not exhibit all critical thinking indicators. Nevertheless, the present study indicates that they can still show interpretation, analysis, and limited forms of explanation, evaluation, and self-regulation in the parts of the problem they are able to understand. Thus, low mathematical ability does not mean that critical thinking activities are entirely absent.

Overall, the findings indicate that differences in critical thinking across high, moderate, and low mathematical ability groups are reflected not only in the number of indicators that appear, but also in the depth and continuity of the thinking processes. The student with high mathematical ability was able to connect information, strategies, procedures, evidence, results, and checking in a coherent and comprehensive manner. The moderate mathematical ability demonstrated nearly all of these critical thinking activities, although the reasons provided were relatively brief and simple. In contrast, the student with low mathematical ability showed critical thinking only in the steps that were understood, and the solution process ended when the student encountered an unfamiliar procedure. This pattern is in line with Rimawati et al. (2026), who reported differences in critical thinking characteristics among students with high, moderate, and low mathematical abilities, particularly in interpretation, analysis, evaluation, and inference. Similar variations were also identified in mathematical literacy and numeracy problems, in which students' critical thinking differed according to the indicators and depth of reasoning demonstrated during problem-solving (Pratiwi et al., 2025). A pattern also corroborated by more recent evidence showing that students' critical thinking quality varies systematically with their prior mathematical competence (Wang & Abdullah, 2024). However, this study also indicates that low mathematical ability does not imply the complete absence of critical thinking activities. Another finding shows that Facione's indicators are not restricted to a single Polya stage. Interpretation, for example, emerged not only during the understanding-the-problem stage but also during the carrying-out-the-plan stage when students interpreted directions, coordinate signs, and rotation illustrations. Thus, Polya's stages describe the sequence of problem-solving activities, whereas Facione's indicators describe the critical thinking activities that may emerge in response to the demands of each stage.

These findings have practical implications for mathematics instruction. Teachers should use contextual and multi-step mathematical literacy tasks that require students to explain their strategies, provide evidence, draw conclusions, and check their solutions. Students with lower mathematical ability should receive scaffolding through visual representations, structured solution steps, and prompts that connect one step to the next. Teachers should also provide opportunities for students to compare strategies, identify errors, revise their answers, and explain their conclusions. These activities can support the development of inference and self-regulation.

4. Conclusion

Based on the results and discussion of junior high school students' critical thinking in solving mathematical literacy problems in terms of mathematical ability, the following conclusions were drawn students with high mathematical ability and demonstrated all critical thinking indicators across problem-solving stage. At the understanding-the-problem stage, students identified important information, interpreted the illustration, and wrote coordinates to clarify positions. During the devising-a-plan stage, the student used the outcome of each transformation as the starting point for the following step and planned to apply the Pythagorean theorem to obtain the distance. At the carrying out-the-plan stage, the student chose appropriate transformations according to the movement information, provided reasons for using signs, a scale factor, a center of rotation, and a line of reflection, used illustrations and calculations as evidence, and then obtained the final position and distance. At the looking-back stage, students assessed the consistency of the results, checked the calculations, and corrected identified errors.

The student with moderate mathematical ability exhibited six critical thinking indicators and completed the solution by determining the final distance. They identified information and used an illustration to understand the journey, connected the result of one transformation with the next step, and selected geometric transformations and the Pythagorean theorem as solution strategies. They provided reasons for using each transformation, although the reasons were still simple and some emerged only after follow-up questions. At the looking-back stage, the student matched their responses against the problem and corrected an error by changing the selected transformation from translation to dilation.

Students with low mathematical ability demonstrated critical thinking activities in the steps they understood. They identified the initial position, directions of movement, and the information requested, and understood that the result of one step became the initial point of the next. While carrying out the plan, they identified translation, dilation, and rotation based on the movement information, but could not apply the rotation rule, so the solution stopped. Consequently, inference was not evident and the final distance was not obtained. Nevertheless, the student demonstrated limited evaluation of the translation step, recognized difficulty in determining the image point, and corrected an error in writing the initial point. This study involved only three students from one school and used mathematical literacy problems limited to the space and shape domain. Therefore, the findings are specific to these cases and cannot be generalized. Future studies should involve more students from different schools, use other mathematical literacy domains, and examine scaffolding that supports inference, evaluation, and self-regulation.

5. References

Arikunto, S. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktik*. PT Rineka Cipta.

Haeruman, D. L., Salsabila, E., & Anastassia Amellia Kharis, S. (2024). The Impact of Mathematical Reasoning and Critical Thinking Skills on Mathematical Literacy Skills. *KnE Social Sciences,* 542-550. https://doi.org/10.18502/kss.v9i13.15957

Facione, P. A., & Gittens, C. A. (2016). *Think Critically* (3rd ed.). Pearson.

Haq, M. D., & Prasetiyo, N. T. (2025). Deep Learning sebagai Pendekatan Transformasional dalam Pendidikan: Sebuah Tinjauan Literatur. *Jurnal Studi Guru Dan Pembelajaran*, *8*(3), 1826–1842. https://doi.org/10.30605/jsgp.8.3.2025.7021

Harahap, N. A., Bentri, A., & Musdi, E. (2024). Indonesian Journal of Science and Mathematics Education Analysis of students' critical thinking skills in solving mathematics problems

in terms of students' initial ability. *Indonesian Journal of Science and Mathematics Education*, *7*(1), 39–52. https://doi.org/10.24042/ijsme.v5i1.18014

Hendriana, H., Rohaeti, E. E., & Sumarmo, U. (2017). *Hard Skills dan Soft Skills Matematik Siswa*. PT Refika Aditama.

Insani, M. H., Sujarwo, & Safitri, D. (2025). Efektivitas dan Tantangan Penilaian Berbasis HOTS sebagai Sarana Penguatan Keterampilan Berpikir Kritis di Abad 21. *Sindoro: Cendikia Pendidikan*, *16*(1), 91–100. https://doi.org/10.9644/sindoro.v3i9.252

Ismaimuza, D. (2025). *Konflik Kognitif, Berpikir Kritis dan Kreatif dalam Pembelajaran Matematika*. CV. Ruang Tentor.

Jaelani, A. K., Hasbi, M., & Baharullah, B. (2023). A Critical Thinking Profile of Mathematics Education Students in Solving Ill-Structured Problem based on Mathematical Ability. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *7*(2), 545. https://doi.org/10.31764/jtam.v7i2.13378

Kementerian Pendidikan dan Kebudayaan. (2019). *Panduan Penulisan Soal HOTS (Higher Order Thinking Skills)*.

Kurnia, I., & Caswita. (2020). Students' critical thinking ability in solving contextual problems at a junior high school. *Journal of Physics: Conference Series*, *1521*(3), 032067. https://doi.org/10.1088/1742-6596/1521/3/032067

Malasari, P. N., Herman, T., & Jupri, A. (2017). The Construction of Mathematical Literacy Problems for Geometry. *Journal of Physics: Conference Series*, *895*(1), 012071. https://doi.org/10.1088/1742-6596/895/1/012071

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). SAGE Publications.

Nabila, I., & Aminah, M. (2025). Kemampuan Literasi Matematis Siswa SMK dalam Menyelesaikan Soal Geometri. *JRPM (Jurnal Review Pembelajaran Matematika)*, *10*(1), 1–18. https://doi.org/10.15642/jrpm.2025.10.1.1-18

Niss, M. (2015). Mathematical Competencies and PISA. In *Assessing Mathematical Literacy: The PISA Experience* (pp. 35–55). Springer International Publishing. https://doi.org/10.1007/978-3-319-10121-7_2

OECD. (2013). *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*. OECD. https://doi.org/10.1787/9789264190511-en

OECD. (2019). *PISA 2018 Assessment and Analytical Framework* (PISA). OECD Publishing. https://doi.org/10.1787/b25efab8-en

Polya, G. (2004). *How to Solve It: A New Aspect of Mathematical Method*. Princeton University Press.

Pratama, M. A. (2020). Mathematical critical thinking ability and students' confidence in mathematical literacy. *Journal of Physics: Conference Series*, *1663*(1), 012028. https://doi.org/10.1088/1742-6596/1663/1/012028

Pratiwi, U. M., Novaliyosi, N., & Pujiastuti, H. (2025). Systematic Literature Review: Kemampuan Berpikir Kritis Siswa Ditinjau Dari Penyelesaian Soal Literasi Numerasi. *Sigma: Jurnal Pendidikan Matematika*, *16*(2), 347–356. https://doi.org/10.26618/sigma.v16i2.15353

Rahmasari, S. M., Zaenuri, Z., Junaedi, I., & Cahyono, A. N. (2025). Assessing Critical Thinking Abilities in Solving Mathematics Number Pattern Problems Among Junior High School Students. *Mosharafa: Jurnal Pendidikan Matematika*, *14*(2), 479–492. https://doi.org/10.31980/mosharafa.v14i2.3116

Rahmawati, N. D. (2022). *Pemecahan Masalah Literasi Matematis Ditinjau dari Adversity Quotient (AQ)*. CV Jejak.

Rejeki, S., Riyadi, & Siswanto. (2021). Students' Critical Thinking Skill in Solving Geometry Problems Viewed from Their Emotional Intelligence. *IOP Conference Series: Earth and Environmental Science*, *1796*(1), 012012. https://doi.org/10.1088/1742-6596/1796/1/012012

Rimawati, I., Suprihatiningsih, S., Uripno, G., & Baldemor, M. R. (2026). Mathematical Critical Thinking Skills of Students in Solving Set Theory Problems. *AlphaMath: Journal of Mathematics Education, 12*(1), 53-66. https://doi.org/10.30595/alphamath.v12i1.30338

Rohim, A., & Rofiki, I. (2024). Profil Kemampuan Berpikir Kritis Siswa dalam Menyelesaikan Soal AKM Numerasi. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *4*(1), 183-193. https://doi.org/10.51574/kognitif.v4i1.893

Santos-Meneses, L. F., & Drugova, E. A. (2023). Trends in critical thinking instruction in 21st-century research and practice: Upgrading instruction in digital environments. *Thinking Skills and Creativity*, *49,* 101383. https://doi.org/10.1016/j.tsc.2023.101383

Santoso, S. E., Kurnia Prahani, B., & Widodo, W. (2025). Profil Keterampilan Berpikir Kritis Peserta Didik Pada Materi Sumber Energi Kelas V di Sekolah Dasar. *Didaktika: Jurnal Kependidikan*, *14*(3), 4813–4824. https://doi.org/10.58230/27454312.2299

Setiana, D. S., Purwoko, R. Y., & Sugiman. (2021). The application of mathematics learning model to stimulate mathematical critical thinking skills of senior high school students. *European Journal of Educational Research*, *10*(1), 509–523. https://doi.org/10.12973/EU-JER.10.1.509

Siswono, T. Y. E. (2018). *Pembelajaran Matematika Berbasis Pengajuan dan Pemecahan Masalah: Fokus pada Berpikir Kritis dan Berpikir Kreatif* (Number 1). PT Remaja Rosdakarya.

Slavin, R. E. (2018). *Educational Psychology: Theory and Practice* (12th ed.). Pearson.

Sumarmo, U., Kusnadi, A., & Maya, R. (2018). Mathematical Critical Thinking Ability and Disposition. *Journal of Educational Experts*, *1*(2), 69-80. https://doi.org/10.30740/jee.v1i2p%25p

Tandililing, P., Napitupulu, B., Imawan, O. R., & Ismail, R. (2025). Predictive model of mathematical literacy ability, specifically university students' critical thinking skills: A case study on the inappropriateness of multilevel regression. *Journal of Education and E-Learning Research*, *12*(3), 507–519. https://doi.org/10.20448/jeelr.v12i3.7398

Wang, Q., & Abdullah, A. H. (2024). Enhancing Students' Critical Thinking Through Mathematics in Higher Education: A Systemic Review. *Sage Open*, *14*(3), 21582440241275651. SAGE Publications Inc. https://doi.org/10.1177/21582440241275651