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Students' Critical Thinking Processes in Solving Contextual Number Pattern Problems Based on The Joglo House

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Abstract: Mathematics learning often emphasizes final answers rather than students' thinking processes, which limits the development of critical thinking. This study aims to analyze junior high school students' critical thinking processes in solving contextual number pattern problems based on the Joglo traditional house. This research employed a descriptive qualitative approach involving 35 eighth-grade students at MTsN 4 Sragen. The instrument consisted of contextual essay questions on number patterns. The data were analyzed by classifying students into high, medium, and low categories using the mean and standard deviation, followed by an in-depth analysis of three selected students based on Facione's indicators. The findings show clear differences in students' critical thinking processes across ability levels. High-category students fulfilled all indicators of critical thinking. Medium-category students showed weaknesses in explanation and self-regulation. Low-category students only fulfilled the interpretation indicator. These findings indicate that the completeness of students' critical thinking processes varies across ability levels in solving contextual number pattern problems based on the Joglo traditional house.

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INTRODUCTION

Mathematics education at the junior high school level plays an important role in developing students' critical thinking (Wisudojati et al., 2024). Critical thinking is an essential component of higher-order thinking abilities that students need to face the challenges of the 21st century (Ngatminiati et al., 2024). Therefore, mathematics learning should not only focus on procedural mastery and formulas but should also emphasize the development of students' reasoning and reflective thinking. Meaningful, relevant, and contextual learning can encourage students to think critically, creatively, and independently when solving real-life problems (Ratnaningsih et al., 2025)

Critical thinking is important not only in academic contexts but also in everyday life, as it enables individuals to make rational decisions, identify weak arguments, and evaluate information appropriately (Gustianingrum et al., 2023). In mathematics, this ability is closely related to mathematical literacy, which involves formulating, applying, and interpreting mathematics in various real-life situations (N. Safitri, 2023). Students who are accustomed to thinking critically tend to be better prepared to deal with the complexity of information in the digital era and are able to solve problems creatively and responsibly (Haryanto et al., 2022). However, previous studies indicate that Indonesian students' critical thinking ability is still relatively low (Sutarni & Gatiniggsih, 2022). Students often experience difficulties in reasoning, identifying patterns logically, and constructing systematic solutions (Usman et al., 2021).

Critical thinking is particularly relevant in the topic of number patterns, which requires students to identify regularities, make predictions, formulate generalizations, and provide logical explanations for patterns (Puspita et al., 2022). These processes align with the six indicators of critical thinking proposed by (Facione, 2011), namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. Understanding how students engage in these processes is essential to reveal their thinking processes rather than merely measuring their performance outcomes.

One approach to fostering critical thinking is contextual learning, which connects mathematical concepts with real-life situations (Oktaviani et al., 2023). Contextual learning encourages students to think actively, engage in discussions, and reflect on their problem-solving processes (Sapitri et al., 2024). In mathematics, contextual problems allow students to translate real-life situations into mathematical models and solve them using logical reasoning (Hidayatulloh et al., 2025). The contexts used in such problems can be drawn from students' environment, social phenomena, or cultural elements (Chavarría-Arroyo & Albanese, 2023).

The integration of local culture in mathematics learning is one way to create contextual and meaningful learning experiences. Previous studies have shown that the ornaments of the Rumah Gadang in West Sumatra can illustrate numerical regularities (Alghar et al., 2022). Research on the Tongkonan house in Toraja has identified various mathematical concepts, particularly related to geometric structures (Sari, 2023). Other studies have also revealed that the arrangement of elements in Indonesian traditional houses reflects number patterns that can serve as contexts for mathematics learning (Nurfauziah & Putra, 2022).

However, previous studies have mainly focused on identifying general mathematical concepts or geometric aspects of traditional houses. In the case of the Joglo traditional house, most studies emphasize geometry and three-dimensional structures (Zulkifli & Rahmawati, 2020). Other studies also focus on spatial and geometric representations rather than number-related concepts (A. W. Safitri, 2023). These studies have not specifically examined number patterns within the Joglo context, nor have they analyzed students' critical thinking processes based on Facione's framework in solving contextual mathematical problems.

Recent research has begun to explore ethnomathematical aspects of the Joglo traditional house, showing that its structure contains mathematical patterns and regularities (Faiziyah et al., 2024). These regularities can be interpreted as number patterns, providing opportunities to support students' understanding through contextual learning.

Therefore, this study aims to analyze junior high school students' critical thinking processes in solving contextual number pattern problems based on the Joglo traditional house. The novelty of this

study lies in the integration of ethnomathematical context with number pattern material and the analysis of students' thinking processes using Facione's framework. This study is important as it provides insights into how contextual and culturally relevant learning can support the development of students' critical thinking processes.

METHOD

This study employed a descriptive qualitative approach. This approach was selected because the objective of the study was to describe in depth students' critical thinking processes in solving contextual mathematics problems. Qualitative research emphasizes the exploration of meaning and processes within natural settings, with the researcher serving as the primary instrument (Sugiyono, 2023). Therefore, this approach was considered appropriate to comprehensively reveal students' critical thinking processes based on their written responses.

The study was conducted at MTsN 4 Sragen with 35 eighth-grade students as research participants. The research site was selected because it is located in Central Java, where the cultural context of the Joglo traditional house is relevant and familiar to the students' daily lives. The participants were eighth-grade students who had studied number pattern material. All students in the class were involved in completing the written test, ensuring that the data represented the variation of students' critical thinking abilities within the class. This approach ensures that the data capture the full range of students' critical thinking ability within the class.

Although this study does not aim to generalize findings to a wider population, the inclusion of all students provides a sufficient representation of the research context. Furthermore, to obtain in-depth data, three students representing high, medium, and low critical thinking categories were selected as research subjects using purposive sampling based on the results of the initial categorization of students' scores. This sampling technique involves selecting participants based on specific considerations aligned with the research objectives to obtain rich and meaningful information (Ahmad et al., 2024).

The research instrument was a written test consisting of two contextual essay questions related to number patterns based on the Joglo traditional house within the topic of arithmetic sequences. The instrument aimed to capture students' critical thinking processes through their written explanations.

Prior to implementation, the instrument underwent expert validation by mathematics education lecturers. The validation focused on the alignment of the items with critical thinking indicators, clarity of language, and suitability of the contextual problems with number pattern material. The validation results indicated that the instrument was feasible for use with minor revisions based on the validators' suggestions. The reliability of the instrument was ensured through consistent scoring using clearly defined critical thinking indicators based on Facione's framework, as well as repeated analysis to maintain consistency in interpreting students' responses.

The analysis of students' responses referred to the six aspects of critical thinking proposed by Facione, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. Data collection was conducted by administering the written test to all eighth-grade students. Students' responses were then analyzed and scored based on critical thinking indicators derived from Facione's framework.

Data analysis followed three stages: data reduction, data display, and conclusion drawing. During the data reduction stage, each critical thinking indicator was scored 1 if fulfilled and 0 if not fulfilled to ensure consistent classification of students into high, medium, and low ability levels. The scoring was used solely for categorization purposes, while the main analysis focused on describing students' critical thinking processes qualitatively.

The categorization of students' critical thinking ability was determined using the mean and standard deviation. According to (Arikunto, 2013), these statistical measures can be used to classify students into high, medium, and low categories. Students in the high category are those who obtain scores greater than or equal to the mean plus the standard deviation, while students in the low category are those who obtain scores less than or equal to the mean minus the standard deviation. Students

whose scores fall between these thresholds are categorized as medium. This categorization was used to ensure an objective and data-driven classification based on the distribution of students' scores.

The categorization refers to students' critical thinking ability, while the analysis focuses on their critical thinking processes. The classification of students into high, medium, and low categories is presented in Table 1.

Table 1. Criteria for Critical Thinking Categories

Score	Category
Score $\geq \bar{x} + SD$	High
$\bar{x} - SD <$ Score $< \bar{x} + SD$	Medium
Score $\leq \bar{x} - SD$	Low

From these categories, three students were selected purposively to represent each level for in-depth qualitative analysis of their critical thinking processes. To ensure data credibility, the analysis was conducted by carefully examining students' written responses as the primary data source and comparing patterns of responses across students with different ability levels (high, medium, low).

RESULTS

The critical thinking ability test administered to the eighth-grade students at MTsN 4 Sragen consisted of two contextual number pattern problems, with a maximum possible score of 28 and a minimum score of 0. The test was completed within 45 minutes. The distribution of the students' critical thinking categories is presented in Table 2.

Table 2. Critical Thinking Skill Test Result

Score Range	Category	Number of Students	Percentage (%)
Score ≥ 21	High	7	20
5 < Score < 21	Medium	18	51
Score ≤ 5	Low	10	29

As shown in Table 2., students' critical thinking ability is distributed across three categories. The high category accounts for 20% of the students, with 7 students obtaining scores of 21 or above, whereas the low category comprises 29% (10 students) with scores of 5 or below. The largest percentage constitutes the medium category at 51%, representing 18 students whose scores fall between 5 and 21. This indicates that, in general, students demonstrated partial fulfillment of critical thinking indicators, but not comprehensively across all aspects.

To explore students' critical thinking processes in more depth, one representative student from each category was selected for further qualitative analysis: TG (High), SD (Medium), and RD (Low), as presented in Table 3. below.

Table 3. Subject Selection Based on Critical Thinking Test Scores

No.	Code	Score	Category
1.	TG	28	High
2.	SD	16	Medium
3.	RD	2	Low

Data presentation

Critical thinking process of high-category student (TG)

Question number 1

Based on Figure 1., subject TG fulfilled the interpretation aspect by writing both the known information (I1) and the information asked (I2). The student explicitly wrote that there were 10 rows of tiles, with 24 tiles in the first row, 27 in the second row, and 30 in the third row. Furthermore, the

student identified that starting from sixth row, the number of tiles doubled. In addition, the student clearly wrote the questions as$U_n = \cdots$ and $S_{10} = \cdots$.

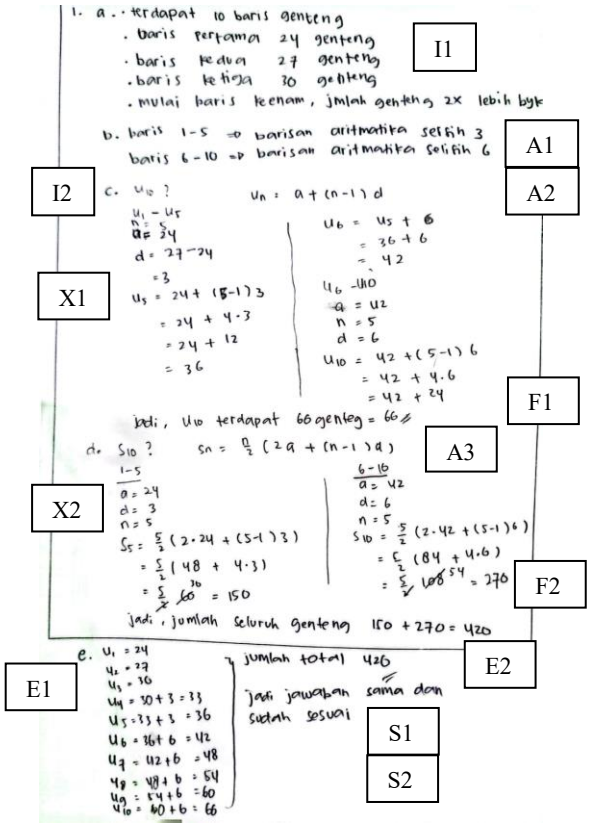

Figure 1. High Category Students' Answers to Question Number 1

In the analysis stage, TG identified the number pattern in the Joglo roof tile arrangement (A1) by recognizing two arithmetic sequences. The student showed that rows 1-5 formed an arithmetic sequence with a common difference of 3, while rows 6-10 formed another arithmetic sequence with a common difference of 6. Based on this, TG correctly determined the common difference (A2) and selected and applied the appropriate arithmetic sequence formulas (A3), namely $U_n = a + (n-1)d$ and $S_n = \frac{n}{2}(2a + (n-1)d)$.

In the explanation aspect, TG presented the solution process systematically when finding the required term (X1) and the total sum (X2). The student showed a clear sequence of steps, such as determining intermediate terms U_3 and U_6 before calculating the final term U_{10}, and then continued by calculating partial sums S_5 before determining S_{10}. Furthermore, TG fulfilled the inference aspect by providing correct answers to both the term question (F1) and the total sum question (F2), with the final results $U_{10} = 66$ and $S_{10} = 270$.

TG also demonstrated evaluation and self-regulation by rechecking the answers using another method (S1), namely by listing the sequence manually (e.g., $U_1 = 24, U_2 = 27, U_3 = 30, U_4 = 30 + 3 = 33, U_5 = 33 + 3 = 36$, and so on). This process produced consistent and accurate results for both the term (E1) and the sum (E2). Finally, TG was able to draw an appropriate conclusion (S2) by confirming that the obtained answers were correct.

Question number 2

Based on Figure 2., subject TG was able to fulfill the interpretation aspect by writing both the known information (I1) and the information asked (I2). The student explicitly wrote that there were 6 steps, with the height of the first step 120 cm, the second 126 cm, and the third 132 cm, and also stated that every 100 cm requires one can of paint. In addition, the student clearly formulated the questions as $U_6 = \cdots$ and $S_6 = \cdots$.

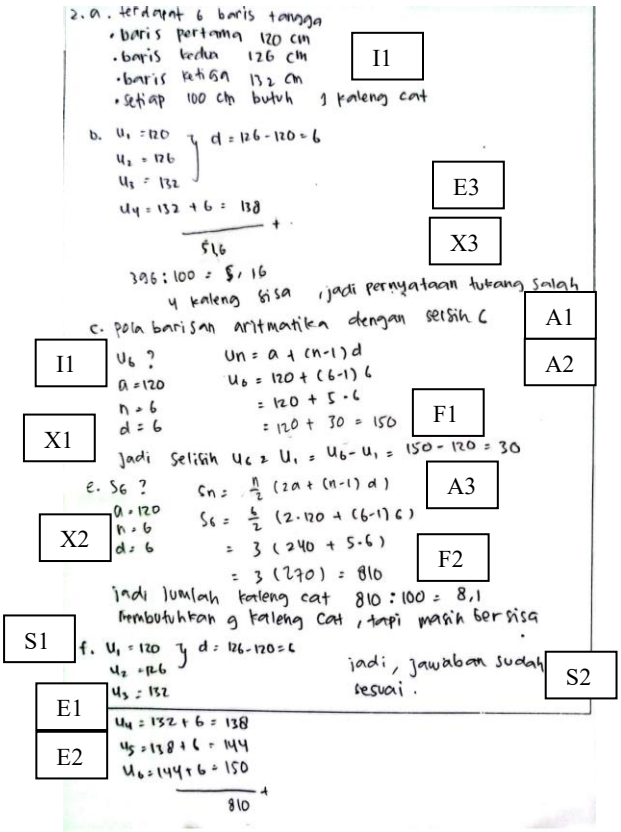

Figure 2. High Category Students' Answers to Question Number 2

In the analysis stage, TG identified the number pattern as an arithmetic sequence (A1) with a constant difference of 6, which was consistently shown in the sequence of step heights. Based on this, the student correctly determined the common difference (A2) and applied the appropriate arithmetic sequence formulas (A3), by writing $U_n = a + (n-1)d$ and $S_n = \frac{n}{2}(2a + (n-1)d)$.

In the explanation aspect, TG presented the solution process systematically when determining the sixth term (X1) and the total sum (X2). TG also explained the builder's statement (X3) by determining an intermediate value to support the reasoning. Furthermore, TG fulfilled the inference aspect by providing correct final answers for both the term (F1), $U_6 = 150$, and the total sum (F2), $S_6 = 810$.

TG also met the evaluation and self-regulation stages by rechecking the results using another method (S1), namely by listing the sequence manually (e.g.,$U_1 = 120$, $U_2 = 126$, $U_3 = 132$, $U_4 = 132 + 6 = 138$, $U_5 = 138 + 6 = 144$, and so on). This verification produced consistent results for both the term (E1) and the total sum (E2). In addition, the student evaluated the builder's statement (E3) by converting the total height into the number of paint cans needed, showing that 810 cm requires approximately 9 cans of paint and some left over. Finally, TG drew an appropriate conclusion (S2) by confirming that the solution was correct.

Critical thinking process of medium-category student (SD)
Question number 1

Based on Figure 3., subject SD was able to fulfill the interpretation aspect by writing both the known information (I1) and the information asked (I2). The student explicitly wrote that there were 10 rows of tiles, with 24 tiles in the first row, 27 in the second row, and 30 in the third row, and also noted that starting from sixth row, the number of tiles doubled. In addition, the student formulated the questions as $U_n = \cdots$ and $S_{10} = \cdots$.

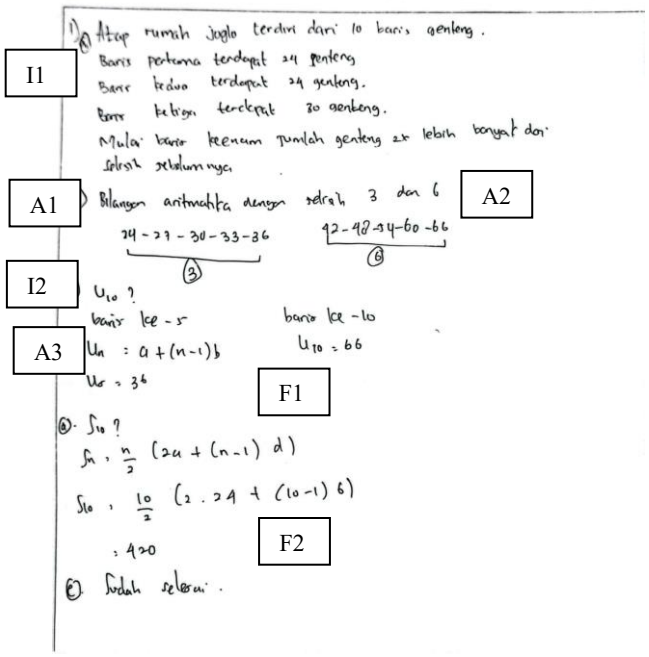

Figure 3. Medium Category Students' Answers to Question Number 1

In the analysis stage, SD identified the number pattern in the Joglo roof tile arrangement (A1) as an arithmetic pattern with differences of 3 and 6. The student showed the differences between rows and was able to determine the common differences (A2), although the explanation was not presented in a detailed manner. The student also selected and wrote the appropriate arithmetic sequence formulas (A3), namely $U_n = a + (n-1)d$ and $S_n = \frac{n}{2}(2a + (n-1)d)$.

In the explanation aspect, SD failed to provide a comprehensive solution process for finding the required term (X1) or the total sum (X2). SD directly wrote the final answers without showing the steps used to obtain them. However, SD was able to provide a brief response related to the problem context (X3), although the reasoning was not fully explained.

Despite the absence of a clear process, SD fulfilled the inference aspect by providing answers to the term question (F1) and the total sum question (F2), namely $U_6 = 36$ and $S_{10} = 420$. However, SD did not demonstrate evaluation or self-regulation, as the student did not recheck the solution using another method (S1). As a result, the correctness of the answers (E1 and E2) could not be confirmed through verification, and no clear conclusion was drawn (S2). Nevertheless, SD fulfilled indicator (E3) by responding to the contextual statement, as shown by the student's answer "it is correct" although without further justification.

Question number 2

Based on Figure 4., subject SD was able to fulfill the interpretation aspect by writing both the known information (I1) and the information asked (I2). The student explicitly wrote that there were 6 steps, with the height of the first step 120 cm, the second 126 cm, and the third 132 cm, and also noted that every 100 cm requires one can of paint. In addition, the student formulated the questions as $U_6 = \cdots$ and $S_6 = \cdots$.

In the analysis stage, SD identified the number pattern as an arithmetic sequence (A1) with a common difference of 6, as shown in the sequence of step heights. The student correctly determined the common difference (A2) and wrote the appropriate arithmetic sequence formulas (A3), similar to those used in the previous problem.

In the explanation aspect, SD omitted a complete procedural solution for finding the required term (X1) or the total sum (X2). SD directly wrote the final results without showing the steps. However, SD demonstrated partial reasoning related to the problem context (X3) by adding $120 + 126 + 132 + 138 = 516$, although this reasoning was incomplete and did not fully represent the required total. Despite the absence of a clear process, SD fulfilled the inference aspect by providing

correct answers to the term question (F1) and the total sum question (F2), namely $U_6 = 150$ and $S_6 = 810$.

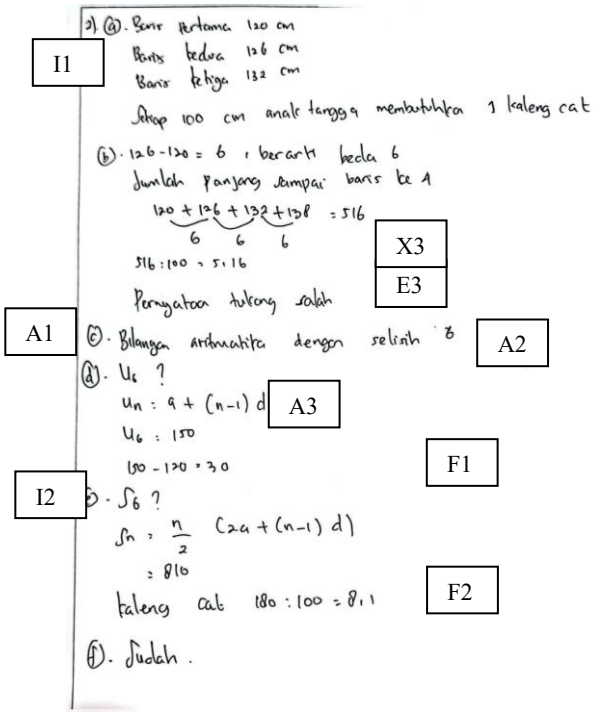

Figure 4. Medium Category Students' Answers to Question Number 2

However, SD did not exhibit evaluation and self-regulation, as the student did not recheck the solution using another method (S1). Therefore, the correctness of the results (E1, E2) could not be verified through alternative procedures, and no explicit conclusion was written (S2). Nevertheless, SD fulfilled indicator (E3) by responding to the builder's statement, stating that the statement was incorrect and supporting it with a calculation result of 5.16, although the explanation was not fully elaborated.

Critical thinking process of low-category student (RD)
Question number 1

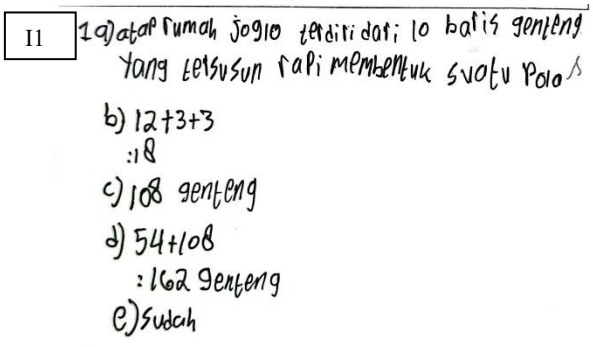

Figure 5. Low Category Students' Answers to Question Number 1

Based on Figure 5., subject RD only partially fulfilled the interpretation aspect, as only some of the known information from the problem was written (I1). The student only stated that the Joglo roof consisted of 10 rows of tiles arranged in a pattern, without including specific numerical details such as the number of tiles in each row. In addition, RD did not write the information being asked in the problem (I2).

In the analysis stage, RD was unable to identify the number pattern in the Joglo roof tile arrangement (A1). The student did not show any attempt to determine the pattern or recognize the differences between rows, and therefore was also unable to determine the common difference (A2) or select and apply an appropriate arithmetic sequence formula (A3).

In the explanation aspect, RD did not provide any solution process for finding the required term (X1) or the total sum (X2). The student did not demonstrate any structured steps or reasoning related to the problem.

In the inference aspect, RD provided incorrect answers for both the term question (F1) and the total sum question (F2), indicating a lack of understanding of the underlying pattern. This is reflected in the student's response, such as writing "$12 + 3 + 3 = 18$" when determining the required result, which does not correspond to an appropriate mathematical procedure.

Furthermore, RD did not demonstrate evaluation or self-regulation, as the student did not recheck the answers using another method (S1). As a result, the correctness of the answers (E1, E2) could not be verified, and no conclusion was drawn (S2).

Question number 2

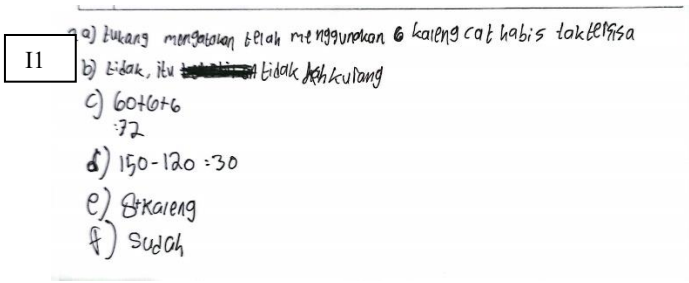

Figure 6. Low Category Students' Answers to Question Number 2

Based on Figure 6., subject RD partially fulfilled the interpretation aspect by identifying limited and less relevant known information (I1). The student only wrote that the builder used 6 cans of paint without any remaining, which was not the main information required in the problem. In addition, RD did not state the information being asked (I2).

In the analysis stage, RD was unable to identify the number pattern in the Joglo roof tile arrangement (A1). This is reflected in the student's response, such as writing "$60 + 6 + 6 = 72$" when asked to determine the form of the pattern, which does not represent a valid arithmetic sequence. The student did not demonstrate any understanding of the arithmetic pattern, and therefore was unable to determine the common difference (A2) or select and apply the appropriate arithmetic sequence formula (A3).

In the explanation aspect, RD failed to provide any mathematical formulation or procedural steps for finding the required term (X1), the total sum (X2), or for explaining the reasoning related to the builder's statement (X3). No clear steps or justification were presented in the answer.

In the inference aspect, RD provided a partially correct response by identifying the difference value (F1), but gave an incorrect answer for the number of paint cans required (F2), indicating an incomplete understanding of the problem context.

Furthermore, RD did not meet the evaluation and self-regulation stages, as the student did not recheck the solution using another method (S1). As a result, the correctness of the answers (E1, E2) could not be verified, and no conclusion was drawn (S2).

DISCUSSION

The findings indicate clear differences in students' critical thinking processes across ability levels, particularly in how they fulfilled Facione's. Students in the high category were able to fulfill all critical thinking indicators proposed by Facione, including interpretation, analysis, evaluation, inference, explanation, and self-regulation. They systematically constructed solution strategies,

accurately identified number patterns, formulated appropriate general formulas, evaluated the correctness of their results, and rechecked their answers using alternative approaches.

This finding is in line with (Puspita et al., 2022), who state that students in the high category tend to construct solution strategies systematically, connect real-world contexts with mathematical concepts, provide rational justifications, and produce logical and consistent conclusions. The results of this study similarly show that high-category students were able to integrate the cultural context of the Joglo traditional house with mathematical concepts in a structured and reflective manner, indicating comprehensive critical thinking processes.

In contrast, students in the medium critical thinking category were able to fulfill the indicators of interpretation and analysis. They correctly wrote the known and asked information and were able to identify the number pattern, determine the common difference, and select the appropriate arithmetic sequence formula. However, their explanation was not consistently systematic, and their final answers were not supported by detailed step-by-step reasoning. Evaluation and self-regulation ability were also not clearly demonstrated, as students did not recheck their answers or use alternative strategies to confirm the correctness of their results.

This finding is consistent with (Nastiti et al., 2020), who report that students with medium critical thinking ability are generally capable of identifying relevant information and applying appropriate concepts but are not yet optimal in providing complete justification and reflective evaluation. This suggests that medium-category students tend to approach problems procedurally and focus on obtaining correct answers, yet lack consistency in articulating reasoning and engaging in deeper metacognitive reflection.

Meanwhile, students in the low critical thinking category were unable to fulfill most of Facione's indicators. They only partially identified known information and did not clearly state what was being asked. In the analysis stage, they did not systematically present the pattern, determine the common difference explicitly, or clearly apply the arithmetic sequence formula, resulting in unclear and partially incorrect solutions. Although some students were able to state certain numerical results, they did not provide supporting reasoning or calculation steps. Evaluation and self-regulation were absent, as students did not recheck their answers or reflect on their reasoning processes.

This condition supports the findings of (Sintya & Sari, 2024), who reported that students with low critical thinking ability generally fulfill only the interpretation aspect and experience difficulty progressing to higher-order stages such as analysis, evaluation, and self-regulation. The results of the present study reinforce the view that limited conceptual understanding and weak analytical ability hinder students' ability to develop systematic reasoning in solving contextual mathematical problems.

Overall, the findings confirm that differences in analytical and reflective abilities significantly influence students' success in solving contextual number pattern problems based on Joglo traditional house. The ethnomathematical context of the Joglo house not only serves as a meaningful learning medium but also effectively reveals variations in students' critical thinking processes.

These findings imply that mathematics learning should not only emphasize correct answers but also focus on developing students' critical thinking processes, particularly in explanation and self-regulation. Teachers are encouraged to design learnijng activities that promote reasoning, justification, and reflection. furthermore, the use of ethnomathematical contexts, such as the Joglo traditional house, integrating ethnomathematical contexts, such as the Joglo traditional house, can support students in understanding mathematical concept more meaningfully while enhacing their engagement and depth of thinking.

CONCLUSION

This study aimed to analyze students' critical thinking processes in solving contextual number pattern problems based on the Joglo traditional house. The findings reveal that students' critical thinking processes predominantly fall into the medium category, with clear distinctions across ability levels. Studets in the high-category demonstrated comprehensive critical thinking processes by fulfilling all indicators of interpretation, analysis, evaluation, inference, explanation, and self-

regulation. Meanwhile students in the medium-category were able to perform interpretation and analysis adequately but lacked consistency in providing systematic explanations and reflective evaluation. In contrast, low-category students experienced difficulties progressing beyond basic interpretation, indicating limitations in higher-order and metacognitive processes. These findings show clear differences in the completeness of students' critical thinking processes across categories in solving contextual number pattern problems.

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