PRISMA, 15(1), 10-20, June 2026
https://jurnal.unsur.ac.id/prisma
DOI:10.35194/jp.v15i1.5867

p-ISSN 2089 3604
e-ISSN 2614 4611

Algorithmic Reasoning: A Type of Imitative Reasoning in Solving Geometry Problems

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Submitted: *30-10-2025*	*Revised*: *07-04-2026*	*Accepted*: *15-04-2026*	*Published: 05-06-2026*

ABSTRACT

This study aims to describe students' imitative reasoning of the algorithmic reasoning type in solving mathematical problems. This research employed a qualitative descriptive approach and involved eighth-grade students at one MTsN in Kediri City in the 2024/2025 academic year. Two subjects were selected based on their written test responses, which indicated the use of imitative procedures. Data were collected through written tests and semi-structured interviews and analyzed using qualitative data analysis techniques. The results showed that both subjects were able to identify the given information and recall relevant formulas; however, their problem-solving processes were not systematically organized. S1 experienced difficulties in processing information, which led to incorrect answers, while S2 tended to accept answers as correct based on the plausibility of the results without adequate verification. Both subjects relied on previously learned procedures and were unable to provide clear justification for the strategies they chose. Therefore, it can be concluded that students' reasoning is dominated by algorithmic imitative reasoning, characterized by dependence on procedures, weak conceptual understanding, and limited justification ability.

Keywords: algorithmic reasoning, geometri problems; imitative reasoning

INTRODUCTION

Mathematical reasoning plays an important role in learning mathematics because it enables students not only to apply procedures but also to understand mathematical concepts (Yusril & Rachmani, 2025). Through reasoning, students are able to solve mathematical problems and construct proofs; thus, reasoning and proof are closely interconnected (Yulianti et al., 2025). Mathematical reasoning involves a flow of thinking used to generate conclusions (Lithner, 2017). Given its importance, students need to develop this ability in order to think critically, solve problems, and express ideas logically (Hidayat et al., 2019). Mathematical reasoning has consistently been identified as a higher-order thinking skill and has become one of the main focuses in mathematics education research, particularly at the junior high school level (Ariati & Juandi, 2022). In line with this, reasoning is recognized as one of the essential process standards in mathematics education, alongside problem solving and communication, and plays a crucial role in developing students' higher-order thinking skills. Therefore, the application of mathematical reasoning is expected to enhance students' creative reasoning, defined as the ability to develop their own solution strategies or to modify procedures derived from previously learned concepts, algorithms, or formulas.

Mathematical reasoning contributes not only to academic thinking skills but also to solving problems in everyday life (Syafa'atun, 2024). The ability to reason mathematically is very important not only for academic success but also for developing students' mathematical literacy, enabling them to interpret and engage with real-world situations more effectively (Kusumawardani et al., 2018). In the context of problem solving, two types of reasoning are identified, namely imitative reasoning and creative reasoning. Imitative reasoning refers to the use of previously known procedures or algorithms through recalling, imitating examples, or reproducing solution steps without a deep understanding of the underlying concepts (Lithner, 2006). It is often based on following examples in textbooks, memorizing algorithms, or recalling answers from prior solutions (Bergqvist, 2012). In practice, many students still rely on procedural approaches rather than conceptual understanding. This is reflected in the dominance of imitative reasoning, where students solve problems by applying previously learned procedures without meaningful reflection. When student complete tasks using prescribed algorithms, their reasoning tends to manifest as a reflectionless application of methods. This pattern to AR is highly likely to result in rote learning rather than genuine mathematical concept (Jonsson et al., 2020).

Imitative reasoning is classified into two types: Memorised Reasoning (MR) and Algorithmic Reasoning (AR) (Lithner, 2008). MR involves direct recall of answers, whereas AR refers to the use of known algorithms to solve problems. The key distinction is that MR relies entirely on recall and simple reproduction, while AR involves recalling and applying algorithms (Kusaeri et al., 2021). Furthermore, AR can be categorized into several subtypes—Familiar AR, Delimiting AR, and Guided AR—based on how individuals select and apply algorithms (Lithner, 2008). These subtypes reflect different cognitive processes, particularly in decision-making when selecting solution strategies.

Several studies have examined imitative reasoning. For example, Sukirwan et al. (2018) found that students' reasoning is still dominated by imitative reasoning. In accordance with the findings of Oz & Is¸ık (2024) that seventh-grade students more often demonstrate Algorithmic Reasoning, one subtype of imitative reasoning, even when faced with various types of problems, which indicates a tendency to rely on familiar algorithms. Similarly, Agusti et al. (2023) reported that imitative reasoning predominates in learning linear equations. In addition, Bahanan et al. (2023) showed that although students understand procedural steps, they tend to focus on calculations rather than logical reasoning and are unable to justify their answers conceptually. However, previous studies have generally focused on identifying imitative reasoning without examining in depth the internal variations of Algorithmic Reasoning, particularly in terms of students' decision-making processes in selecting algorithms and within the context of geometry. This is very important considering that geometry is one of the topics where students often feel difficulty, because difficulties in solving geometry problems often stem from weak conceptual understanding, not merely procedural errors (Afriansyah, 2017). Based on these conditions, several gaps remain, including: (1) limited exploration of Algorithmic Reasoning subtypes and (2) a lack of studies in the context of geometry.

This study focuses on analyzing Algorithmic Reasoning as part of imitative reasoning by examining its subtypes (Familiar AR, Delimiting AR, and Guided AR) in the context of solving geometry problems. This research not only identifies the types of reasoning used by students but also explores the underlying cognitive processes involved in selecting and applying algorithms. This is important because the dominance of imitative reasoning without conceptual understanding may hinder students' ability to solve non-routine problems and develop higher-order thinking skills, as well as lead to misconceptions in geometry learning. Based on this background, the research questions are: (1) how do junior high school students demonstrate Algorithmic Reasoning in solving geometry problems, (2) what types of Algorithmic Reasoning emerge, and (3) how do students select and apply algorithms? Accordingly, this study aims to describe and analyze students' Algorithmic Reasoning based on Lithner's classification, with a focus on the types of reasoning and the underlying decision-making processes.

RESEARCH METHODS

This study employed a qualitative descriptive method with a case study design to describe students' imitative reasoning in solving problems on polyhedra (flat-faced solid figures). The population of this study consisted of eighth-grade students at a State Islamic Junior High School (MTsN) in Kediri City in the 2024/2025 academic year. The sample involved 33 students who had studied the topic of polyhedra.

Participants were selected using a purposive sampling technique based on their participation in the test and their relevance to the research objectives. From the test results, 15 students were identified as demonstrating procedural solution patterns and were grouped based on similarities in their methods. Furthermore, 10 students were selected for in-depth analysis and interviews. The selection criteria included: (1) students who had not encountered exactly the same problems before but had experience with similar types of problems, (2) students who demonstrated clear and systematic solution steps, and (3) students who were able to communicate their reasoning effectively. From these 10 students, two representative students were selected for detailed analysis in the results section. These students were chosen to represent different types of imitative reasoning identified in this study, namely Familiar Algorithmic Reasoning and Delimiting Algorithmic Reasoning. The selection was based on the clarity of their solution patterns and their ability to explain their reasoning during the interviews.

The instruments used in this study consisted of a written test and a semi-structured interview guide. The written test consisted of two essay-type problem-solving questions related to polyhedra, as shown in Figure 1 for Problem 1 and Figure 2 for Problem 2.

1. Two identical rectangular prisms are stacked vertically. The total height of the stack is 32 cm, and the width of each prism is 11 cm. If the volume of each prism is 3.168 cm³, determine the length of each prism.

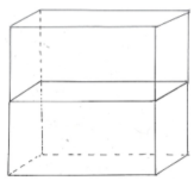

Figure 1.Problem 1

2. If the ratio of the length, width, and height of a rectangular prism is 4: 1: 3, and the surface area of the prism is 8.550 cm², find the volume of the prism.

Figure 2: Problem 2

These questions required students to determine unknown dimensions and volume based on the given information. Each item was designed to resemble previously learned problem types while still requiring students to apply procedures in different contexts, thereby allowing the identification of imitative reasoning through students' solution processes. The test was administered individually within 45 minutes. The interview guide was developed to explore students' reasoning processes in selecting and applying solution strategies. The questions focused on how students understood the problem, selected procedures, and verified their answers. Both instruments were validated by two experts in mathematics education to ensure content relevance, clarity, and alignment with the research objectives. Revisions were made based on the experts' feedback.

Data from the written tests and interview transcripts were analyzed through several stages. First, the data were reduced by selecting relevant information related to students' reasoning processes. Second, the reduced data were coded and categorized based on predetermined indicators of imitative reasoning used in this study. The analysis was based on predetermined indicators of reasoning. Students' reasoning processes were examined through four stages: (1) Identifying a problematic situation, (2) selecting a solution strategy, (3) implementing the strategy, and (4) drawing a conclusion. Furthermore, students' reasoning was categorized into types of imitative reasoning, particularly algorithmic reasoning. Algorithmic reasoning was identified when students selected a strategy by recalling a known procedure and implemented it without generating a new solution. Two types of algorithmic reasoning were identified in this study. Familiar Algorithmic Reasoning occurred when students recognized a problem as similar to previously encountered tasks and directly applied a known algorithm. Delimiting Algorithmic Reasoning occurred when students selected strategies based on surface features of the problem and evaluated their answers based on expected results without in-depth verification. Third, the categorized data were analyzed to identify patterns of students' reasoning. Based on these patterns, students' reasoning was classified into types of imitative reasoning. Representative cases were then selected to illustrate each type of reasoning. Finally, the data were interpreted to describe the characteristics of each type of reasoning. To ensure data validity, triangulation was conducted by comparing students' written responses and interview data. Consistency across data sources was examined to ensure the accuracy of the findings. In addition, clear selection criteria and systematic analysis procedures were used to support the credibility and replicability of the study. All analyses were conducted systematically without the use of specialized software.

RESULTS AND DISCUSSION

This section presents the results of students' algorithmic reasoning in solving geometry problems. Prior to the test, students were asked about the formulas for the surface area and volume of rectangular prisms and cubes. The results showed that 88% of students were able to correctly recall these formulas. However, variations were observed in students' ability to apply the formulas in problem-solving tasks. Analysis of 33 students' written responses identified 15 distinct solution patterns. These patterns were further examined through interviews to explore students' reasoning processes. Based on this analysis, students' reasoning was categorized into two types: Familiar Algorithmic Reasoning and Delimiting Algorithmic Reasoning.

Two representative subjects, S1 and S2, were selected to illustrate each type of reasoning. The analysis of each subject is presented in the following subsections

Algorithmic Reasoning (AR) : Familiar AR in the S1 Problem Solving Process

Problem 1

- **Identifying the Problem**

  S1 identified the known and unknown information in the problem, as indicated by the written statements on the answer sheet. In understanding the problem situation, S1 interpreted the two rectangular prisms as a single larger prism and focused on determining one of its dimensions. This approach indicates that S1 attempted to relate the given information to a familiar representation.
- **Strategy Selection**

  S1 selected a solution strategy by recalling a familiar formula related to volume based on prior experience. The strategy was chosen without analyzing the specific structure of the problem but by associating it with previously encountered tasks. This is reflected in S1's statement: "I have not seen the exact same problem, but I often encounter similar types." S1 further explained the use of a remembered procedure:

"If the volume is known, to find a dimension, we divide the volume by the product of the known dimensions."

- **Implementation of The Strategy**
  S1 directly substituted the known values into the formula without adapting it to the specific context of the problem. The procedure followed a routine pattern commonly used in similar tasks, particularly in determining one dimension by dividing the volume by the product of the other dimensions. The written work of S1 is presented in Figure 3.

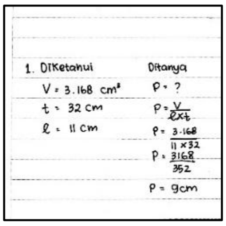

Figure 3. Answers and strategies for problem 1

  During the interview, S1 was unable to explain the origin of the formula and relied solely on memorized knowledge: "I just remember from my teacher that the formula is like that."

- **Drawing a Conclusion**
  S1 obtained an incorrect result and concluded the solution without verifying whether the applied procedure was appropriate. The conclusion was based on confidence in the procedure rather than on evaluation of the result, as indicated by the statement: "I am sure because the method is the same as I remember."

Problem 2

- **Identifying the Problem**
  S1 attempted to understand the problem by writing down the known information, including the surface area and the ratio of the dimensions. However, the relationship between these elements and the required solution was not fully established. S1 recognized that additional steps were needed to determine the volume but showed uncertainty in connecting the given information.
- **Strategy Selection**
  S1 again selected a strategy based on previously learned procedures involving ratios and formulas. The strategy was chosen based on familiarity rather than a complete understanding of the problem. This is reflected in S1's statement: "I have not seen the exact same problem, but I often encounter similar types with different numbers." S1 further explained that ratio problems are typically solved by representing the quantities in variable form and applying known formulas.
- **Implementation of the strategy**
  S1 represented the ratio $p : l : t = 4 : 1 : 3$ as $4x : x : 3x$, and then substituted these expressions into the surface area formula based on previously encountered procedures. The process was carried out without modification to suit the specific problem context. The written work of S1 is shown in Figure 4.

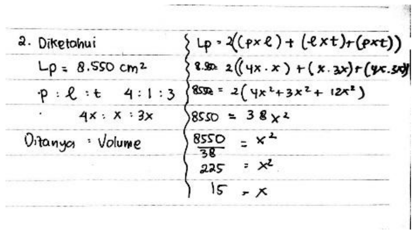

Figure 4. S1 answers and strategies for problem 2

S1 was unable to explain how the formula was derived and relied on memorization: “I cannot explain how to derive it because I only use the usual formula and substitute it.”

- **Drawing a conclusion**

  S1 did not arrive at a complete or correct conclusion, as the solution process stopped after determining an intermediate value. S1 showed uncertainty about the final answer but remained confident in the procedure used. This is reflected in the statements: “I am not sure about the answer, but I am sure about the strategy because it is similar to what I usually do.” Additionally, S1 demonstrated limited understanding of the meaning of the obtained variable: “I do not really understand the meaning of x.”

Algorithmic Reasoning (AR) : Delimiting AR in the S2 Problem Solving Process
Problem 1

- **Identifying the Problem**

  S2 identified the known and unknown information in the problem based on the written statements on the answer sheet. At the beginning of the process, S2 experienced a problematic situation in determining how the given information, particularly the height of two stacked prisms, should be interpreted. To resolve this, S2 attempted to relate the information to prior knowledge of rectangular prism problems and began organizing the known data before selecting a solution approach.

- **Strategy Selection**

  S2 selected a solution strategy by recalling several familiar formulas related to volume and surface area. The selection of the formula was based on matching the given information with previously encountered problem types rather than deriving a new approach. This is reflected in S2’s statement: “I have seen similar types of problems, although with different numbers.” S2 further explained that the choice of formula depends on the type of given information: “If the problem provides volume, I use the volume formula; if it provides surface area, I use the surface area formula.”

- **Implementation of the Strategy**

  S2 applied the selected formula by directly substituting the known values from the problem. In addition, S2 adjusted the given information by dividing the height into two parts, assuming that the total height represented two stacked prisms. However, this adjustment was not fully justified through mathematical reasoning, but rather based on interpretation of the problem context. The written solution is presented in Figure 5.

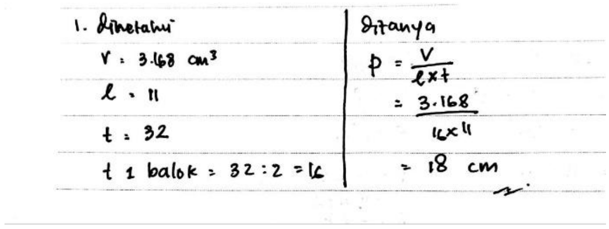

Figure 5. Results of S2 answers and strategies

During the interview, S2 stated that the parameter x was used based on prior experience: "After identifying the ratio, I usually introduce x and substitute it into the formula."

- **Drawing a Conclusion**

  S2 concluded the solution based on the obtained result without further verification of its correctness. The justification was based on the consistency of the numerical result rather than conceptual validation, as reflected in the statement: "I am confident because the result is an integer, and usually similar problems also give integer results."

Problem 2

- **Identifying the Problem**

  S2 attempted to understand the problem by identifying relevant information from the given context. At this stage, S2 again experienced a problematic situation in determining which formula should be applied due to the presence of multiple possible representations (ratio, surface area, and volume). To address this, S2 recalled previously learned procedures and began linking the given information to familiar problem structures.
- **Strategy Selection**

  S2 selected a strategy by considering multiple remembered formulas and choosing the one perceived as most suitable based on surface features of the problem. This selection was guided by recognition of familiar patterns rather than deep structural analysis. S2 stated: "I look at the information in the problem first, then connect it with formulas I remember from similar problems." S2 further explained that ratio-based problems are typically solved by introducing a parameter x and substituting it into known formulas.
- **Implementation of the Strategy**

  S2 represented the ratio using a parameter form and attempted to determine the actual dimensions by substituting into relevant formulas. The selection of the formula was based on perceived relevance (e.g., volume or surface area), rather than a structured derivation process. The written work is shown in Figure 6.

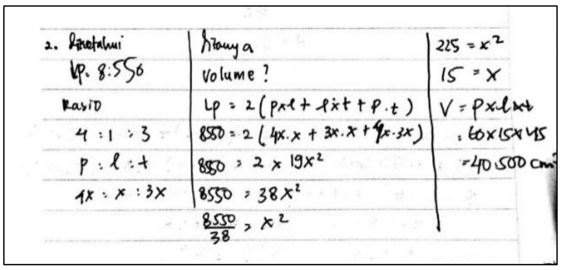

Figure 6. Answers and strategies for problem 2

S2 also admitted uncertainty regarding the mathematical justification of the steps: "I am not completely sure when substituting the values, but I follow what I remember from similar problems."

- **Drawing a Conclusion**

  S2 did not fully verify the final result and relied on the obtained numerical outcome as validation. Although S2 expressed partial uncertainty, confidence was based on procedural familiarity rather than conceptual understanding, as reflected in the statement: "I am not completely sure, but because I obtained a result, I believe it is correct." Additionally, S2 demonstrated limited understanding of the meaning of the parameter used: "I do not really understand what x represents, I only know it is used in ratio problems."

  The research results show that S1 consistently demonstrates Familiar Algorithmic Reasoning (AR), in which problem solving is based on recalling and directly applying known procedures without any conceptual adaptation. S1 tends to recognize problems as variations of tasks previously encountered and immediately selects memorized formulas. This is in line with (Lithner, 2008), which explains that imitative reasoning occurs when students rely on remembered algorithms without constructing or justifying the mathematical meaning behind them. Recent studies also highlight that this type of reasoning ability is based on repeated task patterns and imitation of procedural steps, rather than deep conceptual understanding (Lithner, 2017)(Braithwaite & Sprague, 2021).

  In S1's case, even when faced with unfamiliar problem contexts, the student simplifies the situation into commonly encountered structures (for example, treating two prisms as a single object) and applies known formulas without validation. This indicates that S1's reasoning is driven by surface similarity rather than structural understanding. Empirical evidence from eye-tracking studies further confirms this tendency, showing that students who practice with algorithmic solution templates tend to focus exclusively on procedural cues while disregarding information essential for deeper mathematical comprehension(Norqvist et al., 2019) . Similar findings are reported by (Jonsson et al., 2020)(Bahanan et al., 2023) (Agusti et al., 2023), who found that students often rely on familiar examples without analyzing the underlying mathematical relationships. As a result, S1's reasoning reflects limited engagement in evaluative thinking, as the student does not verify the accuracy of the chosen strategy. This confirms the claim (Lithner, 2017) that algorithmic reasoning can lead to procedural success in routine tasks but does not always support conceptual development.

In contrast, S2 demonstrates Delimiting Algorithmic Reasoning, characterized by selecting strategies based on surface cues and narrowing procedural possibilities through recognizing familiar elements such as ratios, volume, or surface area. Although S2 appears to consider several formulas, the selection process is not based on deep mathematical justification, but rather on matching problem information with remembered procedures. This behavior aligns with Lithner (2008) description of delimiting AR, where students search for suitable algorithms by interpreting the surface of the task. Recent research also supports this pattern, showing that students often rely on contextual cues visible on the surface as a basis for choosing which procedures to apply, especially in geometry problems involving many elements (Setyo et al., 2025). The behavior reflects a limited form of reasoning, where the student is not constructing a solution but rather selecting from a limited set of remembered strategies. In addition, S2 shows a tendency to accept results as correct when the numerical output appears “reasonable” (for example, producing an integer value), indicating a weak verification process.

The comparison between S1 and S2 highlights two different forms of imitative reasoning within Lithner’s framework: S1 relies on the direct recall of a single known algorithm (more rigid and procedural). S2 engages in a broader selection, yet still at a surface level, among several remembered procedures (slightly more flexible). However, both remain within the limits of imitative reasoning, as neither engages in mathematical justification or conceptual derivation. This limits students’ engagement in Creative Mathematical Reasoning (CMR), which requires justification, novelty, and a mathematical foundation. A large portion of mathematics education continues to center around memorization and repetition rather than conceptual understanding, which reinforces imitative reasoning patterns and constrains students' capacity to develop CMR (Jonsson et al., 2022). These findings indicate that students’ learning experiences are strongly shaped by procedural instruction, which encourages the selection of algorithms rather than conceptual reasoning. Repeated exposure to routine tasks reinforces imitative strategies and reduces opportunities for the development of creative reasoning. From an educational perspective, this suggests the need for task design that reduces reliance on memorized algorithms and promotes the construction of reasoning.

This study is limited by its small sample size and its exclusive focus on geometry, which restricts the generalizability of the findings to other mathematical domains or broader student populations. Future research should involve larger, more diverse cohorts across various topics and learning contexts to deepen the understanding of mathematical reasoning development, particularly in addressing the prevalence of imitative reasoning.

CONCLUSION

This study examined students’ imitative reasoning in solving geometry problems based on Lithner’s framework, particularly focusing on Algorithmic Reasoning in the forms of Familiar Algorithmic Reasoning and Delimiting Algorithmic Reasoning. The findings show that both S1 and S2 relied on imitative reasoning when solving the given problems, although with different characteristics. S1 demonstrated Familiar Algorithmic Reasoning by directly recalling and applying previously learned procedures without adapting them to the problem context. In contrast, S2 demonstrated Delimiting Algorithmic Reasoning by selecting strategies based on surface features of the problem and matching them with several remembered formulas. Despite these differences, both students did not engage in justification or verification of their solutions, indicating limited involvement in conceptual reasoning. These findings suggest that students’ problem-solving processes are still dominated by procedural approaches rather than Creative Mathematical Reasoning. This highlights the need for instructional practices that emphasize conceptual understanding, justification, and flexibility in problem solving. Designing tasks that require students to construct and explain their reasoning may help reduce reliance on imitative strategies and support the development of deeper mathematical understanding.

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