Analysis of the Use Intelligent Guess and Test Strategy in Solving Realistic HOTS Problems for Junior High School Students

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Abstract. There are various strategies for solving realistic HOTS-type problems, one of which is the intelligent guess and test strategy. However, students have not yet fully understood the use of this strategy. Therefore, this study aims to analyze the use of the intelligent guess and test strategy in solving realistic HOTS-type problems. This research employs a qualitative approach with a case study type. The study was conducted at SMP Widiatmika in Badung Regency, Bali Province, involving 27 eighth-grade students. Data collection techniques included tests and documentation. Data analysis employed qualitative content analysis, thematic coding, constant comparative analysis, and narrative analysis. The results of this study indicate that 96.3% of students chose to solve problems using an arithmetic approach, while 3.7% used an algebraic approach. The study also revealed that students faced difficulties in solving realistic HOTS-type problems, particularly in understanding the problems and determining the methods to use. Furthermore, the study identified three patterns in the use of the intelligent guess and test strategy: incomplete, complete but indirect, and complete and direct. The incomplete pattern occurs when students determine a formula without a strong basis to arrive at the final answer to a problem. The second pattern, complete but indirect, begins after the student understands the problem and makes the most reasonable guess, followed by testing. The student then analyzes the test results and makes the next guess based on the initial guess. This process is carried out cyclically until the student finds the most accurate guess. The third pattern, complete and direct, occurs when the student makes a direct guess because they fully understand the problem and have considered various aspects of the issue. The student tests the first guess and obtains the expected result.
Keywords: Intelligent Guess and Test Strategy, Problem Solving, Realistic HOTS Problems, Arithmetic, Algebra

INTRODUCTION

Mathematical problem-solving ability is a fundamental skill that is crucial for students' cognitive and academic development. According to the National Council of Teachers of Mathematics (NCTM, 2000), problem-solving is not only a goal of mathematics education but also a primary means of gaining a deep understanding of mathematical concepts. Schoenfeld (2016) emphasized that this skill helps students develop logical, critical, and creative thinking, which can be applied in various real-life contexts. Polya (1957), in his famous work, ouICined that the process of mathematical problem-solving involves a series of systematic steps that assist students in organizing their thoughts and developing effective strategies. Furthermore, a study conducted by Căprioară (2015) revealed that students proficient in mathematical problem-solving tend to perform better academically overall and are better prepared to face future challenges. Additionally, research by Tambychik and Meerah (2010) found that mathematical problem-solving ability positively correlates with increased self-confidence and learning motivation among students. Finally, as noted by English and Gainsburg (2016), mathematical problem-solving skills also prepare students to participate effectively in a society that increasingly relies on technology and quantitative reasoning.

Although mathematical problem-solving skills have been recognized as a crucial component of mathematics education (NCTM, 2000), many teachers still do not focus their instruction on problem-solving tasks. Schoenfeld (2014) observed that the pressure to complete the curriculum within a limited time often drives teachers to emphasize procedures and formulas rather than problem-solving. A study conducted by Mayer and Wittrock (2006) revealed that many teachers lack confidence in teaching problem-solving strategies due to inadequate training. Furthermore, Schoen and Pritchett (1998) found that standardized tests that focus more on procedural skills tend to lead teachers to "teach to the test" rather than develop students' problem-solving abilities. Tambychik and Meerah (2010) also noted that many teachers experience difficulties in designing and evaluating effective problem-solving tasks. As a result, despite the widespread recognition of its importance, the implementation of problem-solving-focused teaching still faces various challenges in the field.

In the world of mathematics education, there are various types of problem-solving tasks that can be used to develop students' thinking skills. Polya (1957) classified mathematical problems into two main types: problems to find and problems to prove. Meanwhile, Yee (2002) identified five types of mathematical problems: routine problems, process problems, puzzle problems, application problems, and situation problems. Among these various types, realistic problem-solving tasks of the HOTS (Higher Order Thinking Skills) type are becoming increasingly important in the context of modern education. According to Wijaya et al. (2014), realistic problem-solving tasks involve meaningful real-world contexts for students, while the HOTS components, as explained by Brookhart (2010), include the abilities of analysis, evaluation, and creation based on the revised Bloom's taxonomy. Furthermore, a study conducted by Jäder et al. (2020) showed that realistic problem-solving tasks of the HOTS type not only enhance students' mathematical abilities but also develop critical and creative thinking skills essential for facing the challenges of the 21st century. Therefore, as argued by English and Gainsburg (2016), it is important for educators to incorporate more realistic HOTS problem-solving tasks in mathematics instruction to prepare students for the complexities of the real world.

Recent research on the use of the "Intelligent Guessing and Testing" strategy in mathematical problem-solving has yielded valuable new insights. A study conducted by Özcan et al. (2017) revealed that students who were explicitly taught this strategy showed significant improvement in their non-routine problem-solving abilities. Similarly, Rott (2020) found that the use of intelligent guessing and testing often emerged as a key strategy in the problem-solving processes of gifted students. In the context of educational technology, Li et al. (2018) developed an intelligent tutoring system that supports and analyzes the use of intelligent guessing strategies, demonstrating its potential in adaptive learning. Czocher's (2017) research explored how engineering students use this strategy in mathematical modeling, emphasizing its importance in the STEM context. Furthermore, a longitudinal study by Stylianides and Stylianides (2014) showed that students' ability to use intelligent guessing and testing develops over time and contributes to a deeper conceptual understanding. In an international context, Kaur et al. (2019) compared the use of this strategy across different countries, revealing cultural variations in its application. Finally, a meta-analysis conducted by Scherer and Beckmann (2014) confirmed the effectiveness of the intelligent guessing and testing strategy in enhancing overall mathematical problem-solving performance.

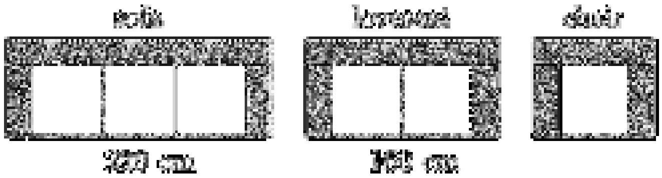
Although the Intelligent Guess and Test strategy has been extensively researched in the context of mathematical problem-solving, there are significant research gaps regarding its use in solving HOTS (Higher Order Thinking Skills) realistic problems at the junior high school level. Özcan et al. (2017) investigated the use of problem-solving strategies with 6th-grade students, but their focus was not on HOTS realistic problems. Meanwhile, Rott (2020) explored problem-solving strategies with gifted students but did not specifically examine the Intelligent Guess and Test strategy in the context of HOTS realistic problems. Stylianides and Stylianides (2014) did research on the development of students' problem-solving abilities, but it did not focus on junior high school level or HOTS realistic problems. Furthermore, although Kaur et al. (2019) compared the use of problem-solving strategies across different countries, they did not specifically analyze the use of the Intelligent Guess and Test strategy in the context of HOTS realistic problems at the junior high school level. Additionally, there is no comprehensive research analyzing how junior high school students use the Intelligent Guess and Test strategy to solve HOTS realistic problems and the factors influencing its effectiveness. This gap highlights the need for more in-depth research on how junior high school students apply the Intelligent Guess and Test strategy in the context of HOTS realistic problems and its implications for developing their higher-order thinking skills.

METHOD

This type of research uses a qualitative case study approach. Creswell and Poth (2018) state that qualitative approaches are well-suited for exploring and understanding phenomena in depth, especially when researchers seek a holistic understanding of students' problem-solving strategy categorization. Case studies, as described by Yin (2018), allow researchers to investigate contemporary phenomena (the use of the Intelligent Guess and Test strategy) in real-life contexts (solving HOTS realistic problems), particularly when the boundary between the phenomenon and the context is not clear. In this case, the focus is on how junior high school students solve HOTS realistic mathematical problems using the Intelligent Guess and Test strategy. This study is conducted at SMP Widiatmika in Badung Regency, Bali, involving 27 8th-grade students who have already studied arithmetic and algebra.

The research instruments consist of two HOTS (Higher Order Thinking Skills) realistic test questions. The two questions are:

1. Modern Furniture Store sells sofas, loveseats, and chairs that are made from identical parts (of the same size) as shown in the image below. There is only one pair of armrests on each piece of furniture, and all armrests have the same width. The width of the sofa is 220 cm and the width of the loveseat is 160 cm. What is the width of the chair?



2. *Level Twenty One* is one of the malls located in the center of Denpasar and is frequently visited by the public, especially young people, one of whom is Stefan. Stefan, who aspires to work in the Department of Transportation, enjoys observing parking lots by counting the total number of vehicles present. That morning, Stefan recorded 30 vehicles consisting of cars and motorcycles. The total number of wheels of the vehicles in the parking lot was 84. How many cars and motorcycles were there?

Data Collection Techniques are Problem-Solving Test: Design and administer a specific test consisting of HOTS (Higher Order Thinking Skills) realistic problems that allow the use of the Intelligent Guess and Test strategy. This test can be used to measure students' ability to apply the strategy in various contexts. Document Analysis: Collect and analyze students' written work, including worksheets, notes, and test answers involving HOTS realistic problems. This can provide insights into how students apply the Intelligent Guess and Test strategy in written form.

Data Analysis Techniques are Qualitative Content Analysis: This involves careful and systematic reading of students' written documents. The researcher identifies patterns and categories related to the use of the Intelligent Guess and Test strategy. As described by Krippendorff (2018), this analysis allows the researcher to uncover hidden meanings and the context of the strategy's use. Thematic Coding: Miles et al. (2014) suggest using thematic coding to organize and categorize data. The researcher can develop codes related to various aspects of the use of the Intelligent Guess and Test strategy, such as IC (Incomplete), CID (Complete Indirect), and CD (Complete Direct). Constant Comparative Analysis: This technique, derived from Grounded Theory (Corbin & Strauss, 2014), involves continuously comparing new data with previously collected and analyzed data. In this case, the researcher develops and refines analytical categories iteratively, providing a deeper understanding of how students use the Intelligent Guess and Test strategy in various contexts. Narrative Analysis: This technique, as described by Riessman (2008), can be used to analyze students' stories and explanations about their experiences using the Intelligent Guess and Test strategy. Narrative analysis can reveal how students understand and interpret the use of this strategy in their problem-solving contexts.

Below is the categorization of the use of the Intelligent Guess and Test strategy by junior high school students when solving HOTS (Higher Order Thinking Skills) realistic problems:

TABLE 1. Categorization of the use of the Intelligent Guess and Test strategy

Intelligent Guess and Test category	Code	Description
Incomplete	IC	Students choose guesses using formulas without a basis and do not test the results of these guesses
Complete Indirect	CID	Students make an initial guess and test it, then revise the guess to obtain the best correct answer
Complete Direct	CD	Students make an accurate guess directly and test that guess

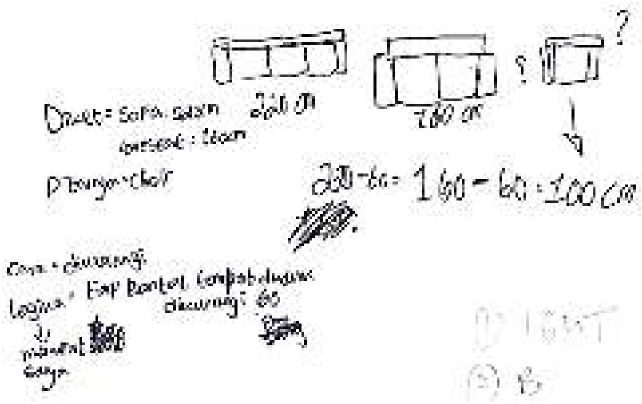
RESULTS AND DISCUSSION

Out of the 27 students tested, 26 used an arithmetic approach through the "intelligent" guess and test strategy to solve HOTS realistic problems, while only 1 student used an algebraic approach. This finding indicates a tendency for students to prefer the arithmetic approach using the "intelligent" guess and test strategy over the algebraic approach using equations. Several factors influence this preference. According to Drijvers et al. (2019), many students face difficulties in transitioning from arithmetic to algebra, especially in modeling problem situations into algebraic equations. As a result, they tend to choose a more familiar and concrete approach. Walkington et al. (2019) found that students often feel more confident with numerical strategies like intelligent guess and test because these strategies allow them to start with specific values and adjust iteratively. Research by Napaphun (2017) revealed that students using the intelligent guessing strategy showed higher levels of engagement and motivation in problem-solving, possibly due to the exploratory and hands-on nature of this approach. Furthermore, Khoshaim and Nwabueze (2022) observed that students who lack confidence in formal algebra manipulation often choose the trial-and-improvement method as a more accessible alternative. Ojose (2020) argued that the preference for arithmetic approaches might stem from students' prior experiences and curricula that emphasize numerical computation before formal algebra introduction. Finally, Hitt et al. (2017) highlighted that the ability to switch between arithmetic and algebraic representations is an important skill that develops gradually, suggesting that an initial preference for arithmetic methods might be a natural stage in the development of students' mathematical understanding.

From the 27 students, 13 students (48.15%) answered question 1 correctly, and 7 students (25.93%) answered question 2 correctly. The students who answered correctly were then analyzed based on the Intelligent Guess and Test strategy they used. For question 1, the distribution was as follows: 9 students (69.23%) were categorized as IC (Incomplete), 3 students (23.08%) were categorized as CID (Complete Indirect), and 1 student (7.69%) was categorized as CD (Complete Direct). For question 2, the distribution was: 3 students (42.86%) were categorized as CID and 4 students (57.14%) were categorized as CD. These findings indicate that students did not fully understand the problems and faced difficulties in analyzing HOTS realistic problems. Several factors contribute to this issue. According to Wijaya et al. (2014), students often struggle to transfer their mathematical knowledge to real-world situations, primarily due to a lack of contextual understanding. Apino and Retnawati (2017) identified that many students have difficulty identifying relevant information in complex problems, which is a key skill in HOTS. Research by Jäder et al. (2020) revealed that students often stick to routine procedures and struggle to switch to higher-order thinking required for non-standard problems. Furthermore, Gurat (2018) found that many students lack metacognitive skills, which are essential for monitoring and evaluating their own understanding when facing complex problems. Saleh et al. (2018) highlighted that a lack of experience with contextual problems in everyday learning contributes to students' difficulties in analyzing realistic problems. Finally, Yuberti et al. (2019) argued that mathematical anxiety and lack of confidence often hinder students' ability to engage effectively with HOTS problems, causing them to avoid the in-depth analysis required. These factors collectively explain why many students face challenges in understanding and analyzing HOTS realistic problems.

Based on these results, the next step is to describe the patterns of students solving problems using the Intelligent Guess and Test strategy for each category. Specifically, Subject 1 represents a student categorized as IC for question 1, Subject 2 represents a student categorized as CID for question 1, and Subject 3 represents a student categorized as CD for question 1. Furthermore, Subject 4 represents a student categorized as CID for question 2, and Subject 5 represents a student categorized as CD for question 2. The following is a description of the five subjects when using the Intelligent Guess and Test strategy to solve HOTS realistic problems.

Description of Subject 1 (S1)



Translate:

Given: Sofa = 220 cm
Loveseat = 160 cm
Asked: Chair

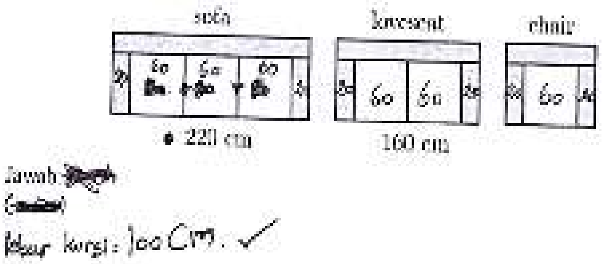
220 – 60 = 160 – 60 = 100 cm

Method: Subtraction
Logic: Each cushion is reduced by 60 (in my opinion)

FIGURE 1. S1's answer when solving question 1

Subject 1 (S1) began by writing down the known information and the question from the problem, then creating an illustration in the form of a diagram. This indicates that S1 understood the problem at hand. Next, S1 chose a strategy by "subtracting, each cushion reduced by 60." S1 implemented this as a formula: 220 minus 60 results in 160, then 160 minus 60 results in 100 cm. S1's answer is correct but incomplete, as there was no testing of the initial guess and final result obtained. In this case, S1 made a guess but did not test that guess. Additionally, the logic used for the initial guess was based on the assumption that 60 cm refers only to the cushion width excluding the armrests.

Description of Subject 2 (S2)



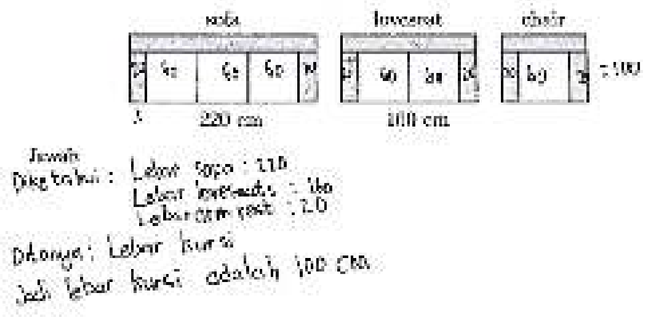
Translate

Answer:
Width of the chair = 100 cm

FIGURE 2. S2's answer when solving question 1

Subject 2 (S2) initially guessed that the width of each cushion for the sofa was 80 cm, then tested this guess and found that the total exceeded 220 cm. S2 then revised the guess to 60 cm per cushion and 20 cm per armrest, and upon summing these, the result was 220 cm. This was then applied to the loveseat, resulting in the correct measurement of 160 cm. S2 then applied the same approach to the chair and obtained 100 cm. In this case, S2 used their intelligence in making guesses (not just random guessing). S2 made an initial guess and revised it after testing the initial guess. The second guess also demonstrated intelligence, where the guess of 80 cm was adjusted to 60 cm. The second guess was smaller than the first because the analysis showed that a guess of 80 cm resulted in 240 cm. Therefore, the next guess needed to be smaller to get a total less than 220 cm. This indicates that the Intelligent Guess and Test strategy was used comprehensively.

Description of Subject



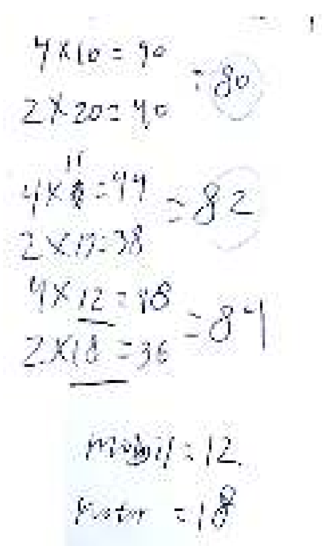
Translate

Given: Width of the sofa = 220 cm
Width of the loveseat = 160 cm
Width of the armrest = 20 cm
Asked: Width of the chair?
So, the width of the chair is 100 cm.

FIGURE 3. S3's answer when solving question 1

Subject 3 (S3) initially identified the known values: width of the sofa as 220 cm, width of the loveseat as 160 cm, and provided additional information by guessing the width of the armrest as 20 cm. S3 then determined what was being asked, which was the width of the chair, and concluded that the width of the chair was 100 cm. The final result of 100 cm was obtained from the testing conducted (as shown in the image), starting with tests for the sofa width of 20, 60, 60, 60, and 20. Then the loveseat width was tested as 20, 60, 60, and 20. Finally, the chair was tested with 20, 60, and 20, resulting in 100 cm. In this case, S3 made guesses and tested them directly. The intelligence demonstrated by S3 was in determining the armrest width as 20 cm.

Description of Subject 4



Translate

Answer
4 x 10 = 40 = 80
2 x 20 = 40

4 x 11 = 44 = 82
2 x 19 = 38

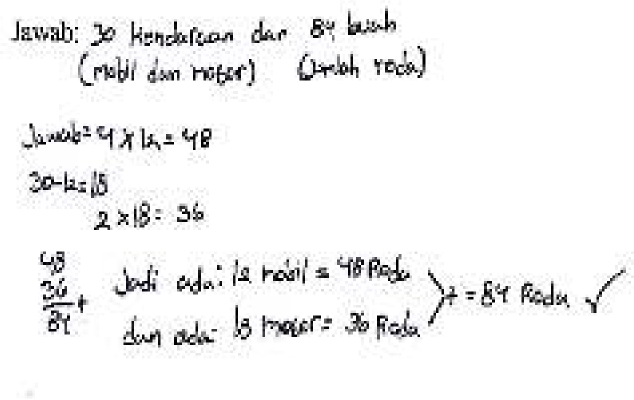
4 x 12 = 48 = 84
2 x 18 = 36

Car = 12
Motor = 18

FIGURE 4. S4's answer when solving question 2

Subject 4 (S4) began by understanding the problem that there were 30 vehicles consisting of cars and motorcycles, with their individual quantities unknown. Additionally, it was understood that the total number of wheels was 84. This understanding was reflected in the consistent pattern of guesses made. S4 started with an initial guess of 10 cars and 20 motorcycles. Upon adding these, the total number of wheels was found to be 80. S4 then revised the guess to 11 cars and 19 motorcycles, resulting in 82 wheels. Next, S4 tried 12 cars and 18 motorcycles, which yielded a total of 84 wheels, matching the given condition. S4 concluded that the number of cars was 12 and the number of motorcycles was 18. In this case, S4 used the Intelligent Guess and Test strategy comprehensively, starting with understanding the problem, determining the strategy, and implementing it step-by-step by making initial guesses, testing them, analyzing results to refine the guesses, and eventually finding the correct final answer.

Description of Subject 5



Translate
Answer: 30 vehicles (cars and motorcycles) and 84 wheels

Calculation:

4 wheels per car × 12 cars = 48 wheels
30 vehicles – 12 cars = 18 motorcycles
2 wheels per motorcycle × 18 motorcycles = 36 wheels
48 wheels + 36 wheels = 84 wheels
So, there are 12 cars (48 wheels) and 18 motorcycles (36 wheels), totaling 84 wheels.

FIGURE 5. S5's answer when solving question 2

Subject 5 (S5) began by identifying the given information: 30 vehicles consisting of cars and motorcycles, and 84 wheels in total. S5 then made an initial guess of 12 cars and 18 motorcycles. This guess was tested by calculating: 4 wheels × 12 cars = 48 wheels and 2 wheels × 18 motorcycles = 36 wheels. Upon testing, the total was found to be 48 + 36 = 84 wheels, which matched the problem statement. In this case, S5 made a direct guess and tested it accordingly. The intelligence demonstrated was in determining the number of cars as 12 and aligning this with the information provided in the problem.

Patterns of using the "Intelligent Guess and Test" strategy in solving realistic HOTS problems have been the focus of recent research. The results of this study reveal three patterns of using the "Intelligent Guess and Test" strategy: incomplete, complete indirect, and complete direct.

1. The incomplete pattern begins with students determining a formula without a strong basis and then providing an answer without testing whether the answer is correct. This is supported by Yeo (2017), who identifies the pattern of using "Intelligent Guess and Test" as a bridge between intuitive and formal understanding, where students use intelligent guesses to explore problems before developing more rigorous solutions.
2. The complete indirect pattern starts with students understanding the problem and making the most reasonable guess, then testing this guess. They analyze the results of the test and make subsequent guesses based on the initial guess. This process is cyclical until they find the most accurate guess. Loc and Uyen (2014) observe that in the context of realistic problems, students often use their situational knowledge to make reasonable initial guesses, which they then refine through iteration. Meanwhile, Gurat (2018) finds that students frequently use this strategy in a cyclic pattern, where they make a guess, test it, reflect on the results, and then make a better guess. Research by Betlich et al. (2015) reveals a pattern where students use "Intelligent Guess and Test" as an initial strategy to understand the structure of the problem before transitioning to a more formal approach.
3. The complete direct pattern involves students making a direct guess because they understand the problem well and have considered various aspects of the issue. Students test the initial guess and achieve the expected result. Metacognitive skills and extensive experience in solving similar problems are key factors for this third pattern. This is reinforced by Rott (2020), who identifies three main steps in using the "Intelligent Guess and Test" strategy: (1) initial guess based on intuition, followed by systematic adjustment; (2) use of domain knowledge to make more informed guesses; and (3) combining guesses with other problem-solving strategies.

CONCLUSION

The tendency of students to solve problems using an arithmetic approach rather than algebra is evident. This is shown by 96.3% of students choosing to solve problems using an arithmetic approach. This preference is due to students' difficulties in converting realistic HOTS problems into algebraic equations. Additionally, the arithmetic approach is more practical compared to algebra, which requires strong, formal systematic knowledge. The research also indicates that students face challenges in solving realistic HOTS problems, particularly in understanding the problem and determining the approach to use. This is reflected in the fact that out of 27 students, 13 (48.15%) answered question 1 correctly and 7 (25.93%) answered question 2 correctly.

The results of this study reveal three patterns of using the intelligent guess and test strategy: incomplete, complete indirect, and complete direct. The incomplete pattern begins with students determining a formula without a strong basis for arriving at the final answer. The second pattern is complete indirect, where after understanding the problem, students make the most reasonable guess and then test it. They analyze the results of the test and make subsequent guesses based on the initial guess. This process is cyclic until they find the most accurate guess. The third pattern is complete direct, where students start with a direct guess because they understand the problem well and have considered various aspects of the issue. The students test their initial guess and achieve a result that meets their expectations.

For future research, it is hoped that there will be development of HOTS learning modules focused on realistic HOTS-type exercises. Additionally, there should be a student-centered approach based on problem-solving and realistic mathematics education. The incomplete intelligent guess and test strategy pattern indicates that students need guidance in organizing more systematic problem-solving steps. Teachers can provide step-by-step guidance and emphasize the importance of logical justification in each stage of problem-solving. Students using the complete indirect pattern require more practice in identifying initial assumptions and testing solutions effectively. Exercises with progressively increasing difficulty can help students strengthen their strategies to achieve more efficient problem-solving. Students already using the complete direct pattern can serve as examples or models in learning. Involving them in class discussions to share problem-solving strategies can inspire other students to be more meticulous and critical in analyzing problems.

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