

Students' Problem-Solving Strategies in Solving Equation and Linear Inequality Problems of One Variable

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Abstract

Background - Students' ability to solve mathematical problems reflects their mastery of mathematical concepts, their thinking processes, and the strategies they use when facing cognitive challenges. Examining these strategies helps clarify how students interpret problems, organize information, and develop solutions.

Purpose - This study aimed to identify and describe students' problem-solving strategies when solving linear equations and inequalities with one variable, focusing on students with different mathematical ability levels.

Method/approach - The study employed a qualitative approach with a single instrumental case study design and an evaluative method. Three students representing high, moderate, and low mathematical ability levels were selected from 29 potential participants. Data collection involved written task sheets on one-variable linear equations and inequalities and semi-structured interviews. The analysis followed three stages: data condensation, data display, and conclusion drawing.

Findings - The three selected students demonstrated different problem-solving strategies. The student with high mathematical ability predominantly used logical reasoning to develop systematic solutions. The student with moderate ability organized data to understand the available information and structure the solution process. The student with low ability relied on trial-and-error strategies. Written responses and interview explanations provided complementary insights into how each student approached the tasks.

Conclusion - The study identified three problem-solving strategies: logical reasoning, data organization, and trial and error. Each strategy involved a different approach to interpreting information and developing solutions. These findings describe variations across the three selected cases.

Novelty/Originality/Value - The study integrates written solutions with interview explanations to describe contrasting strategy profiles among three students working on one-variable linear equations and inequalities. This combination provides a more detailed account of students' solution processes than written answers alone.

Keywords: problem solving strategies; one variable linear equation; one variable linear inequality

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INTRODUCTION

Problem solving ability is one of the important components in learning mathematics because it encourages students to think critically, creatively, and reflectively in solving problems. According to [Polya \(1973\)](#), a problem arises when someone is faced with a situation that has no known answer and cannot be resolved directly, so it requires systematic thinking and solving efforts. [Wahyudi and Anugraheni \(2017\)](#) stated that a problem becomes a challenge that cannot be solved with routine procedures, so it requires a deep understanding and the right strategy. [Posamentier and Krulik \(1998\)](#) also emphasized that a mathematical problem requires individuals to use their existing knowledge to find solutions that are not immediately apparent.

In mathematics learning, problem-solving skills are closely related to the strategies students use to reach solutions. According to [Ogilvie \(2009\)](#), strategies must make sense to students, and they must see how to apply the ideas. Finally, students need to experience that the strategies produce some success. Problem solving strategies are approaches or steps that a person takes to find a solution to a problem that cannot be solved directly [Yunarti et al. \(2024\)](#). In line with this, according to [Andayani and Madani \(2023\)](#), teachers can identify students' strengths and weaknesses based on assessment results and provide appropriate guidance on how to improve their learning achievement. [Polya \(1973\)](#) himself suggested four steps of problem solving, namely understanding the problem, planning a solution, implementing the plan, and checking back. Meanwhile, [Posamentier and Krulik \(1998\)](#) formulated ten problem-solving strategies commonly used in mathematical contexts, namely: (1) looking for patterns, (2) making diagrams, (3) making lists, (4) trial and error, (5) working backwards, (6) solving simpler problems, (7) using analogies, (8) thinking logically, (9) making reasonable guesses, and (10) organizing information. These strategies can help students overcome difficulties and formulate systematic steps in solving math problems.

In addition, problem solving strategies are also explained by several other experts. [Yunarti et al. \(2024\)](#) divided problem-solving strategies into three, namely: cognitive strategies, metacognitive strategies, and affective strategies. Cognitive strategies are related to logical and systematic thinking skills, metacognitive strategies are related to awareness in choosing and controlling strategies, while affective strategies involve students' motivation and confidence in solving problems. By understanding the various types of strategies, teachers can help students choose the most appropriate approach in solving math problems. Learning design provides a broader context for examining how students explain and organize their solutions. [Sari et al. \(2024\)](#), including Imam Shofwan as a coauthor, developed a TPACK-based team-based project learning module for digital literacy, placing problem solving and communication within an active learning design. Although that study did not investigate one-variable algebra, it supports the pedagogical rationale for asking learners to make their reasoning explicit through meaningful tasks.

However, in practice, many students still experience difficulties in solving math problems, especially in the material of linear equations and inequalities of one variable (PLSV) which is the basic material at the junior high school level. Students often experience obstacles in converting information from story problems to mathematical forms, lack of understanding of algebraic concepts, to repeated procedural errors ([Sulastri & Arhasy, 2017](#); [Permaganti & Zanthi, 2023](#); [Mattoliang et al., 2024](#)). In fact, the material of linear equations and inequalities of one variable is very important because it is the basis for further learning algebra and often appears in everyday life. Based on this description, this study aims to find out and describe the problem-solving strategies used by students in solving linear equations and inequalities of one variable. This research will specifically examine the types of strategies used by students based on the problem-solving strategy model of [Posamentier and Krulik \(1998\)](#), as well as describe how their thought process while solving problems on the material of linear equations and inequalities of one variable. The results of this study are expected to provide an overview of the tendency of students' strategies in solving problems, so that it can be taken into consideration in the development of problem-solving-oriented mathematics learning.

METHODS

This study employed a qualitative approach using a single instrumental case study design combined with an evaluative method. The single instrumental case study was selected to provide an in-depth exploration of students' thinking processes and problem-solving strategies when solving problems on one-variable linear equations and inequalities (PLSV). A qualitative approach was considered appropriate because it enables researchers to gain a comprehensive understanding of participants' experiences and reasoning through an interactive and flexible research process (Creswell, 2014). Meanwhile, the evaluative method was used to assess the effectiveness and appropriateness of the problem-solving strategies identified during the study based on predetermined criteria (Arif, 2019). Thus, the case study design served to explore students' cognitive processes in depth, whereas the evaluative method was employed to evaluate the quality and effectiveness of the strategies that emerged.

The research instruments consisted of the researcher as the primary instrument, assignment sheets containing descriptive questions on linear equations and inequalities with one variable, and semi-structured interview guidelines. Data were collected through descriptive tests and in-depth interviews. The tests were used to identify problem-solving strategies emerging from students' answers (Masdy et al., 2021), while interviews were conducted to further explore the reasons for students' strategy choices and provide context for their thinking processes (Dwiguningtyas et al., 2025). Interviews were recorded to ensure accurate data collection.

The data analysis technique in this study refers to the Miles et al. (2014); Rijali (2018), which includes three stages: data condensation, data presentation, and conclusion drawing and verification. Data condensation was done by filtering and categorizing important information from the test and interview results. Furthermore, data presentation was done through descriptive narratives and strategy categorization tables. The final stage of drawing conclusions was done to find patterns of problem-solving strategies used by students in solving problems of linear equations and inequalities of one variable.

The research was conducted at SMP Negeri 26 Bandar Lampung in the odd semester of the 2024/2025 school year. The research subjects were 29 students of class VII-1, which were selected based on the recommendation of the mathematics teacher because they had diverse cognitive abilities. Of these, 3 students were selected as the main subjects representing the high, medium, and low ability categories (Aimi et al., 2024). The selection was made based on the results of daily assessments, midterm exams, and student answer sheets. Furthermore, each subject was interviewed in turn, which was conducted immediately after the subject completed the task.

Table 1. Categories of Research Subjects

	Category	Score
1.	High	$75 \leq x \leq 100$
2.	Medium	$60 \leq x < 75$
3.	Low	$0 \leq x < 60$

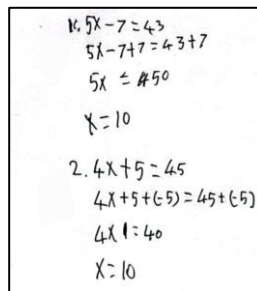
Table 2. Research Subject

Categories of Potential Subjects	Many Subject Candidates	Number of Data Selected	Research Subject
1	9	1	S1
2	8	1	S2
3	12	1	S3
Quantity	29	3	3 Subject

RESULTS AND DISCUSSION

The results showed that there were three strategies developed to solve problems of linear equations and inequalities of one variable, namely logical reasoning strategies, data organizing strategies, and trial and error strategies. In addition, there were also differences in each strategy used. The problem-solving strategies of the three subjects selected as representatives of each category are as follows.

High Ability Students (S1)



$$\begin{array}{l}
 1. 5x - 7 = 43 \\
 5x - 7 + 7 = 43 + 7 \\
 5x = 50 \\
 x = 10 \\
 2. 4x + 5 = 45 \\
 4x + 5 + (-5) = 45 + (-5) \\
 4x = 40 \\
 x = 10
 \end{array}$$

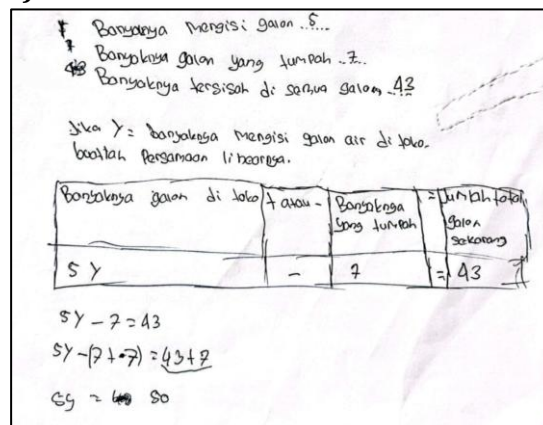
Figure 1. Answer S1

Subject S1 demonstrated the ability to understand the meaning of variables and constants within the context of the problems and to apply the balance principle in solving one-variable linear equations. In the first problem, the subject constructed the mathematical model ($5x - 7 = 43$), where (x) represented the volume of water in each gallon. The subject explained, "5x - 7, then first I make the 7 become zero... then I also add it to the other side," indicating an understanding of performing the same addition operation on both sides of the equation to maintain equality. As a result, the subject was obtained ($x = 10$).

In the second problem, the subject formulated the equation ($4x + 5 = 45$), interpreting the four milk cartons as the variable term and the five additional cans of milk as the constant term. This was reflected in the subject's statement, "There are four milk cartons, but I don't know how much each contains, so it becomes $4x + 5$." The subject then applied the inverse operation by subtracting 5 from both sides of the equation, ultimately obtaining ($x = 10$).

These findings indicate that the subject was able to translate contextual situations into mathematical models, understand the roles of variables and constants, and correctly apply algebraic operations to solve one-variable linear equations. Thus, the strategy used is logical reasoning, shown by the correct application of algebraic operations and the ability to relate the situation to the mathematical model.

Medium Ability Students (S2)



Banyaknya mengisi galon ... 5...
 Banyaknya galon yang penuh ... 7...
 Banyaknya tersisa di semua galon ... 43

Jika x = banyaknya mengisi galon air di foto.
 buatlah persamaan linear.

Banyaknya galon di foto	atau	Banyaknya yang penuh	= jumlah total galon sekarang
$5x$	-	7	= 43

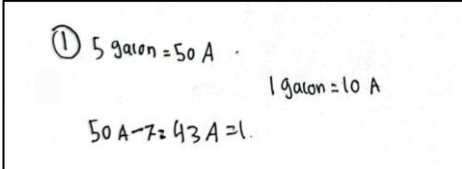
$$\begin{array}{l}
 5x - 7 = 43 \\
 5x - (7 + 7) = 43 + 7 \\
 5x = 50
 \end{array}$$

Figure 2. Answer S2

Subject S2 demonstrated the ability to understand contextual information and organize it into a mathematical model. In the first problem, the subject interpreted the five gallons as representing five containers with equal amounts of water, recognized that one gallon had spilled 7 liters, and identified that the remaining total volume of water was 43 liters. To facilitate the solution process, the subject first organized the given information into a table and then formulated the equation ($5y - 7 = 43$). This is reflected in the subject's statement, "So it becomes ($5y - 7 = 43$), then I add 7 to both sides, so ($5y = 50$).". After being prompted to continue the solution, the subject correctly determined that ($y = 10$).

These findings indicate that the subject was able to identify relevant information, organize the data into a table, and translate it into an appropriate mathematical model. Although the written response was incomplete due to time constraints, the interview revealed that the subject understood the steps required to solve the one-variable linear equation and was able to obtain the correct solution. Thus, the subject has understood how to construct the initial model but still needs guidance in applying algebraic operations to solve the equation. Based on this description, the strategy used by the subject is to organize the data, as seen from his efforts to process the problem information into tabular form. This strategy helps the subject to organize information systematically, reduce confusion, and make it easier to identify relationships between data.

Low Ability Students (S3)



① 5 gallon = 50 A
1 gallon = 10 A
 $50 A - 7 = 43 A = 1$

Figure 3. Answer S3

Subject S3 demonstrated the ability to interpret the contextual information by determining that the total amount of water before the spill was 50 liters and then dividing this total by five gallons to obtain 10 liters for each gallon. This is reflected in the subject's statement, "Forty-three plus seven equals fifty, so five gallons equal 50a. Then I divide 5 by 5 and 50 by 5." However, instead of constructing an appropriate one-variable linear equation, the subject formulated the expression ($50a - 7 = 43$), indicating that the variable was not used to represent its intended mathematical meaning.

These findings indicate that the subject was able to identify the relationships among the given pieces of information and apply arithmetic operations to obtain the correct answer. However, the subject was unable to represent the contextual situation using an appropriate mathematical model. Thus, the strategy used by the subject leads more to a trial-and-error strategy, characterized by the use of an approximate approach to determine the value of a variable without forming the correct equation. Although the subject has understood some basic concepts such as addition and division, the application of the balance principle in one-variable linear equations has not been fully mastered.

This study aims to identify problem-solving strategies used by students in solving linear equations and inequalities with one variable. The results show variations in strategies based on students' mathematical ability categories: high, medium, and low. Students in the high category (S1) predominantly use logical reasoning strategies. They are able to apply algebraic operations correctly, organize systematic steps, and understand the relationship between problem information and the mathematical model they have developed. This is in line with the opinion of [Jannah & Wijayanti \(2021\)](#). This strategy demonstrates good conceptual understanding and aligns with the logical reasoning strategies according to [Posamentier and Krulik \(1998\)](#) and the heuristic strategies in the classification of [Yunarti et al. \(2024\)](#). In the moderate category (S2), students used more data organization strategies, compiling information in the form of tables or lists. However, there were still some minor errors in data organization, such as inaccurately writing numbers or errors in interpreting the information they had

compiled (Permaganti and Zanthi, 2023). Furthermore, the inability to connect the organized information with the appropriate solution method also hindered obtaining the correct answer, which is in line with Sulastris and Arhasy (2017). This strategy helped them understand the patterns and relationships between problem elements. Although this strategy does not fully guarantee success in solving problems, data organization has been shown to reduce confusion and support initial understanding, as mentioned in the views of Posamentier and Krulik (1998), Polya (1973), and Yunarti et al. (2024) who linked this strategy to a visual approach.

Students with low ability (S3) tend to rely on trial-and-error strategies, namely guessing variable values and checking their accuracy. This strategy reflects the trial-and-error strategy according to Posamentier and Krulik (1998), which is classified as a heuristic by Yunarti et al. (2024) and called the guess and check strategy by Polya (1973). Although sometimes successful, this strategy is less efficient because it is not supported by a strong conceptual understanding. Calculation errors and inaccuracies also occur more frequently in this group. According to Kushendri and Zanthi (2019), students with low ability do not understand the problem well, so when implementing the problem-solving strategy, students are not optimal in implementing it. In these three cases, the student using logical reasoning demonstrated the clearest conceptual justification. The case study does not establish the comparative effectiveness of the strategies for other students or settings. These findings also support previous research by (Nailah et al., 2023) and (Fauziah et al., 2016), which stated that students who think logically are more effective in solving mathematical problems. Meanwhile, visual strategies such as organizing data serve as a bridge for students with moderate understanding to build more logical thought structures. Meanwhile, trial-and-error strategies are more frequently used by students with low ability who are still in the early stages of understanding mathematical concepts. These findings are relevant to Posamentier and Krulik's (1998) problem-solving theory and the cognitive approach, which emphasizes the importance of systematic thinking skills in mathematics education.

These cases suggest that teachers could combine verbal explanations, tables, and algebraic symbols when guiding students to compare solution strategies. In a different setting, Ilyas et al. (2025), including Imam Shofwan as a coauthor, examined multimodal technopreneurship learning in equality education and described opportunities for active participation, communication, and creative expression. This offers a pedagogical analogy for using multiple forms of representation; it does not establish effectiveness for junior secondary algebra. Such an adaptation should therefore be evaluated in further research. Because the analysis concerns three purposively selected students in one class, the findings describe these cases and cannot establish the general superiority or causal effectiveness of any strategy.

CONCLUSION

The results of this study show that there are three problem-solving strategies in solving linear equations and inequalities of one variable, namely logical reasoning strategies, data organization strategies, and trial-and-error strategies. The logical reasoning strategy is applied by using the principles of integer operations appropriately, examining the situation systematically, and concluding answers based on the existing problems. Meanwhile, the data organization strategy was carried out by presenting information from the problem in the form of a table or recording the known things from the problem, making it easier for them to recognize patterns or relationships between elements. On the other hand, the strategy of trial and error was done by making initial estimates of variable values and testing them through substitution, although this approach did not fully reflect a deep understanding of the concept. The findings provide recommendations for teachers to provide more support to students who still rely on less effective strategies and encourage the development of more appropriate strategies. In addition, for further researchers, it is recommended to choose materials that have the potential to bring out a variety of student thinking strategies in solving mathematical problems.

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