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Analysis of Problem-Solving Ability of Junior High School Students in A System of Linear Equations with One Variable

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Abstract

This research is motivated by the low ability of students to solve mathematical problems, which is reflected in the results of surveys and previous research. Even though mathematics is considered an important subject, many students still experience difficulties in understanding and solving mathematical problems, including solving problems with systems of linear equations in one variable. The research method used is descriptive with a quantitative approach. This research aims to describe and analyse students' problem-solving abilities. The subjects used were 30 selected class VIII students at Al-Faruqi Middle School. Data was collected through tests and then analysed to identify student errors in solving problems on systems of linear equations in one variable. The results of the research show that the majority of students experience difficulty in understanding basic concepts, are less thorough in the problem-solving process, have difficulty understanding problem questions, and have difficulty allocating time when working on questions. Based on data analysis, the percentage of student errors is classified as moderate. From these results, it is concluded that further efforts are still needed to improve students' mathematical problem-solving abilities, especially in the context of one-variable linear equation systems. This can be done by focusing more on identifying factors that cause student errors and developing learning strategies that are more effective in improving students' understanding and problem-solving skills in mathematics.

Keywords: An analysis, Problem-solving, System of linear equations in one variable.

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1. Introduction

Mathematics is a fundamental discipline that underpins human life and serves as a cornerstone for solving real-world problems (Widada et al., 2019). Beyond its practical applications in daily life, mathematics plays a pivotal role in advancing other scientific fields, including physics, astronomy, and education (Malasari et al., 2017). Its continuous evolution, driven by the complexities of modern challenges, highlights its enduring relevance as a foundational science. Consequently, this necessitates pedagogical approaches that foster active engagement, creativity, and critical thinking among students, ensuring their ability to navigate and contribute to a rapidly changing world.

Mathematics education is essential for developing problem-solving abilities. However, many students face difficulties in comprehending and solving mathematical problems (Andayani & Lathifah, 2019). Effective problem-solving requires students to analyse, evaluate, and creatively address challenges and skills that are often underdeveloped due to traditional teaching methods or insufficient practice (Kusuma et al., 2017). These challenges are evident in international assessments, such as the TIMSS and PISA surveys, which consistently highlight the low problem-solving abilities of Indonesian students. The 2018 PISA survey, for instance, ranked Indonesia 72nd out of 78 participating countries, with an average score of 379, far below the standard average of 489 (OECD, 2019).

Problem-solving ability is a fundamental aspect of mathematics education and is essential for mastering higher-order thinking skills, such as critical and creative thinking (Mariam et al., 2019). Despite its importance, students often struggle with this skill due to limited exposure to problem-solving tasks and teacher-centred learning approaches (Husna & Munawarah, 2018). A study by Kushendri and Zanthy (2019) identified that students performed poorly in key indicators of problem-solving, such as selecting appropriate strategies (60%) and interpreting results (31%). These findings emphasise the need for mathematics instruction to prioritise problem-solving-oriented learning (Shufriyah et al., 2020).

National data further corroborate the low mathematical abilities of Indonesian students. For example, a study by Hidayat et al. (2022) revealed that 10 out of 20 students scored below the competency standard of 75 in mathematics, with many struggling to meet even basic problem-solving indicators. Similarly, Meika et al. (2021) reported an average student score of 58, significantly below the Minimum Completion Criteria (KKM) of 70. These findings highlight the persistent challenges students face in developing mathematical problem-solving skills, particularly in understanding problems, planning solutions, and verifying results.

To address these critical challenges, this study aims to systematically analyse students' problem-solving abilities in the context of linear equations and inequalities with one variable.

While prior research has extensively explored other mathematical domains, such as social arithmetic (Andayani & Lathifah, 2019) and algebra (Handayani & Munandar, 2023), limited attention has been given to the unique cognitive and procedural demands associated with one-variable linear equation systems. This study distinguishes itself by focusing on this foundational topic, identifying prevalent errors, and uncovering the underlying cognitive and instructional factors contributing to these challenges. The findings are expected to provide evidence-based recommendations for enhancing mathematics education, particularly in fostering students' problem-solving proficiency and addressing conceptual misconceptions.

The primary objective of this research is to conduct an in-depth analysis of students' errors in solving problems involving linear equations and inequalities with one variable. Furthermore, this study seeks to propose evidence-based strategies to effectively address these challenges, thereby contributing to improved pedagogical practices and enhanced student outcomes in mathematics education.

2. Methods

This study employs a descriptive research design augmented by a qualitative approach to examine students' errors and the underlying factors influencing their difficulties in solving problems related to systems of linear equations with one variable. The qualitative component is instrumental in identifying and categorising the types of errors through a detailed analysis of students' test responses, while interviews provide deeper insights into the cognitive and instructional factors contributing to these errors. By integrating these methods, this research aims to offer a comprehensive and nuanced understanding of students' problem-solving abilities and the challenges they encounter.

The study was conducted at Al-Faruqi Middle School, situated at Jl. Kubang Raya No. 27 Kuala, Tambang Sub-District, Kampar Regency. This school was selected for its accessibility and diverse student demographic, which reflects a range of mathematical competencies. The participants consisted of junior high school students engaged in learning about systems of linear equations in one variable. This focus aligns with their curriculum and addresses a critical area of mathematical problem-solving that is essential for their academic development.

Data collection took place on Tuesday, April 30, 2024, a date chosen to align with the school's academic schedule for convenience and optimal participation. The data was gathered through three primary means. First, students were given a series of test questions that included a mix of difficulties—categorised as easy, medium, and hard—to evaluate their conceptual understanding, procedural accuracy, and ability to verify solutions. Second, interviews were conducted to delve deeper into the reasons behind the students' errors, focusing on their thought processes and problem-solving strategies. Third, the research incorporated documentation, such as past test records, to provide additional context and support the analysis.

To uphold ethical integrity, informed consent was obtained from all participants and their guardians. Anonymity and confidentiality were assured throughout the study, which also received prior approval from the school administration.

The research was conducted in four systematic stages. In the preparation stage, test instruments and interview protocols were meticulously designed and piloted to ensure validity and reliability. During the implementation stage, tests were administered, and in-depth interviews were conducted with selected students to uncover specific challenges in their problem-solving processes. The data analysis stage involved a structured approach comprising three key steps: data reduction by categorising recurring errors and extracting relevant insights, data presentation in the form of organised narratives and tables, and conclusion drawing through synthesis of findings and identification of trends. Finally, the report preparation stage entailed compiling and structuring the results for dissemination, ensuring clarity and alignment with academic publication standards.

The qualitative analysis method was particularly well-suited for this research, as it facilitated a nuanced examination of patterns in students' problem-solving behaviours. These patterns were systematically mapped to specific problem-solving indicators, which included understanding the problem, devising a plan, executing the plan, and evaluating the solution. By integrating descriptive and qualitative techniques, this study offers a comprehensive analysis of students' problem-solving abilities, uncovering both their strengths and areas for improvement. Furthermore, it provides actionable recommendations aimed at enhancing mathematics education by addressing observed challenges.

The data analysis followed the qualitative methodology outlined by Aida et al. (2017), ensuring a systematic and detailed examination of the collected information. Initially, the data was reduced by selecting and categorising key information from test results and interviews to identify patterns of conceptual and procedural errors. The reduced data was subsequently presented in narrative and tabular formats to enhance clarity and accessibility for interpretation. Conclusions were drawn using a formula to calculate the percentage of errors, providing an objective assessment of students' problem-solving abilities. For instance, if a student answered three out of five questions incorrectly, their error percentage was determined as 60%.

As highlighted by Lestari et al. (2019), the percentage of errors in solving problems related to One-Variable Linear Equations (PLSV) can be calculated using the following formula:

$$P = \frac{Total\ \sum s}{Total\ \sum s + Total\ \sum b} \times 100\%$$

Information:

P = Percentage of errors experienced by students.

Σs = Number of incorrect questions (experiencing errors in understanding concepts and solving mathematical problems) out of the total of all questions.

Σb = Number of correct questions (no errors in understanding concepts and solving mathematical problems) from the total of all questions.

This approach ensures a quantifiable and transparent evaluation of students' performance, facilitating targeted strategies for addressing specific areas of difficulty. To determine the high and low percentages of students' mathematical understanding and problem-solving abilities, researchers used the following references:

Table 1 - Percentage of Student Abilities

Percentage (%)	Criteria
$0 \leq P < 20$	Very low
$20 \leq P < 40$	Low
$40 \leq P < 60$	Currently
$60 \leq P < 80$	Tall
$80 \leq P < 100$	Very high

Note: P is the percentage of student errors in mathematical problem-solving abilities

The following section outlines the key indicators of problem-solving abilities, accompanied by the test instruments used to evaluate them:

Table 1 - Indicators of Problem-Solving Abilities

Indicator	Question
1. Identify elements that are known, asked about, and the adequacy of the elements needed	1. Andi's age is three times Budi's age. If Andi is 22 years older than Budi, then Budi's age now is...
2. Formulate mathematical problems or construct mathematical models	2. Pak Rahman's flower garden is rectangulaparensh diagonal dimensions $(3x + 15)$of metfivers and $(5x + 5)$meters. What is the length of the diagonal of the garden....
3. Implement strategies to solve problems	3. The difference between two numbers is 7, and their sum is 31; determine the two numbers!
4. Explain or interpret the results of problem-solving	4. The price of 1 book is the same as the price of 3 pencils. Dinda wants to buy four books and three pencils for IDR 24,000. If in the end it is decided only to buy three books and one pencil, then the total price is...

3. Results and Discussion

3.1. Results

The subjects in this research were 30 class VII students at Al-Faruqi Middle School. The researcher then gave several detailed test questions, namely four questions on mathematical problem-solving abilities. Based on the student's answers regarding solved problems, data is obtained and then analysed using mathematical problem-solving abilities. To make it clearer, it can be seen in the table.

Table 2 - Errors Experienced by Students on Each Question

	Question number				Total
	1	2	3	4	
Correct Amount	30	5	22	9	66
Wrong Amount	0	25	8	21	54

$$p = \frac{Total \sum s}{Total \sum s + Total \sum b} \times 100\%$$
$$p = \frac{54}{54 + 66} \times 100\%$$
$$p = \frac{54}{120} \times 100\%$$
$$p = 0{,}45 \times 100$$
$$p = 45\%$$

Based on the analysis and calculations, it was determined that the percentage of student errors reached 45%, which falls within the medium criteria. This figure represents the proportion of incorrect responses relative to the total number of questions attempted. In other words, nearly half of the students' answers contained errors, indicating notable challenges in their problem-solving processes. The errors identified among the students can be categorised into several recurring patterns, as described below:

1. Incomplete Identification of Problem Elements

A notable challenge observed among some students was their difficulty in fully identifying the key components of the problems they were tasked with solving. This included incomplete recognition of critical elements, such as what was known, what was being asked, and whether the provided data was sufficient to formulate a solution. In some instances, students completely omitted these foundational aspects, which significantly impeded their ability to construct a clear and structured approach to problem-solving. Such gaps in comprehension underscore the importance of fostering a deeper understanding of problem analysis as a prerequisite for practical mathematical reasoning.

2. Inaccuracies in Preparing a Solution Plan

A common issue among students was the lack of precision in formulating solution plans. These errors often arose from misunderstandings of the problem requirements or an unclear approach to the solution. Such imprecision frequently resulted in incorrect outcomes.

3. Errors in Solution Implementation

While some students managed to write solutions based on their plans, they often made mistakes during execution. These implementation errors included arithmetic miscalculations or the incorrect application of problem-solving procedures. Such mistakes led to erroneous results, even when the initial understanding of the problem was accurate.

4. Lack of Verification

A significant number of students neglected to verify the correctness of their answers. While some arrived at correct conclusions without performing verification, others skipped this critical step entirely. The lack of verification indicates a gap in their problem-solving processes, as it is an essential step for ensuring accuracy and reinforcing understanding.

5. Errors in Following Formulas and Performing Calculations

Another recurring issue was the improper use of formulas and errors in algorithmic calculations. These mistakes often occur during the later stages of problem-solving, leading to incorrect final answers despite accurate initial steps.

The error rate of 45% underscores the need for targeted efforts to enhance students' problem-solving skills. Particular attention should be given to improving students' abilities to thoroughly analyse problems, accurately execute solution steps, and consistently verify their answers. By addressing these specific challenges, educators can help students develop a more robust and accurate approach to solving mathematical problems, especially those related to systems of linear equations in one variable. This improvement not only strengthens their mathematical proficiency but also builds a solid foundation for tackling more complex mathematical concepts in the future.

3.2. Discussion

The findings of this study revealed a spectrum of student performance levels categorised into high, medium, and low achievement groups. Each group exhibited distinct error patterns in their problem-solving processes, which were systematically analysed and classified into specific categories. These categories highlight critical challenges faced by students, ranging from conceptual misunderstandings to procedural inaccuracies. By identifying these patterns, the study provides valuable insights into the underlying difficulties encountered by learners. It establishes a foundation for the development of targeted instructional strategies aimed at improving mathematics education and fostering more effective problem-solving skills.

3.2.1 Difficulty in Understanding Basic Concepts

Answer:

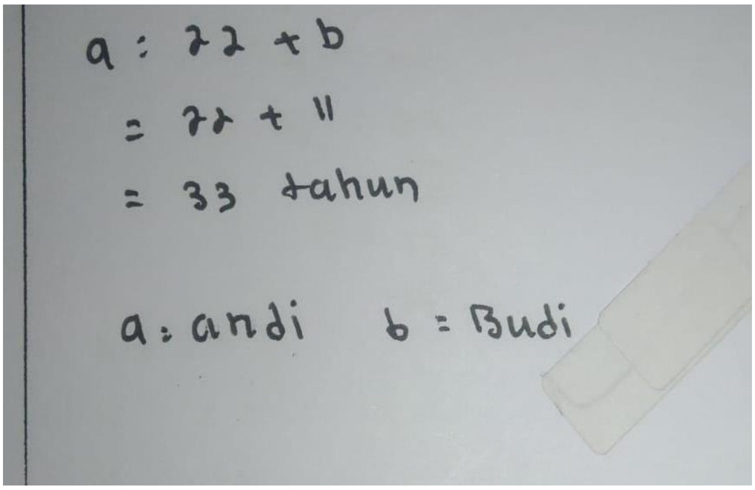

Figure 1 Example of Student Work of Understanding Basic Concepts

Students appear to be unskilled in stating what is known, what is asked, and the adequacy of data related to the questions that have been given correctly. Apart from that, students are less able to relate the information contained in the questions, so students cannot answer questions correctly, formulate mathematical problems or develop mathematical models, apply strategies to solve problems and explain or interpret the results of problem-solving. According to Dwi et al. (2018), students can understand the meaning of the question, but they do not understand how to determine the value of *x* asked in the question, so they guess. According to the questionnaire, information was obtained that students did not enjoy mathematics lessons because they were considered difficult to understand.

Across all performance levels, students encountered difficulties in accurately identifying the known elements and requirements of problems. This issue manifested in varying degrees: High-scoring student's errors in this group were generally minor. For example, some students misinterpreted critical terms in problem statements, such as understanding "twice as much" to mean "two more than". These misinterpretations, while subtle, occasionally led to inaccuracies in formulating equations. Medium-scoring students exhibited inconsistent comprehension, often struggling to distinguish between known and unknown variables. An example includes incorrectly assigning numerical values to variables in problems involving age relationships without proper justification. Low-scoring students in this group often failed to recognise what the problem required, resulting in incomplete problem statements or reliance on guesswork. For instance, when faced with the problem of dividing items equally, many students overlooked the need to calculate the total number of items first.

3.2.2 Inaccuracy in The Problem-Solving Process

Answer:

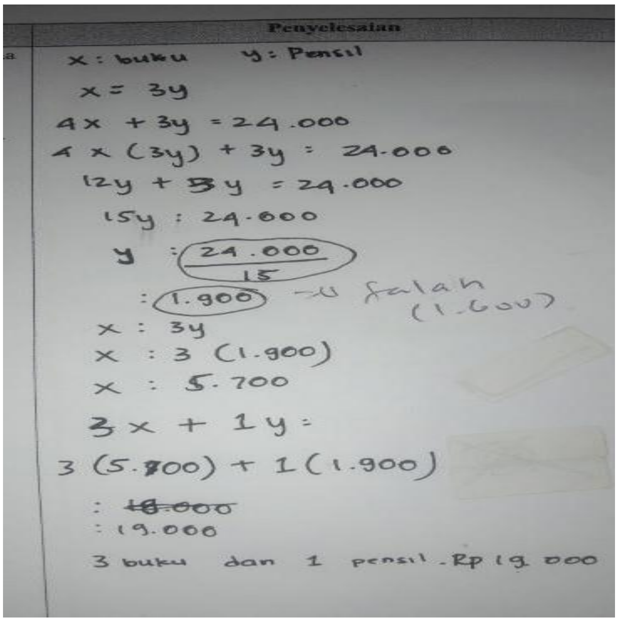

Figure 2 Example of Student Work of Problem-Solving Process

On the question of mathematical problem-solving abilities, students appear unable to state correctly what is known, what is being asked, and whether the data contained in the question is sufficient. However, students are unable to make connections between the information in the problem and are less able to identify the steps used to solve the problem entirely. At the same time, students also succeeded well in checking the correctness of the answers they had obtained. In this case, students can do it correctly, but there are still a few answers that have been calculated. According to Yuliani et al. (2019), some factors cause students to forget to write what they know and ask, including a). Students understand the meaning of the question, so there is no need to rewrite it; b). Students are in a hurry, considering the large number of questions that must be solved simultaneously.

Students also faced challenges in employing effective strategies for solving problems, with distinct patterns emerging across the performance levels: High-Scoring Students: While generally successful, these students occasionally missed critical steps in their calculations. For example, some neglected verification steps after solving for a variable, leading to minor but avoidable errors. Medium-scoring students' strategy selection was inconsistent in this group. While many began with correct approaches, they often abandoned them midway when encountering difficulties. A typical scenario involved students attempting substitution in systems of equations but stopping short of completing the process. Low-Scoring Students: This group exhibited a lack of structured problem-solving strategies, often defaulting to trial-and-error methods. For instance, when dealing with multi-step problems, many guessed answers rather than following a systematic approach.

3.2.3 Difficulty in Understanding the Problems in the Questions Given

Answer:

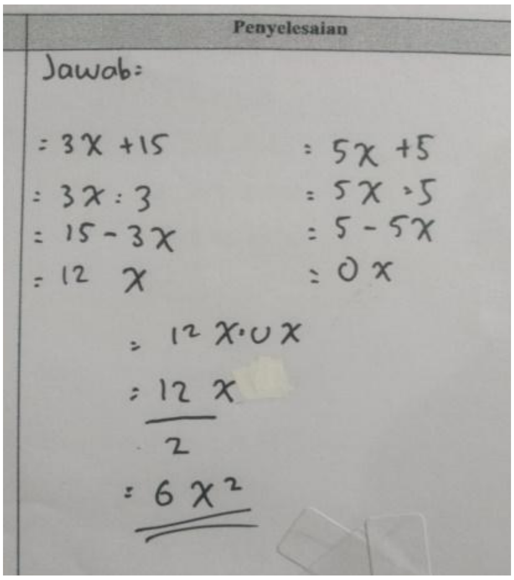

Figure 3 Example of Student Work of Understanding the Problems

Students appear less skilled in stating what is known, the questions asked, and the adequacy of data relevant to the questions given correctly. Apart from that, students are less able to connect the information in the questions, resulting in students not being able to solve the questions correctly because there are still answers that are calculated to be less accurate. At the same time, students seem unable to do this at the stage of re-testing the correctness of the answers they obtain; they are unable to find other ways that can relate them to the known elements of the question. Students are unable to identify problem-solving strategies. This is in line with Lestari et al. (2019), who stated that in solving problems, students are expected to understand the process of solving the problem and become skilled in selecting and identifying relevant conditions and concepts, looking for generalisations, formulating a resolution plan, and organising. Previously possessed skills.

Implementation errors, often due to procedural misunderstandings or carelessness, were prevalent among all groups. High-scoring students' errors were typically minor, such as arithmetic miscalculations. An example includes the incorrect addition of terms while solving linear equations, which slightly affected the final solution. Medium-Scoring Students: Frequent procedural errors were observed, such as incorrect transposition of terms. For instance, students isolating a variable might mistakenly subtract a positive term instead of adding it. Low-Scoring Students: These students struggled significantly with procedural execution, often failing to apply basic algebraic principles. For example, many incorrectly simplified expressions lead to nonsensical outcomes.

3.2.4 Difficulty in Allocating Time to Work on Each Question

Answer:

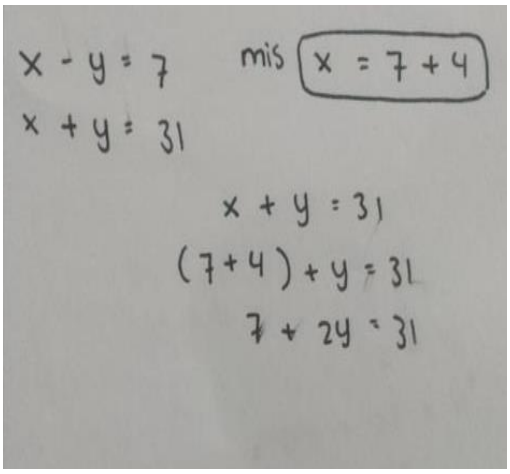

Figure 4 Example of Student Work of Allocating Time to Work

Verifying solutions proved to be a significant challenge for students at all levels. High-scoring student's verification steps were occasionally skipped, resulting in unchecked errors. For instance, while solving equations correctly, some students did not substitute their solutions back into the original equations to confirm accuracy. Medium-scoring student verification was often incomplete or incorrectly performed. An example includes substituting solutions into modified equations rather than the original ones, leading to inaccurate confirmation. Low-Scoring Students: Verification was rarely attempted in this group. Many students left problems incomplete or moved to the next question without reviewing their answers.

The findings from this study highlight a spectrum of challenges faced by students in solving problems related to systems of linear equations in one variable. High-scoring students encountered minor procedural and verification errors, medium-scoring students showed inconsistencies in strategy and execution, and low-scoring students struggled with foundational understanding and problem-solving processes. To address these issues, instructional practices should focus on emphasising verification steps, encouraging systematic approaches, and strengthening students' ability to interpret problem statements. Such measures could significantly enhance students' problem-solving abilities and contribute to improved performance in mathematics.

The analysis of students' problem-solving processes reveals a variety of errors that illustrate their challenges in understanding and solving problems related to systems of linear equations in one variable. These difficulties can be grouped into several categories, each reflecting specific aspects of the students' problem-solving abilities. A recurring issue was students' inability to clearly articulate the known elements, identify the questions being asked, or determine the adequacy of the provided data. For instance, some students, when interpreting word problems, recognised one variable while ignoring another critical variable mentioned in the problem. In other cases, they failed to evaluate the sufficiency of the data, leading to incomplete or incorrectly formulated equations. These shortcomings hindered their ability to establish a clear foundation for problem-solving.

Another common error involved students' failure to connect the information presented in the problem. This often resulted in incoherent equations or illogical solutions. For example, when solving a problem involving age relationships, several students misinterpreted phrases such as "three years older than," leading to incorrect mathematical representations. Such disconnections frequently caused the students to construct irrelevant equations that did not align with the requirements of the problem. Verification of solutions and the exploration of alternative methods posed significant challenges for many students. Examples include Numerous students stopped working after deriving a solution, neglecting to verify whether their answer satisfied the original equation. Others lacked the flexibility to explore alternative problem-solving strategies, highlighting a gap in creative and critical thinking. Students also struggled to manage their time effectively during the test, which further impacted their performance. For example, some students left several problems unfinished due to poor time allocation. Rushing through the final steps of solutions often led to careless errors and incomplete answers.

The findings of this study are consistent with previous research conducted by Martin et al. (2018), students with low mathematical understanding were shown to struggle significantly with problem-solving, with 80.9% of low-performing students exhibiting poor problem-solving skills. Conversely, 100% of students with strong mathematical understanding demonstrated proficient problem-solving abilities. Putra et al. (2018), familiarity with structured problem-solving processes was shown to improve students' ability to tackle mathematical problems effectively. Regular exposure to such practices enabled students to approach problems systematically and confidently.

Based on these findings, it is clear that students require targeted interventions to overcome their challenges. Structured training provides regular practice in structured problem-solving steps that can help students better identify known information, develop effective strategies, and verify their solutions. Encouraging creative thinking is training students to explore multiple solution methods, fosters adaptability, and enhances critical thinking skills. Improving Time Management: Teaching students to allocate time effectively during problem-solving tasks is crucial for reducing unfinished work and careless mistakes.

In conclusion, the errors identified in this study underscore the need for a comprehensive approach to enhancing students' problem-solving skills. Addressing difficulties in understanding problem elements, connecting information, verifying solutions, and managing time will not only improve mathematical performance but also equip students with essential skills for broader academic and real-world applications. These efforts are vital in preparing students to face increasingly complex challenges with confidence and competence.

4. Conclusions

The results of this research highlight several significant challenges faced by students in solving problems related to systems of linear equations in one variable. Key issues include difficulties in understanding fundamental mathematical concepts, lack of precision during the problem-solving process, challenges in comprehending problem questions, and poor time management skills. These factors collectively hinder students' ability to solve problems effectively. Many students struggle with foundational concepts, making it difficult for them to approach and solve problems systematically. Carelessness during the problem-solving process often leads to avoidable errors, while misinterpretation or incomplete understanding of problem statements prevents students from formulating and executing accurate solutions. Additionally, ineffective allocation of time during tests or problem-solving tasks often results in unfinished work. Although the error rate is classified as moderate, indicating some level of mathematical understanding, there remains considerable room for improvement.

To address these issues, the following recommendations are proposed: Students need a strong foundation in mathematical principles. Educators can facilitate this by incorporating activities that focus on the fundamental aspects of linear equations. Using visual aids, real-world examples, and interactive exercises can make abstract concepts more tangible and relatable for students. Students should be taught systematic approaches to problem-solving. This includes identifying the known elements, formulating clear strategies, and verifying the correctness of their solutions. Guided practice sessions, where students receive constructive feedback, can help reinforce these skills. To improve their understanding of problem questions, students can be trained to analyse and break down problem statements effectively. Techniques such as highlighting key information or rephrasing questions in their own words can enhance comprehension and clarity. Providing students with timed practice sessions can help them learn to allocate their time effectively. Teaching prioritisation techniques, such as solving simpler problems first, can boost their confidence and allow more time for complex tasks. Diagnostic assessments can be conducted to pinpoint specific areas where students face challenges. Tailored remedial programs that address these weaknesses through personalised learning approaches can help students improve significantly. By adopting these strategies, educators can support students in overcoming their difficulties and enhancing their problem-solving abilities. These efforts not only improve academic performance in mathematics but also equip students with critical thinking and analytical skills essential for broader academic and real-world challenges.

Conflict of Interest

The authors declare no conflicts of interest.

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