Volume 5, Number 1, December 2023
Journal of Research on Mathematics Instruction
DOI: https://doi.org/10.33578/jrmi.v5i1.86
Journal's Webpage: http://jrmi.ejournal.unri.ac.id

Analysis Error Student Class X Vocational School in Solve Story Questions on the Material System of Three Variable Linear Equations

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ARTICLE'S INFORMATION

Article history:

Received: Feb-04-2024

Reviewed: Mar-23-2024

Accepted: Mar-28-2024

Keywords: Analysis, Error, System of Three Variable Linear Equations

ABSTRACT

Conducting formative assessments can help students grasp the fundamentals of the subject matter and foster a deeper interest in mathematics. To better understand student difficulties in solving word problems related to SPLTV, researchers have conducted studies to analyze the errors made. This research aims to discover and analyze students' mistakes in solving story problems on the material of three-variable linear equation systems. This type of research is descriptive research with a qualitative approach. The subjects of this research were six students from 31 students of class X TKJT 1 SMK Muhamadiyah 2 Pekanbaru, each consisting of 2 students from the upper, middle and lower groups. In this research, data collection techniques were based on observation, instrument test questions, and interviews, which were used to determine students' errors in solving three-variable linear equation systems. In this research, it can be concluded that students' mistakes are a lack of mastery of concepts in three-variable linear equation systems material and a lack of deeper student mathematics learning so that students make any mistakes in solving problems.

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INTRODUCTION

Education is crucial for enhancing individual quality and preparing for future developments. Education is fundamentally the most significant form of learning, conducted through teaching, training, or study to nurture and enhance each student's innate potential [1]. According to Law No. 20 of 2003 concerning the National Education System, education is a deliberate and structured effort to cultivate a learning environment and process, enabling participants to actively develop their abilities, encompassing spiritual, self-discipline, personality, moral intelligence, and the skills necessary for personal, societal, and national needs. In education, mathematics is a pivotal subject that every student is required to study, given its critical role in fostering logical and analytical thinking skills. Through education, students must be endowed with the competencies essential for the present era, which include adaptability, communication skills, reactivity, digital literacy, comprehension, critical thinking, resilience, and creativity [2]. One of the subjects learned through education is mathematics.

Mathematics is an essential subject in the academic curriculum, providing the foundation for critical thinking and problem-solving skills that are vital in various fields of study and professional endeavors. As a discipline, it encourages logical reasoning, precision, and analytical thought, equipping students with the ability to tackle complex problems systematically. The importance of mathematics extends beyond the classroom, influencing technological advancements, scientific discoveries, and economic strategies. In educational settings, it serves as a key tool for fostering intellectual discipline

and cognitive development, enabling students to understand and manipulate abstract concepts, and apply these skills in real-world scenarios.

Mathematics is a crucial science in everyday life, offering tools to solve various problems. Learning mathematics aims to equip individuals to think logically, analytically, systematically, critically, and creatively. The Minister of National Education Regulation No. 22 of 2006 emphasizes that mathematics education is not only for academic achievement but also for developing the capacity to think in complex, innovative, and creative ways. Mathematics extends beyond rote memorization of formulas and quick calculations; it involves developing, applying, and appropriately using formulas to solve real-world problems.

Mathematics is a science centered on abstract objects, meaning the symbols and elements used in mathematics do not have physical counterparts in the real world [3]. This abstraction is exemplified in solving story problems, which are mathematical tasks embedded in narrative contexts that students must decipher and resolve using mathematical principles. One of the topics studied in mathematics is the system of three-variable linear equations (SPLTV).

The System of Three Variable Linear Equations (SPLTV) is a fundamental component of advanced mathematics education, highlighting the intricacies of algebraic manipulation and problem-solving in a multi-variable context. This subject matter is pivotal in cultivating students' ability to analyze and solve complex problems that involve three interrelated linear equations. Mastery of SPLTV is crucial for developing a deeper understanding of linear algebra and its applications in various scientific and engineering disciplines. It enables students to engage with more sophisticated mathematical models and provides a strong foundation for further studies in mathematics and related fields. Understanding SPLTV is essential for students to effectively navigate the mathematical challenges they will encounter in their academic and professional careers.

The System of Three Variable Linear Equations (SPLTV) is often presented in the form of story problems, which requires students to apply their mathematical knowledge to real-life situations. These story problems are designed to test students' understanding of SPLTV by challenging them to extract relevant information, translate it into a set of linear equations, and then solve these equations to find the solutions. This approach not only assesses their grasp of the mathematical concepts but also enhances their problem-solving skills, critical thinking, and ability to connect abstract mathematical theories with practical applications. Through solving SPLTV story problems, students learn to navigate complex scenarios and develop a more comprehensive and applied understanding of linear algebra.

Story problems in mathematics are presented as narratives or meaningful sentences that relate to students' everyday experiences, embedding mathematical concepts within familiar contexts [4]. These problems serve not only to apply mathematical theory to practical situations but also to assess students' understanding of the mathematical concepts they have studied. Proficiency in mathematics is thus demonstrated through the ability to solve these story problems accurately [5].

Story problems in mathematics are designed to develop mathematical skills and enhance students' understanding of mathematical concepts. These problems encourage students to practice deductive reasoning, recognize the relevance and application of mathematics in daily life, and strengthen their mastery of mathematical skills and concepts [6]. However, it is often in the process of solving these story problems that students encounter difficulties and make mistakes.

Mistakes in mathematics are deviations from correct procedures or understandings, often starting with an inability to comprehend the problem fully [7], [8]. Students' inability to solve problems

will result in errors in solving them [9]. Errors in early steps can propagate, leading to further mistakes in subsequent steps. Identifying and understanding these errors can illuminate the factors affecting students' learning achievements, providing insights into minimizing these mistakes and enhancing mathematical understanding and problem-solving skills.

Students' errors in mathematics can be attributed to various internal and external factors. As identified by Lyan and Kahar, internal factors include a lack of motivation, minimal interest in the subject, perceived difficulty in mathematics, and innate talent or lack thereof [10]. External factors encompass the learning environment, the influence of peers, and family support. Ika highlights specific causes of errors such as insufficient understanding of prerequisite and fundamental material, inadequate mastery of mathematical language, incorrect interpretation or application of formulas, miscalculation, lack of thoroughness, and concept forgetfulness [11].

Errors in mathematics are categorized into three main types: conceptual, procedural, and technical [12]. Conceptual errors involve misunderstandings or misapplications of mathematical concepts and principles, such as incorrect use of variables or misinterpreting the problem [13]. Procedural errors occur in the methodology of solving problems, including incomplete steps and a lack of systematic approach in developing solutions. Technical errors are seen in computational operations, including mistakes in basic arithmetic operations and their hierarchical execution.

In the context of teaching mathematics, the System of Linear Equations with Three Variables (SPLTV) is a significant topic. Solving SPLTV problems involves substitution, elimination, and a combination of both. Effective resolution of these problems requires mathematical modeling, where students transform real-world problems into mathematical models, identify the variables involved, and apply suitable problem-solving procedures.

Despite these methodologies, students often struggle with the concept of SPLTV. Research indicates that many students make errors in SPLTV story problems due to difficulties in understanding the language of the problems and weaknesses in mathematical manipulation [14]. A common issue is the inability to correctly transform problems and formulate the final answer, often stemming from a lack of comprehension of the key information within the problem [15].

Based on observations made by researchers during activities involving the solution methods for SPLTV, it has been noted that many students are particularly confused when implementing the substitution method. Moreover, some students struggle with basic algebraic operations such as addition, subtraction, multiplication, and division. An unconducive learning environment hinders students from focusing and actively participating in class. This can lead to poor learning outcomes. Engaging students and enhancing their interest in mathematics is crucial as a teacher. One strategy could be to provide clear and repeated explanations of concepts that students find challenging.

Additionally, conducting formative assessments can help students grasp the fundamentals of the subject matter and foster a deeper interest in mathematics. To better understand student difficulties in solving word problems related to SPLTV, researchers have conducted studies to analyze the errors made. The study by [16] analyzed student errors in solving systems of linear equations with three variables (SPLTV) problems, but this research differs from the one currently undertaken. In the study by [16], error analysis was carried out using Newman's procedure. Furthermore, the research conducted by [17] to analyze the mistakes made by students in solving SPLTV story problems also employed Newman's procedure. In contrast, the errors analyzed in the current study are categorized into misconceptions, principles, and calculation errors.

METHODS

The research that the researcher conducted was descriptive research with a qualitative approach. Qualitative descriptive research is defined as research that examines natural social action events, emphasizing how a person interprets and understands their experiences to understand a social reality so that individuals can solve their problems [18]. This research aims to find out and analyze accurately and precisely students' mistakes in completing formative tests on the System of Three Variable Linear Equations (SPLTV) material. The subjects in this research were students of class X TJKT 1 SMK Muhamadiyah 2 Pekanbaru, which took six from 31 person students, with each two students from the upper, middle and lower groups. Qualitative research presents three stages, namely: (1) the pre-field stage, (2) the fieldwork stage, and (3) the data analysis stage. The following is an explanation of each stage in the research carried out:

a. Stage Pre-field

The pre-field stage is an activity that researchers carry out before collecting data. This stage begins with observing the field to determine the problem or thing that will be the focus of the research. This stage in detail includes (1) preparing a field design; (2) selecting and determining the research field; (3) administering all permits; (4) observing and assessing the field; (5) selecting and utilizing information; (6) preparing the equipment needed during the research; and (7) research ethics issues.

b. Stage Fieldwork

The fieldwork stage is a researcher's activity at the research site. In this implementation stage, researchers collect data according to the focus of the problem and objectives of the research. This data was collected through observation, interviews and test instruments. After the required data has been collected, the next step is processing the research data results.

c. Stage Analysis Data

Stages analysis data consists of 3 steps that are: (1) give a test written to students; (2) correct identifying types of student answer sheets; and (3) describe the type of error in each question item. These errors include (1) misconceptions, (2) principle errors, and (3) calculation errors.

Data collection techniques in this research are observation, written tests, and interviews. The teacher observes the learning process, whether it is running well, and the teaching module used. The written test is carried out to show students' mistakes in solving questions related to SPLTV material. Interviews were conducted to triangulate answers written by research subjects, which were then studied and traced to the subject's mistakes in solving the questions given. Data analysis in this study is oriented towards a deep understanding of the phenomena being researched, specifically student errors in solving SPLTV story problems. Observation data analysis is conducted to comprehend students' activities while solving SPLTV problems. Written test analysis involves identifying and interpreting students' errors, such as misconceptions, principle errors, and calculation errors. Interviews are analyzed in depth to understand the students' perspectives and experiences and the reasons behind their errors.

RESULTS AND DISCUSSION

The research was conducted during the odd semester to evaluate the understanding of SPLTV material by class X TJKT 1 students at SMK Muhamadiyah 2 Pekanbaru, comprising six students. The objective was to identify and analyze the errors made by students in solving story problems related to SPLTV. The findings from the descriptive assessment indicate that many students, particularly those with lower performance levels, struggled with the test questions.

Journal of Research on Mathematical Instruction, Vol. 5, No. 1, December 2023, 10-18
DOI: https://doi.org/10.33578/jrmi.v5i1.86
jrmi.ejournal.unri.ac.id, Online ISSN: 2715-6869

The study subjects were selected based on the outcomes of a formative assessment administered to 31 students. From this, six research subjects were chosen, with two students selected from each performance group: the high-achieving group with scores ranging from 86-100, the intermediate group with scores from 61-85, and the lower-performing group with scores between 0-60. This division comprehensively analyzed formative test results across different proficiency levels.

Table 1. Results Formative Test

Subject Study	Results Test	Level Ability
1	100	High
2	100	High
3	85	Intermediate
4	75	Intermediate
5	60	Low
6	55	Low

In the research, three errors were identified among students when completing the formative assessment questions. These errors include (1) misconceptions, (2) principle errors, and (3) calculation errors. Here is an explanation of the three types of errors students encounter in solving story problems.

1. Misconceptions

Conceptual errors experienced by students in solving SPLTV questions, namely internal error in interpreting the meaning of the question given and error in changing sentence questions to a mathematical model. The error is identified as follows. Students continue to face challenges in correctly interpreting the questions and constructing a mathematical model from the given problem statements. This issue is evident in the analysis of students' work, where recurring errors in understanding and model formulation are observed.

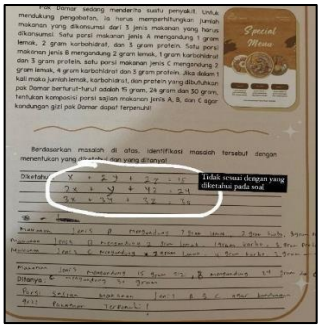


Figure 1. Error Student in Make Model Mathematics

Figure 1 illustrates that students erred in formulating mathematical models from the provided story problems. Upon noticing the mistake, the researcher followed up with the student to clarify the error. Subsequent confirmation through an interview revealed the student's unawareness of their error in addressing the story questions.

(Transcript 1)

P : How do you create a mathematical model that aligns with the information given in the question?

S-6 : By defining the variables, for instance.

P : Is that just an example?

S-6 : Yes, it's about the content.

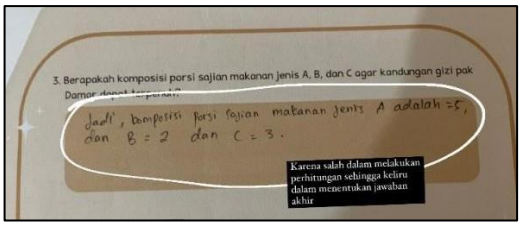
P : Why isn't a specific example, such as a variable?

S-6 : I'm confused, ma'am, about how to exemplify.

Transcript 1 indicates the student's confusion in interpreting the provided question and lack of understanding in transforming problems into a mathematical model. This confusion leads to incorrect interpretation of the questions and errors in creating mathematical models. These misunderstandings contribute to the student's difficulty in solving story problems, as they have not fully grasped the concept of SPLTV. The findings of this study are consistent with those of [19], indicating that the most common error students make is in understanding the problem, particularly with the indicators, followed by issues in reading the material. Students struggle to identify keywords within the problem, leading to merely rewriting the questions and being unable to proceed with solving the problem.

2. Principle Error

The error principle experienced by students in the story of the finished question is wrong in using rules, formulas, and principles related to SPLTV material, such as making mistakes in concluding when determining the final answer and going through the completion steps. Students often fail to document the complete steps of the solution process, leading to errors and inaccuracies in their work. Additionally, they tend to draw incorrect conclusions, resulting in final answers that do not align with the instructions provided in the questions.



Figrue 2. Error Student in Draw a Conclusion

In Figure 2, it is observed that the student made an error in concluding. Upon review, the researcher identified that the mistake stemmed from an incorrect process, leading to an erroneous conclusion. Interviews revealed that the students were unaware of their mistakes in tackling the given story questions, particularly in deriving the conclusions. This error was due to a flawed process in addressing the questions, resulting in incorrect conclusions.

(Transcript 2)

P : Do you think the conclusion you reached is correct or incorrect?
S-4 : It's correct, ma'am.
P : Are you sure there are no errors when deriving the conclusion?
S-4 : Yes, ma'am, I'm sure.
P : Could you please review the process to ensure it’s correct?
S-4 : Okay, ma'am.

Transcript 2 illustrates that students are prone to not revisiting their work. They tend to finalize conclusions without reassessing the preceding steps, leading to inaccuracies in the conclusions drawn. The results of this study align with those conducted by [20], indicating that students have not yet been able to solve problems correctly and completely.

3. Calculation Error

Error student, the most frequently found, is an internal error in calculation. Calculation errors that often occur are incorrect use of operating or calculation rules and not being careful when carrying out calculations.

Journal of Research on Mathematical Instruction, Vol. 5, No. 1, December 2023, 10-18
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jrmi.ejournal.unri.ac.id, Online ISSN: 2715-6869

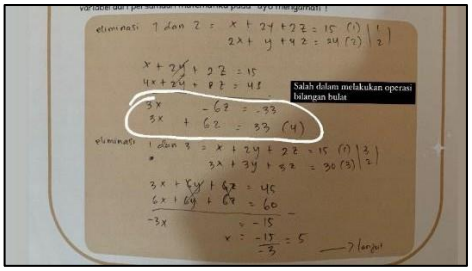

Figure 3. Error Student in Do Calculations

Figure 3 reveals that the student made a calculation error. The student was not careful when executing numerical operations. Upon detecting the mistake, the researcher sought confirmation from the student. An interview revealed the student was aware of their mistake in solving the questions. (Transcript 3)

P : Why did you conclude that $3x + 6z = 33$?
S-4 : It's correct. I divided it by a negative, so that's the result.
P : If three is initially positive and then divided by a negative, why is the result still positive?
S-4 : Oh yes, ma'am, I forgot, sorry.
P : What should the result be, then?
S-4 : It should be $-3x + 6z = 33$.

Transcript 3 indicates that the student struggles with basic mathematical operations, as evidenced by incorrect answers. The findings of this research are consistent with the study conducted by the researcher [21]. In that study, students made errors in multiplication operations, leading to incorrect final answers.

CONCLUSIONS AND SUGGESTIONS

Based on the analysis of student errors in solving story problems, it can be concluded that the types of errors encountered by students in SPLTV material are as follows: (1) Conceptual errors, where students misinterpret the questions and struggle to create mathematical models from the given sentences; (2) Principle errors, where students incorrectly apply rules, formulas, and principles related to SPLTV material, leading to incorrect conclusions and mistakes in the solution process; (3) Calculation errors, where students misuse operational rules and are careless in performing calculations.

Conceptual errors indicate a lack of comprehensive understanding of the content presented in the problems. Principle errors arise when students fail to determine the correct final answer due to mistakes made in earlier steps. Calculation errors occur when students are not meticulous with numerical operations, leading to subsequent errors.

These errors reflect a broader issue of students not fully grasping the material and struggling to interpret the given story problems accurately. The factors contributing to student errors on formative tests for SPLTV material include:

1. Difficulty in interpreting the meaning of the questions.
2. Inaccuracy in handling negative numbers.
3. Inadequacy in integrating information.
4. Lack of thoroughness in reading the questions.
5. Rushing through the story problems.
6. Failure to review the work before submission.

7. Poor time management, and
8. Copying answers from peers.

To enhance student comprehension and reduce errors in solving SPLTV problems, it is recommended that educators focus on improving problem interpretation skills through targeted training that emphasizes keyword identification and logical problem structuring. A solid foundation in SPLTV rules, formulas, and principles should be established, connecting theoretical concepts with practical applications. Encouraging meticulous documentation of each solution step can help students track and understand their thought processes, facilitating easier identification and correction of errors. Regular collaborative sessions to analyze and reflect on mistakes can promote a learning culture where errors are seen as opportunities for improvement. Additionally, providing ample practice in arithmetic operations and integrating technological tools can improve computational fluency and offer personalized learning experiences. Finally, implementing consistent feedback and reflection mechanisms can deepen students' understanding and enhance their problem-solving skills in mathematics.

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