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Error Analysis of Junior High School Students on Linear Equations of Two Variables Topic

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ABSTRACT

Mathematics is an important science and has a lot to do with the development of other sciences. One of the essential topics in physics is linear equations of two variables. However, many students experience errors on this topic. The purpose of this study is to identify students' errors on the material of linear equations of two variables. The research is a descriptive study conducted on 83 students at SMPN 1 Tanjung Jabung Barat. The instrument used in this question is five description questions. This question has been validated and tested empirically. The five questions are suitable for research. The data analysis technique used in this research is descriptive analysis. The results showed that students made many errors in operations, concepts, and skills.

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1. INTRODUCTION

Mathematics plays a crucial role in developing students' logical, analytical, and problem-solving abilities, especially during their formative years in junior high school [1]. One of the foundational topics introduced at this stage is the Linear Equations of Two Variables (LETV), which is pivotal for understanding algebraic concepts at more advanced levels. This topic is vital for solving real-world problems involving relationships between two variables and serves as a key element in higher mathematical topics such as systems of equations and graph theory [2] – [5]. Despite its importance, many students struggle to grasp the underlying concepts of LETV, which often leads to poor performance in this topic and future algebraic applications. These difficulties may stem from a lack of foundational knowledge in algebra, insufficient practice, or a misunderstanding of how to apply algebraic principles to solve real-world problems. The consistent struggles observed among students warrant a deeper exploration of the specific challenges they face when learning LETV.

Several factors contribute to students' difficulties in understanding linear equations of two variables. One major factor is students' challenges when translating real-world problems into algebraic expressions [6] – [8]. For instance, many students struggle to comprehend how to formulate equations from word problems, a skill critical to mastering LETV. Additionally, the graphical interpretation of equations, such as plotting points on a coordinate plane and understanding the meaning of the slope and intercepts, often confuses students. This gap in understanding can make solving problems more challenging as students struggle to connect the algebraic equation with its geometric representation. Another contributing factor is the procedural aspect of solving systems of linear equations using methods like substitution or elimination,

where students frequently make errors in algebraic manipulation. These common errors highlight the need for educators to investigate these difficulties more closely.

Prior research has indicated that the teaching methods used in the classroom may also play a role in the difficulties students face in learning LETV [9]. Traditional teacher-centered approaches, which focus on direct instruction and rote memorization, often fail to engage students in deep, conceptual understanding. This lack of engagement can lead to superficial learning, where students can follow steps but do not fully understand the logic behind them. Moreover, students who experience anxiety or lack confidence in their mathematical abilities may struggle even more with complex topics like LETV, as they may become easily discouraged by mistakes or difficulties in comprehension. Such emotional barriers can further compound their cognitive challenges, making it even more difficult for them to develop the skills needed to master this topic. Students ' difficulties will likely persist without addressing these emotional and pedagogical factors.

The impact of these difficulties is far-reaching, as understanding linear equations of two variables serves as a building block for future mathematical learning. Topics such as quadratic equations, functions, and advanced equations systems are more accessible to students who have a solid grasp of LETV. If students fail to master LETV, they will likely face increasing challenges as they progress in their mathematical education, potentially leading to long-term disengagement with the subject. Therefore, teachers and curriculum designers must focus on identifying and addressing students' specific difficulties in this area. A thorough understanding of these challenges will allow for the development of targeted interventions and teaching strategies that can support students in overcoming these obstacles. In light of these challenges, this study aims to analyze the difficulties experienced by junior high school students in learning linear equations of two variables. By investigating the specific errors, misconceptions, and learning obstacles that students encounter, this research seeks to provide insights that can inform more effective teaching practices [10] – [14]. The results of this study are expected to contribute to the development of teaching strategies that address the cognitive challenges students face, help reduce anxiety, and build confidence in their mathematical abilities. Ultimately, this research could serve as a foundation for improving student outcomes in algebra, thus better preparing them for more advanced mathematical topics.

2. METHOD

This research is descriptive. Descriptive research seeks to describe a phenomenon as closely as possible to the actual situation [15]. This research aims to analyze the difficulties that occur in junior high school students when solving linear equations of two variables. We divided these student errors into concept errors, operation errors and principle errors. It was conducted at SMPN 1 Tanjung Jabung Barat on 83 students who have learned LETV material. The instrument used in this question is five description questions. This question has been validated and tested empirically. The five questions are suitable for research.

The data analysis technique used in this research is descriptive analysis, which analyzes data by describing or describing the data that has been collected. The data obtained in this study are diagnostic test result data. After the data is collected, data reduction is carried out, focusing the data on things that will be studied. Reducing data is an activity of simplifying and abstracting all data from test results.

3. RESULTS AND DISCUSSION

In learning mathematics, especially on the topic of Linear Equations of Two Variables (LETV), students often face various errors that can be classified into three main categories, namely concept errors, skill errors, and operation errors. These three categories are the cause of many students' failure in solving LETV problems, as researched by Zulfah [16]. A deep understanding of these types of errors is very important to help teachers identify the source of the problem and provide appropriate interventions in the learning process.

First, students make many conceptual errors. Concepts are fundamental understandings of ideas or principles in mathematics. In the context of LETV, concepts include understanding what a linear equation of two variables is, the general form of the equation (i.e. $ax + by = c$), as well as the geometric meaning of the equation in cartesian coordinates, such as how the equation is represented by a straight line on a graph. Conceptual errors occur when students have a wrong or incomplete understanding of the basic idea of LETV. In this study, we found that students did not understand that a two-variable linear equation must have two variables and a solution that represents the pair (x, y) that satisfies the equation. Some students may assume that linear equations only have one single solution or mistakenly assume that all mathematical equations are in the same form as one-variable linear equations. Other errors can occur when students cannot understand the relationship between the equation and the graph, so they have difficulty drawing a line from the equation or reading the intersection points of the graph.

The second error is a skill error. Skills are the ability to apply knowledge and procedures in solving problems. In LETV, skills include the ability to construct an equation from a contextual problem, draw a

graph based on the equation, and solve a system of linear equations using various methods, such as substitution, elimination, or graphing. Skill errors occur when students are unable to perform the steps or procedures correctly, although they may understand the basic concepts. The skill errors we found were students not being able to plot the points correctly on the graph or failing to use the substitution or elimination methods appropriately. For example, in the elimination method, students may incorrectly multiply one of the equations to remove a variable, or in the substitution method, they may incorrectly simplify the equation. Errors are also common when students have to determine the gradient (slope) of a line; they may incorrectly calculate the difference between coordinates or be unable to interpret the result of the gradient.

Finally, there are operation errors. Operations in mathematics refer to calculation actions such as addition, subtraction, multiplication, or division that are required in the problem-solving process. Operation errors occur when students make mistakes in algebraic manipulations or arithmetic calculations, which are often caused by a lack of accuracy or mechanical errors in performing the operations. The operation errors we found were that students were wrong in performing basic operations when solving a system of equations, for example, incorrectly adding or subtracting two equations or incorrectly multiplying variable coefficients. For example, when using the substitution method, a student may incorrectly simplify the equation by making a mistake in multiplication or division, which then results in an incorrect final result. Other operation errors involve making mistakes in calculating the intersection points on the x and y axes, which eventually leads students to draw inaccurate graphs.

A lack of understanding of the underlying theory or a lack of emphasis on the concept during the learning process usually causes concept errors. Skill errors often occur due to a lack of practice or difficulty in applying learned methods, while operation errors are often caused by a lack of accuracy or bad habits in performing calculations. The impact of these errors can be significant, as they will affect students' understanding of more advanced topics in algebra and geometry and their ability to solve more complex math problems in the future.

To overcome these errors, teachers need to design a more comprehensive and in-depth learning strategy, with an emphasis on three main aspects: concept understanding, skill mastery, and accuracy in operations. First, learning that focuses on in-depth concept understanding should include a thorough explanation of the meaning and application of two-variable linear equations. Teachers should ensure that students understand the relationship between variables, how the equation is represented graphically, and how this concept relates to real situations. One approach that can be applied is the use of problem-based learning methods, where students are faced with contextual problems that encourage them to dig deeper into the concepts before starting the solution process. Second, to train skills, teachers need to increase the number of varied and challenging problem exercises, both in the form of routine problems and non-routine problems. Various problem exercises will help students strengthen their understanding of the various ways to solve equations, either through substitution, elimination, or graphical representation methods. In addition, problems with gradual difficulty levels allow students to develop problem solving skills gradually, from basic understanding to problems with more complex contexts. It is also important for teachers to provide constructive feedback so that students can identify their mistakes and learn from them. Collaborative learning can also be applied, where students can discuss and share solving strategies with each other, which will enrich their skills in solving math problems. Third, strategies to reduce operation errors should be an important part of teaching. Teachers can teach students to always double-check every step in problem solving, especially at critical stages such as when performing algebraic manipulations or calculating the final result. Engaging students in self-reflection and metacognitive learning practices, where they are invited to realize and evaluate their thinking and process in solving problems, can be an effective method to improve their rigor. Students need to understand the importance of not only arriving at the correct final answer, but also going through a logical and structured process.

With these approaches, students will be more prepared and confident in facing problems on the topic of Linear Equations of Two Variables. In addition, their ability to think critically and systematically will be more honed, so that errors that are conceptual, skills, and operations can be minimized. In the end, this integrated learning approach is expected to not only help students in the short term, but also prepare them for more complex mathematics topics in the next level of education.

4. CONCLUSION

The findings of this study highlight the importance of addressing the three main categories of errors—conceptual, skill, and operational—that students commonly face when learning Linear Equations of Two Variables (LETV). These errors significantly hinder their ability to solve LETV problems effectively, as seen in the research of Zulfah [16]. Conceptual errors, which stem from a misunderstanding or incomplete grasp of fundamental mathematical principles, often lead students to struggle with recognizing the general

form of linear equations and their graphical representations. Skill errors, on the other hand, arise from students' inability to apply procedures accurately despite an understanding of the underlying concepts. These errors, such as incorrect graph plotting or misapplication of substitution and elimination methods, prevent students from successfully navigating LETV problems. Lastly, operational errors, usually caused by a lack of accuracy in performing basic arithmetic operations, further complicate the problem-solving process.

Addressing these errors requires a multi-faceted teaching approach. Teachers must prioritize conceptual clarity by providing thorough explanations of the relationship between variables and their graphical interpretations. Skill mastery should be cultivated through a variety of problem-solving exercises, both routine and non-routine, with escalating levels of difficulty to develop students' proficiency and confidence. Lastly, improving students' accuracy in operations can be achieved by instilling careful double-checking habits and encouraging reflective learning practices. Through these methods, students can better understand the material, reduce errors, and improve their overall mathematical competency. By implementing such comprehensive teaching strategies, students are more likely to overcome their challenges with LETV, enhancing not only their short-term performance but also their readiness for more advanced mathematical concepts. This approach will empower students to think critically, solve problems systematically, and achieve long-term success in mathematics.

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