Error Analysis of Social Science Student with High Intelligence in Solving Linear System

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Abstract. Linear system is one of the important material in mathematics learning. But, students often find difficulties to solve about this material. In this research, researcher use limitation in linear system in three variables. This research is descriptive with a qualitative approach. The purpose of this article is to know the social science student with high intelligence's error in solving the linear system in three variables and what factors that impact it. The subject of this research were 23 students of favorite school. Data are collected by testing and interview. The error this research refer to Newman Error' Analysis Model, reading, comprehension, transformation, process skill, dan encoding. Based on this study, it was found that students' errors in solving the linear system in three variables were certainly varied. Therefore, the teacher as a facilitator must guides students to avoid mistakes in solving word problems. The result of the study said that some students who get errors are because of a lack of understanding at the reading stage so that implies difficulty in the encoding stage. Another mistake found in social science students is calculation in process skills. From this data, we can conclude that the most error made by students is encoding error with percentage 57,5%. This encoding errors happened because the social students learning by memorizing.

Keywords: linear system, analysis, Newman error

1 Introduction

Mathematics is an important and useful lesson. However, students often get errors in solving mathematics problems. Menchinskaya in [1] said that there are four areas of cause and effect of student errors that are inseparable such as errors due to incorrect implementation of operations, errors due to understanding inadequate conceptual understanding, mechanical errors due to prioritizing interest in diversion, damage due to improper application or algorithm effects. Meanwhile, according to [2] the error in student answers was a lack of understanding, procedures being forgotten, negligence in transcribing information from the question, carelessness and guesswork. It is in line with [3], the cause factor the students were less thorough, did not understand the meaning of the problem, less know the concept of the formula, and students who did not check again the answers that have been made. Students also get wrong in content knowledge [4]. Research conducted by [5] about difficulties in solving context-based PISA mathematics tasks that were carried out with 362 Indonesian ninth- and tenth-grade students said that students made most mistakes in the first two stages of the solution process. Low performing students make higher misunderstandings and transformations than high performing because they may have been trapped in the early stages of the modeling process so they cannot continue to the next stage. Meanwhile, other studies

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conducted by [6] by taking subjects in grade 8 at Muhammadiyah Middle School 17 Surabaya said that the most mistakes made by students in working on the PISA problem were at the encoding stage with a percentage of 26%, while the least error was in the reading stage with a percentage of 12%.

One of the materials of mathematics that is important is the linear system in three variables. Although, linear system in three variables is a simple material but the students often have difficulties in mathematics learning. Based on observations when the researcher taught Social Sciences of grade tenth, the linear system in three variables in the school included material that was not so difficult because students in this school have middle until high intelligent. Although linear system in three variables is just topic that look like linear system in two variables, but student still find difficult to solve this problem and get wrong in solving the task about mathematics modeling about linear system in three variables from the words problem. Linear system in three variables is taught for ten years students of natural sciences and also social sciences.

Based on interviews with teachers and social sciences students, most social sciences students prefer to learn by memorizing. This is confirmed by [7] that the subjects studied took down notes and memorized keywords during discussion. They listen carefully during discussion. However, researchers want to try to examine what kind of errors faced by social sciences with high intelligent students that learn by memorizing the material of the linear system in three variables. Research on student errors in solving linear system in three variables has been done by [8] by taking the sample of language and culture sciences student, conducted by [9] by taking the sample of natural sciences student, conducted by [10] by taking samples of natural sciences students and there is no percentage for each type of student error yet. The other research is conducted by [11] but does not use Newmann Error Analysis.

This study aims to know the social science student with high intelligence error in solving the linear system in three variables and what factors that impact it.Errors in the solving of mathematical questions can be analyzed by Newman's analysis. This analysis was first introduced by Anne Newman in 1977. According to Newman [12], this analysis consists of five hierarchies, they are reading, comprehension, transformation, process skill, and encoding.analisis ini terdiri dari lima hierarki meliputi reading, comprehension, transformation, process skill, dan encoding. The researcher was interested in taking a sample of social sciences with high intelligence of grade tenth because the research about it does not exist yet.

2 Method

This type of research is descriptive qualitative research. The subjects of this study were 23 social science student of grade tenth in one of the favorite schools in DIY.

2.1 Data Collecting

The instrument for collecting data from this study is a test questions sheet consisting of 5-word problems related to three variable linear equation systems and interviews.
The test questions is as follows:

1. Solution set of linear system in three variables:

$$\begin{cases} 2x + y - z = 3 \\ x + y + z = 1 \\ x - 2y - 3z = 4 \end{cases}$$

is...

2. Given the linear system:

$$\begin{cases} \frac{2}{x} + \frac{2}{y} - \frac{4}{z} = 2 \\ \frac{3}{x} - \frac{2}{y} + \frac{5}{z} = 10 \\ \frac{4}{x} + \frac{5}{y} - \frac{3}{z} = 17 \end{cases}$$

Find the of x + y + z.

3. There are three numbers. The first number plus the second number equals the third number. The difference between the first and third numbers is equal to a quarter of the second number. If the third number is 15, find those three numbers.
4. Three siblings Andi, Budi, and Cindy respectively as first, second and third children. Six times Cindy's age is the same as the age of Andi and Budi. The difference between the number of ages of Budi and Cindy is 1. If the total age of the three is 21. How many years are they each?
5. If A and B work together, they can complete the work in 4 days. If B and C work together, they can complete within 3 days. Whereas if A, B and C work together, they can complete in 2 days. If they work alone, how many days B can finish the work?

2.2 Data Analysis

Data on student test results are analyzed with the "New Error Analysis Model" (NEA model). This analysis model includes reading, comprehension, transformation, process skill, and encoding. Questions for respondents related to the five hierarchies according to [13] and [4] these are as follows:

- Reading Error: Can you read the problem?
  This type of reading error occurs when students fail to write down the words or symbols contained in the problem.
- Comprehension Error*:* What does the question ask you to do?
  This type of comprehension error occurs when students can read questions, but fail to understand what is needed.
- Transformation Error: What do you use to solve the problem?
  This transformation type error occurs if students can understand what is needed in solving the problem, but the student fails to identify what mathematical operations are being used.
- Process Skill Error*:* Can you show me the working steps that you have used to find the answer?
  This type of process skill error occurs if the student has been able to identify the mathematical operations used, but students find errors in the steps or calculation process.
- Encoding Error*:* Tell me what is the answer?
  This type of encoding error occurs if students can solve the problem, but students fail to conclude the answer to the problem.

These student errors are then analyzed for each process. Student errors are also strengthened by interviews. The interview data is used to find out more about the mistakes made by students.

3 Result and Discussion

The researcher gave five questions to 23 students in a favorite school. The student answer then analyze using Newmann's analysis. The type of student's error is in table 1.

Table 1. Type of Student's Error

reading	comprehension	transformation	process skill	encoding
12,5%	10%	5%	15%	57,5%

- Reading Error

In this stage, social science students with high intelligent could pass problems related to word problems in daily activity except about word problems related to time. The problem number five is as follows:

"If A and B work together, they can complete the work in 4 days. If B and C work together, they can complete within 3 days. Whereas if A, B and C work together, they can complete in 2 days. If they work alone, how many days B can finish the work?"

In this section, students have little understanding of how to model word problems into a mathematical model but some parts are not understood. The researcher then interviewed the student. In the question section "If A and B work together, they can complete the work in 4 days" students correctly model it to $\frac{1}{A}+\frac{1}{B}=\frac{1}{4}$. But after that, the student multiplies by 12, because the student thaught if multiplied by 12 then the equation does not contain any fraction anymore but students are not careful in multiplication. The right-hand side has been multiplied by 12 but the left-hand side is not multiplied by 12. Then the student also doesn't understand in the next writing, the equation that is still written in $\frac{1}{A}+\frac{1}{B}$ then replaced by itself to be A + B. After being interviewed the student does not understand and they didn't think that fractions $\frac{1}{A}$and$\frac{1}{B}$ could be changed by other letters such that x and y to make calculations easier.Other cases, students can model the mathematics, but students get confused in understanding the requirements needed to solve it so that students only understand until modeling and confuse in solving the problem. So that students cannot solve the problem. After interviews with these students, students acknowledge that they have not understood the requirements to solve number 5.

At this stage, most students have been able to change word problems into symbols or mathematical models. However, some students have difficulty in modeling mathematics related to time. It is in line with [14] that one type of error that student done is concept error with indicators the student is wrong in interpreting the terms and concepts, wrong in using terms and concepts, does not adjust the use of the definition to the conditions of the prerequisites, and does not write the definition to answer the problem.

- Comprehension Error

From the test results of grade X students at the favorite school shows that students who have been able to go through the reading stage can definitely pass the stage of comprehension. While students who are still confused in making mathematical models at the reading stage, get difficulties in the comprehension stage. According to [15] the student's error in solving the problem of linear equations is due to the inability to understand and interpret other sentences to proceed to the process and encoding skills. Most social science students at favorite schools can pass comprehension stage. This is in line with [13] that good performers' errors did not occur at reading level, but poor performers' errors occurred mostly at comprehension level.

- Transformation Error

At this stage students are able to understand what is needed to solve the problem, but there are some students who are confused to determine what mathematical operations are suitable. The student has been able to determine one of the variable values, but cannot determine the value of the other two variables. May be the student does not understand the prerequisite topic needed to look for other variables, which are related to the elimination and substitution methods that have been obtained when student at eightth grade at Junior High School.In the student worksheet of number three, students are able to model the mathematics, but students are confused in understanding the requirements needed to solve it so that students only understand until modeling and confuuse in solving the problem. So that students cannot solve the problem. After interviews with these students, students acknowledge that they have not understood the requirements to solve number 5. According to [16], at this transformation's stage, error is observed when students are not able to use appropriate means and strategies or mistakes in using what is known into its strategy.Meanwhile, according to [17], student difficulties at the transformation stage occur because students do not know or lack experience to choose what operations are used in the work on the problem.

- Process Skill Error

From the results of tests conducted by students it was found that some social science students were not careful in mathematical calculations. From the student worksheets of number three students already understand the prerequisite topic, namely elimination, but students are not careful in calculating 0 minus 15. Students answer the result is 15, then the answer is wrong. Because the calculation process is wrong, the next process to get results is not correct too. The The student worksheet of number 5 also show about process skill error. The error start from $3y = \frac{1}{4}$ and then student solve $y = \frac{1}{7}$. It's definitely wrong. He or she do not understand about division of fraction. He or she should memorize the topic of fraction that had been learned before. According to the observations of researchers, miscalculations due to inaccuracy of students are the types of errors that are often faced when researchers teach social studies classes. Students of social sciences in Indonesia have not depth understanding as natural science in mathematical calculation. This is in line with the research of [12] that the students' error in solving problems was due to their weaknesses in basic arithmetical operations. In line with [14] and [18] operational error is one of the type of error that student often done.

- Encoding Error

At this stage, students have been able to solve the problem well, but students cannot make conclusions about what the problem wants. From the results of interviews with students it was found that errors at this stage were based on an understanding of the process of reading.

Students only know the mathematics model by memorizing it about the type of problem. Therefore at the conclusion stage students do not understand what is really the problem wanted. This is in line with (Watkins & Biggs, 2001) in [19], learning by memorization way may cause result did not optimal whereas according to [7] social sciences students studied by took down notes and memorized keywords during discussion.Their mathematics learning was dominated by memorization activities

4 Conclusion

Based on this study, it was found that students' errors in solving problems certainly varied. Therefore, the teacher as a facilitator must direct students to avoid mistakes in solving word problems. From this study, it was found that most social science students in favorite schools can solve problems about the system of three-variable linear equations well. Some students who get error are because of lack of understanding at the reading stage so that implies difficulty in the encoding stage. Another mistake found in social science students is that it is less thorough in the calculation process found in process skills. The most errors that had done by student is encoding error with percentage 57,5. This is in line with the research conducted by [8]who have studied about linear system in three variables too, but she took sample of language and culture class. She said that the most errors that made by student was encoding error. This research is in line with the research conducted by [6] who examined students' error in solving PISA level questions also said that the most errors were at the encoding stage with percentage 26%. [20] also said that the most students error was encoding errors. When compared with research on other material, namely trigonometry for student of grade tenth, [13] the data suggested that most of students' errors occurred at comprehension level for structured questions while the errors for multiple choice questions occurred at the transformation level. Suggestions that can be given by research to minimize this type of error is to increase students' understanding in learning Three Variable Linear Equation Systems by means of variations in methods or approaches to learning carried out by teachers and with other types of questions related to the linear system in three variables.

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