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Error analysis of students with Concrete Sequential Thinking Styles in Solving Elimination-Substitution Problems

J S Winarti, S Gembong, W Murtafi'ah*, D Apriandi

Mathematics Education Study Program, Faculty of Teacher Training and Education
Universitas PGRI Madiun, Jalan Setiabudi No. 85 Madiun Indonesia

* wasila.mathedu@unipma.ac.id

Abstract. This study aims to find out the errors of students with concrete sequential thinking in solving the problem of Elimination-Substitution. Error analysis is revealed based on Newmann's theory. The research method used is a qualitative approach. The subjects of the study consisted of 2 students with concrete sequential thinking skills selected from 32 students of eight grade of SMPN 1 Sawahan. Data collection is obtained through structured interviews. Data analysis techniques consist of three lines, namely data reduction, data presentation, and conclusion drawing. The data validity technique using time triangulation. The results showed that students who had concrete sequential thinking styles in solving Elimination-Substitution problems tended to experience Process Skill and Encoding type errors.

1. Introduction

Mathematics is one of the subjects taught at every level of education. Mathematics is used as a provision for students in living their daily lives. However, most students do not like mathematics because it is considered severe. This is as expressed by [1] that many students view mathematics as a difficult subject. One of the most basic causes that students do not like mathematics is that it is always related to numbers and formulas.

In math lessons, problems are not only presented in the form of numbers but are also associated with everyday life. One of the mathematics subjects that can be used to solve problems in daily life is a two-variable system of linear equations. The two-variable linear equation system is a system of equations consisting of two linear equations, where each linear equation has two variables and the highest rank of the variable is one. In the problem of a system of linear two-variable equations, there are 4 methods used to solve them, including elimination, substitution, Elimination-Substitution (combined) and graph.

Mathematical problems related to the system of two-variable linear equations are in the form of story problems so that in their completion they must do the modeling phase into mathematical form. This means that in solving problems, students should be able to change verbal sentences to mathematical models. Given that the settlement with the Elimination-Substitution method is very much related to the other materials. Students are expected to complete in solving the problem of Elimination-Substitution.

Based on the observations and interviews results with teachers during the 3 Education Internship (PPL) at SMPN Sawahan 1 in September to November 2018, information was obtained that eight grade students had diverse abilities and thinking styles. This causes the students' mindset to solving problems differently. The mathematics teacher interviewed on October 30, 2018, said that the low learning



outcomes in the two-variable linear equation system material were 71% below the Minimum Completion Criteria (KKM).

The low learning outcomes are caused by students' understanding in solving problems related to the method of completion that is lack, especially in using the Elimination-Substitution method. Elimination-Substitution Method is a method of settlement that must be mastered by students, because this method is often and easily used in solving system problems in two-variable linear equations. Also, the Elimination-Substitution Method is a prerequisite for other materials, so students are expected to be able to apply it. When students are asked to solve a system of linear equations two variables, the work of students is not in accordance with the procedure or sequence in solving the problem. Students tend to solve problems quickly so that they do not go through the stages/procedures in the completion of Elimination-Substitution appropriately.

Students often experience errors in solving mathematical problems so that they can affect the student's learning outcomes. Making mistakes in solving math problems is normal. But mistakes are often repeated in working on math problems. This can cause a problem, given that mathematical material is related to the previous material. As stated by [2] that in the third step, will be answered correctly if students do not make mistakes in the second step. Likewise, the second step will be answered correctly if students do not make mistakes in the first step. So the importance of the accuracy of student work at each step of solving the problem.

In solving a mathematical problem, of course someone answers and writes problems should be able to go through several sequential stages, including reading, understanding, transformation, process skills, and writing answers. This is in line with the types of errors based on Newman's procedures which include: errors in reading questions, understanding problems, transformation errors, process skill errors, and answer writing errors [3].

Research on student errors in mathematics learning has been carried out by several researchers [4], [5], [6], [7]. [4] has examined that high-ability students experience errors in the loss of important information on problems. Students with high and low abilities both experience errors in the presentation of the diagram. [5] state that the teacher considers mistakes not only because of students but also because of other factors arising from the teaching and character of the subject. [6] have classified student errors in solving algebraic problems. Whereas [7] states that there are several student errors in solving inequality problems that include basic algebraic operating errors.

The results of these studies indicate that student error analysis based on students' thinking styles has not been done. Errors made by each student can be different because students with one another have diverse thinking styles. [8] explained that a thinking style is a form of behavior that is caused by the dominance of the left or right brain in receiving information, thus producing an equivalent solution in solving problems in different conditions. Students' thinking styles according to [9] are divided into four types, which include: concrete sequential, sequential abstract, concrete, and abstract random.

This research is focused on students who have a concrete sequential thinking style. This is because from the results of preliminary observations, it was found that students who have particular sequential thinking styles in processing information are processed regularly, sequentially, and linearly. Also, students who have specific sequential thinking styles pay attention to and remember facts and formulas. Although students have solved the problem through step by step, sequentially students often experience errors in the computing process. Errors made by students will lead to errors in the next stage, because of the mistakes made by the student the researcher focuses on students who have a concrete sequential thinking style.

Thus, this study aims to find out how errors made by students with concrete sequential thinking styles in solving problems of Elimination based on Newman's theory.

2. Method

This type of research is qualitative, namely, descriptive analysis. According to [10], states that qualitative research is a research process that is carried out naturally in accordance with the objective conditions in the field with what is available without manipulation, as well as the types of data collected

mainly qualitative data. The research subject was determined through purposive sampling, or this purpose sample in sampling was based on specific considerations [10]. The subjects of this study were two students with concrete sequential thinking skills chosen from 32 students of the eighth grade of State SMPN 1 Sawahan.

The research instrument consisted of (1) a test of thinking style according to [9]; (2) problem tests; and (3) unstructured interviews. Data analysis was conducted qualitatively based on data obtained from tests and interviews as a basis for analyzing student errors based on Newman's theory in terms of concrete sequential thinking styles.

The data validity technique used in this study is time triangulation. Time triangulation is done by checking the data to the same source with the same technique by checking with interviews, observations or other techniques in different times or situations [11]. The procedure is done by conducting interviews twice about the results of written tests given at different times using the same written test to get credible data. Data testing is done by checking from the exposure to the results of the data from interviews and tests, both writing. If the comparison of exposure to the results of the first and second data is the same, so the data are said to be valid.

Data analysis techniques include data reduction, data presentation, and drawing a conclusion. Data obtained from the results of written tests and interviews. After obtaining data from written tests and interviews, a reduction is made on the data. Data reduction is done by choosing the main things, focusing on the essential things, and discarding the ones that are not important. Then the reduction data is classified and identified so that there is a clear picture and allows to conclude by presenting narrative data in the form of text. The final step is to conclude.

According to [12], some several factors and indicators cause students to make mistakes in solving questions that are based on Newman's procedures. The table of elements and indicators of the causes of students to make mistakes [12]:

Table 1. Factors and Indicators Cause Student Errors

Factors	Indicators
Reading errors	a. Students are unable to read the sentence in the question correctly. b. Students are not able to interpret the meaning of each word and term in the problem.
Comprehension errors	a. Students do not understand any information that is known in the question completely. b. Students do not understand anything asked questions in full.
Transformation errors	a. Students are not able to make model mathematics of information obtained. b. Students do not understand the formula used to solve the problem. c. Students do not understand the counting operation used to solve the problem.
Process Skill errors	a. Students do not understand the procedure or steps used to solve the problem correctly. b. Students cannot apply the steps or procedures correctly.
Encoding errors	a. Students are not able to find the final results of the problem based on the procedures or steps that have been used. b. Students cannot show the final answer to solving the problem correctly. c. Students cannot write end answers in accordance with the conclusion.

3. Result and Discussion

3.1. Subject 1

At the stage of understanding the problem subject 1 can translate and identify the most important part of the problem, namely determining what is known and what is asked in the problem correctly. In identifying the problem, subject 1 is able to understand and mention the items known from the problem. Subject 1 also explains the items that are used as variables. So that the subject includes recognizing the form and translation of sentences/system problems of two-variable linear equations. Judging from the results of the test and interview the subject can mention the elements of understanding the problem well and completely. So that it can be concluded that subject 1 at the stage of understanding the problem does not occur Reading and Comprehension type errors. This is in line with the research conducted by [13] that students can explain and mention what is known and what is asked about the questions correctly.

At the stage of planning the problem-solving subject 1 can plan problem-solving in a coherent manner by writing down every known step of completion, being asked and answered in planning the solution of the subject 1 problem using the Elimination-Substitution method. Because subject 1 has used the method that should be used, it can be concluded that subject 1 at the stage of planning the problem solving does not have a Transformation type error. This is in line with [14] research that students can determine the method that should be used.

At the stage of carrying out the subject 1, a problem-solving plan is able to carry out each step of completion according to what was planned. Subject 1 carried out the initial step by writing down what was known and asked from the question, then continued working on the problem using the planned Elimination-Substitution method. However, the results obtained are not in accordance with the real answer, because after eliminating equation 1 and equation 2 subject 1 performs substitution into equation 3 so that the results obtained are false. This is in line with [15] research that the obstacles faced by students are the use of procedures that are not mastered, even though at this stage students' actual abilities can be considered how skilled students are in solving problems. Errors in these steps result in inappropriate variable results. It can be concluded that at the stage of carrying out the planning for solving the problem, subject 1 experienced an error in the Process Skill type.

At the stage of seeing the completion of the subject problem 1 write down the problem solving and complete the results of the work. Subject 1 can re-check the completeness of each work by adjusting the results based on the problem and interpreting the findings. On the first and second tests can show conclusions from the completion that has been done. However, the final results obtained by subject 1 are incorrect, because in the previous stage subject 1 has experienced an error at the stage of implementation of the solution plan. It can be concluded that subject 1 at this stage made an Encoding type error.

3.2. Subjek 2

At the stage of understanding the subject matter 2, it can identify the most important part of the problem, namely determining what is known and what is being asked in the problem correctly. In identifying the problem, subject 2 is able to understand and mention the item known from the problem. Subject 2 also describes items that are used as variables in the example. So that the subject includes recognizing the form and translation of sentences/system problems of two-variable linear equations. Judging from the results of the test and interview the subject can mention the elements of understanding the problem well and completely. So it can be concluded that subject 2 at the stage of understanding the problem does not occur Reading and Comprehension type errors. This is in line with [13] that students can determine what is known and what is asked correctly.

At the stage of planning, the problem-solving subject 2 can plan problem-solving in a coherent manner by writing down every known step of completion, being asked and answered in planning the resolution of subject 2 using the Elimination-Substitution method. Because subject 2 has used the method that should be used, it can be concluded that subject 2 at the stage of planning to solve the problem, there is no Transformation type error. This is in line with [14] research that students can determine the method that should be used in problem-solving.

The stage of carrying out the subject 2 problem-solving plan is able to carry out each step of completion according to what was planned. Subject 2 carries out the first step by writing down what is known and asked from the question, then proceed to work on the problem using the planned Elimination-Substitution method. But the results obtained are not in accordance with the real answer, after eliminating equation 1 and equation 2, subject 2 performs substitution into equation 1 after one variable value is found, subject 2 does substitution in equation 2. However, from substitution to in equation 2, subject 2 re-substitutes to equation 3. So one variable has 2 different values. So that the results are later substituted into equation 3. The error in this step results in an inappropriate variable. Because subject 2 feels confident that the results of his work are correct so that errors occur in subject 2. This can be concluded that at the stage of carrying out the planning problem solving subject 2 experienced errors in the type of Process Skill. The results of this study are in line with [7] that is error students are caused by basic algebraic surgery, which is part of the problem-solving procedure.

Stage of seeing the completion of the subject matter 2 writing down the problem solving and completing the results of the work. Subject 2 can check the completeness of each job by adjusting the results based on the problem and interpreting the findings. In the first and second stage tests can show conclusions from the completion that has been done. However, the final results obtained by subject 1 are incorrect, because in the previous stage subject 1 has experienced an error at the stage of implementation of the solution plan. It can be concluded that subject 1 at this stage made an Encoding type error.

4. Conclusion

The results showed that students who had a concrete sequential thinking style in solving Elimination-Substitution problems tended to experience Process Skill and Encoding type errors.

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