An analysis of students’ error in completing the contextual problems based on Newman’s procedure

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Abstract. The aim of this study is to determine the students’ errors in solving mathematical problems of the system of two-variable linear equations based on Newman’s Procedure in terms of students’ cognitive styles. The type of this research is descriptive qualitative research. The subjects were eighth-grade students of Pangudi Luhur 1 Junior High School in Yogyakarta 2018/2019. The research method used is descriptive. The data were collected through documentation, interviews, and test. The data analysis is done by data reduction, data presentation, and conclusion drawing. Based on the results of this study, it can be concluded that students still have errors in solving the story question problems of the system of two-variable linear equations. The cause of errors based on Newman's theory in terms of the cognitive style of students is that students are not able to understand the questions well, students also have lack mastery of the material, so the students are confused in determining step-by-step work of the questions. Students also tend to be less careful in working on problems and are less accustomed to working on problems in a structured manner.

1. Introduction

“Education is one of the important aspects that can affect national vision. Success in educational implementation is key to a better future” [1]. “In education, assessment is an important matter in order to identify an educational success. The results of the educational assessment have a major function that will be useful in further educational processes” [2]. One way to respect the quality of education can be seen based on the assessment of students both academically and non-academically. The assessment can be done by analyzing the students’ answers. As said by Herholdt, et.al [3] “An analysis of learner errors does require mathematical content and pedagogical content knowledge on the part of teachers, but it would also serve to broaden teachers’ knowledge of mathematical cognition and concept development”.

Mathematics is a science of study with abstract objects and is formed based on logic, reasoning, and deductive proof. As a science, mathematics aims to train humans to think logically and critically. Without realizing the role of mathematics is actually very important for humans in everyday life, for example, when carrying out buying and selling transactions means that humans carry out activities that use the mathematical principle of social arithmetic. Mathematical learning is intended not only to provide abstract knowledge for students but also expected that students can connect what has been learned in mathematics with the real things that exist in life.

As said by Soedjadi [4] that “one of the general goals of mathematics is to prepare students to be able to use the mathematical mindset in everyday life”. In addition, mathematics is also used as a basis
for technological development, enhancing the human mindset, and also used in various other disciplines such as chemistry, physics, accounting, economy, and others. As stated by Hudojo [5] that “mathematics deals with ideas, structures, and relationships that are arranged logically so that mathematics is related to abstract concepts”. However, any extract of mathematics does not mean that there is absolutely no connection with life. Agreeing with Retnawati et al. [6], “mathematics is also known as a knowledge which belongs to human beings”. This knowledge arises because of the need for human beings to comprehend the nature around them.

Mathematics as one of the fields of study that is always studied at various levels of education, both elementary, secondary and tertiary schools, is often regarded as a field of study that is difficult to understand because the concept is abstract, so students often become less interested in mathematics. Inevitably, mathematics needs to be introduced and mastered by humans because without realizing it with mastery of mathematics, humans will also be helped in doing everyday problem-solving. One way to train students to use problem-solving in life is by giving story questions.

There are still many students who experience confusion in solving story problems. This statement is in line with the research conducted by Budyono [7] about “working on story problems in mathematics learning that prove that the story matter is still a fairly difficult problem for some students”. In solving a problem, of course, a correct understanding of the problem is needed. Here lie the difficulties that are usually experienced by students, which are difficult to understand the intent of the problems that exist in the problem. “Student difficulties allow mistakes in problem-solving in certain material” [8]. Students who lack mastering the material aren’t only found in difficult problems but can also occur in problems that are included in the easy category. Based on research Rahmania & Rahmawati [9] regarding the analysis of student errors, the results show that the subject's answers don’t match with the problem presented. That is because the subject can’t grasp the message contained in the problem. So, in this case, the mistakes made by students in solving story problems are caused by a lack of understanding of the problem. If there is no follow up on the case, then the purpose of learning will not be carried out properly. Therefore, Rahmania & Rahmawati [9] added, “teachers, need to give emphasis on understanding mathematical story problems, especially at the stage of changing the sentence problem to its mathematical model”. In addition, an analysis of students' mistakes in detail will help teachers explore student mistakes and better know the types of errors experienced by students, especially in the matter of mathematical stories.

Haji [10] argues that “the story problem is the result of modification of the calculation questions related to the reality that exists in the student environment”. Thus, giving a story question in mathematics learning where the question is related to real events in life is expected that students will more easily understand the problem so that they can solve the problem given. Giving story questions in mathematics learning requires students to think mathematically, logically, and critically. The most important thing in learning is connecting the material learned with problems in life so that it will be more lasting and meaningful for students.

Success in learning mathematics can be seen based on learning achievement. Learning achievement is important in determining students' understanding when participating in teaching and learning activities. Students with satisfying learning achievements certainly have a good understanding of receiving knowledge. Based on the assessment conducted by the Organisation de coopération et de développement économiques (OECD), France, the results of PISA in 2018 show that the average ability of Indonesian students in Mathematics is 371, far below the OECD average of 487 [11]. Based on these results, it can be concluded that student achievement in Indonesia is still in the low category.

Students' ability to mathematics is very diverse. Not all students can understand mathematics perfectly. Students who do not understand the material more often just keep quiet and are reluctant to ask the teacher. This resulted in students often making mistakes in working on math problems. Here is the important role of the teacher to recognize and understand students. Hopefully, the teacher can identify any mistakes that students often make in working on math problems. With the information that has been obtained, the teacher can use it to improve the quality of student learning activities so that students' mathematics learning achievements can increase.
It is undeniable in the assessment of learning achievement; students must make mistakes. Errors can be caused by many factors and those carried out between students one and the other students must be different. In mathematics, errors made in the first step will result in errors in the next step. As stated by Budiyono [7] 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.

In his book, White [12] states that the errors of Newman procedure are classified as follows: (1) Reading Error: This error problem occurs if students cannot read the keywords or symbols that are written on the problem. Error reading the problem (reading error) is usually called a type R-error; (2) Comprehension Error: This error occurs if students are able to read all the words in the problem but cannot understand the whole question so they cannot predict the steps that will be taken to solve the problem. Errors in understanding this problem (comprehension error) are commonly called type C errors; (3) Transformation Error: This error occurs when students understand the question in the problem but can’t determine the appropriate operation or sequence of operations needed to solve the problem. Error transforming problems (transformation error) is usually called a type T-error; (4) Process Skills Error: This error occurs if the student already knows the operation or sequence of operations used but does not know the proper procedure in carrying out the operation to solve the problem. Process skills errors are commonly referred to as type P errors; dan (5) Encoding Error: This error occurs when students have been able to work until they get the solution correctly but cannot or incorrectly draw conclusions. Wrong writing on the answer (encoding error) is usually called type E error.

2. Method

2.1. Type of research
This research is descriptive qualitative which aims to analyze the errors of eighth-grade students in completing math questions about the system of two-variable linear equations based on the Newman procedure. The study was conducted in December 2018. Researchers identified student errors in solving story problems. Classification of errors students use the Newman Procedure, better known as Newman’s Error Procedure (NEP), which consists of reading errors, comprehension errors, transformation error problems, process skill errors, and encoding error.

2.2. Research subject
The subjects of this study were eighth-grade students of Pangudi Luhur 1 Junior High School in Yogyakarta. The sampling technique uses a purposive sample. The subject of the study consisted of 40 students with abilities in the cognitive domain that were heterogeneous. In this subject, it is assumed that students have studied the system of two-variable linear equations before being given a test.

2.3. Instruments and Research Steps
Moleong [13] states that in qualitative research the methods usually used are interviews, observation, and utilization of documents. The document used in this study is a test instrument that is useful for measuring students’ cognitive abilities. Documents are collected using tests in the form of questions where students are required to write down the steps for completing their answers. The test consists of two package questions where each package consists of six questions. Of the six question items, researchers have selected four-item questions in the material system of two-variable linear equations. The four items selected were a matter of the story. Classification of errors students use the Newman Procedure, better known as Newman’s Error Procedure (NEP), which consists of reading errors, comprehension errors, transformation error problems, process skill errors, and encoding error. Errors are identified independently so it is possible for a student to make more than one mistake.

Tests given to students will also be used to determine student learning achievement in the material system of two-variable linear equations. Therefore, students will solve the problem seriously so that it
can be ascertained if the answers generated really describe the students' abilities in terms of cognitive. To maintain the confidentiality of the subject and objectivity, the identity of the student's subject will be disguised.

2.4. Data analysis

Data is analyzed qualitatively. Data analysis in qualitative research is carried out with the following stages data reduction, data presentation, and data verification [14]. The thing that will be described in this study is the students’ mistakes in solving the story problems in the material system of two-variable linear equations based on the types of errors according to Newman's procedure. Assessment is done by direct observation, namely analyzing students’ test answers and based on the results of interviews conducted. Interviews were conducted to determine the cause of the subject's mistakes in solving the questions given. The type of interview used is an unstructured or free interview. According to Arikunto [15], free interviews, where respondents have the freedom to express their opinions, without being limited by the standards made by the subject of evaluation. Whereas Sugiyono [16] argues that unstructured interviews are free interviews where researchers do not use interview guidelines that have been arranged systematically and completely for data collection.

3. Results and Discussion

3.1. Results

Based on the results of the study, there were still many students who made mistakes in solving the story problems. The table below is a summary of the analysis of student errors in solving the system problems of two-variable linear equations and also identified the number of students whose answers are correct and students who do not answer.

| Quest. 1 | Quest. 2 | Quest. 3 | Quest. 4 | Quest. 5 | Quest. 6 | Average Percentage |
|----------|----------|----------|----------|----------|----------|-------------------|
| n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| Correct Answer | 29 | 70.73 | 13 | 31.71 | 3 | 7.32 | 9 | 21.95 | 24 | 58.54 | 8 | 19.51 | 29.97 |
| Not Answer | 2 | 4.88 | 2 | 4.88 | 1 | 2.44 | 7 | 17.07 | 5 | 12.20 | 9 | 21.95 | 9.06 |
| Reading | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0.00 |
| Comprehension | 10 | 24.39 | 12 | 29.27 | 11 | 26.83 | 19 | 46.34 | 3 | 7.32 | 16 | 39.02 | 24.74 |
| Transformation | 3 | 7.32 | 4 | 9.76 | 4 | 9.76 | 1 | 2.44 | 6 | 14.63 | 8 | 18.12 | 8.01 |
| Process Skills | 5 | 12.20 | 10 | 24.39 | 14 | 34.15 | 5 | 12.20 | 7 | 17.07 | 11 | 26.83 | 18.12 |
| Encode | 0 | 0.00 | 1 | 2.44 | 2 | 4.88 | 2 | 4.88 | 0 | 0.00 | 1 | 2.44 | 2.09 |

Students’ mistakes in solving contextual problems in this study are interpreted as a form of neglect to answers when students’ did the tests. The mistakes made can occur due to several causes. In this study, students analyzed errors in solving story problems in the system of two-variable linear equations based on Newman's procedures. Where errors in the Newman procedure are classified into five factors, namely reading errors, misunderstandings, errors in transformation errors, processing skills errors, and writing error answers (coding errors). The following will be discussed more students' mistakes in solving story problems.

3.1.1. Comprehension Error

Errors in understanding the problem given can be identified based on what is asked and what is meant by the question. Based on Newman's procedures, errors can occur because of the inability of students to understand the whole question so they cannot predict the steps to be taken. Table 2 below is an example of students' mistakes in understanding problems. Seen in the picture in table 2, students are able to change the sentence in the story problem to a mathematical model but students do not know how to solve the problem, students cannot determine the next step to do. It can be seen from what is
written, the written answer does not represent or does not answer what is asked. Students also do not write down variables a and b, each of which explains what. Students only guessed at the possible answers to the price of chocolate bread and shredded bread. Even though students should use the method of elimination or substitution to solve the problem.

| Table 2. Example of Comprehension Error |
|----------------------------------------|
| **Question**                           | **Answer**                                      |
| On Sunday, Belle, Nadine, and Olivia will go to the Breadsaid bakery. At the bakery, they buy bread with different amounts. Belle bought two roti coklat and three roti abon. Nadine bought one roti coklat and one roti abon. When they arrived at the cashier, Belle had to pay for all the bread he bought at a price of Rp52,000.00. Whereas Nadine must pay Rp21,000.00. a. Make a mathematical model of the problem above b. Help Olivia to calculate how much money she has to give if she buys four roti coklat and two roti abon in the same shop |

The following in table 3 is also an example of the students’ answer which is indicated to have an error understanding the problem. The mistake made is that students do not write down any information that they obtain. From what the student writes on the answer sheet, he writes "32 − 26 = 16" where it is not the information that is in the problem. Therefore, students who are thus indicated have errors understanding the problem.

| Table 3. Example of Comprehension Error |
|----------------------------------------|
| **Question**                           | **Answer**                                      |
| A number is five times the other number. If the difference between the two numbers is 16, specify both numbers. | 55 − 16 = 16 |

Another case example of a student's error in understanding the problem is shown in table 4. The student's answer to the picture shown in table 4, the student does not give permission or does not explain the meaning of the representative variables. The answer is written does not lead to an answer that does not even describe the desired problem. Students seemed to be trying to do some counting operations but that was not related to the information in the problem. Thus, indicated having difficulty in interpreting the problem.

| Table 4. Example of Comprehension Error |
|----------------------------------------|
| **Question**                           | **Answer**                                      |
| In a family, there are siblings whose differences in age are 8 years. This year, two times the age of the older plus the age of younger siblings is 19. In the next 3 years, is the older sister's age a multiple of the younger? | $x + y = 19$  
$-x - y = 8$  
$19 - 8 = 11$  
$11 + 8 = 19$ |

3.1.2. Transformation Error Problems

Error transforming problems done by students can be marked by students unable to determine the appropriate operation or sequence of operations needed to solve the problem. Other indications that show students experiencing errors in transforming problems are mistakes in choosing the right
formula, errors in solving problems, and mistakes in developing mathematical models based on the information presented in the problem given.

An example of a problem transforming a problem is shown in table 5. From table 5 shows that students did not provide an explanation regarding the variables used in mathematical models. For completion (in the circled part), the students’ mistake is to use the smallest multiple of alliances to find a solution. Planning in choosing the solution written by students is wrong, the smallest multiple of alliances’ operation cannot help in solving the problem of the system of two-variable linear equations. Students can easily solve the problem using the method of elimination or substitution. Because the operation to find a solution chosen by students is not right, it causes students to be unable to find a solution to the problem given.

Table 5. Example of Transformation Error

| Question | Answer |
|----------|--------|
| Veni is Tari’s friend from childhood. Their age is not far adrift. Let's guess their age if it's known to be three times the age of Veni and twice the age of Tari is seven. Whereas three times the age of Tari is the age of Veni plus five. Are Veni and Tari the same age? | $\begin{align*}
3x + 2y &= 7 \\
x - 3y &= 5
\end{align*}$ |

Examples of other errors made by students are presented in table 6. Errors made by students in the example in table 6 are almost the same as the errors made in the example in table 5. Students make mistakes that begin by not explaining the meaning of the variables that represent the mathematical model. Furthermore, students use the smallest multiple of alliances as a solution to existing problems where the solution does not help students find problem-solving. Because of mistakes made by students, of course, students fail to find the expected solutions to the problems presented. This analysis strongly shows that students experience difficulties in transforming problems.

Table 6. Example of Transformation Error

| Question | Answer |
|----------|--------|
| Cindy and Dewi will make 19 flower arrangements that must be finished within a week. In a day, Cindy was able to make three flower arrangements while Dewi was able to make two sets. The difference between the two flower arrangements was made by Cindy and Dewi is eight. Is the time Dewi needs in flower arranging longer than the time needed by Cindy? | $\begin{align*}
12x - 8y &= 38 \\
6x - 4y &= 20
\end{align*}$ |

3.1.3. Process Skills Error

Indications from students who experience process skill errors are that students already know the operation or sequence of operations that are used but do not know the right procedures in carrying out the operation. Errors in student skills can be seen in students' mistakes in using formulas, errors in mathematical calculations, and errors in manipulating algebra. The research conducted by Hadi, et.al
[17] states that “process skill errors are the most common mistakes made by students and that occur in all test items.”

Table 7 shows examples of student errors in process skills. Visible mistakes made by students are actually not a fatal mistake, only small mistakes but have an impact on the results of student work. From table 7 we can see the first mistake that students make is not giving information or explanation for the variable that represents. Students actually understand and understand the purpose of the problem; it appears that students can change the problem given to the mathematical model but students make mistakes when calculating the algebraic operations (circled). Students want to eliminate the variable y but the operation chosen is a reduction, even though the operation used is the sum. In order for the y variable to be lost then −2y + 2y produces 0y or 0. Errors in this process skill result in students being wrong in determining the value of the variable x and also impacting on errors in finding the y variable so that students cannot solve the problem being asked. These findings indicate that difficulties are still encountered in mathematical process skills, especially in performing algebraic operations.

Table 7. Example of Process Skills Error

| Question                                                                 | Answer |
|-------------------------------------------------------------------------|--------|
| Cindy and Dewi will make 19 flower arrangements that must be finished within a week. In a day, Cindy was able to make three flower arrangements while Dewi was able to make two sets. The difference between the two flower arrangements was made by Cindy and Dewi is eight. Is the time Dewi needs in flower arranging longer than the time needed by Cindy? | ![Answer Image] |

3.1.4. Encoding Errors

Students’ mistakes in writing answers are actually very trivial errors, but sometimes students make these mistakes because they are not thorough. Errors in writing answers are marked by students being able to work until they get the solution correctly but cannot or incorrectly write the final solution, draw conclusions, or write conclusions. In table 8 is an example of student error in writing answers. In the early stages, students actually made a mistake that is not giving information about the variables used in mathematical models. Mathematical models are used to solve a problem into a mathematical form to make it easier to solve, but these errors indicate students are not used to working on questions in a structured manner. The next error is in the step of the algebraic operation it appears students want to eliminate the variable x by performing a reduction operation but when eliminating the variable y students make mistakes. Students write y − (−2y) to produce −y, the answer should be 3y. As a result of writing the answers to errors, students cannot find the right solution and in accordance with the existing problems.

Table 8. Example of Encoding Error

| Question                                                                 | Answer |
|-------------------------------------------------------------------------|--------|
| In a family, there are siblings whose differences in age are 8 years. This year, two times the age of the older plus the age of younger siblings is 19. In the next 3 years, is the older sister’s age a multiple of the younger? | ![Answer Image] |
3.2. Discussion

Based on the results of the data analysis described above, it shows that the mistakes made by students in solving story problems are errors in understanding problems, errors in transforming problems, errors in process skills, and mistakes in writing answers. These results are in line with the research conducted by Abdullah, et al. [18] who found that “errors experienced by students in solving mathematical problems were errors in understanding problems, transforming errors of problems, process skill errors, and coding errors”. From the error analysis based on the Newman procedure, it was found that there was one type of error that was not found in this study. In solving the story problems, the two-variable linear equation system was not found by students who made errors in reading (reading error). It turns out that this result is the same as Abdullah, et al. [18] which stated that “there were no subjects in the test who had difficulty in reading problems in the questions”. This happened because the subjects in this study were eighth-grade students who already had good reading skills. Other researchers, Singh et al., also state the same thing, that “the pupils faced more problems in content knowledge compared to language difficulties when tackling mathematical” [19].

The mistake that students tend to make in solving the system of two-variable linear equations is at the stage of understanding the problem. Students cannot understand the information obtained based on the problems presented. It is assumed that students are still confused if faced with a story matter. Then the most common error found in students’ answers is that students are not used to solving problems in mathematics in a structured manner. The most obvious error in working on the story problem is the system of two-variable linear equations, namely students do not provide information on the example performed. Though this information is also an important thing in solving math problems. For teachers, this is also important to use as an assessment to see the extent to which students understand the understanding of story problems.

From the results of the study, it was found that the eighth-grade students of Pangudi Luhur 1 Yogyakarta Junior High School were still having errors in solving the system of two-variable linear equations’ story problems. Some mistakes made by students are known after going through interviews. Before the interview is conducted, the researcher has chosen in advance the form of the student’s answer which if it were the same, it would be enough to be justified by one so that there was no information build-up. The interview was conducted with five students whose answers represented the answers of their friends. The following will be elaborated on the mistakes made by students when completing the story problem on the system of two-variable linear equations. Based on the research of Agustyaningrum & Maman [20], the result showed that “it was found that the most dominant errors made by the students were conceptual error”. By this statement, we know if the students’ concepts that they have are wrong, then they will be confused about how to solve something problems. All of those things are related.

Based on results of interviews, for students who make mistakes in understanding the problem say the cause is: first, students have difficulty understanding the sentence, how to interpret the relationship of each sentence that describes the problem, students can only solve problems related to the material if it is in the form of system equations. Second, because students lack the mastery of the system of two-variable linear equations, students are confused about how to change the information in a problem to a sentence or mathematical model. Third, because students rush in reading the problems given so they do not understand the information correctly. In research conducted by Yunus et.al [21] also stated the same thing, that is “Misunderstanding caused by the students forgetting and rushing in doing the problem”. In fact, to find a solution to a problem, students must first understand the problem presented. Without understanding the problem, of course, students will find it difficult to find problem-solving. This statement is in accordance with Rahardjo [22] who argues that “without an understanding of the problem given, students are not able to solve the problem correctly”.

In the category of transformation error, the results of the interview show that most students find it difficult to change the problem in the story problem to the form of mathematical sentences. As stated by Yunus et.al [21] in his study which showed “Stages of transformation, mistakes made by the subject consist of not making mathematical models correctly, that causing errors in using the formula,
because the student is less skilled in making the mathematical model because of lack of practice”. In addition, students also said that during learning, they were not accustomed to writing or changing contextual questions to mathematical models.

From the process skill error, it is said by the student that he understands what does it mean in the problem, but they did not careful in calculating. Also said by Singh et.al [19] that “the calculation process error is a type of error made by students where he has been able to determine the count operation, but cannot calculate correctly”. The results of student answers also show that the procedure chosen by students to solve the problem was correct, but in the middle of the road, students appear to make mistakes in algebraic operations so that the next step is also wrong.

The last category is the writing error of the answer (encoding error) where actually students have been able to obtain a solution to the problem given but students experience errors in determining the answer that matches the questions. The thing that caused that happened was because the students were not careful and too rushed, so they did not re-check their work. The research by Yunus et.al [21] also gave the conclusion that “the mistakes made by the students consist of not making conclusions answers, not finding the final answer, the mistake in writing the final result of the answer due to not re-check the answer sheet. The causes are the students did not find the final answer, write conclusions, and hasten in solving them so that students mistakenly write down the final answer.”

4. Conclusion

The results of the study using analysis based on the Newman procedure show that students still make mistakes in solving the story problems of the system of two-variable linear equations. From the results of the analysis and discussion, there were no students who had difficulty in the reading or reading stage because the subjects were junior high school students who already had good reading skills. But errors are found at another stage, namely errors in understanding problems (comprehension) where students do not understand the problems that exist in the story problems indicated by students unable to explain the information in the problem. There was an error in transforming the problem (transformation error) which was shown by students’ difficulties when converting mathematical problems to mathematical models. Another mistake made is process skills error where students make mistakes when completing an algebraic operation which results in students' answers being wrong. The answer writing phase is also found an error (encoding error) where students appear to be wrong in making conclusions.

Based on the results of the research and discussion above, the researcher suggested: for the teaching teacher, seeing the mistakes that are still often made by students in completing the system of two-variable linear equations, it is recommended that more varied training be in the form of story questions related to life problems so that students are encouraged to be eager to learn. For further research, it is advisable to look at other aspects that influence the errors made by students in solving problems.

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