Analysis of mathematical problem solving based on stages Newman in equality and inequality one variable

C D V S Swari¹, Mardiyana¹ and D Indriati²

¹Postgraduate Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia.
²Mathematics Department, Faculty of Mathematics and Science, Universitas Sebelas Maret, Surakarta, Indonesia.

Corresponding author*: clara.rabbit001@gmail.com

Abstract. Problem-solving is one of the purposes of learning mathematics. According to Newman, problem-solving consists of five stages, (1) reading, (2) comprehension, (3) transformation, (4) process skill and (5) encoding. The purpose of this study is to analyse students' problem-solving abilities based on Newman's steps for the topic of linear equality and inequality in one variable. The type of this research is qualitative descriptive. The subjects of this study were 8 students from 8th grade at SMP Negeri 2 Kebakkramat, which was taken by purposive sampling. The data was collected by test and interview. The results of this study are (1) the stage of reading, there were 16.67% students who could not write a complete mathematical sentence (2) the stage of understanding, there were 4.17% students could not write the question of the problem, (3) the stage of transforming, there were 75% students who still cannot inform the steps of the plan of completion that will be used in writing, (4) the stage of process skills, 33.33% students who made mistakes in understanding the concept and changing mathematical sentences, (5) the stage of encoding, 8.33% students who did not write the conclusion.

1. Introduction

In the 2013 curriculum, the government requires students to develop thinking skills in solving problems, in Mathematics. Mathematics is a science that is very important for students to learn. Using mathematics in life can improve the ability to think and argue, contribute to solve everyday problems and in the world of work and provide support in developing science and technology [1]. Students need to equip themselves with mathematics because, in learning mathematics, students are required to be thorough in solving problems and require students to think rationally and logically. So, human resources production will be high and good.

Today, mathematics is the most difficult science for students. This is because there are still many educators who do not use existing technology in learning mathematics, so students are less interested in learning and not responding well. Teachers require their students to follow the complete steps given by the teacher, even though students have many settled ideas. NCTM [2] says that problem-solving ability is the main goal of mathematics lessons. It defines problem solving as an activity that is part of the learning process to lead to the use of existing concepts in solving a problem. Problem-solving ability is to develop existing concepts and solve the problem under what they understand students. This follows the 2013 curriculum which has become the basis of learning today. The aim of the government is to apply this approach so that students can plan their own learning, not learning in
the form of memorization anymore. It introduces students to see, pay attention, ask questions, and observe so that the teacher can give students more freedom of opinion and be able to be a companion for their students [3].

Reviewing the problem-solving ability of the results of the National Examination at SMP Negeri 2 Kebakkramat in 2016, which is still in the poor category with an average value of 45.98. In 2017 it was at the less category with an average value of 52.08, while in 2018 it was also at the less category with a declining average value of 43.69. From the results of the past three years of examinations, it is necessary to analyze at what stage students made mistakes. According to White [4], to improve learning students can use the Newman Procedure, in mathematical problems in the form of stories, in the material of one-variable linear equations. One variable linear equation is a new material for 8th-grade students and is the most common student in daily life.

In carrying out assessments, in any curriculum, assessors always use written assessments (paper and pencil tests) because they are economical and fast in copying and correcting. Whereas the matter of writing and analysis students’ mistakes, we bid to get the information that many of the students and the success of problem-solving [5]. To help with problem solving analysis, linear story material, can use a system of equations and inequalities linear of one variable, solve a theory, this is the case by Newman. Newman designed a simple procedure. Newman states that students will solve problems, then students must pass through some intoxication: (1) Reading, (2) Understanding, (3) Transformation, (4) Process Skills, and (5) Encoding. Rohmah [6], stated that Newman had the same ideas as Polya’s problem-solving theory and PISSA’s mathematical literacy, reading, understanding problems and transforming problems. Based on Newman, expects to help students in solving problems because Newman adjusts students’ needs in solving problems. In its implementation, students will not avoid mistakes in solving problems. Problem solving that sees and concludes from the student’s final answer so it is difficult to know where the students are experiencing difficulties. However, by using problem-solving from Newman, we can study the mistakes and problems faced by students in the problems of linear one-story stories. Stage-solving problems by new people can conduct an analysis of student problem solving based on indicators at each stage. In Table 1, based on Jha [7], the indicators determine the ability to solve problems using Newman’s theory.

| Stages of Newman | Indicator |
|------------------|-----------|
| Reading          | If students can’t read keyword or symbol that prevent it continued, could classify it as a read error. |
| Comprehension    | The student read all the words in the question but had not understood the overall meaning and thus unable to proceed further. |
| Transformation   | The student unable to identify the operation, or series of operations. |
| Process Skill    | The student could identify the operation or series of operations but did not know the measures to carry out these operations. |
| Encoding         | The student worked out the solution to a problem but could not express the solution in an acceptable written form. |

2. Methods
This research is qualitative research. Subjects taken were students in Kebakkramat Middle School 2 in the 2019/2020 school year, with the consideration that the students had received one-variable linear equation material, and algebra. A sampling of data using a purposive sampling method [8], by taking 8
students from 8G classes at SMP Negeri 2 Kebakkramat. This study comprised four stages named: the preparation phase, the implementation phase of the study, the stage of data analysis, and the stage of preparing the report. The preparation phase, he compiled a research instrument with a test of problem-solving ability in the form of a one-variable linear equation problem. In the implementation phase of the study, the research subject will work on testing the linear equation of the variable based on the story, where the chosen validator has validated the questions on the test. In this test problem solving applies Newman’s theory with 5 stages. By interviewing with students who provide answers in analyzing student mistakes done, not following the stages in Newman’s theory. After data collection and interviews, the data analysis report is in descriptive form. Based on these results, the results of the analysis of problem-solving errors see from the results of data analysis.

3. Result and Discussion
The results of the study, by providing a one-variable linear equation problem in SMP Negeri 2 Kebakkramat which was followed by 8 students. Prakitipong and Nakamura proclaimed that the success in the initial two steps (Reading and Comprehension) signifies that the learner has interpreted the question in the mathematical context correctly. The completion of the final three steps (Transformation, Process Skill and Encoding) signifies that the learner has successfully executed the mathematical processes required in order to solve the problem [9]. These results will be analyzed using Newman's theory.

| Question | Number of students who made a mistake |
|----------|--------------------------------------|
|          | Reading | Comprehension | Transformation | Process Skill | Encoding |
| 1        | 2       | 0             | 7              | 4             | 2        |
| 2        | 1       | 1             | 4              | 1             | 1        |
| 3        | 1       | 0             | 7              | 3             | 1        |
| **Total**| **4**   | **1**         | **18**         | **8**         | **4**    |
| **Percentage** | **16.67%** | **4.17%** | **75%** | **33.33%** | **16.67%** |

Based on these results, the reading and encoding stages have the same results which is 16.67%. The lowest stage of making a mistake is the comprehension stage, the error is only 4.17%. While the stage with the highest value in making mistakes is the transformation stage. The error analysis made by students at the transformation stage was 75% and followed by the second highest error value is the process capability stage of 33.33%. If sorted from the smallest error value starts from the comprehension stage, encoding stage, reading stage, process capability stage and the transformation stage. These results are the same as the statement by Rohmah that mistakes in the reading stage will continue with making mistakes in transformation and process skills [10].

3.1. Reading Stage
In the reading stage, the analysis of problem-solving in the reading stage occurs in question number 1. Whereas question number 1 is the simplest problem is because there is no need to define variables in the problem, and students only need to solve the problem being asked. Problem number 1, students often make mistakes at the reading stage, just like in subjects 1 and 2, which turns out there are still many students who could not understand the problem in the problem. Here, will discuss problem solving errors from Subject 1.

We can see in Figure 1, subject 1 only read the questions in passing and was not careful, so only wrote what he felt was the matter of the story knew what. Subject 1 mix what he knows from the problem and what is the question of the problem. Subject 1 was not used to writing what they knew, because they accustomed it to the process skill stage.
Based on the results of the interview, subject 1 can tell what he knows from the problem that can help in solving the problem and he can pick the important keywords that are the problem. He stated this because subject 1 was familiar with the problem because often the teacher gave the same problem as the questions in number 1 with different numbers. Subject 1 states that he will solve what the problem is if he only needs to include what he knows in the problem without looking around at the problem. Subject 1 was only familiar with the problem but did not understand the problem. This resulted, when asking Subject 1 to explain how to solve the problem, because he was already familiar with the problem, he could not answer it.

3.2. Transformation Stage
In the Transformation stage, this stage is the stage where students make the most mistakes. The transformation stage is the stage of applying existing concepts, in this case the concepts in the material equation and the linear inequality of one variable, so they can explain their ideas or plans to solve the problem. At this stage, it turns out students cannot identify mathematical sentences on problems or a series of operations on mathematical sentences.

In Figure 2 can conclude for question number 1, Subject 3 could write a little of the ideas she would use to solve the problem, even though she could not write it down in mathematical sentences. In transformation stages, subject 3 didn’t understand the problem. She can’t take keywords in the problem and they make mistakes in the next stage, transformation stage. The students need to read and understand the requirements needed for the question because the transformation process will assist students in choosing the arithmetic operations to solve the problem. Subject 3 can’t explain how her idea to solve the problem.

Subject 6 can write the initial steps in solving the problem, transforming into variables, as in Figure 3. Subject still makes mistakes in explaining variable he took. However, he could not write a problem-solving plan that he would do. Habit is also a problem in this case, because in school allows him finish the problem just with the process skill stage. Subject 6 is accustomed to completing without using the stages in Newman. Even though he knew that he had to write whatever he knew about the problem according to the instructions in the problem, then write what the problem asked and how he would solve the problem, before he entered the process skill stage. But even so he still went to the process skill stage and ignored the other stages.
Figure 3. Student answer for Question 2 for the Transformation stage.

Based on the results of interviews with subjects who asked him to explain his writing or the purpose of his writing on the answer sheet, he could explain what steps he would take to solve the problem and the reasons for choosing that step. Subject 6 can explain what arithmetic operations he will use in solving this problem step by step. He could also imagine how he would solve this problem, only he could not express in writing how the plan he had explained earlier in mathematical sentences. He used to write how to solve it as he wrote on the process skill without going through the stages of transformation.

3.3. Process Skill Stage
At the Process Skill stage, this stage is the most important work in solving problems. At this stage, it requires students to understand the questions, be able to explain the questions of the questions and plan a solution before running the problem-solving process skills. Based on Table 1. at the Reading stage, there were still 16.67% of students who did not understand the questions and 75% of students unable to plan. In transformation, they know that it accustoms subjects to solve problems without writing solutions so they can still do the skill process. However, if students do not understand the questions and cannot write a solution plan with mathematical sentences, it will affect the process skills to solve the problems that he will do One key we see to success in solving the problem is not only from its ability to represent problem-solving but also seen on the ability of students to understand the problem well [11].

Figure 4. Student answer for Question 1 for Process Skill stage.

Subject 1, can write what he will do to solve the problem in a story problem, but can’t write it in the form of mathematical sentences following the concepts of equations and linear inequalities of one variable. When Subject 1 does not understand the purpose of the story, the results will be. Subject 1 only writes how to solve the problem without paying attention to anything that can help solve the problem and under the question of the problem or not. This proves Raduan’s statement that mistakes in the reading stage will continue with making mistakes in transformation and process skills.

Based on test results and interviews could conclude that Subject 1 only relied on his memory to solve the problem without understanding the material of a one-variable linear equation. This is the
same as the results written on the answer sheet, he does not understand what he wrote and what he did in solving problems. This differs from subject 4, subject 4 has similarities with subject 6, which has never written the transformation stage. However, he could solve the problem given. At the transformation stage, subject 4 only wrote how he would solve problem number 3.

In the process skills performed by subject 4, he did not solve by using the concept of linear equations from one variable he got. However, Subject 4 solves problems by developing his own problem-solving methods or using ways that he understands and can produce correct answers. Based on the results of interviews conducted, subject 4 and subject 6 can understand the purpose of the problem and can explain the solution even in a way that is different without using the concept of one linear equation variable. Although this is not wrong, students still need to explain using the concept of the equation and linear inequality of one variable under the problem-solving command.

At the Encoding stage, students write the results at the process skill stage without looking back whether the result is the answer to the process skill able to answer the question. Students assume the encoding stage only needs to write the final answer at the process skill stage or just write the conclusions. By only writing conclusions at the encoding stage, students already feel the answer is correct. However, some students did not write conclusions. This happens because the omission by the teacher and the teacher only prioritizes student answers without drawing conclusions.

4. Conclusion
Based on the results of the discussion and discussion, it can conclude that the results of the analysis of problem solving in SMP Negeri 2 Kebakkramat on the linear equation problem of one variable in the form of a story problem are (1) the reading stage, there are 16.67% who cannot write a mathematical sentence as students’ understanding of the problem, (2) At the stage of understanding, there are 4.17% of students who still cannot write anything that helps solve problems and are not used to writing, (3) the transformation stage, there are 75% of students unable to write a plan that the student will do to solve the problem, this is due by students not accustomed to planning the problem solving that they will do to the story problem, students are accustomed to solving problems at the process skill stage, (4) the process skill stage, there are 33.33% of students unable to solve problems due to lack of
understanding the problems and errors in changing into mathematical sentences, and (5) the encoding stage, students have drawn many conclusions from problem solving so that there are only 8.33% of students who do not write conclusions because of problem solving that cannot be done.

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