Error type analysis based on Newman's theory in solving mathematical communication ability of junior high school students on the material of polyhedron

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Abstract. This study aims to analyze students' mistakes in doing mathematical communication ability on polyhedron Newman error indicators. This research used a qualitative approach with a case study method. The subjects of the study were the eighth grade students of at one of the public high schools in the city of Bandung in solving questions about Building polyhedron. The research instrument was a test that was analyzed using the Newman error indicator. Based on the results of data analysis, it was known that the average mathematical communication ability of students were still low. The indications were: (1) 8.3% of students misread questions (do not know the meaning of the questions); (2) 13.3% of students misunderstood the questions for (did not know what to look for); (3) 30.0% of students incorrectly transformed questions (could not form the generating function of the questions); (4) 18.3% of students did not have process ability (errors in calculations); and (5) 21.7% of students mistakenly wrote the final answer (error writing the final answer to the problem).

1. Introduction
Mathematics is a subject that is studied from elementary school to university level. Mathematics is also a lesson that can build the character of students, therefore mathematics has a very important role for life. The National Council of Teachers of Mathematics (NCTM), sets standards of mathematical ability such as problem solving, reasoning and proof, communication, connections, and representations, should be able to be owned by students [1]. One of the most important abilities students have is mathematical communication ability. Mathematical communication is a way for students to express and interpret mathematical ideas verbally and in writing, both in the form of pictures, tables, diagrams, formulas, or demonstrations [2]. Mathematics has various characteristics and one of them has an abstract object. It is trait that causes many students to experience difficulties in mathematics. Difficulties experienced by students is probably occurs when students answer questions. Mathematics is one of the subjects that can have a great opportunity for students to make mistakes.

Errors can be considered as deviances from the accurate things which are orderly, reliable, and related in certain areas [3]. The characteristics of the problems experienced by students: 1) show lower learning outcomes ie below the average value; 2) the results achieved are not balanced with the effort done; 3) slow in carrying out learning tasks; 4) show inappropriate attitudes; 5) shows missbehave; and 6) show
emotional symptoms that are not reasonable [4]. While the causes of errors that are often made by students include due to lack of understanding of the prerequisite material and subject matter studied, lack of mastery of mathematical language, incorrectly interpreting or applying formulas, miscalculation, lack of accuracy, and forget / wrong concepts [5].

One of the materials in mathematics that requires students to have mathematical abilities is the material about building polyhedron. In the material of polyhedron, students are required to understand what is asked in the problem, understand the problem, and then communicate the answers in mathematical form. The stages of error analysis that are appropriate and that can be done in the form of mathematical communication problems are the stages of error analysis according to Newman (NEA).

NEA stands for Newman’s Error Analysis. NEA is designed as a simple diagnostic procedure in solving mathematical communication description problems. Newman stated that if students want to solve math problems, then students must go through 5 steps, namely asking students to: (1) read the questions (reading), (2) understand the problem (comprehension), (3) transformation, (4) process ability, and (5) writing the final answer (encoding) [6].

When students try to answer a problem, then the student has passed a series of obstacles in the form of stages in problem solving, which include: a) Reading a problem (Reading), when someone reads a text, then the reader will be represented according to his understanding of what he reads, or known as the result of representation of the mental abilities of the reader. Furthermore, students’ reading abilities in dealing with problems affect how students will solve problems; b) Understanding the problem (Comprehension), at this stage it is said to be able to understand the problem, if students understand from the intent of all the words used in the problem so that students are able to express the problem story with their own sentences. In this phase, the students are facilitated to find idea of problem through general story problem by WH-questions. Where the problem ideas in mathematics are represented in the elements known, asked and prerequisites. Furthermore, to check the ability to understand the problem, students are asked to mention what is known and asked in the problem; c) Transformation problem, at this stage, students try to look for a relationship between facts (known) and those asked. Furthermore, to check the ability to transform a problem that is changing the form of a story problem into its mathematical form, students are asked to determine what methods, procedures or strategies will be used in solving problems; d) Process ability, at this stage, students are asked to implement the design of problem solving plans through the stages of problem transformation to produce a desired solution. At this stage that is to check the processing ability or procedures, students are asked to solve story problems in accordance with the mathematical rules that have been planned at the stage of transforming the problem; e) Writing answers (Encoding), at this stage, students are considered have reached the stage of writing answers if students can write the answers asked correctly. Furthermore, to check the ability to write answers, students are asked to recheck the answers and students are asked to interpret the final answer [7].

At the junior high level, most errors on math tests and examinations are caused by reading, understanding or transformation of errors, or by carelessness. Often, students can do one or more four operations (+, -, x, ÷) needed to answer the question, but do not know which operation to use [8]. Language whether in teaching or learning mathematics is essential [9]. Other researchers also argue that deeper levels of mathematics are needed beyond procedural abilities, and that conceptual knowledge of mathematics is the goal [10]. So in summary, while language demands an important mathematics curriculum and needs to be developed, language also contributes to the difficulties experienced by students who struggle with mathematics. So the mathematics teacher must be aware of the problem of literacy and counting involves word problems. But surely this cannot be very important because students who reach elementary school and early high school can read, count, and write. [11].

The results showed that there were still quite a lot of class IX students of SMPN 1 Banyubiru who made mistakes in solving story questions on the material system of two-variable linear equations [12]. The results of other studies show that reading errors are 4.35%, understanding errors 17.39%, transformation errors 34.78%, and error processing ability 23.91%, and encoding errors 19.57%. The
student error factor does not absorb information well, not comprehending the transformation of the problem, not following the material clearly, and understanding mathematics from weak concepts [13].

The same thing is also suspected to have happened to students of class VIII at one of the public high schools in the city of Bandung in solving questions about Building polyhedron. Therefore, researchers conducted research with the aim of analyzing students' errors in working on mathematical communication ability on polyhedron using the Newman error category.

2. Methods
This study uses a qualitative approach because it examines the natural conditions of objects, researchers are key instruments, taking research subjects conducted purposively, carried out triangulation of data, data analysis is inductive / qualitative, and research results emphasize more on meaning rather than generalization [14]. Triangulation as a blend or blended of various methods utilized to study interconnected phenomena from different views and views [15]. Qualitative research is a type of research that explores and understands meaning in a number of individuals or groups of people stemming from social problems [16]. This study uses a case study method relating to the mistakes of students of class VIII of a public junior high school in Bandung in solving mathematical communication ability on the material to build polyhedron based on Newman's theory. The selection of research subjects is done, by using purposive sampling technique [17].

The instrument used in this study was a test in the form of a description arranged in accordance with indicators of mathematical communication ability in the material of polyhedron as much as 4 items. Mathematical communication indicators in this study: (1) Writing situations, drawings, diagrams, or real objects into language, symbols, ideas, or mathematical models; (2) Representing mathematical, reasonable, and correct explanations; and (3) Arranging their arguments in a mathematical description or paragraph that is arranged logically and mathematically. The validity derives from expert judgment.

The classification of students' mistakes in working on mathematical communication ability according to Newman's theory refers to the following Table 1.

| Stages in Newman Error Analysis | Error Indicator |
|-------------------------------|----------------|
| Reading                       | Students wrong in reading terms, symbols, words or important information in the problem. |
|                               | a. Students do not know what is actually asked about the problem. |
| Comprehension                 | b. Error capturing information in the problem so that it cannot resolve to the next process. |
|                               | c. Students write what is known and asked exactly the same problem but does not continue the process. |
| Transformation                | a. Students fail to change to the correct form of mathematical models. |
|                               | b. Students incorrectly use arithmetic operations marks to solve problems. |
|                               | c. Students have changed the information to the problem, but do not write the full information (in tens, hundreds, or thousands). |
| Process skill                 | a. Students are wrong in calculations or computing. |
|                               | b. Students do not continue the completion procedure. |
|                               | c. Students continue the computational process but it is not right because there is an algebraic concept. |
| Encoding                      | a. Students can not write the final answer requested by the problem. |
Stages in Newman Error Analysis

| Error Indicator                                                                 |
|--------------------------------------------------------------------------------|
| b. Students cannot deduce answers according to mathematical sentences.          |
| c. Error due to carelessness or inaccuracy                                      |

3. Result and Discussion

The results of data analysis about students’ mistakes in doing mathematical communication ability based on Newman’s theory can be seen in Table 2.

### Table 2 Categories of Student Error Types

| Error Type | Number 1 | Number 2 | Number 3 | Number 4 | Average Error |
|------------|----------|----------|----------|----------|---------------|
| Reading    | 3.3%     | 10.0%    | 6.7%     | 13.3%    | 8.3%          |
| Comprehension | 6.7%     | 3.3%     | 20.0%    | 23.3%    | 13.3%         |
| Transformation | 26.7%    | 30.0%    | 33.3%    | 30.0%    | 30.0%         |
| Process skill | 10.0%    | 13.3%    | 16.7%    | 33.3%    | 18.3%         |
| Encoding   | 23.3%    | 20.0%    | 16.7%    | 26.7%    | 21.7%         |

For item 1, reading errors (3.3%), understanding errors (6.7%), transformation errors (26.7%), process ability errors (10%), and writing errors (23.3%) occur. This means that all students tend to make mistakes in writing or notation and when doing transformation. Most of the transformation errors in problem number one are caused by students making mathematical models, but do not add information clearly. In the type of process skill errors, most of them are caused by miscalculations or not continuing the calculations. Whereas the type of writing error or notation, mostly caused by students not careful in the use of units such as square or cubic writing;

For item 2 number read errors (10%), understanding errors (6.7%), transformation errors (30%), process ability errors (13.3%), and notation writing errors (20%). This means that students have not been able to change to the correct form of mathematical models, it is seen in the error of transformation which has the highest percentage. Reading errors are caused because students are still confused with the pictures provided. Mistakes of understanding type are caused by students writing down what is known and asked exactly as written in the problem but they do not continue the other processes. The type of process skill error in this number is largely due to an error between using the volume formula or the surface area formula. The wrong type of writing notation in question number 2 is students cannot answer the question in question.

For item 3, reading errors occurred (6.7%), understanding errors were (20%), transformation errors (33.3%), processing ability errors (16.7%), and notation writing errors (16.7%). Process skill errors and notation writing errors have the same percentage. In problem number 3, the biggest transformation error. This is because students are confused to use formulas, so that many answer them carelessly.

For item 4, reading errors occur (13.3%), understanding errors are (23.3%), transformation errors (30%), process skill errors (33.3%), and notation writing errors (26.7%). The biggest process skill error, because students do not continue the completion procedure. The difficulties of questions are criticised by many students.

In general, the average student error in reading was 8.3%, the average student error in comprehension was 13.3%, the average student error in transformation was 30%, the average student error in process ability was 18.3%, and the average student error in notation is 21.7%. This means that there are still quite a lot of students who experience errors in working on mathematical communication problems. Here is a large graph of the average student error in answering students’ mathematical communication problems based on Newman's theory.
Based on the graph above, the most errors students make in solving mathematical communication problems occur in transformation errors. On the other hand, the fewest mistakes students solve mathematical communication problems occur in reading errors. The following is the sequence of the most errors until the smallest starting from transformation errors, notation errors, error in process ability, misunderstandings and finally reading errors. Transformation errors become illustrations of the most mistakes in students. Error transformation on students is the first student fails to change to the form of a mathematical model as students are rarely given story problems and the teacher always gives questions in the form of ordinary counts. The second transformation error is students are wrong in using arithmetic operations or formula use. This happens because students have not been able to distinguish the volume formula from the surface area formula. The third transformation error is that student change information but it is incomplete as a unit value. This happens since the teacher does not pay attention to the units used by students in answering questions. It causes students to have the habit of ignoring the unit in solving problems.

4. Conclusion
The types of errors experienced by students of class VIII in solving mathematical communication problems for the material on polyhedron are reading errors of 8.3%, understanding errors 13.3%, transformation errors 30%, processing ability errors 18.3%, and notation errors of 21.7%. The results of this study indicated that students’ mathematical communication ability were still not optimal because there were still many errors when solving problems. Almost half of all students were not able to absorb information properly, students did not understand what is problem transformation, students did not understand the material fully, weaknesses of the prerequisite concepts owned by students, lack of student experience in doing problems, students were not careful and thorough in the process of doing task and students have not been able to answer with mathematical symbols or images.

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