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Analysis of Learning Barriers and Elementary School Students' Errors in Solving Mathematical Story Problems

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ABSTRACT

The errors made by students can be used as a benchmark for students' understanding of the material. This study aims to determine the obstacles to students' learning in solving mathematical story problems based on Brousseau & Balacheff's theory, to find out students' errors in solving mathematical story problems based on Newman's Error Analysis theory, and the factors that cause students to make mistakes in solving mathematical story problems. This research was conducted at MI GUPPI Wironanggan from September 2023 to March 2024. The subjects of this study were grade V students. The type of research is qualitative. Data collection used semi-structured interviews and observations. This study uses supporting instruments like mathematical story problems on speed and discharge material. The data analysis technique uses source triangulation and technique triangulation. The results of this study are the existence of learning obstacles experienced by students, including Ontogenic Obstacles, Didactic Obstacles, and Epistemological Obstacles; the errors made by students include errors in reading, understanding, transforming, and concluding. Several factors that cause student errors include low accuracy in solving problems, not memorizing formulas and not understanding their use, and low student ability in performing arithmetic operations. Based on the study results, teachers are expected to increase the intensity of giving varied questions at various levels.

INTRODUCTION

The essence of mathematics learning lies in developing logical, critical, and systematic thinking skills that are the basis for solving problems in everyday life. Mathematics is related to formulas or numerical calculations and understanding and applying abstract concepts that can broaden a person's insight and analytical abilities. Effective mathematics learning helps students connect theory with practice and improve deductive and inductive thinking skills

needed in various fields of science and professions. According to the NCTM (National Council of Teachers of Mathematics), the essence of mathematics learning is to develop the ability to communicate mathematically, solve problems, and model real situations with mathematical concepts (NCTM, 2000). Learning that focuses on understanding concepts, not just memorizing formulas, helps students become more critical and creative thinkers in facing complex challenges. Mathematics learning plays an important role in everyday life. Mathematics is a basic skill useful in everyday life and future careers (Dewi et al., 2023). However, many students still think that mathematics is a difficult subject. As found in class V MI GUPPI Wironanggan, 19 out of 24 students think mathematics is difficult because it uses too many formulas.

The presentation of mathematical problems is not only in the form of symbols, pictures, or numbers. However, it can also be in the form of verbal sentences or what is commonly called story problems (Goldin, 1998). Solving mathematical story problems requires both arithmetic skills and the ability to reason and understand what is known and what is asked in the problem. In line with Laily's opinion (2014), various skills are needed to solve problems, such as reading and understanding problems, making mathematical models, performing arithmetic operations, and drawing conclusions.

Based on the results of initial observations, many students in class V MI GUPPI Wironanggan still make mistakes in solving mathematical story problems, even though the problems given are simple. Research conducted by Sari and Najwa (2021) also found several errors made by students, such as 1) conceptual errors, where students do not understand the problem and cannot determine the formula; 2) procedural errors, where students cannot carry out the steps to solve the problem correctly, and 3) errors in arithmetic operations. Errors made by students need to be identified as evaluation material to improve student understanding and learning outcomes. So that teachers can create more appropriate learning strategies to minimize the occurrence of the same errors in students solving story-based math problems.

Students' inability to understand the context of story problems can hinder their ability to apply mathematical concepts in real situations, even though the questions are relatively simple. This condition can confuse applying the correct formula or method and reduce their confidence in solving math problems effectively. Hiebert and Grouws (2007) stated that errors in solving story problems occur due to a lack of in-depth understanding of the concepts being taught, resulting in difficulty linking mathematical concepts to real-world situations.

In addition, as stated by Fuadiah (2016), mistakes made by students are a sign that the student is experiencing learning obstacles. Learning obstacles can occur, one of which is due to

misconceptions between students and learning. The impact of learning obstacles on students is that learning activities are less than optimal, and learning achievement is low.

The learning obstacles that occur in students must vary; a study by Ulfa (2021) found that learning obstacles include weak learning motivation and limited student understanding of the material. Learning obstacles need to be analyzed to evaluate learning so that it is effective. In line with Hamalik's opinion (2015), teachers must analyze learning obstacles to improve the quality of education. Research by Sudrajat and Anggrella (2023) shows that internal and external factors influence student learning obstacles.

Identifying and understanding the difficulties faced by fifth-grade students of MI GUPPI Wironanggan in solving mathematical story problems is important. These difficulties can be an inability to interpret the problem correctly or choose the right solution strategy. By analyzing students' obstacles and errors, this study provides a clear picture for educators to design a more effective learning approach. In addition, the results of this study are expected to help students improve their mathematical problem-solving skills while building their motivation and confidence in facing the challenges of learning mathematics (Dwidarti, et al,. 2019; Noviantii & Maimunah, 2020).

This study focuses on analyzing learning barriers based on the theory of Brousseau & Balacheff (1988). Also, it uses Newman's Error Analysis theory (Wicaksono, 2021) to analyze the variations in errors made by students in solving story problems along with the causal factors. This result differs from other studies, which only aim to discover learning barriers or student errors. In this study, learning barriers and student errors will be analyzed simultaneously.

METHOD

This study uses a qualitative method with a case study approach. Researchers explore and understand the factors that cause students' difficulties in solving mathematical story problems. Through a qualitative approach, researchers collect data through observation, interviews, or document analysis to identify the obstacles students face in understanding mathematical concepts, problem-reading skills, and cognitive errors that arise during the problem-solving process. Researchers then analyze the data in depth to find patterns and provide a clearer picture of the factors that effectively influence students' performance in solving mathematics problems. The subjects of this study were grade V students of MI GUPPI Wironanggan in the 2023/2024 academic year, with the informant being the grade V mathematics teacher. This

study was conducted from September 2023 to March 2024. The data collection techniques used were semi-structured interviews and documentation. Interviews were conducted with five randomly selected students and the grade V mathematics teacher, who were randomly selected to avoid the same answers. The questions in this study include the types of errors that students often make, both related to calculations and understanding the language of the questions, as well as factors that influence students' abilities, such as reading ability and external factors. In addition, this study aims to identify solutions or strategies that teachers can apply to overcome obstacles and reduce student errors in solving mathematical story problems. In addition, this study uses supporting instruments in the form of story problems on speed and debit material.

The supporting instruments are used to determine the location of errors made by students and as a reference for in-depth interviews. The data obtained were tested for validity using source triangulation and technique triangulation. Then, the data was analyzed using the Miles and Huberman model analysis, which included data reduction, data presentation, and conclusion.

RESULTS AND DISCUSSION

After being given supporting instruments in the form of mathematical story problems on speed and discharge, students' answers were classified based on Newman's Error Analysis theory on each question item. The goal was to discover where students made mistakes in solving story problems. Then, five students were randomly selected to be interviewed in-depth to discover the factors causing errors and learning obstacles in students.

Student Learning Obstacles in Solving Mathematical Story Problems

Based on the theory of Breusseau and Balacheff (1988), learning obstacles are divided into 3, namely: 1) ontogenic obstacles, 2) didactic obstacles, and epistemological obstacles :

Ontogenic obstacles

Ontogenic obstacles can be interpreted as learning obstacles that occur due to student readiness factors in the learning process (Bintara, 2021). There are three types of ontogenic obstacles, namely: 1) psychological ontogenic obstacles, 2) instrumental ontogeny barriers, and conceptual ontogeny barriers. After conducting analysis and interviews, two types of ontogeny barriers were found that occurred in grade V students of MI GUPPI Wironanggan in **Figure 1** as follows:

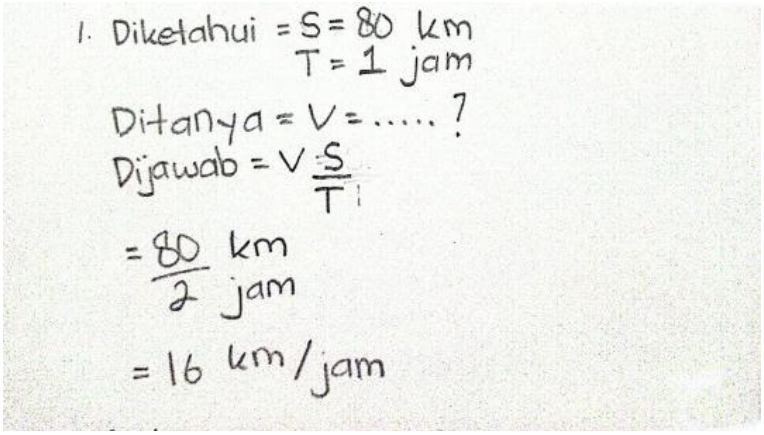

Figure 1. Ontogeny Barriers

In the picture above, one of the students experiences two types of ontogeny obstacles, namely 1) conceptual ontogeny obstacles, where the student's learning demands are higher than the student's abilities. This result is evidenced by the student's basic ability to perform arithmetic operations, which is still lacking, so to follow higher material, the student experiences difficulties or is hampered. 2) psychological ontogeny obstacles, shown through student interviews, where students stated that they were less interested in the debit material and did not respond to the teacher during the learning process. The final impact is that students do not understand the debit material, so they cannot answer the questions given, and the results obtained are less than optimal.

Didactic obstacles

Didactic learning obstacles occur due to miscommunication during the learning process with theoretical presentation of material. As a result, students look for instant ways to solve problems (Fauzi & Suryadi, 2020). This result was found in one of the fifth-grade students of MI GUPPI Wironanggan. During an in-depth interview, the student admitted copying his friend's answer because he did not understand how to solve it.

Epistemological obstacles

Didactic learning obstacles can occur because students do not understand the material as a whole and only remember the material that is considered easy (Setiawan, 2020). After the interview, it was found that students experienced epistemological obstacles. The students' statements proved that they only remembered the speed material, which was considered easier than the debit material. Not only that, the student also did not remember the formula for solving the speed material questions as a whole.

Interviews were conducted with five students; here are some answers from students who had difficulty understanding the debit material and expressing the many formulas.

Researcher: "Now I want to ask, what about the questions you gave?"

Informant: "It's difficult, sis"

Researcher: "Where is it difficult, sis?"

Informant: "I don't understand the debit material, sis."

Researcher: "The teacher has taught it, right?"

Informant: "I have, sis, but when the teacher explained it, I didn't respond."

Researcher: "Why is that?"

Informant: "Because it's confusing, sis, there are too many formulas and numbers, like thousands."

Student Errors in Solving Mathematical Story Problems

Errors are a form of deviation from predetermined steps or procedures (Rohmah, 2021). Based on Newman's Error Analysis theory, students' errors in solving mathematical story problems are divided into 5, namely: reading errors, comprehension errors, transformation errors, skill errors, and encoding errors. Students in grade V of MI GUPPI Wironanggan made many transformation errors with 18 students, skill errors with 18 students, and Encoding Errors with 17 students. The following are the findings obtained by researchers in grade V MI GUPPI Wironanggan.

Reading errors

Based on in-depth interviews conducted, it was found that students made reading errors. This result is shown through students' statements that they did not read the entire question. The students assumed that all the units in the question were the same despite being different. Students who make reading errors will have difficulty in the next stage. In line with the opinion of Lutvaidah and Hidayat (2019), in solving story problems, great care is needed in reading the questions to avoid making mistakes because there is insufficient information.

Reading comprehension errors

Comprehension errors are continuously impacted by reading errors. The understanding in question is understanding what is known and what is asked in the question. After conducting interviews, it was found that students experienced comprehension errors because they were not careful in the reading process.

Transformation errors

One crucial aspect in solving math problems is the ability of students to transform information from the problem into a formula or correct solution steps. However, students still have difficulty transforming information, as shown in **Figure 2**:

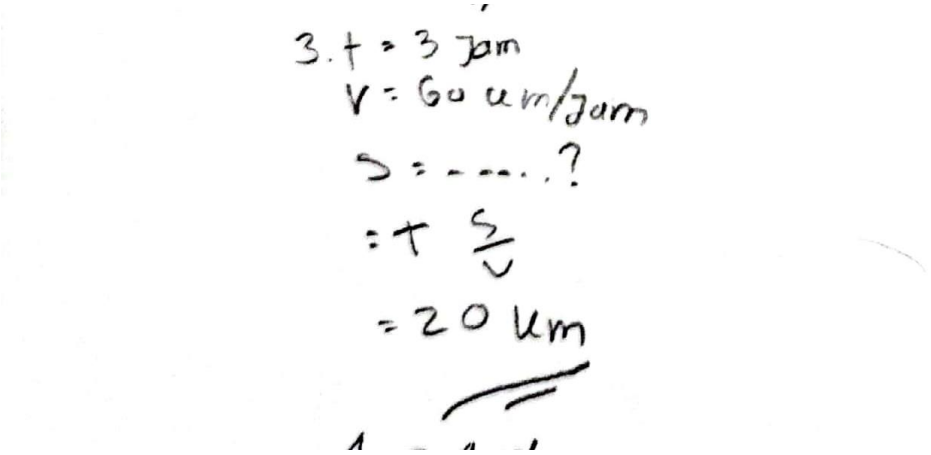

Figure 2. Student's difficulties in information transformation

The image above shows that a fifth-grade student of MI GUPPI Wironanggan experienced a transformation error. This result is indicated by the formula chosen by the student to solve the wrong problem. Students can already understand and correctly write down what is known and asked in the problem. Research conducted by Sari & Najwa (2021) found that 30% of students experienced transformation errors. Determining the formula is the key to solving the problem.

Skill errors

The ability to solve mathematical story problems requires conceptual understanding and skills in applying operational steps correctly. However, there are still errors in skills, as shown in **Figure 3.**

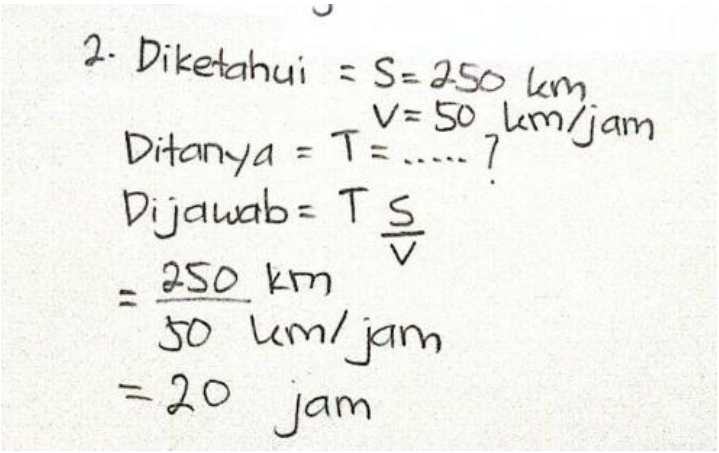

Figure 3. Skill errors

The picture above shows that one of the fifth-grade students of MI GUPPI Wironanggan experienced a skill error. The skill in question is the process of performing arithmetic operations. As research conducted by Utari and Damayani (2019) shows, 10 out of 15 students experienced skill errors in solving mathematical story problems.

Encoding errors

Concluding is the last stage in solving problems. The error found is an incorrect use of units as

requested in the problem and even not writing the final answer to solve the problem, as shown in **Figure 4.**

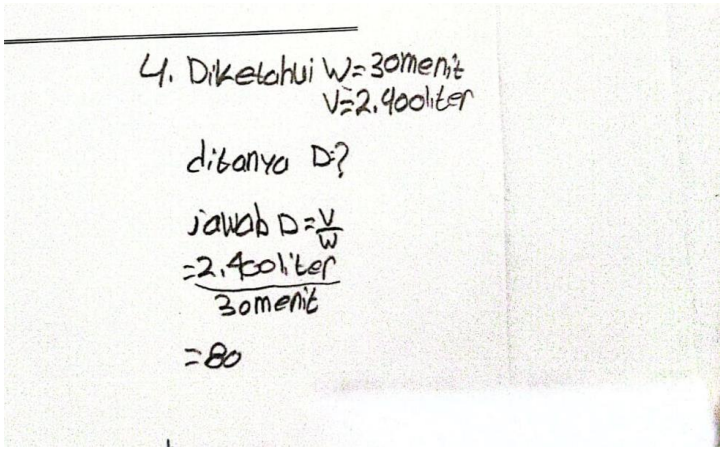

Figure 4. Conclusion Error

The picture shows that students experience Encoding Errors, namely not writing the units according to those requested in the question. Even though the student has done the arithmetic operation well, the step is still incomplete. Research conducted by Savitri and Yuliani (2020) also found that 47% of students experienced Encoding Errors, namely not writing the final answer, not using units, and using the wrong units.

Factors Causing Students to Make Mistakes in Solving Mathematical Story Problems:

The factors that cause students to make mistakes need to be analyzed to help teachers determine the right solution so that the same mistakes will not occur later (Harahap, 2019). Through the results of the analysis and interviews, several factors were found that caused fifth-grade students of MI GUPPI Wiroanggan to make mistakes in solving story problems, namely as follows:

Students are not careful when reading the questions.

Reading the questions is the earliest stage in solving math story problems. At the reading stage, students will learn what is known and what is asked in the question. However, students often only skim the questions, so some information is missed. Most of the information students miss is about units known in the question and units requested in the question. The impact is that students do not convert to different units, so the final answer is incorrect. This result aligns with research by Rejeki & Sari (2021) that if students write down the information they know incorrectly because they are not careful, it will impact the steps in solving math problems. This finding aligns with the research results by Rohman and Sutiarso (2018), which show that students' lack of accuracy and caution in solving problems is the main factor causing calculation errors.

Students are in a hurry to solve the problem.

This factor is one of the factors that causes students to make the most mistakes. Elementary school students are happy when competing with their peers. In addition, students often feel that the time is given to solve the problem. So often, students are in a hurry to read the problem and do arithmetic operations; this causes students to make many mistakes in solving mathematical story problems. In solving mathematical story problems, it is necessary to understand the problem and have good calculation skills.

Students do not memorize and understand the formulas that can be used to solve problems.

Formulas are one of the keys to solving math story problems. In each math material, sometimes there is not only one formula but two to three formulas that students must master. Suppose students do not understand the meaning of the formula. In that case, they will have difficulty connecting the formula with the context given in the story problem, affecting the answers. This result is in line with the opinion of Rejeki & Sari (2021) that at the stage of understanding errors, students make mistakes such as a lack of understanding of what is being asked in the problem, as well as failing to recognize important information or figures, in addition to a lack of accuracy in working on the problem. This statement aligns with the findings of Retnowati et al. (2018), which state that students' incomplete understanding of the problem will impact the relevant information from the problem. A similar statement was expressed by De Bock et al. (2002), who found that calculation errors occurred because students could not use the algorithm sequentially and correctly. This error was caused by students' forgetfulness in determining which operations should be carried out first and a lack of accuracy during the calculation process. 4. Students cannot perform arithmetic operations properly.

Students do not understand the operating procedures, forget the calculation steps, or are inaccurate when performing computations. This result impacts the inaccuracy of the final results in the questions. This result is in line with the research of Rejeki and Sari (2021), which states that errors in solving mathematics problems are caused by students making mistakes in computing and being less skilled in the calculation process.

Students do not recheck the answers that have been written

Rechecking the answers is the final stage to ensure that the answers are correct. However, many students still do not recheck the answers written because they already feel correct or are in a hurry to collect the answer sheets from the teacher.

Students learning barriers in mathematics, including ontogeny, didactic, and epistemological barriers, are related to the types of errors made in solving story problems. Ontogeny barriers are related to student's cognitive development, such as reading or reading comprehension errors, which can occur

because reading and understanding text skills are not fully developed. Didactic barriers include how the material is taught, which affects students' ability to transform errors and master skill errors; if the teaching method is inadequate, students may make mistakes in applying the correct formulas or algorithms. Meanwhile, epistemological barriers related to students' understanding of mathematical concepts can cause errors in the data transformation process and in compiling the correct solution steps (encoding errors) because students do not fully understand how to connect the problem to relevant mathematical knowledge. Thus, these barriers directly contribute to students' errors in solving math story problems.

CONCLUSION

This study shows that fifth-grade students of MI GUPPI Wironanggan experience various obstacles and errors in solving mathematical story problems on the material of speed and discharge. Based on the analysis with Newman's Error Analysis theory, student errors are divided into five categories: reading errors, understanding errors, transformation errors, skill errors, and conclusion errors. The factors causing these errors include lack of accuracy in reading the questions, rushing in the work, not understanding the formula, and the inability to perform arithmetic operations properly. In addition, student learning obstacles are also categorized into three types, namely ontogeny, didactic, and epistemological obstacles. To overcome this problem, special attention is needed from teachers to increase student accuracy when reading questions, help students understand the formulas used in story problems, and provide opportunities to improve their arithmetic operation skills. In this way, it is hoped that students can reduce errors and improve their ability to solve mathematical story problems more effectively.

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