Analysis of Students' Difficulties in Solving Numeracy Problems Based on Pólya's Theory

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Abstract. This study uses a qualitative descriptive method to describe the difficulties faced by fifth-grade elementary school students in solving numeracy problems. The focus of this research is on numeracy content, covering basic mathematical operations and word problems, analysed based on specific indicators of students' numeracy skills. Data collection techniques involved administering numeracy problem tests and conducting in-depth interviews with several students as research samples. The results indicate that most students experience difficulties in understanding and solving word problems, especially in determining the appropriate solution steps. Students with high proficiency levels demonstrate good comprehension of the problems and are able to plan and execute solution steps adequately. Meanwhile, students with low proficiency levels generally struggle with planning solution steps, performing calculations accurately, and reflecting on the final results obtained. The conclusion of this study highlights the need for more interactive teaching strategies, the use of visual aids, and varied problem-solving exercises to help students overcome difficulties in understanding and solving numeracy problems.

Keywords: Numeracy, Pólya's Theory, Problem Solving, Elementary School

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INTRODUCTION

Based on the results of the Program for International Student Assessment (PISA) issued by the Organisation for Economic Co-operation and Development (OECD), Indonesian students' mathematical literacy is ranked 69th out of 81 countries. Although the ranking has increased, the results or values are still worrying. Of the 14,340 students, only 0.1% (14 people were able to complete level 5 and 6 questions), and there were 8,461 students who were unable to complete level 2 questions and above (OECD, 2023). In line with these findings, researchers tried to provide a numeracy test using ANBK (Asesmen Nasional Berbasis Komputer) questions given to 5th grade students. The results found that the average student score only reached 10 out of a total score of 100. This very low score indicates that students have difficulty in solving numeracy problems. After being investigated, it was discovered that one of the main causes of students' difficulties was their inability to solve mathematical problems effectively.

Numeracy ability can be interpreted as a person's ability to formulate, apply and interpret mathematics in various contexts, including the ability to reason mathematically and use concepts, procedures and facts to describe, explain or predict phenomena/events (Ekowati et al., 2019). Another opinion states that numeracy is the ability to interpret and apply the concept of arithmetic operations and numbers in everyday life (Pendidikan & Kebudayaan, 2017; Setiyawati et al., 2024; Susilawati et al., 2024). Meanwhile, mathematical literacy is defined as an individual's ability to formulate, apply, and interpret mathematics in various contexts. This ability includes mathematical reasoning and the ability to use mathematical concepts, procedures, facts and mathematical functions to describe, explain and predict a phenomenon

(OECD, 2013). Based on several opinions above, it can be concluded that numeracy is the initial foundation needed for students to develop in mathematical literacy. Numeracy equips students with basic skills, while mathematical literacy prepares them to think deeply, critically, and be able to apply mathematics in various more complex life contexts.

Low mathematical literacy skills have the potential to hinder individual development in academics and work and worsen socio-economic inequality in society. UNESCO (United Nations Educational, Scientific and Cultural Organization), an international organization engaged in education, has proclaimed its slogan, namely "Literacy for All". This slogan affirms the right of every human being to be "literate" as capital to face life. Literacy empowers individuals, families, and communities to improve their quality of life. Furthermore, literacy has a multiplier effect, namely eradicating poverty, reducing child mortality, curbing population growth, achieving gender equality and ensuring sustainable development, peace, and democracy (UNESCO, 2005).

In response to the PISA results, the Indonesian government launched the Minimum Competency Assessment (AKM) which also replaced the National Examination (UN). So far, the UN has been the main factor in determining whether or not students graduate from school. However, this has changed since 2021, where the AKM was implemented by the Indonesian government as a replacement for the UN (Rijoly, 2021). AKM is a policy released after the announcement of the 2018 PISA scores by the Minister of Education and Culture (Mendikbud) regarding the independent learning policy (Sholehah et al., 2022). This policy is expected to help students develop their basic skills so that they can be independent and participate in positive activities in the community. Meanwhile, the community considers that, with the AKM, students not only memorize theories, but also begin to learn to understand, reason, and apply basic concepts directly such as in reading literacy and numeracy (Muta'ali, 2020; Rini et al., 2021; Sari et al., 2021).

Some experts argue that AKM is a basic competency assessment by all students to develop their capacity and participate positively in society and government. This is done to accustom students to critical thinking that is appropriate to their daily context (Ayuningtyas & Sukriyah, 2020; Harfiyani & DI, 2018). AKM is only applied to students in grades V, VIII, and XI in the form of assessments on two competencies, namely literacy and numeracy (Sulastini & Handajani, 2021). Based on this opinion, it is known that one of the aspects tested is numeracy which is part of mathematical literacy. Meanwhile, the numeracy content in AKM consists of numbers, geometry, measurement data, algebra, data and uncertainty (Kemdikbud, 2020).

Problem-solving ability is an essential aspect in learning mathematics. Some opinions say that one of the goals of learning mathematics in schools is to solve problems that include the ability

to understand problems, investigate problems, collect problems, design mathematical models, solve models, and interpret the solutions obtained (Daulay & Ruhaimah, 2019; Widyasari & Rosiyanti, 2018). This indicates that problem solving is one of the most important skills where mathematical knowledge and skills are used at the highest level (Jawad et al., 2021; Maulyda et al., 2019; Saygılı, 2017; Zamnah, 2021). Problem solving is also part of life skills which consist of analysis, interpretation, prediction, evaluation, and reflection (Anderson, 2009; Tambunan, 2019; Ulya, 2016). Some experts say that a problem is a gap between the current situation and the future situation or desired goal (Anderson, 1980; Treen et al., 2020; Tsfati et al., 2020). This ability is very necessary for students in relation to the students' needs to solve problems they face in everyday life and be able to develop themselves (BK & Hamna, 2021; Darmawan & Suparman, 2019; Mulyati, 2016; Nadila et al., 2023).

In relation to problems in mathematics, there is one theory that is often used, namely Pólya's theory. The problem-solving theory developed by Pólya, which emphasizes four important steps: understanding the problem, planning a solution, implementing the plan, and evaluating the results (Pólya, 2014). Pólya emphasized that the problem-solving process requires not only conceptual understanding but also effective strategies in solving it.

According to Pólya, there are four basic principles in problem solving. The first principle is understanding the problem, which is the initial and very important step in solving a problem. At this stage, we need to identify the problem at hand, understand the conditions and data available, and sort out those conditions. Questions such as, "What is the problem at hand?" or "What are the conditions and data?" are part of this process. After understanding the problem, the next step is to make a plan. Making this plan involves finding the relationship between known data and unknowns, and considering whether there are similar problems that have occurred before and can be used as references. The third stage is implementing the plan. At this stage, the plan that has been made is carried out with the aim of finding a solution. Each step needs to be checked carefully to ensure that the method used is correct. The last principle is to look back, which is to evaluate and review the solutions that have been found. This is important to ensure that the resulting solution is effective and in accordance with the problem at hand. These four principles provide a systematic framework for solving problems effectively (Auernhammer & Roth, 2021; Holmes & Tuomi, 2022; Pólya, 2014). Based on the explanation above, the researcher intends to conduct research that explores students' difficulties in solving AKM questions based on Pólya's theory.

Previous research was conducted by Iswara (2022) which aims to analysed students' numeracy literacy skills in ethnomathematics-based problem solving in 28 fourth grade elementary school students. The results show that students' numeracy literacy skills in level 1

questions are classified as high, while for levels 2 and 3 they are categorized as moderate. Limitations in the problem understanding stage cause students to have difficulty in planning, implementing, and reviewing solutions. This is driven by low numeracy skills and the immaturity of students' mathematical concepts.

Yeni (2020) also examined the difficulty of solving problems of fifth grade students based on Newman's theory in fraction material. Based on research on 34 students, it was found that students faced difficulties in understanding questions, mathematical concepts, procedures, and representation of problems in mathematical models. Students also tend not to re-evaluate the answers given, so that errors are often not detected.

The study of Logistica and Awalludin (2024) focused on analysing students' errors in mathematical literacy and numeracy. The results showed variations in errors depending on the students' ability level: students with high abilities generally had difficulty at the understanding stage, while students with medium and low abilities made errors at almost all stages. These findings are expected to help educators in designing strategies to reduce these errors.

Based on a review of previous research, research on students' difficulties in numeracy literacy and mathematical problem solving has been conducted, but each focuses on different aspects. Iswara (2022) analysing ethnomathematics-based numeracy literacy skills in grade IV students, with the finding that students have limitations in planning and implementing solutions due to lack of numeracy skills. Yeni (2020) focuses on students' difficulties in solving fraction problems using Newman's theory, while Logistica and Logistica and Awalludin (2024) analysing the error rate in mathematical literacy and numeracy questions in students with various ability levels.

Based on previous research, there has been no research that specifically analyses the difficulties of fifth grade students in solving numeracy problems based on the stages of problem solving according to Pólya's theory. Therefore, the title of the research that will be taken in this study is "Analysis of Students' Difficulties in Solving Numeracy Problems Based on Pólya's Theory". The novelty of this research lies in its focus on identifying the stages of students' difficulties based on the steps of Pólya's theory (understanding the problem, planning, implementing, and reviewing), which are expected to provide new insights to improve students' numeracy skills as a whole. Based on the title of the research, the objectives of this study are to (1) analyse student error patterns in solving numeracy problems; and (2) identify factors that influence students' difficulties in solving numeracy problems.

METHODOLOGY

This study uses a qualitative research approach. Qualitative research is research that seeks to understand phenomena in their original environment and context without manipulating what is observed (Sarosa, 2012). Then the research design used is descriptive research, namely research that aims to describe a situation or phenomenon as it is (Sukmadinata, 2019). The subjects used in this study were 9 fifth grade elementary school students, six male and three female.

The data collection technique was carried out by providing test questions in the form of numeracy questions followed up with interviews with each student. The number of questions given to students was 7 items with a time limit of 60 minutes. In addition to looking at the scores obtained by students from working on the AKM numeracy questions, the researcher also considered the student's completion process written on the answer sheet. The numeracy question indicators can be seen in Table 1, while the interview indicators can be seen in Table 2.

Table 1. Indicators for Numeracy Questions

Indicator	Description
Measurement	Measuring students' ability to calculate length, area, volume, time, weight, and use relevant units of measurement. This indicator includes an understanding of the concept of size and its application in the context of everyday life.
Geometry	Identifying and understanding geometric shapes, their properties, and spatial relationships between them. This indicator includes recognition of plane shapes, spatial shapes, angles, and symmetry.
Number	Measures students' ability to understand, calculate, and operate numbers, including whole numbers, fractions, decimals, and percentages. This indicator also includes the application of number concepts in problem solving.
Uncertainty	Measures students' ability to read, analyze, and summarize data from graphs, tables, or diagrams. This indicator also includes an understanding of probability and basic statistics to make predictions or decisions.

After being collected, the students' answers will then be analyzed. Data analysis in this study was carried out through three main stages. The first stage is data reduction, where data from students' answer sheets is reduced by recording error patterns, work steps, and scores. In

addition, data from interviews is recorded and transcribed to identify the factors of difficulty faced by students. The second stage is data presentation, where the reduced data is presented in the form of tables and narrative descriptions. Tables are used to display student error patterns, while narratives describe the difficulty factors found from interviews. The last stage is drawing conclusions, where conclusions are drawn based on the analysis of student error patterns and identified difficulty factors. By implementing these steps, the study was able to provide a comprehensive picture of error patterns and factors that influence students' difficulties in solving numeracy problems.

Table 2. Interview Indicators

Indicator	Description
Perception of Mathematics	Explore students' views on mathematics, including their likes, interests, and feelings about the subject.
Experience with Numeracy Problems	Identifying students' previous experiences in working on numeracy problems, including their level of difficulty and familiarity with the type of problem.
Identifying Specific Difficulties in Numeracy	Analyze certain parts of a numeracy problem that students find difficult, such as calculations, understanding the problem, or solution steps.
Resolution Strategies and Sources of Help	Understanding the strategies students use to solve numeracy problems and the sources of help they rely on, such as teachers, friends, or learning materials.
Perceptions of Learning Process and Environmental Support	Identifying students' views on the mathematics learning process in the classroom and the extent to which the environment supports them in learning.
Impact of Hardship and Need for Assistance	Examining the impact of students' difficulties on their motivation to learn and the type of assistance they need to overcome these difficulties.

RESULTS AND DISCUSSION

In this section, the research results are presented in the form of a table to provide an initial overview of the level of student success in answering questions based on the type of questions given. Furthermore, the results are analyzed in depth based on each question category, namely measurement, numbers, geometry, and uncertainty. Table 1 is the data on the results of student evaluations based on the type of questions given. This table shows the number of questions in each category, the number of questions successfully answered, and the number of students who were able to answer questions correctly for each category.

Table 3. Student Evaluation Result Data

No	Type of Questions	Number of Questions	Successfully Answered Questions	Number of Students Who Successfully Answered the Questions
1	Measurement	5	1	1
2	Number	5	1	3
3	Geometry	5	2	3
4	Uncertainty	5	3	5

The results of the analysis showed different success patterns for each type of question. For the measurement category questions, only one student was able to answer one question correctly out of the five questions given. In the number category, there were three students who managed to answer one question out of the five questions provided. Furthermore, in the geometry questions, two questions were answered correctly by three students. Finally, for the uncertainty questions, five students managed to answer three questions correctly. Further analysis was conducted to understand the factors that influence the level of success in each question category, both in terms of students' difficulty in solving the problem and other factors that influence it.

1. Students' Difficulty in Solving Numeracy Problems based on Pólya Theory

In this section, we will discuss how students' difficulties in solving problems are seen from Pólya's Theory. The discussion will be divided into four parts based on the type of questions given, namely numbers, measurements, geometry and uncertainty.

a. Measurement

In this category, the student success rate is very low. Of the five questions given, only one question was answered correctly by one student. This shows that the material on measurement is likely to be a significant challenge for most students. It also shows that students' ability to

solve measurement problems is very low. Figure 1 shows some examples of student answers to questions with a measurement aspect.

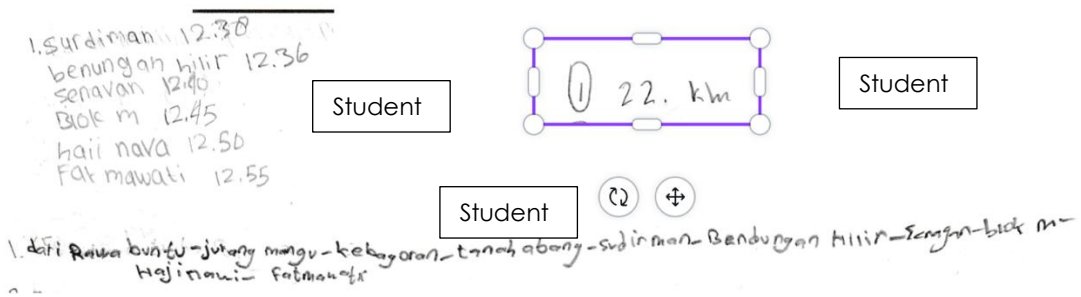

Figure 1. Example of Student Answers to Measurement Questions

In this question, students are given pictures of several travel options to a place. Then students are asked how many choices can be used. The answer to the question is "KRL, MRT and Online Ojek". However, based on Figure 1, of the three examples of student answers, none of them match the question. This shows that students cannot understand the problem or question given.

After being investigated through interviews, it was discovered that students experienced various difficulties in understanding numeracy problems, especially those in the form of stories. Most students claimed to understand the general content of the problem, but they were confused about determining the correct steps to solve it. This is in line with the results of the measurement problem, where no students were able to provide the correct answer, even though the necessary information was already available in the picture. This difficulty indicates an obstacle in connecting visual information with questions, so that students fail to understand the context of the problem as a whole.

Through interviews, it was also discovered that there are several strategies that students often use, such as reading questions repeatedly or looking for examples of similar questions, but they are less effective for questions that require in-depth analysis.

b. Number

In the number category, although only one question was answered correctly, the number of students who succeeded increased to three compared to the measurement. This shows that the difficulty level of the number category questions is relatively high for them, but still easier than the measurement category. This shows that students' numeracy skills in the number aspect are also very low. Figure 2 is an example of questions and answers from students.

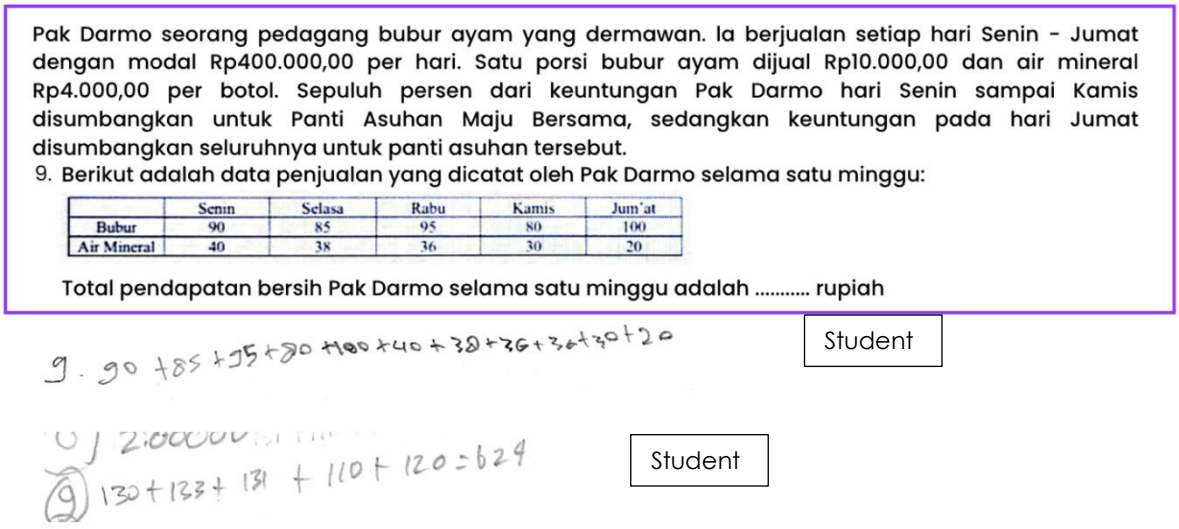

Figure 2. Example of Student Answers for Number Questions

Based on Figure 2, it can be seen that students are basically able to understand the questions but have difficulty in determining the steps or solution plans. This shows that students have reached the first stage in the problem-solving steps according to Polya's theory, namely understanding the problem, but still experience obstacles in the second stage, namely designing a solution plan. This analysis is in line with the results of the interview which showed that students tend to understand the contents of the questions but are confused about determining the right way or method to answer them.

After being investigated through interviews, many students revealed that their main difficulty was at the stage of “determining the formula” or “understanding the steps to solve”. Some students stated that they needed help from teachers to explain the process, while others tried to find examples of similar problems to use as references. When faced with story-based problems, they admitted that they understood the content of the problem but were not sure how to solve it. For example, one student explained that although story problems were understandable, he felt confused about starting the first step in solving the problem.

c. Geometry

The results of the geometry category showed an increase, with two questions successfully answered and three students were able to answer them. This shows that the geometry concept is better understood by students compared to the previous category. However, there are still a large number of students who have not shown adequate understanding. Figure 3 is an example of a student's answer.

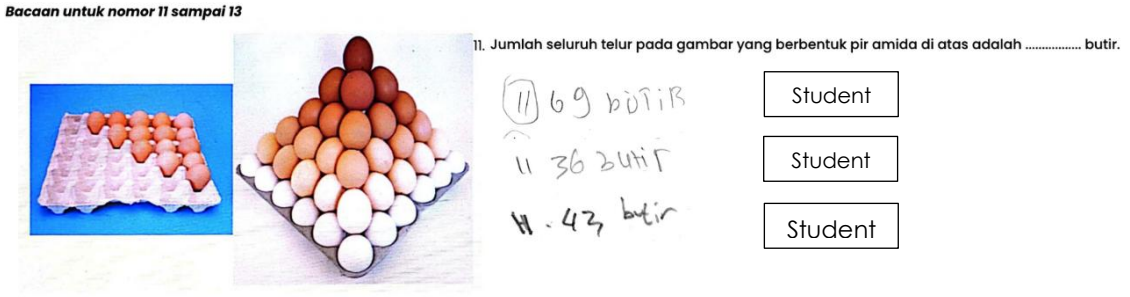

Figure 3. Example of Student Answers for Geometry Aspects

Figure 3 shows that students were able to achieve the first stage in Polya's theory, namely understanding the problem, but failed in the second stage, namely making a plan to solve the problem. The interview results also revealed that students had difficulty in determining the steps needed to solve the problem, especially on problems that require more complex mathematical calculations. Some students claimed to understand the basic concepts related to the problem, but were unsure how to start or structure the solution process. For example, some responses indicated that students were more focused on the end result without considering the importance of showing a logical and structured process.

In addition, the interview also showed that students were less accustomed to recording the work process systematically. Most students stated that they immediately tried to get answers based on intuition or previous experience, without first breaking down the problem into clear small steps. This habit indicates that they need further guidance in developing a solution plan and implementing the steps sequentially.

d. Uncertainty

In the uncertainty question category, the student success rate is higher than in other categories, as indicated by three questions answered correctly by five students. This shows that the uncertainty material is easier for students to understand or is taught more often in learning. However, these results also reflect that students' abilities in this aspect are still very lacking.

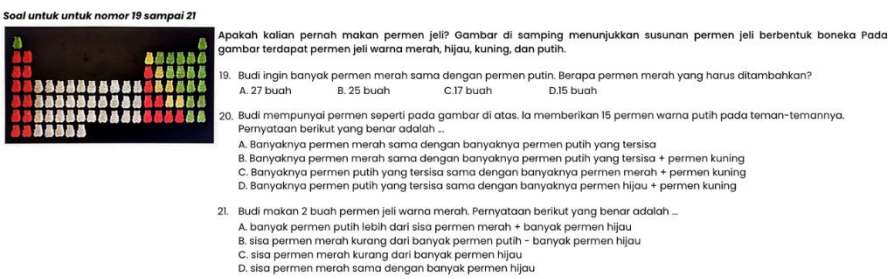

Figure 4. Numeracy questions for the uncertainty aspect

The results of the answers showed that students were able to understand the purpose of the problem, such as the concept of "equalizing the number of red candies with white candies" or "counting the remaining candies after a certain change." However, they were unable to write down the process of working to reach the answer. Students had difficulty converting their logical thinking into mathematical language, such as writing equations or determining the correct mathematical operations. In problem number 19, for example, students understood that the number of red candies needed to be adjusted to the number of white candies, but they were unable to formulate the steps to solve it mathematically. None of the students attempted to write down the process of solving the problem, indicating a lack of skill or confidence in expressing their mathematical thinking.

After being traced based on interviews, most students stated that they needed teacher assistance to understand the steps of solving problems. Most students also said that they often experienced challenges in understanding story problems and determining the formulas to be used. This underlines the gap between students' conceptual understanding and their ability to apply that understanding into mathematical solutions.

2. Factors That Influence Students' Difficulty in Solving Numeracy Problems

As explained in the research method, in addition to the test, interviews were also conducted to strengthen the results of the tests conducted. Based on the interview results, the following information was obtained:

1. Students' Feelings and Self-Efficacy in Learning Mathematics

Many students feel anxious and lack confidence when facing math problems, especially those that require complex steps. When asked “do you feel confident when working on math problems?” one student answered “Not sure because I’m afraid of making mistakes”, another said “When answering questions, I often don’t have confidence. Because many of the questions given are not understood”. These answers show that they are often worried about making mistakes or feel less confident in their abilities. This low self-confidence has an impact on students’ difficulties in understanding and working on numeracy problems. This is in accordance with the results of research from Juhrani et al. (2017) which shows that high levels of self-confidence correlate with better mathematical communication skills. Not only that, self-confidence can also predict students' academic achievement (Enny & Pujar, 2017).

2. Difficulty Understanding Questions and Applying Problem-Solving Steps

Some students showed difficulty in understanding the problem, especially in determining the formula or steps to be taken. One student said "I can't solve the problem because I can't understand the meaning of the problem". Meanwhile, another student said "I understand the

problem but don't know how to calculate it". In addition, students are also often confused in formulating problems into mathematical models, which indicates a need to improve basic understanding and interpretive skills. This finding is in line with research from Sidik and Wakih (2019) which states that students often have difficulty in translating the meaning of the problem into an existing mathematical model. This condition usually occurs because teachers rarely give problems that are directly related to their daily lives. In fact, the learning given to students in training mathematical problem-solving skills must always be linked to students' real lives (Rostika, 2017).

3. Strategy and Approach in Solving Problems.

Some students showed the habit of reading questions repeatedly or looking for examples of similar questions before trying to solve them. However, only a few had a specific method or strategy in solving numeracy problems. Students also stated that the teacher's explanation was sometimes difficult to understand, especially in parts that require more complex concepts, indicating that additional learning approaches and tools may be needed to improve understanding. In addition, some students also felt the need to get further explanation from the teacher regarding the steps in working on the questions. This indicates that the learning methods currently used have not fully helped students understand numeracy problems.

CONCLUSION

Based on the analysis results, it was found that students showed varying levels of success in each category of numeracy questions, namely measurement, numbers, geometry, and uncertainty. Overall, the highest level of success was in the uncertainty category, where five students managed to answer three questions correctly. This indicates that the uncertainty material is easier to understand or is taught more often in learning. However, students still have difficulty in converting conceptual understanding into systematic mathematical steps. Most students are able to understand the intent of the question but have difficulty writing down the process, which indicates limitations in the skills of planning solutions and expressing mathematical thinking.

In the number category, only three students were able to answer one question correctly, while in the geometry category, three students managed to answer two questions. These results indicate that the level of student understanding in these categories is still very low, even though they are able to understand most of the context of the questions. The measurement category showed the lowest level of success, where only one student was able to answer one question correctly. This difficulty is caused by limited ability to understand visual information and relate it to the context of the questions.

Through interviews, it was found that students often felt anxious and insecure when facing numeracy problems, especially those that required complex steps. In addition, students also admitted to having difficulty understanding story problems and determining the appropriate formula. Many of them relied on teacher assistance or similar examples to solve problems, but still had difficulty in formulating mathematical steps. Overall, these findings highlight the gap between students' conceptual understanding and their ability to apply that understanding into a structured solution.

In answering the research question, namely "what are the patterns of student errors in solving numeracy problems?", it can be concluded that the pattern of student errors in solving numeracy problems generally occurs in three important stages: understanding the problem, planning the solution, and executing mathematical steps. Although many students are able to understand the meaning of the problem, such as in the uncertainty category, they often fail to convert this understanding into a mathematical model or logical solution steps. In the number and geometry categories, students tend to immediately provide answers without going through a coherent analysis process, indicating a lack of attention to the importance of designing and writing down the solution steps. Another error is that students are wrong in determining the right formula or method to solve the problem, especially in story-based problems that require in-depth interpretation.

Meanwhile, in answering the question "what factors influence students' difficulties in solving numeracy problems?", students' difficulties in solving numeracy problems are influenced by low self-confidence, difficulty in understanding the problem, and ineffective learning strategies. Many students feel anxious and insecure, especially when faced with complex problems, which hinders their ability to think critically. Difficulty in understanding the problem, especially in determining the correct formula or steps, is exacerbated by the lack of learning that is connected to real-life contexts. In addition, students' problem-solving strategies are still limited to rereading the problem or finding similar examples without a structured method. Teachers' explanations that are difficult to understand for complex concepts add to the challenge, indicating the need for a more relevant and strategic learning approach.

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