

Analysis of Students' Mathematical Reasoning in Solving Story Problems According to Polya's Steps

Alfina Zahrotul Chusna¹, Maftukhah Rosyada², Rusmalinda Gustia³, Inarotul Wafiroh⁴, Fatimatus Solikha⁵, Ratri Rahayu⁶

^{1,2,3,4,5} Primary Teacher Education, Universitas Muria Kudus, Indonesia.

⁶Mathematics Education, Universitas Muria Kudus, Indonesia.

ratri.rahayu@umk.ac.id

*Corresponding author

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Abstract:

The purpose of this study was to analyze the ability of mathematical reasoning in solving story problems according to Polya's steps. This study is a qualitative descriptive study. Data collection techniques were interviews, observations and mathematical reasoning tests. The research instrument used mathematical reasoning test questions in the form of 6 reasoning questions based on multiplication story problems, interview sheets, and observation sheets. The subject in this study was one fourth grade student of SDN 3 Bulung Kulon in the high category. The results showed that students in the high category could complete all indicators of mathematical reasoning completely by using Polya's steps, namely understanding the problem, planning problem solving, implementing problem solving planning, and rechecking the answers.

Keywords: polya, multiplication, mathematical reasoning, story problems, elementary school

Introduction

Elementary education is an important phase in the formation of students' character and academic abilities. In this stage, students begin to recognize and understand basic concepts that will be the foundation for future learning. According to Ulya & Rahayu, (2018) one of the subjects that plays an important role in elementary education is mathematics. Mathematics not only teaches students to count, but also trains them to think logically, critically, and systematically. Mathematics, with its complexity and uniqueness, is often a challenge for students. In grade IV of elementary school, students begin to be introduced to more abstract and complex concepts such as multiplication and division. (Ardhani, 2024)

According to (Ulya et al., 2019) mathematics learning emphasizes understanding mathematical concepts as the main foundation of mathematical abilities. Understanding mathematical concepts is very basic and important in learning mathematics. However, to overcome more complex challenges in mathematics, it is important for students to also be trained in solving real problems that combine various



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aspects of mathematical abilities. Mastery of basic mathematical concepts is very important because it is the basis for learning mathematics at a higher level (Febrianti et al., 2022) . According to Wau Anjani et al., (2022) mathematical reasoning skills are very important for students to have because this ability can improve students' mathematical skills, so that they are able to think critically, systematically, logically, and creatively in the mathematics learning process itself. In the mathematics learning process, mathematical reasoning plays a role as the main key in solving story problems.

Mathematical reasoning is the ability of students to think logically and analytically in solving mathematical problems (Nasyihah et al., 2022) . Meanwhile, according to Kusumawardani et al., (2018), mathematical reasoning is a thinking process involving mathematical objects, which is needed to draw conclusions or produce new statements that can be considered true. Rosydiana, (2017) argues that Polya provides a statement about mathematical reasoning that involves several important steps, namely submitting temporary conjectures, carrying out mathematical manipulations, drawing conclusions, compiling evidence, providing reasons for solutions, checking the validity of arguments, and finding patterns or properties of mathematical phenomena to make generalizations. At the elementary school level, especially grade IV of elementary school, students' mathematical reasoning abilities are often evaluated through solving problems that require the application of multiplication and division concepts. These questions are designed not only to measure students' numeracy skills, but also to hone their mathematical reasoning skills, and test their ability to think logically and analytically (Amalia et al., 2022) .

According to Cahyani & Sritresna, (2023) mathematical reasoning is a skill that can be developed through structured practice and learning. However, many studies show that students often have difficulty in developing their mathematical reasoning skills. Meanwhile, according to Dinda Kurnia Putri et al., (2019) many students have difficulty in applying mathematical reasoning indicators, namely submitting correct guesses, carrying out mathematical manipulations correctly, and drawing logical conclusions. This difficulty indicates that a more effective learning strategy is needed to help students develop their mathematical reasoning skills.

Mathematical reasoning ability in compiling evidence and providing valid reasons for the solutions obtained is also a challenge for students. This is because compiling evidence and providing reasons requires a deep understanding of the mathematical concepts being studied. This is in accordance with research conducted by Nikmah et al., (2020) explaining that from the results of the analysis and interviews that have been carried out, it was found that the differences in the test scores of students named KAK and MFM were different, this was due to the different levels of student understanding. According to Vebrian et al., (2021) stated that practice in mathematical reasoning must be directed at developing critical and analytical thinking

skills. Students need to be trained not only to solve problems mechanically, but also to understand and apply mathematical concepts in various contexts. Other indicators such as checking the validity of arguments and finding patterns or properties of mathematical phenomena are also important aspects of mathematical reasoning. This ability helps students to evaluate the accuracy of the solutions they obtain and to generalize from the patterns found. Research conducted by Fathinatusholihah et al., (2024) shows that students with good mathematical reasoning abilities tend to have a deeper understanding of mathematical concepts.

Based on this, the results of observations that have been carried out by the author obtained information that teachers provide understanding to elementary school students in the mathematics learning process by teaching concepts sequentially with strategies that are easy for students to understand, after which the teacher gives questions to find out whether students really understand or not. This study is important because it is to find out the extent of students' mathematical reasoning abilities in solving multiplication and division story problems in order to anticipate the lack of understanding in students' mathematical reasoning, especially in multiplication and division material. This study aims to analyze the ability of fourth grade elementary school students in solving mathematical reasoning problems based on indicators from Polya. (Mauliyda, 2020) This analysis is expected to provide a clear picture of students' mathematical reasoning abilities and become the basis for developing more effective learning strategies.

Research Methods

This study uses qualitative descriptive research with data collection techniques in the form of interviews, observation results and mathematical reasoning tests. The research instrument uses a mathematical reasoning test. Data on the results of the mathematical reasoning test are in the form of 6 reasoning questions based on multiplication and division story problems used to determine the abilities of fourth grade students of SDN 3 Bulung Kulon. The test questions are in the form of essays that are adjusted to the reasoning indicators. The subject of this study was one fourth grade student in the high category.

This also involves validating the results by checking the conformity between student answers and existing reasoning indicators. The validation results show that student answers are in accordance with the indicators used, indicating that the test is quite valid in measuring the mathematical reasoning abilities of grade IV students. Sample assessments were carried out in detail through the reasoning process carried out by subject A through interviews and observations, it was found that subject A in the high category was able to explain the steps to solve the problem correctly. This observation provides deeper insight into students' critical thinking skills and mathematical understanding.

Based on the results of the mathematical reasoning test on subject A, it shows that one of the fourth grade students of SDN 3 Bulung Kulon, namely subject A, is in the high category because he got a score of 88.3%. In addition, Subject A can be invited to communicate so that the interview results are obtained which show that Subject A can work on the questions well using Polya's steps.

Results and Discussions

The following is a presentation of the results of the analysis of answers from subject A, with 6 questions given, as follows:

First Question

" A farmer has 24 seedlings that he wants to plant in his garden. If he plants each seedling 3 meters apart, how do you estimate the total length of the line used to plant all the seedlings?

Figure 1 below is the result of Subject A's work on question number 1.

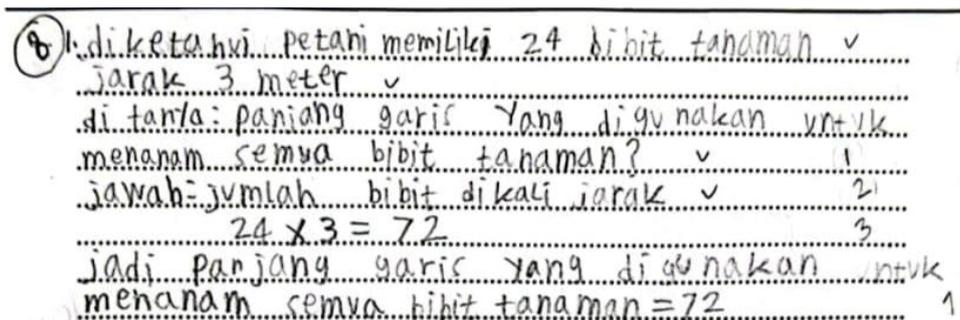


Figure 1. Student Answers to Question 1

Based on the results of the analysis of subject A's answers in Figure 1, the subject was able to write down what was known from the question. This was also reinforced by the results of the interview which stated that subject A read the question five times before starting to answer question number 1 and the subject was able to understand the situation of the question being worked on. It can be concluded that subject A can work on the question correctly.

In the second Polya step, namely planning a strategy, subject A was able to write the formula that would be used to solve the story problem. The interview results showed that subject A was able to write the formula correctly. This is shown in the picture of the answer sheet, there is a multiplication formula used to answer the question correctly.

Polya's third step is to implement the problem-solving plan, subject A in Figure 1 is able to implement the problem-solving plan correctly, systematically and with very good accuracy. This is shown that subject A can solve the problem according to plan by writing down the results with the right and correct calculation method.

In the fourth step according to Polya, namely the stage of re-checking the answers, subject A was able to re-check the results obtained by using multiplication and division formulas so that the results obtained were appropriate and consistent in concluding the answers. This is indicated by subject A who was able to write conclusions and the subject was able to explain the results of the answers obtained during the interview. It can be concluded that subject A succeeded in going through all of Polya's steps in solving mathematical problems with mathematical reasoning indicators, namely submitting temporary conjectures. (Ita & Abadi, 2019) . In addition, the subject has succeeded in carrying out reasoning communication well, this is known based on students' skills in compiling and writing symbols and formulas to solve problems, as stated by Fazriansyah, (2023) regarding mathematical communication indicators.

Second Question

"In a bookstore, Kara buys 2 books for Rp 35,000,- each and 1 book for Rp 25,000,-. If the purchase tax is 10%, how much is the total price that Kara must pay?"

Figure 2 below is the result of Subject A's work on question number 2.

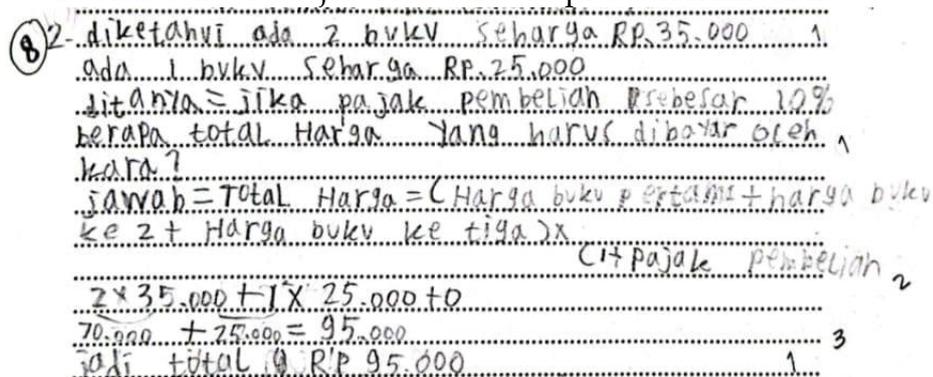


Figure 2. Student Answers to Question 2

The results of the analysis of subject A's answers in Figure 2, the subject was able to write down what was known and asked from the questions but not completely. This is also reinforced by the results of the interview which stated that subject A read the questions repeatedly before starting to answer question number 2 and the subject was able to understand the situation of the questions being worked on. It can be concluded that subject A can work on the questions correctly.

Polya's second step is to plan a strategy, subject A has been able to write the formula that will be used to solve the story problem. The interview results showed that subject A was able to write the formula for calculating purchase tax and the total price to be paid using multiplication and division correctly. This is shown in the answer sheet image, there is a multiplication formula used to answer the question correctly.

Polya's third step is to implement the problem-solving plan, subject A in Figure 2 is able to implement the problem-solving plan correctly, systematically and with very good accuracy. This is shown that subject A can solve the problem according to plan by writing down the results with the right and correct calculation method.

In the fourth Polya step, namely the stage of re-checking the answers, subject A was able to re-check the results obtained by using the multiplication and division formulas but the answer results were not quite right. This is indicated by subject A who was unable to write a conclusion and explain the results of the answers obtained during the interview. It can be concluded that subject A successfully passed the first, second and third Polya steps but in the fourth step was not quite right. This shows that the subject has carried out the four Polya steps on the mathematical reasoning indicator, namely carrying out mathematical manipulation but not perfectly (Afwa, 2024).

Question Third

" At the flower shop, Kejora bought 3 packages of flowers. Each package of flowers contains 5 roses. If the price of each rose is Rp 10,000, how much is the total price that Kejora must pay if Kejora currently has Rp. 200,000? Is Kejora's money enough?

Figure 3 below is the result of Subject A's work on question number 3.

3. diketahui 3 paket bunga setiap paket ada 5 bunga mawar 1 tangkai 10.000 yang yang dimiliki kejora adalah 200.000
ditanya cukupkah uang yang dimiliki kejora
jawab total harga = harga setiap bunga mawar x jumlah bunga mawar x jumlah paket bunga
total harga = 10.000 x 5 bunga x 3 paket
= 10.000 x 15
= 150.000
jadi uang yang dibayar karena 150.000 yang dimiliki

Figure 3. Answer to Question 3

Based on the results of the analysis of subject A's answers in Figure 3, the subject was able to write down what was known from the questions. This was also reinforced by the results of the interview which stated that subject A read the questions four times before starting to answer question number 3 and the subject was able to understand the situation of the questions being worked on. It can be concluded that subject A can work on the questions correctly.

In the second Polya step, namely planning a strategy, subject A was able to write a multiplication formula to find the total interest price that Kejora had to pay if Kejora's money was Rp. 200,000 which would be used to solve the story problem. The interview results showed that subject A was able to write the formula correctly. This is shown in the picture of the answer sheet, there is a multiplication formula used to answer the question correctly.

Polya's third step is to implement the problem-solving plan, subject A in Figure 3 is able to implement the problem-solving plan correctly, systematically and with

very good accuracy. This is shown that subject A can solve the problem according to plan by writing down the results with the right and correct calculation method.

In the fourth Polya step according to (Ismi Hanifah et al., 2024) , namely the stage of re-checking the answers, subject A was able to re-check the results obtained but the subject was unable to review the answers the subject gave. This shows that the subject has carried out the four Polya steps on the mathematical reasoning indicator, namely drawing conclusions, compiling evidence, and providing reasons for the correctness of the answer.

Question Four

" In a class there are 30 students who will be divided into 6 groups to work on a project together. How many students will be in each group? Draw a conclusion from the answer above!

Figure 4 below is the result of Subject A's work on question number 4.

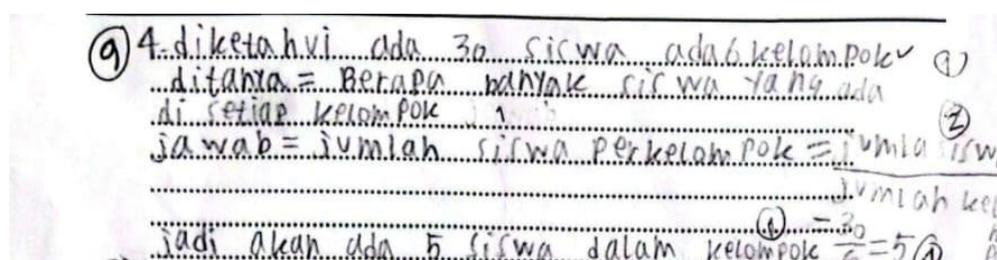


Figure 4. Answer to Question 4

The results of the analysis of subject A's answers in Figure 4, the subject was able to write down what was known from the questions but was incomplete. This is also reinforced by the results of the interview which stated that subject A read the questions repeatedly before starting to answer question number 4 and the subject was able to understand the situation of the questions being worked on. It can be concluded that subject A can work on the questions correctly.

In the second Polya step, namely planning a strategy, subject A was able to write down the multiplication and division formulas that would be used to solve the story problem. The interview results showed that subject A was able to write the formula correctly. This is shown in the picture of the answer sheet, there are multiplication and division formulas used to answer the questions correctly.

Polya's third step is to implement the problem-solving plan, subject A in Figure 4 is able to implement the problem-solving plan correctly, systematically and with very good accuracy. This is shown that subject A can solve the problem according to plan by writing down the results with the right and correct calculation method.

In the fourth Polya step, namely the stage of re-checking the answers, subject A was able to re-check the results obtained but the subject was unable to review the answers the subject gave. This shows that the subject has carried out the four Polya steps on the mathematical reasoning indicator, namely drawing conclusions from statements.

Question Fifth

" A trader has 45 apples that he wants to sell in packages of 9 apples per package. How many packages should he prepare to sell all his apples? Is it true that the trader must prepare 5 packages to sell apples ?

Figure 5 below is the result of Subject A's work on question number 5.

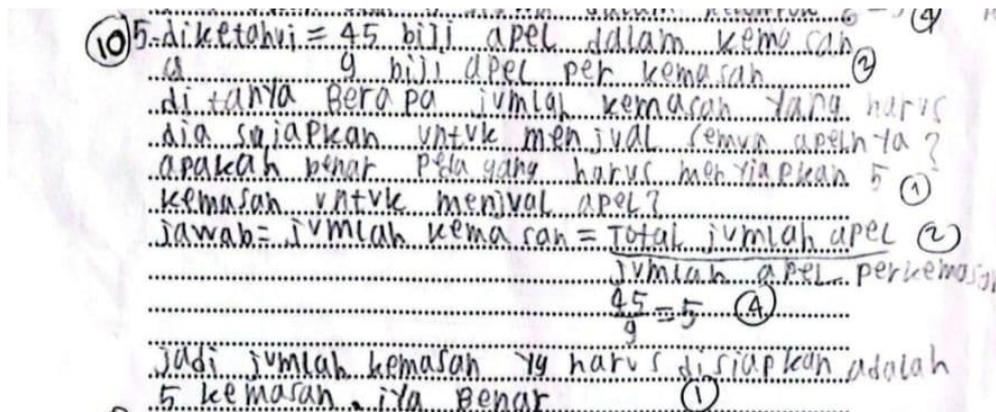


Figure 5. Answer to Question 5

Based on the results of the analysis of subject A's answers in Figure 5, the subject was able to write down what was known from the questions. This was also reinforced by the results of the interview which stated that subject A read the questions repeatedly before starting to answer question number 5 and the subject was able to understand the situation of the questions being worked on. It can be concluded that subject A was able to work on the questions correctly.

In the second Polya step, namely planning a strategy, subject A was able to write the formula that would be used to solve the story problem. The interview results showed that subject A was able to write the formula correctly. This is shown in the picture of the answer sheet, there is a multiplication formula used to answer the question correctly.

Polya's third step is to implement the problem-solving plan, subject A in Figure 5 is able to implement the problem-solving plan correctly, systematically and with very good accuracy. This is shown that subject A can solve the problem according to plan by writing down the results with the right and correct calculation method.

In the fourth Polya step according to (Ismi Hanifah et al., 2024) , namely the stage of re-checking the answers, subject A was able to re-check the results obtained by using multiplication and division formulas so that the results obtained were appropriate and consistent in concluding the answers. This is indicated by subject A who was able to write conclusions and the subject was able to explain the results of the answers obtained during the interview. It can be concluded that subject A succeeded in going through all of Polya's steps in solving mathematical problems with the indicator of mathematical reasoning, namely checking the validity of an argument.

Question Six

" Students of SDN 1 Maju Jaya are on a field trip to an automotive museum. The students who are participating in the field trip consist of 3 classes with 30 students in each class and there are 3 buses available. How many people can be accommodated in each bus?

Figure 6 below is the result of Subject A's work on question number 6.

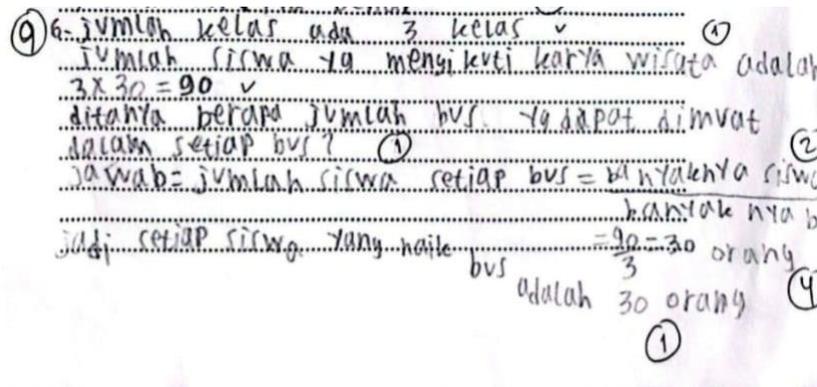


Figure 6. Answer to Question 6

Based on the results of the analysis of subject A's answers in Figure 5, the subject was able to write down what was known from the questions. This was also reinforced by the results of the interview which stated that subject A read the questions repeatedly before starting to answer question number 5 and the subject was able to understand the situation of the questions being worked on. It can be concluded that subject A was able to work on the questions correctly.

In the second Polya step, namely planning a strategy, subject A was able to write the formula that would be used to solve the story problem. The interview results showed that subject A was able to write the formula correctly. This is shown in the picture of the answer sheet, there is a multiplication formula used to answer the question correctly.

Polya's third step is to implement the problem solving plan, subject A in Figure 5 is able to implement the problem solving plan correctly, systematically and with very good accuracy. This is shown that subject A can solve the problem according to plan by writing down the results with the right and correct calculation method .

In the fourth Polya step, namely the stage of re-checking the answers, subject A was able to re-check the results obtained by using the multiplication and division formulas so that the results obtained were appropriate and consistent in concluding the answers. This is indicated by subject A who was able to write conclusions and the subject was able to explain the results of the answers obtained during the interview. It can be concluded that subject A succeeded in going through all of Polya's steps in solving mathematical problems with mathematical reasoning indicators, namely finding patterns or properties of mathematical phenomena to make generalizations (Kurniawati & Machromah, 2024)

Based on the description of the results of the analysis of the answers to the mathematical reasoning ability test and interviews from one subject in the high category, it can be found that it is important to pay attention to the diversity of student abilities in the class (Nahrisah, 2023) . Significant differences in mathematical reasoning test scores indicate that teachers should consider approaches that can meet the needs of individual students. Indicators in mathematical reasoning also need to be considered, the indicators of mathematical reasoning in this study are: first, submitting temporary conjectures, second, carrying out mathematical manipulations, third, drawing conclusions, compiling evidence, providing reasons for the truth of the solution, fourth, drawing conclusions from statements, fifth, checking the validity of an argument, and sixth, finding patterns or properties of mathematical phenomena to make generalizations (Endrawati & Ramlah, 2021) . Teachers should invite students to apply effective strategies to solve story problems to support students' mathematical reasoning abilities. Through these efforts, it is hoped that students can gain maximum benefits from learning mathematics, especially by improving their mathematical reasoning abilities (Sopwatillah, 2021) .

According to Hijrilliawanni et al., (2023) students have different conceptual understandings between one student and another in solving story problems so that it can trigger students' lack of understanding in working on the problems. This means that it is one of the factors that triggers mathematical reasoning abilities so that teachers are expected to provide students with a better understanding. Meanwhile, according to Asdarina & Ridha, (2020) stated that each student's ability in mathematical reasoning abilities is also influenced by limited mastery of the material so that students are unable to associate concepts that have been studied for a long time with the problems being worked on.

Conclusions and Suggestions

Based on the results of written tests, interviews, and observations, subject A in the high category can complete all indicators of mathematical reasoning completely by using Polya's steps, namely understanding the problem, planning problem solving, implementing problem solving planning, and rechecking the answers. This shows that the subject has a good understanding of the concept of multiplication and division and is able to apply this understanding to solve problems in story problems. His good mathematical reasoning ability can help him in studying mathematics and other fields that require mathematical reasoning. The recommended suggestion is that teachers are expected to be able to improve the learning methods that will be used in delivering learning materials. While suggestions for further research are expected that researchers can improve mathematical reasoning by using various learning methods.

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