ANALYSIS OF STUDENTS' ERRORS IN SOLVING STORY PROBLEMS ON RELATIONAL MATERIAL BASED ON POLYA STAGES

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Abstract: This study aims to analyze the types of errors made by female students in solving mathematical story problems on the topic of relations using Polya's problem-solving stages. Employing a qualitative descriptive approach, the research involved 30 eighth-grade students from SMP Al-Faruqi. Data were collected through written tests and interviews, then analyzed through data reduction, data presentation, and conclusion drawing. The findings revealed that errors occurred in all stages of Polya's framework, with 50% of students making errors in understanding the problem (moderate category), 47.7% in planning (moderate), 63.3% in implementing the plan (high), and 26.7% in rechecking (low). The most frequent error was found in the implementation stage, indicating that while students could generally comprehend and plan problem solutions, they often faced difficulties in accurately executing those plans. This suggests that female students still need to strengthen their procedural understanding and problem-solving execution skills to improve overall mathematical performance, particularly in applying strategies effectively and verifying their solutions.
Keywords: Mathematical Errors, Story Problems, Relationships, Polya Stages

1. INTRODUCTION

Education is a stage where students are influenced to adapt as well as possible to their environment, so that they can cause changes in themselves and benefit the lives of those around them [1], [2]. To realize quality education, the involvement of educators and students has a very large role, because these two components influence each other and determine the success of an educational process [3]. A good and interactive relationship between teachers and students is the key to achieving learning goals effectively.

Mathematics education is an important part of learning that directs students to have critical and analytical thinking skills [4]–[6]. Mathematics is a science that plays an important role in everyday life, in line with what is said [7] Mathematics is included in the subjects that must be taught in all levels of education in schools, from elementary

to high school. Mathematics can not only be used for counting, but can also help us understand different patterns, relationships, and structures in various situations.

According to [8] problem solving is a general goal of teaching mathematics, even as the heart of mathematics. Problem solving is a basic skill in learning mathematics. Therefore, mathematical problem solving is one of the important skills that students must develop when learning mathematics. Students who are trained in problem solving will be skilled in selecting relevant information, analyzing and evaluating the results [9]. Problem solving is usually found in the form of story problems.

Math story problems are questions that contain mathematical problems, usually related to daily activities and presented in the form of spoken language or writing [10]. According to [11] Story problems are problems that are closely related to everyday life which are presented in the form of a story and in which problems are found that are solved using numeracy skills. Story problems are questions that are considered to have a higher level of difficulty compared to math problems that display mathematical models directly [12].

In solving mathematical story problems, students often experience difficulties because they must first understand and change the problem into a mathematical model. This is in line with [13] that students have difficulty in working on story problems because students are not careful in reading and understanding sentence by sentence and regarding what is known in the problem and what is asked, and how to solve the problem correctly.

Based on the results of observations with junior high school mathematics teachers, Alfaruqi said that in the learning process of class VIII relation material, students had difficulty in solving the questions given, this was because students only learned how the steps from the example questions given previously. However, when the practice questions given varied in form such as story questions, students had difficulty in solving the problems. As prospective educators, we should strive for students to understand the learning we convey and play an active role in the learning that takes place, as stated by researchers [14] Active and capable teachers can carry out various learning activities in order to increase student interest, motivation and learning outcomes.

Therefore, it is important to analyze students' errors in solving story problems, in order to find out what types of errors students make in solving mathematics problems. By knowing these errors, teachers can design appropriate actions to help students improve their ability to solve story problems.

2. RESEARCH METHODS

This research is a Qualitative research with a descriptive approach that analyzes Student Errors in Solving Story Problems Based on Polya's Stages. Qualitative research is a research process to understand human or social phenomena by creating a comprehensive and complex picture that can be presented in words, reporting detailed views obtained from informant sources, and carried out in a natural setting [15]. Descriptive is a research with a method to describe a research result. As the name implies, the type of descriptive research aims to provide a description, explanation, and validation of the phenomenon being studied (Ramadhan Muhammad, 2021). This research was conducted at SMP AL-FARUQI with 30 female students in class VIII.2. The class selection was carried out using the Purposive Sampling technique. The Purposive Sampling technique is a sample determination technique with certain considerations or special selection [17]–[19].

In the study, data collection was carried out using 2 techniques, namely test question techniques and interview techniques. The test questions given were related to the Relation material which refers to the stages of completion according to Polya (1973), namely (1) Understanding the problem, (2) Making a plan, (3) Carrying out the resolution plan and (3) Rechecking the resolution plan. In this study, the test was given to students who had studied the relation material. The test questions were given to find out students' mistakes in solving story problems on the relation material.

Interviews were conducted with students who had completed story problems. Interviews were designed to dig deeper information related to students' errors in solving story problems based on Polya's stages. The students who will be interviewed will be selected by the researcher as many as 8 students who make many errors in solving story problems based on Polya's stages. This aims to dig deeper into the forms of errors made

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and understand the causes of these errors through interviews. [20]stated that in qualitative research, subjects are selected because they are considered to be able to provide the richest and most relevant information to the focus of the problem being studied. The interviews in this study used structured interview guidelines, namely a list of questions that had been prepared in advance by the researcher.

The data collection instrument in this study was a test consisting of 3 questions and an interview sheet that was adjusted to Polya's error stages. Before the data collection instrument was given to the students, the instrument validation process was first carried out by experts to ensure that the story questions and interview sheets that were prepared had met good quality standards and to perfect the instrument based on input from the validator.

Next, the questions were tested on female students and analyzed based on the Validity of Question Items, Question Reliability, Question Distinguishing Power and Difficulty Index using Anates Software. According to [21] Basically, anates has the same use as other data processing items, but it is easier to operate. In addition, the results have been directly analyzed by the program. So, we don't need to bother analyzing them again with the existing criteria. After being tested and analyzed on female students and proven to be valid, the test questions were then given to the class selected as the research subject.

Data analysis in this study refers to the interactive model proposed by Miles and Huberman, which consists of three main steps, namely, reducing data, presenting data, and drawing conclusions. The first stage in the data analysis technique is reducing data. Data reduction carried out in this study is to correct the test results that have been completed by students as a whole to get a clear picture of students' errors in solving story problems on relation material.

Analysis of students' errors was carried out by looking at the answers and identifying them according to the student error indicators based on the Polya Stages presented in the following table.

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Table 1. Student Error Indicators Based on Polya Stages

No	Error Type	Indicator
1	Understand the problem	1. The student made a mistake in determining what was known in the question. 2. The student made a mistake in determining what was asked in the question. 3. The student did not write what was known in the question 4. Students do not write down what is asked in the question
2	Make a plan	1. The student made a mistake in determining the correct formula to answer the story problem. 2. The student wrote the formula used incompletely. 3. The student did not write down the formula used in the question
3	Implement the plan	1. The student completed the steps of the solution incorrectly 2. The student made a mistake when entering known things into the formula 3. The student made a calculation or computation error 4. The student made a mistake because he could not complete the calculation to get the answer 5. The student made a mistake because he could not complete the steps of the solution completely 6. The student did not write down the steps used in solving the problem
4	Check again	1. The student made a mistake in drawing a conclusion according to what was asked in the question 2. The student wrote a conclusion that did not match the problem given 3. The student did not rewrite the results of the solution obtained

Source:[22]

Next, calculating the errors made by students in each type of error in answering mathematical story problems can be expressed as a percentage using the following formula: (Sudijono, 2012)

$$P = \frac{Number\ of\ errors}{number\ of\ question\ \times number\ of\ subjects} \times 100\%$$

The grouping of the percentage of students' error rates for each type of error is presented in the following table:

Table 2. Student Error Level Category

Percentage of Achievement	Category
$0\% \leq P < 20\%$	Very Low

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$20\% \leq P < 40\%$	Low
$40\% \leq P < 60\%$	Currently
$60\% \leq P < 80\%$	Tall
$80\% \leq P < 100\%$	Very high

Source: [23]

After reducing the data, the next stage is Data Presentation, which is done by displaying the data that has been arranged in the form of categories or groupings so that conclusions can be drawn and actions taken. Through data presentation, the data is organized and arranged in a relationship pattern, so that it will be easier to understand [24]. The last step is Drawing Conclusions, Drawing conclusions is done after the two previous steps have been completed. According to [24]Conclusions in qualitative research are new findings that have never existed before. Findings can be in the form of descriptions or images of an object that was previously still dim or even dark, so that after being studied it becomes clear. The results of the analysis process are then used as the basis for compiling conclusions descriptively and analytically, taking into account the data and findings obtained during the research.

3. RESULTS AND DISCUSSION

A. RESULTS

The overall explanation of each error for the 3 questions made by 30 female students is presented in the following table:

Table 3. Types Of Students' Errors Based On The Polya Stage

No	Subject Name	Question 1	Question 2	Question 3
1	S1	C	B	BC
2	S2	AC	CD	AC
3	S3	C	D	ABC
4	S4	BCD	AC	ABC
5	S5	C	M	BC
6	S6	C	D	ABC
7	S7	BC	AC	AC
8	S8	BC	ABCD	ACD
9	S9	AC	AC	ABC
10	S10	C	A	AC
11	S11	ABCD	ABCD	ABCD

12	S12	C	M	BC
13	S13	M	B	A
14	S14	C	M	AC
15	S15	C	AB	ABC
16	S16	AB	BC	ABC
17	S17	AB	AD	N
18	S18	B	BD	BC
19	S19	C	BC	ABCD
20	S20	M	N	N
21	S21	BC	ABCD	ABCD
22	S22	ABC	AB	ABC
23	S23	M	AD	BCD
24	S24	AD	BD	ACD
25	S25	ABCD	ABCD	ABCD
26	S26	D	M	ABCD
27	S27	A	BC	A
28	S28	C	M	AC
29	S29	A	BC	N
30	S30	AC	AB	ABC

Description:

A: Misunderstanding the Problem

B: Mistake in Making a Plan

C: Mistake in Executing the Plan

D: Mistake in Rechecking

M: No mistake

N: Question not answered

The following are the percentage results of each type of error made by students:

Table 4. Recapitulation of Student Errors on Question Number 1

Error Type	Number of Female Students	Percentage	Category
Misunderstanding the Problem	11	36,7%	Low
Mistakes in Making Plans	10	33,3%	Low
Mistakes in Executing the Plan	20	67%	Tall
Back Check Error	5	16,7%	Very Low

In Question number 1, there were 11 students (36.7%) who made mistakes at the stage of understanding the problem, the mistakes made were, the students were wrong in determining what was known in the question, then the students did not write down

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what was known and what was asked in the question. Furthermore, there were 10 students (33.3%) who made mistakes at the stage of making a plan, in this question the students wrote down the mathematical formula/model used incompletely, then the students did not write down the formula/model used at all. At the stage of implementing the plan, there were 20 students (67%) who made mistakes, these mistakes occurred because the students could not complete the steps of the solution completely and did not write down the steps used in solving the problem. Meanwhile, at the re-checking stage, there were 5 students (16.7%) who made mistakes, namely not writing down the results of the solution obtained. In contrast to 3 students (10%) who did not make mistakes at each stage of solving the problem.

Table 5. Recapitulation of Student Errors on Question Number 2

Error Type	Number of Female Students	Percentage	Category
Misunderstanding the Problem	13	43%	Currently
Mistakes in Making Plans	15	50%	Currently
Mistakes in Executing the Plan	12	40%	Currently
Back Check Error	11	30,5%	Low

In Question number 2, there were 13 students (43%) who made mistakes at the stage of understanding the problem, in this question the students were wrong in determining what was known in the question, then the students did not write down what was known and what was asked in the question. Furthermore, there were 15 students (50%) who made mistakes at the stage of making a plan, the mistakes occurred because the students wrote down the mathematical formula/model used incompletely, then the students did not write down the formula/model used at all. At the stage of implementing the plan, there were 12 students (40%) who made mistakes, the mistakes occurred because the students were wrong in completing the steps of the solution, the students were unable to complete the steps of the solution completely and did not write down the steps used in the solution. Meanwhile, at the re-checking stage, 11 students (30.5%) made mistakes, namely not writing down the results of the solution obtained, Furthermore, there was 1 student (3.3%) who did not answer the question, and 5 students (16.7%) who did not make mistakes at each stage of solving the problem.

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Table 6. Recapitulation of Student Errors on Question Number 3

Error Type	Number of Female Students	Percentage	Category
Misunderstanding the Problem	22	73,3%	Tall
Mistakes in Making Plans	18	60%	Tall
Mistakes in Executing the Plan	25	83,3%	Very High
Back Check Error	8	26,7%	Low

In Question 3, there were 22 students (73.3%) who made mistakes at the stage of understanding the problem, the mistakes made were that the students were wrong in determining what was known in the question, then the students did not write down what was asked in the question. Furthermore, there were 18 students (60%) who made mistakes at the stage of making a plan, the mistakes made were that the students were wrong in determining the right formula/model to answer the story question, then the students wrote the formula/model used incompletely, and the students did not write down the formula/model used at all. There were 25 students (83.3%) who made mistakes at the stage of implementing the plan, the mistakes occurred because the students were wrong in completing the steps of the solution, the students were unable to complete the steps of the solution completely and did not write down the steps used in the solution. Meanwhile, at the re-checking stage, there were 8 students (26.7%) who made mistakes, namely that the students were wrong in drawing conclusions according to what was asked in the question and the students did not write down the results of the solution obtained. Then there were 3 students (10%) who did not answer question number 3.

Based on the test results given to the students, various types of errors were found in answering each question. The overall percentage of each type of error in all questions worked on by 30 students is presented in the table below.

Table 7. Percentage of Each Error for All Questions

Error Type	Number of errors	Percentage	Category
Misunderstanding the Problem	46	51%	Currently
Mistakes in Making Plans	43	47,7%	Currently
Mistakes in Executing the Plan	57	63,3%	Tall
Back Check Error	24	26,7%	Low

Based on the table above, it can be seen that the errors made by 30 female students from the total questions at the stage of understanding the problem were 46 errors with a percentage of 51%, included in the moderate category. At the stage of making a plan, the number of errors was 43 errors with a percentage of 47.7%, included in the moderate category. The number of errors at the stage of implementing the plan was 57 errors with a percentage of 63.3%, included in the high category. The last stage is re-checking, as many as 24 errors with a percentage of 24%, included in the low category. The most common errors made by female students of SMP AL-FARUQI were at the stage of implementing the plan.

B. DISCUSSION

Misunderstanding of the problem occurs when students do not read and understand the information given in the problem. In question number 1, there were 11 students who made mistakes in understanding the problem with a percentage of (36,7%), in question number 2, there were 13 students who made mistakes with a percentage of (43%), and in question number 3, there were 22 students who made mistakes with a percentage of (76,3%). Overall, the percentage of mistakes in understanding the problem was 51%. Misunderstanding the problem is included in the moderate category.

The errors that emerged included students making mistakes in determining what was known and what was asked in the questions, students not writing down what was known and asked in the questions. In understanding the problem, students rushed to read the questions so that they were not precise in writing down the information that had been given. This is in accordance with researchers who stated that in the stage of understanding the problem, the factors that cause errors are lack of language and reading skills [22]. Researchers [25] also revealed that errors that occur in the stage of understanding the problem are caused by students who do not read the questions carefully and prefer to shorten the answers

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Planning Errors. In question number 1, there were 10 students who made mistakes in planning with a percentage of (33.3%), in question number 2, there were 15 students with a percentage of (50%), and in question number 3, there were 18 students who made mistakes with a percentage of (60%). Overall, planning errors had a percentage of 47.7%. Planning errors are included in the moderate category.

Based on the analysis of students' answers, the causes of errors made by students at this stage were that students made errors in determining the correct formula/model to answer story problems, students wrote the formula/model used incompletely and students did not write the formula/model used. This happened because students still did not understand the correct writing rules in mathematics, in writing sets there were still many students who did not use curly brackets, periods, arrows and writing the name of the set. Then the errors that appeared occurred because students were unable to understand the problems given so that it was difficult to create a mathematical model. In line with [26] the errors made by students at this stage were the lack of students' ability to plan and summarize the data contained in the problem into a mathematical formula or model. [27] stated that after understanding the problem, students were not yet able to choose and use the right concept to solve it. The mistakes made included not writing the necessary formula or concept.

Errors in Executing the Plan. In question number 1, there were 20 students who made errors in executing the plan with a percentage of (67%), in question number 2, there were 12 students who made errors with a percentage of (40%), in question number 3, there were 25 students who made errors with a percentage of (83.3%). Overall, errors in executing the plan had a percentage of 63.3%. Errors at this stage are the most common errors made by Alfaruqi Middle School students. This type of error is included in the high category. Students need to have a high level of conceptual understanding and accuracy in verifying their answers to solve problems correctly (Rittle Johnson & Schneider, 2015).

The causes of errors made by students are, incorrectly completing the solution steps, students make mistakes because they cannot complete the solution steps completely, and students do not write down the steps used in solving the problem. This

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happens because of a lack of understanding of the concept and accuracy in designing problem-solving strategies. In line with [28] Accuracy and mastery of the material are very important and necessary at this stage, because the errors that arise are caused by the many inaccuracies in solving problems and errors in the calculation process. In solving story problems, students are expected to have the ability to write and thoroughly explain the process of solving the given problem, identify relevant concepts, generalize and formulate a problem-solving plan, [29]

Rechecking Errors. In question number 1, there were 5 students who made rechecking errors with a percentage of (16.7%), in question number 2, there were 11 students who made errors with a percentage of (30.5%), and in question number 3, there were 8 students who made errors with a percentage of (26.7%). Overall, rechecking errors had a percentage of 26.7%, this error is included in the low category.

The mistakes made by students include students not rewriting the results of the solutions obtained, students writing conclusions that do not match what is asked in the question. This is because students are not used to rechecking their answers every time they work on a problem, students feel that it will waste time working on it. [26] stated that students should recheck the calculations and stages of solving the problem that have been done carefully, this is done to avoid mistakes that could occur. Furthermore, the errors that appear in this stage are because students write conclusions that do not match the problems given. This is in line with[30] who stated that errors occur due to the subject's carelessness when rewriting the answers that have been previously worked on on the worksheet.

4. CONCLUSION

Based on the research results, the errors made by students in solving relational story problems based on Polya's stages can be concluded that Misunderstanding the problem. The results of the study showed that as many as 50% of female students made mistakes at the stage of understanding the problem when working on relational story problems. This mistake occurred because the students did not read the problem until the end. Many of them were in a hurry to finish the problem, so they missed an important step in understanding the information provided thoroughly. mistakes in Making Plans.

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Based on the results of the study, as many as 47.7% of female students made mistakes at the planning stage when solving problems. The mistakes made by female students included students making mistakes in determining the right formula to answer story problems, students writing the formula used incompletely and students not writing the formula used. This happened because female students still did not understand the rules of correct writing in mathematics and female students were unable to understand the problems given so that it was difficult to create a mathematical model. Errors in Executing the Plan. The analysis of this study revealed that 63.3% of female students made errors at the stage of implementing the plan. The causes of errors made by female students at the stage of implementing the plan were that female students completed the solution steps incorrectly, female students made errors because they could not complete the solution steps completely, and female students did not write down the steps used in solving the problem. Errors at this stage are the most common errors made by female students. This type of error is included in the high category.Rechecking Errors. Researchers found that 26.7% of students made mistakes at the rechecking stage. The mistakes made by students included students not rewriting the results of the solutions obtained, students writing conclusions that did not match what was asked in the question. This was because students were not used to rechecking their answers every time they worked on a problem, students felt that it would waste time working on it. The mistakes that appeared also occurred because students wrote conclusions that did not match the problems given.

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