Problem-Solving Abilities Based on Polya Steps: A Study of Remboken 1 Public Middle School Students

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Abstrak

Kemampuan pemecahan masalah sangatlah penting bagi perkembangan kemampuan matematis siswa. Kemampuan ini perlu dideskripsikan secara jelas sehingga menghasilkan kontribusi bagi penyelesaian permasalahan kemampuan pemecahan masalah matematis. Penelitian ini dilakukan dengan tujuan untuk mendeskripsikan kemampuan pemecahan masalah dalam menyelesaikan soal cerita bentuk aljabar berdasarkan langkah Polya, yaitu: memahami masalah, menuyusun rencana, melaksanakan masalah, dan memeriksa kembali. Subjek dalam penelitian ini yaitu dipilih 3 siswa dari 12 siswa kelas VII-C di SMP Negeri 1 Remboken, terdiri dari siswa yang berkemampuan tinggi, sedang, dan rendah berdasarkan hasil tes kemampuan pemecahan masalah matematika. Teknik pengumpulan data yang digunakan yaitu melalui tes tertulis, wawancara dan dokumentasi. Hasil penelitian yang telah dianalisis, diperoleh bahwa kemampuan pemecahan masalah dalam menyelesaikan soal terbagi atas tiga kategori yaitu tinggi, sedang dan rendah. Siswa dengan kemampuan kategori tinggi mampu menguasai 4 langkah Polya untuk 5 soal. Siswa dengan kemampuan kategori sedang mampu menguasai 4 langkah Polya untuk soal nomor 2, 4 dan 5, menguasai 3 dari 4 langkah Polya yaitu langkah ke 1, 2 dan 3 untuk soal nomor 1, dan dapat menguasai 2 dari 4 langkah Polya yaitu langkah ke 1 dan 2. Sedangkan siswa dengan kemampuan kategori rendah dapat menguasai 4 langkah Polya hanya pada soal nomor 1, menguasai 2 dari 4 langkah Polya yaitu langkah ke 1 dan 2 untuk soal nomor 2, dan soal nomor 3, 4 dan 5 subjek dengan kemampuan rendah tidak mampu mengerjakannya.

Kata Kunci: *Kemampuan Pemecahan Masalah, Soal Cerita, Aljabar, Polya, Matematika*

Abstract

Problem-solving abilities are essential for the development of students' mathematical abilities. This ability must be described clearly to contribute to problem-solving and mathematical problem-solving abilities. This research aimed to describe problem-solving abilities in solving algebraic story problems based on Polya's steps: understanding the problem, formulating a plan, implementing the problem, and checking again. The subjects in this research were three students selected from 12 students in class VII-C at SMP Negeri 1 Remboken, consisting of students with high, medium and low abilities based on the mathematical problem-solving ability test results. The data collection techniques used were through written tests, interviews and documentation. The results of the research that has been explained show that problem-solving abilities in solving questions are divided into three categories, namely high, medium and low. Students with high-category abilities can master 4 Polya steps with up to 5 questions. Students with the medium ability category can master 4 Polya steps for questions number 2, 4 and 5, master 3 of the 4 Polya steps, namely steps 1, 2 and 3 for question number 1, and can master 2 of the 4 Polya steps, namely step 1 and 2. Meanwhile, students with low ability categories can master the 4 Polya steps only in question number 1, master 2 of the 4 Polya steps, namely steps 1 and 2 for question number 2, and questions number 3, 4 and 5 for subjects with low ability do not able to do it.

Keyword: Problem Solving Ability, Story Problems, Algebra, Polya, Mathematics

INTRODUCTION

Education is an essential factor in improving a person's abilities and qualities. According to Fadillah [3][21], education is an activity with an institutional nature used to convey knowledge, attitudes, and so on. One of the causes of the low quality of students' understanding is difficulty in understanding story problems, especially in algebra material, namely story questions in algebra form [1][2][3][22]. Algebra is an essential

material that must be explored before exploring other materials. Students will know constants (Fixed Values) and Variables (Changing Values) in algebraic form [2][3][4][23]. Before entering algebraic operations, students must know the terms in algebraic operations, such as constants, coefficients, variables, terms, factors, etc. Every student must understand algebra material to make it easier to understand the following material [3][5][6][24]. However, in reality, some students still experience difficulties in solving problems. In understanding problems or story problems, students still often feel confused, just as in changing story problems into mathematical form, students still experience difficulties [3][7][8][25]. Likewise, in the calculation process, students often experience errors in calculating algebraic operations, dramatically influencing the solution of the story problems they are working on.

Problem-solving is an important thing to learn in mathematics subjects. Solso, in Mairing [9][26], problem-solving is a way of thinking directed at solving a particular problem, which involves forming possible responses and choosing between these responses. According to Krulik et al. in Mairing [9][10][27], problem-solving is a process that begins with students facing a problem until an answer is obtained and students have tested the solution [10][11]. Based on the results of observations in class VII-C of SMP Negeri 1 Remboken and supported by the results of an interview with one of the mathematics teachers on November 4 2022, it was found that 25% of the 12 students or 3 of the 12 students were less able to solve story problems.

To develop the ability to solve problems, you must develop expertise or skills in understanding problems, solving problems, creating mathematical models, and interpreting solutions. Polya's steps in Saedi et al. [12][16] are: 1) Understanding the problem: What problem is being faced? What are the conditions and data? How do we sort these conditions? 2) Develop a plan: Find relationships between data and things that have yet to be discovered. Have you ever had a similar problem? 3) Carrying out the plan: Carrying out the plan to find a solution, checking each step carefully to prove the method is correct. 4) Checking again: Assessing the solution obtained.

The possession of problem-solving skills is of utmost importance in the realm of mathematics, not only for individuals who intend to pursue further studies in mathematics, but also for those who plan to utilise it in various other academic disciplines and in their daily lives. In Hadi & Radiyatul's [5][13][17] study, Branca highlighted the significance of students' problem-solving skills in mathematics. Specifically, Branca emphasised three key points: (1) the overarching objective of teaching mathematics is to develop students' problem-solving abilities, (2) problem-solving, encompassing various methods, procedures, and strategies, is the central and fundamental process in the mathematics curriculum, and (3) problem solving is a crucial skill for learning mathematics. Areas for improvement in addressing student concerns include enhancing problem-solving techniques, closely monitoring the process of finding solutions, and rigorously analysing the outcomes [14][19].

Research conducted by Yuwono et al. [19] with the title "Analysis of Problem-Solving Ability in Solving Story Problems Based on Polya Procedures" stated that students were still unable to understand the meaning of the story questions given and students experienced procedural errors in explaining and do the questions. This happens because students must improve their ability to explain story problems and change them to mathematical form. Therefore, systematic steps are needed to solve mathematical problems, especially story problems, by applying the four stages of problem-solving according to Polya's steps.

METHOD

This research is a qualitative descriptive research. Researchers want to describe problem-solving abilities in solving mathematics story problems based on Polya theory in class VII-C students at SMP Negeri 1 Remboken. This research was conducted at SMP Negeri 1 Remboken, odd semester on 26 October 2023. The subjects in this research were based on the results of a mathematical problem-solving ability test given to 12 students in class VII-C. In this study, researchers chose three research subjects from 12 people. The categorization of students' mathematical problem-solving abilities in this study was based on scores from the results of mathematical problem-solving ability tests, which created criteria for student ability levels and assessment scales in Table 1 below.

Table 1. Ability Level Categories

Scoring Scale	Student Ability Level
80 ≤ Score ≤ 100	High
60 < Score < 80	Middle
0 ≤ Score ≤ 60	Low

Therefore, the researcher divided groups of students into categories and low-ability categories. After this categorization, three students who were differentiated by three levels of ability, namely high, medium, and low ability, were selected for interviews with one student, who was taken for each ability level.

This research was only carried out at the description stage, namely analyzing and presenting facts systematically. The researcher described the research results descriptively according to the results of the written test in solving story problems. Apart from describing the results, the researcher also conducted interviews with students to strengthen the data obtained by the researcher.

The procedures for this research were carried out in 1) the pre-field stage, 2) the field stage, and 3) the post-field stage. This research instrument is divided into the main instrument and supporting instruments. 1) The main instrument is the researcher, who requires objectivity and a neutral attitude; 2) The supporting instrument is a test instrument for mathematical problem-solving abilities, which the supervisor has validated and an interview guide instrument, which aims to obtain a deeper picture of mathematical problem-solving abilities.

The instruments in this research are divided into the main and supporting instruments. The main instrument is the researcher, who requires objectivity and a neutral attitude [15]. Apart from that, supporting instruments often used in qualitative research are also needed: 1) Mathematical problem-solving ability test instruments that the supervisor has validated. This instrument is presented as a description of algebra material with 5 question items. 2) The interview guide instrument aims to obtain a deeper picture of mathematical problem-solving abilities. In this research, the researcher created an interview guide based on students' worksheets in solving problem-solving ability test questions using a semi-structured interview method. The researcher was allowed to ask questions that did not have to be by the specified interview sequence. Examples of questions include "why did you get results like that?", "what was asked in the question?" and "What is known in the problem?".

The data collection techniques in this research are written tests, interviews, and documentation. The analysis used in this research has several stages: analyzing unit data, synthesizing, arranging into patterns, choosing what is essential and what will be studied, and making conclusions that can be shared with others. The stages of analyzing the data carried out by researchers are data reduction, data presentation, and conclusion.

RESULT AND DISCUSSION

This section will present the research results on problem-solving abilities in solving algebraic story problems based on Polya's steps to class VII-C students at SMP Negeri 1 Remboken. This data was collected by taking problem-solving ability tests and interviews. The problem-solving ability test collects data about students' problem-solving abilities. At the same time, interviews determine what processes or stages students carry out in solving problems. The subjects in this research were SMP Negeri 1 Remboken class VII-C students, with 12 students who had studied algebra material, as seen in Table 1.

Table 1. Student Ability Test Results

No	Student Initials	Score	Student Ability Category
1	AHS	80	High
2	AD	25	Low
3	AT	70	Middle
4	CM	15	High
5	DB	100	High

6	NM	10	Low
7	NT	45	Low
8	PS	90	High
9	QS	25	Low
10	SM	45	Low
11	VM	100	High
12	YK	60	Low

As seen in Table 1, in class VII-C of SMP Negeri 1 Remboken, there are four students with high abilities, one with medium abilities, and seven with low abilities. Next, one subject will be selected for each student's problem-solving ability category into three categories, namely high-ability, medium-ability, and low-ability subjects. This subject is chosen based on the students' abilities, as seen from their answer sheets. The selected research subjects can be seen in Table 2.

Table 2. Research Subjects

Student Initials	Problem Solving Ability Category
DB	High (KT)
AT	Middle (KS)
CM	Low (KR)

Based on data obtained in the field, researchers will explain the results of the work of students selected as research subjects with each category of problem-solving ability and using Polya Steps indicators.

1. Data Exposure and Analysis for Subjects with High Ability Levels (KT)

In this section, questions and results of research on high-ability subjects on algebra material based on Polya's steps and results of interviews and data analysis for subjects with a high ability level (KT) will be shown in question number 1.

Problem Number 1. Anto has a rectangular plot of land with a length of (5 + x) m and a width of x m. Determine the area of the land if x = 7.

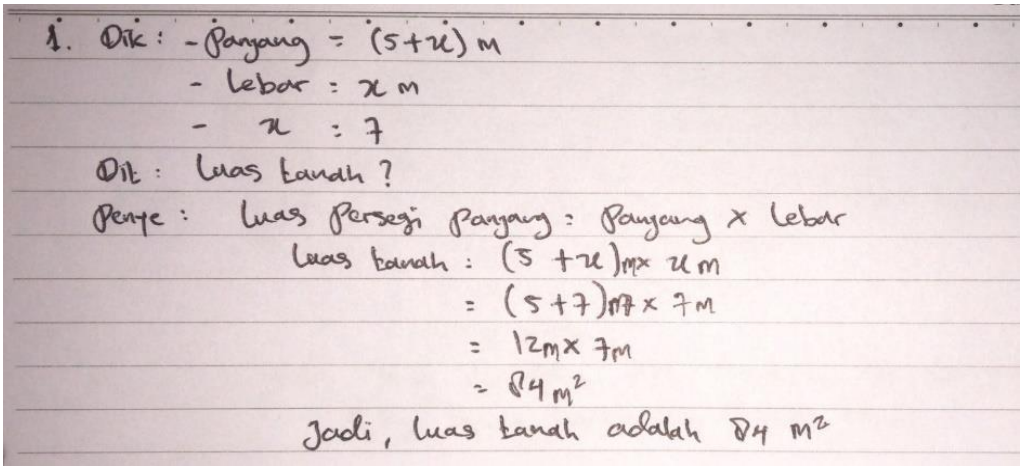

Figure 1. Answer Number 1 Subject KT

Based on Figure 1, it can be seen that the KT subject can write down what is known, namely, length = (5 + x) m, width = x m, x = 7 and what is being asked is the area of the land, this is by the indicators in understanding the problem. The next indicator is Developing a plan. In Developing a KT subject plan, you are

correct in determining the mathematical model: area of a rectangle = Length × Width. The next indicator is implementing the problem plan. At this stage, the KT subject can correctly substitute the known Length and width into the mathematical model. Next, the KT subject can add up what is known to get the final result: the land area is 84 m^2; this is included in the re-examination indicators.

The following are the results of the researcher's interview with the KT subject.

P : Try reading question number 1 first.
DB : (Reading question number 1) that is it, sis.
P : OK. From the questions you have read earlier, state what you know and ask about the questions!
DB : It is known that the Length of the piece of land is (5 + x) m, the width is x m, with x = 7, and what is being asked is the area of the land.
P : Now, explain how to solve the questions you have created!
DB : The first method I made was to write a formula to find the area. Then I changed the Length × Width value to (5 + x) m × x m.
Q : Next?
DB : Then I changed the x value to 7; I added 5 + 7 first and multiplied the result by 7. So, the result obtained was 84 m^2.
Q : Are you sure about the answer?
DB : Sure, sis.
Q : Have the answers you worked on been rechecked? Moreover, what is the conclusion?
DB : Yes. I have rechecked the answer, and the conclusion is that the area of Anto's land is 84 m^2.

2. Data Exposure and Analysis for Subjects with Medium Ability Level (KS)

This section will show questions and research results for medium-ability subjects on algebra material based on Polya's steps, interview results, and data analysis for subjects with a medium ability level (KS) on question number 1.

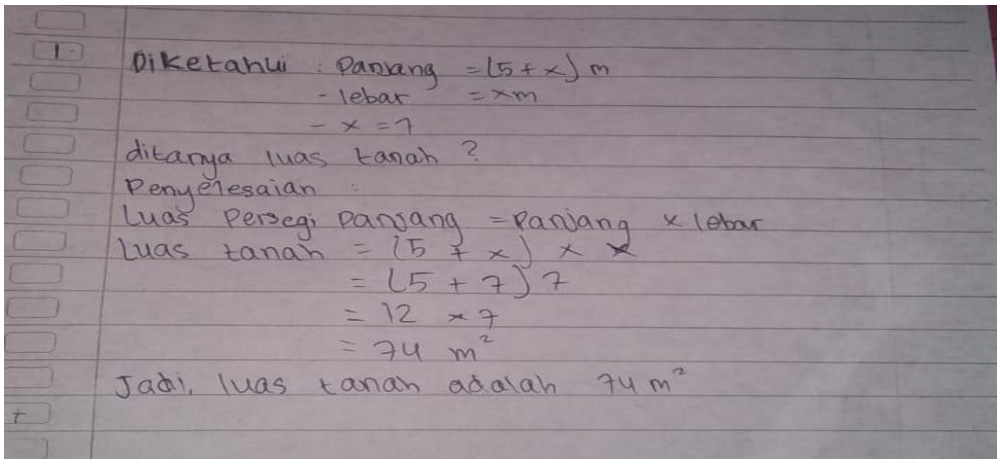

Figure 2. Answer Number 1 Subject KS

Based on Figure 2, it can be seen that the KS subject writes down what is known and what is asked according to the indicators in understanding the problem. Furthermore, the indicator for planning problem-solving at this stage is that the KS subject is correct in determining the mathematical model: area of the rectangle = Length × Width. The next indicator is implementing the problem plan. In this stage, the KS subject correctly substitutes the known Length and width into the mathematical model. However, in adding up what is already known, the KS subject makes a mistake in adding up the final result so that he gets 74 m2, which should be the correct answer of 84 m2; this is already included in the indicator check again.

The following are the results of the researcher's interview with the subject KS.

Q : Please read question number 1 first.
AT : (reading question number 1) that is it, sis.

Q : What do you know and what is asked in question number 1?
A : It is known that the Length of the plot of land is (5 + x) m, and the width is x m with x = 7, so what is asked is the area of the land.
Q : How is it resolved?
A : I wrote the formula to find the area first. Then I changed the Length × width to the value (5 + x) m × x m.
Q : Next?
AT : Then I changed the x value to 7; I added 5 + 7 first and multiplied the result by 7.
Q : How many results did you get?
A : The results I got were 74 m2.
Q : Why 74? Try calculating again; how much is 12 × 7?
AT : (counting). 84 sis
Q : Then why are you written as 74?
A : Sorry, sis, I was not focused enough on calculating
P : Yes, that is okay; focus more next time.

3. Data Exposure and Analysis for Subjects with Low Ability Levels (KR)

In this section, data from research on subjects with low ability levels will be shown on algebra material based on Polya's steps and the results of interviews and data analysis for subjects with low ability levels (KR) in question number 1.

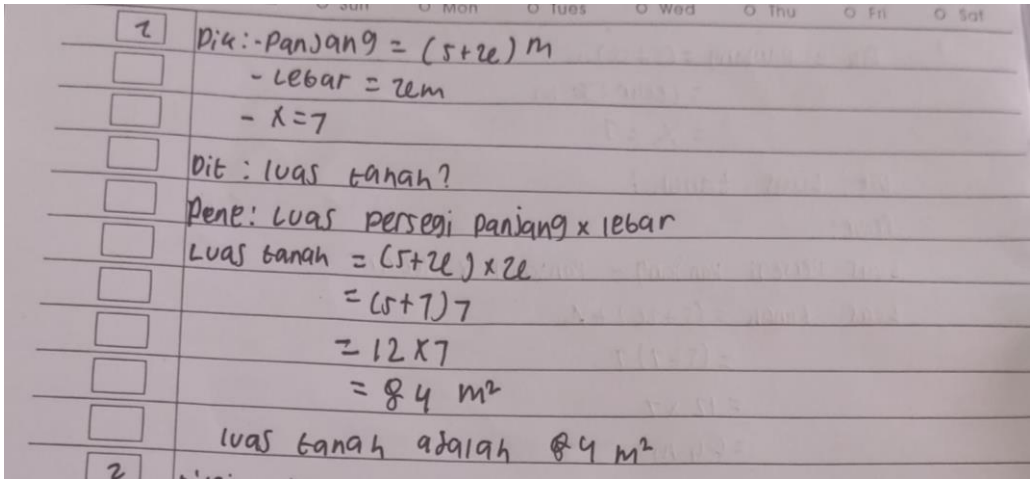

Figure 3. Answer Number 1 Subject KR

Based on Figure 3, it can be seen that the KR subject writes down what is known and what is asked, which is by the indicators of understanding the problem. Furthermore, the indicator for planning problem-solving at this stage is that the KR subject correctly determines the mathematical model: area of the rectangle = length × Width. The next indicator is implementing the problem plan. In this stage, the KR subject correctly substitutes the known Length and Width into the mathematical model; next, the KR subject adds up what is known until the final result is that the land area is 84 m^2. This is included in the indicators for re-examination.

The following are the results of the researcher's interview with the subject KR.

P : OK, try reading question number 1.
CM : (reading question number 1) That is it, sis.
Q : What is known and what is asked in question number?
CM : Known Length is (5 + x), Width is x, and x = 7. The question is land area.
Q : How is it resolved?
CM : I wrote the formula first, then changed the length to (5 + x) and the Width to x.
Q : Next?
CM : Next, I substituted the x value into seven and added it all up
Q : How do you add it up?

CM : 5 + 7 is multiplied by seven, and the final result is 84 m^2
Q : Are you sure about the answer?
CM : Yes, sis
Q : So, what is the conclusion?
CM : In conclusion, Anto's land area is 84 m^2.

Based on the data obtained, the researcher divided the results of the work of the students selected as research subjects into each category of problem-solving ability and used the Polya Steps indicator.

1. Mathematical problem-solving abilities in high-ability subjects (KT)

   Based on data from written tests and interviews with high-ability subjects, it was found that the subject (KT) was able to master all problem-solving indicators, namely:

   a. Understand the problem. In this indicator, the subject (KT) can understand the problem by determining what is known and what is asked from the questions. This is the same as the opinion of Polya [7] that students are said to understand the problem if they can determine what is known and what is asked in formulas, symbols, or simple words.
   b. Make a plan. In this indicator, the subject (KT) can determine other unknown conditions in the questions, such as formulas or learning models that the subject will use, so that the subject can make plans or steps to solve the questions given. This is the same as the opinion of Polya [7] [18] that students can determine concepts or theories that support each other and look for the necessary formulas in this step.
   c. Implement problem plans. In this indicator, the subject (KT) can substitute known values into a mathematical model and calculate the solution to the problem given correctly. This is the same as the opinion of Polya [7] that in this step, students can form a more standard systematic question, in the sense that the formulas that will be used are formulas that are ready to be used according to what is used in the problem so that get the correct final result.
   d. Check again. In this indicator, the subject (KT) can re-examine the final answer obtained and conclude the answer obtained. This is the same as the opinion of Nahdataeni [8] that to re-check their answers, students look for conformity between the solution and what is known by returning the results obtained to what is known.

2. Mathematical problem-solving abilities in medium ability subjects (KS)

   Based on data from written tests and interviews with subjects with moderate abilities, it was found that subjects (KS) were less able to master all problem-solving indicators, namely:

   a. Understand the problem. The subject (KS) can understand the problem for questions 2, 4, and 5 in this indicator. This is the same as research by Mahardhikawati et al. [10] that subjects with moderate logical-mathematical intelligence can determine the relationship between what is known and what is asked. Next, the subject can make a problem-solving plan to determine the final result. But not for questions number 1 and 3. The subject (KS) for question 1 needed to add up to the final results. For question number 3, he was less careful in reading the questions and made the subject (KS) wrong in determining what was known, thus making the subject (KS) less able to understand the problem.
   b. Developing a plan: In this indicator, the subject (KS) is unable to formulate a plan because in the first indicator, namely understanding the problem, the subject (KS) has made a mistake in determining what is known, then in the following indicators the subject (KS) is less capable, namely in Implement the problem plan, and check again. For example, in working on question number 1, there was an error in adding up the final results, and in question number 3, in determining what was known to be wrong, the mathematical model used and the answers and conclusions obtained needed to be corrected.

3. Mathematical problem-solving abilities in low-ability subjects (KR)

   Based on data from written tests and interviews with subjects with low abilities, it was found that subjects (KR) were unable to master all problem-solving indicators, namely:

   a. Understand the problem and develop a plan. In this indicator, the subject (KR) can understand the problem and prepare a plan for questions number 1 and 2, namely determining what is known and determining the mathematical model that will be used for these problems. However, in questions 3, 4

and 5, the subject (KR) could not answer the questions, so the subject (KR) could not understand the problem and formulate a plan.

b. Execute the problem plan and check again. In this indicator, the subject (KR) can answer question number 1 correctly so that the addition operation gets the final result and correct conclusion. However, in questions 2, 3, 4, and 5, the subject (KR) could not answer the questions, so the subject (KR) could not carry out the problem plan and check again. This is the same as research by Mahardhhikawati et al. [10][20], in which subjects with low logical-mathematical intelligence could not understand the problem to solve it, and the subjects also did not recheck the answers they obtained.

CONCLUSION

Based on the results of research on problem-solving abilities in solving algebraic story problems based on Polya steps in class VII-C students at SMP Negeri 1 Remboken, the conclusion was obtained that: 1) The subject's ability (KT) can master the 4 Polya steps for these five questions, namely; understand the problem, develop a plan, carry out the problem plan and check again. 2) The subject's (KS) ability to master the 4 Polya steps in questions number 2, 4, and 5. Meanwhile, in questions number 1 and 3, the subject (KS) did not master the 3rd and 4th Polya steps for question number 1, and Polya steps 2, 3 and 4 for question number 3. 3) The subject's ability (KR) was only able to master 4 Polya steps in question number 1. In question number 2, the subject (KR) only mastered the first Polya step. In contrast, for questions, Subject numbers 3, 4, and 5 (KR) did not master Polya theory because they could not answer the questions.

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