

## Kemampuan Pemecahan Masalah Matematis Siswa Sekolah Menengah Pertama Berdasarkan Polya

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### Abstrak

Kemampuan pemecahan masalah matematis adalah kemampuan mengidentifikasi informasi-informasi yang diketahui, ditanyakan, kecukupan informasi yang diperlukan, terampil membuat atau menyusun model matematika, dapat menemukan strategi pemecahan yang tepat, serta dapat menjelaskan dan memeriksa kebenaran solusi yang didapatkan. Penelitian ini bertujuan untuk menganalisis kemampuan pemecahan masalah matematis siswa pada materi operasi hitung campuran bilangan bulat berdasarkan langkah pemecahan masalah Polya. Penelitian ini menggunakan pendekatan kualitatif dengan jenis penelitian naratif. Subjek penelitian terdiri dari 32 orang siswa SMP. Pengumpulan data dilakukan dengan instrumen tes kemampuan pemecahan masalah matematis serta wawancara kepada beberapa partisipan secara terpilih. Data dianalisis berdasarkan langkah pemecahan masalah Polya. Berdasarkan hasil analisis data, kemampuan pemecahan masalah siswa yang didapatkan berdasarkan empat langkah tersebut berupa siswa yang dapat menentukan informasi penting pada soal dan dapat merencanakan solusi mengakibatkan mereka dapat menyelesaikan permasalahan dengan lebih teratur yaitu dengan mengeksekusi rencana yang telah ia rencanakan. Setelah itu, siswa yang memahami permasalahan dengan baik, ia juga dapat memeriksa kembali kebenaran jawaban yang telah ia peroleh. Oleh karena itu, penelitian ini diharapkan dapat membantu guru agar dapat terlaksananya proses pembelajaran yang dapat mengembangkan kemampuan pemecahan masalah pada materi operasi hitung campuran bilangan bulat.

**Kata Kunci:** kemampuan pemecahan masalah, operasi hitung campuran bilangan bulat

## *Mathematical Problem-Solving Ability of Junior High School Students Based on Polya*

### *Abstract*

*Mathematical problem-solving ability is the ability to identify known information, ask questions, adequacy of the information needed, skill in creating or compiling mathematical models, being able to find the right solution strategy, and being able to explain and check the correctness of the solution obtained. This research aims to analyze students' mathematical problem-solving abilities in the topic on mixed integer arithmetic operations based on Polya's problem-solving steps. This research uses a qualitative approach with a narrative research type. The research subjects consisted of 32 junior high school students. Data collection was carried out using mathematical problem-solving ability test instruments and interviews with several selected participants. Data was analyzed based on Polya's problem solving steps. Based on the results of data analysis, students' problem-solving abilities obtained based on these four steps are in the form of students who can determine important information in the problem and can plan solutions resulting in them being able to solve problems more regularly, namely by executing the plans they have planned. After that, students who understand the problem well can also check the correctness of the answers they have obtained. Therefore, it is hoped that this research can help teachers to implement a learning process that can develop problem solving abilities.*

**Keywords:** *polya's problem-solving; problem-solving ability*

## INTRODUCTION

Mathematics has an important role in solving a problem. Math can support the success of student learning in education because it can train students' thinking skills that can make students think critically and logically. In accordance with the opinion of (Fahrilianti et al., 2019), mathematics can train students to develop systematic, critical, and logical thinking skills. Mathematical ability according to (NCTM, 2000) is an ability that has a very important role to solve problems related to mathematics in everyday life, one of which is mathematical problem-solving ability. According to Kesumawati (2009), mathematical problem-solving ability is the ability to identify information that is known, asked, the sufficiency of the information needed, skillful make or arrange mathematical models, can find the right solution strategy, and can explain and check the correctness of the solution obtained. Math problem solving has four stages, namely understanding the problem presented, planning the problem solving to be done, solving the problem according to the plan in problem solving and re-examining the results obtained (Tasya, 2018). At these stages, students can be declared capable if they meet the indicators of each stage. The indicators for each problem-solving step proposed by Polya (1973) can be seen in Table 1.

Table 1. *Indicators of Problem-Solving Ability According to Polya*

<b>Stages of Problem-Solving</b>	<b>Indicator</b>
Understand the problem	Students are able to understand the description of information or data presented based on the questions from the questions posed
Planning the solution	Students are able to formulate and design solutions to the problems presented along with the reasons for using these solutions
Resolving problem according to with the solution plan	Students are able to carry out what has been designed with the correct answer
Rechecking the results obtained	Students review the project and the results that have been obtained

Table 1 is the indicators of each stage contained in the problem-solving stage according to Polya. Many students are still lacking in their mathematical problem-solving skills (Muliawati & Sutirna, 2022) and have difficulty in solving mathematical problems (Hijada & De la Cruz, 2022). The difficulties experienced by students are due to students' poor cognitive abilities. Cognitive abilities in learning such as the ability to remember, memorize, and understand problem solving (Tambychik & Meerah, 2010).

Unfortunately, there are still many students who do not have problem solving skills. One of the problems that is often obtained is that students do not master the basic topic in math, such as mixed integer operations. Students experience difficulty in solving integer operation problems due to students' low ability in solving problems (Mandasari & Rosalina, 2021). This topic is the topic that will be used to study algebra, function values, systems of linear equations of two variables, and other important topics. For this reason, mathematical problem-solving skills must be improved. In accordance with the findings of (Islamiyah, 2017) in the topic of mixed arithmetic operations there are many operating concept errors and the way of thinking of students is very lacking. Some of the factors that cause student errors are that students do not understand the concepts learned, students do not know the order of the arithmetic operations, and students are also less skilled in working on math problems. However, there has been no research that has carried out an in-depth analysis of the problem-solving abilities possessed by students on the topic of mixed integer arithmetic operations, especially based on Polya's problem-solving steps.

Several studies have been conducted on students' problem-solving abilities in whole number operations topic, including Hamapinda et al. (2021) which states that students' ability to solve problems based on Polya's steps is 59.86% and is in the quite good category. The topic on mixed integer operations has also been researched by Suryadi et al. (2022) who stated that students' problem-solving abilities in the topic on mixed integer operations are generally in the quite good category.

Based on the explanation above, this study aims to analyze students' mathematical problem-solving ability on mixed arithmetic operations of whole numbers based on Polya's problem-solving steps.

**METHOD**

This study used a qualitative approach with a narrative research type. The research subjects consisted of 32 junior high school students in Kota Bandung, West Java. Data collection was carried out with mathematical problem-solving ability test instruments and interviews to selected participants. The data was analyzed using three stages, namely data reduction, data presentation and drawing conclusions.

This research will be analyzed based on the four stages of problem solving according to Polya, namely: understanding the problem, planning the plan, carrying out the plan, and looking back. At the stage of understanding the problem, students understand the problem that has been given. Then, at the stage of planning a solution (planning a plan), students use their knowledge and creativity to develop possible strategies to solve the given problem. At the stage of implementing the plan (carrying out the plan), students apply the chosen strategy to solve the given problem completely. Finally, at the looking back stage, students review their work and make sure they have not made any mistakes.

The data analysis technique begins with reviewing descriptive measures of problem-solving ability test results based on Polya's steps. Based on the scores obtained, students' mathematical problem-solving skills in Polya's steps were qualified according to Table 2.

Table 2. *Qualification of Problem-Solving Ability*

Value	Qualification
$80 < x \leq 100$	Very good
$65 < x \leq 80$	Good
$55 < x \leq 65$	Sufficient
$40 < x \leq 55$	Less
$0 < x \leq 40$	Very less

**RESULTS**

This study aims to analyze students' mathematical problem-solving skills in solving mixed arithmetic operations of whole numbers. The problem consists of 4 description questions given to 32 seventh grade students. All student answers were examined and then compiled so that conclusions were obtained from all answers. From the results of student answers, the mathematical problem-solving ability group can be seen in table 3.

Tabel 3. *Recapitulation of Mathematical Problem-Solving Ability*

Value	Qualification	Students	Percentage
$80 < x \leq 100$	Very good	3	9,38 %
$65 < x \leq 80$	Good	3	9,38 %
$55 < x \leq 65$	Sufficient	12	37,50 %
$40 < x \leq 55$	Less	5	15,63 %
$0 < x \leq 40$	Very less	9	28,13 %

Table 3 above, shows that students' mathematical problem-solving abilities are more in the sufficient category. It also can be seen from the percentage of mathematical problem-solving abilities of students with very poor and poor qualifications which shows a high percentage compared to the percentage of mathematical problem-solving abilities of students with very good and good qualifications.

Furthermore, a recapitulation of 32 students who can answer questions based on Polya's problem solving steps in table 4.

Tabel 4. Recapitulation of Students' Results According to Polya Problem-Solving Steps

Polya's Problem-Solving Steps	Number of Students Who Answered Correctly			
	Number 1	Number 2	Number 3	Number 4
Understand the problem	29	30	26	14
Planning the plan	23	18	7	4
Implement a solution plan	18	26	25	3
Rechecking the answer	16	10	12	3

The following are the results and analysis of student answers in solving 4 questions in solving problems on mixed arithmetic operations of whole numbers.

**Results of student answers**

In problem number 1, there are students who are able to work on the problem correctly and some are still not right. Student 1 can follow Polya's steps and can understand important information topic from the problem, planning steps that can be taken to find a solution to the problem by finding Firda's age, Nadia's age and their total age first, then finding the difference between Firda and Nadia's total age and Auntie's age. This can be seen from the results of the researcher interview (P) with the respondent (R) as follows.

- P : "What is the important information that you know from the question?"
- R1 : "Nadia is 5 years older than Firda, Firda is 23 years younger than auntie, and auntie is 60 years old"
- P : "What steps will you take to solve the problem?"
- R1 : "Find Firda's age, Nadia's age, and the sum of their ages first"
- P : "After that what will you do?"
- R1 : "Calculate the difference between Firda and Nadia's total age and aunt's age"

This is in accordance with the correct answer as shown in Figure 1.

1. Umr bibi = 60  
 $\frac{23}{37}$  (Umr Firda)

2. Umr Firda = 37  
 $\frac{5}{42}$  (Umr Nadia)

$42 + 37 = 79$  tahun  
 $79 - 60 = 19$  tahun

Figure 1. Example of correct answer to question number 1

In Figure 1, R1 can answer question number 1 correctly. He can use the question information well to solve the problems given. He can also follow the stages of problem solving well until he finds a solution to the problem.

There were also students who could not understand the problem properly so that they could not solve the problem correctly. This is because the respondent could not understand the important information in the problem which caused him to find Firda's age incorrectly. Furthermore, Nadia's age was also incorrect. The following is an interview between the researcher and the respondent.

- P : "What is the important information that you know from the question?"
- R2 : "Auntie is 60 years old"
- P : "Is there anything else?"
- R2 : "That's it"

- P : "What is asked in the question?"  
 R2 : "Total difference between Firda's and Nadia's age and aunt's age"  
 P : "What steps will you take to solve the problem?"  
 R2 : "Looking for Firda's age, aunt's age and Nadia's age"

The results of interviews conducted with students are in accordance with the answers he obtained as in Figure 2.

Figure 2. Example of wrong answer on question number 1

In Figure 2, R2 cannot follow the stages of problem-solving based on Polya. He cannot understand the information given correctly. Therefore, the answer he got also contained errors so he was wrong in finding the solution to the problem.

As with problem number 1, problem number 2 also has students who are able to work on the problem correctly and some are still not right. There are students who are able to work on Polya's problem-solving steps correctly and the results are also correct. The following are the results of the researcher's interview (P) with the respondent (R) as follows.

- P : "What is the important information that you know from the question?"  
 R3 : "Antibiotics 3x1 capsules a day, paracetamol 3x2 capsules a day, then the problem is how many capsules Rina eats in 3 days."  
 P : "What steps will you take to solve the problem?"  
 R3 : "Figure out how many capsules Rina takes in a day and then add them up."  
 P : "After that what will you do?"  
 R3 : "Calculating the number of capsules a day eaten is 9 capsules, because there are 3 days, so the total is 3x9 which is 27"  
 P : "How do you make sure your answer is correct?"  
 R3 : "I re-divide the answer obtained which is 27 divided by 3, we get 9 capsules, which corresponds to the number of capsules taken per day."

Here is the correct answer as shown in Figure 3.

Figure 3. Example of correct answer to question number 2

In Figure 3, R3 can use the information in the question correctly. He uses information about the rules for taking medication as initial information in solving the problems given. By using Polya's stages, he can solve this problem correctly.

The results of interviews with other students are as follows.

- P : "What is the important information that you know from the question?"  
 R4 : "He should take antibiotics 3x1 capsules a day and paracetamol 3x2 capsules a day"  
 P : "What do you need to finish here?"

- R4 : "How many capsules did Rina eat in 3 days"  
P : "What steps will you take to solve the problem?"  
R4 : "Number of capsules in a day consisting of antibiotics and paracetamol, then find the total taken over 3 days"

The student has been able to understand the problem well, but he is still less careful so that the answer obtained is still not correct as in Figure 4.

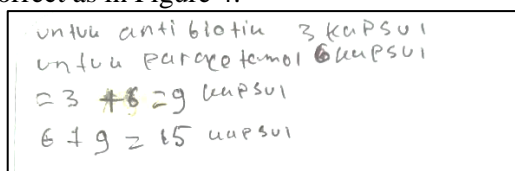


Figure 4. Example of wrong answer on question number 2

In Figure 4, R3 made a mistake in understanding the information contained in the question. He used arithmetic operations incorrectly to solve the problem. It should use multiplication operations instead of addition. This causes the answers obtained to contain errors.

As with questions number 1 and number 2, number 3 also has correct answers and incorrect answers. The following are the results of interviews with students whose answers are correct.

- P : "What is the important information that you know from the question?"  
R5 : "Mom bought 3 kg of mangoes that cost 8,000 per kilo, there are 12 pieces in total, we have to find the price of 1 piece of mango."  
P : "What steps will you take to solve the problem?"  
R5 : "I first find the price of a mango at a price, then find the price of 1 mango"  
P : "How did you look for it?"  
R5 : "There are 12 mangoes in total, and they are 3 kg, so 1 kg has 4 mangoes. After that, the price per kilogram 8,000 per kilo, so the price of 1 mango is 2,000"

The student's answer can be seen in Figure 5.

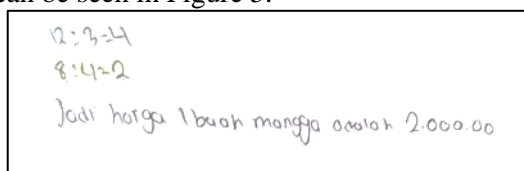


Figure 5: Example of the correct answer to question number 3

In Figure 5, R5 can solve the problem correctly. This can be seen from R5's use of appropriate information. He can understand the questions well and can plan properly. This makes it easier to solve these problems.

There were also students who did not manage to do problem number 3 perfectly. In fact, he can understand the important information in the problem well. Here are the results of his interview.

- P : "What is the important information that you know from the question?"  
R6 : "Mom bought 3 kg of mangoes at 8,000 per kilo. The total number of mangoes is 12"  
P : "What steps will you take to solve the problem?"  
R6 : "Finding the price of 1 mango, but yesterday I didn't have time to do it because of lack of time"  
P : "If there is additional time, are you sure you can do it?"  
R6 : "I'm sure mom"

Students' answers are in accordance with the results of the interview, this can be proven by the answers obtained during the interview. It can be seen in figure 6.

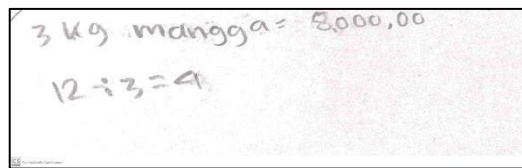


Figure 6. Students' answers during the interview

In Figure 6, R6 cannot solve the given problem correctly. This is caused by the ability of students who cannot understand the information in the questions well. But during interview process, he can answer the question, but he cannot solve the problem completely.

Problem number 4 is considered by students to be the most difficult problem. This can also be seen from the results of student answers, out of 32 students there are only 3 students who can do the problem correctly. The following are the results of an interview with a student who can answer correctly.

- P : "What is the important information that you know from the question?"  
 R7 : "The correct answer gets 4 points, the wrong one is worth -1, and the one who doesn't answer is worth 0. Nafa is given 50 questions, can answer correctly 39 questions and 5 questions are not answered, we have to find out whether Nafa passes or not."  
 P : "What steps will you take to solve the problem?"  
 R7 : "Find how many questions are wrong, find Nafa's Olympic score"  
 P : "How did you look for it?"  
 R7 : "I added up the points and also subtracted the wrong points."

The following student answers can be seen in Figure 7.

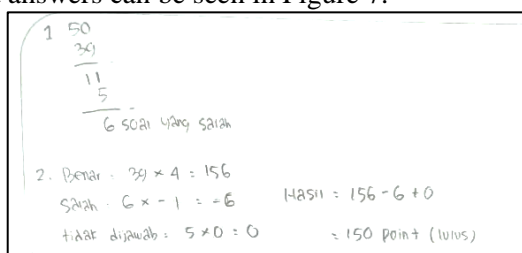


Figure 7. Students' correct answers to question number 4

In Figure 7, R7 can understand the information contained in the question correctly. So, he can solve problems and find the right solution.

There are also students who still haven't managed to do it. Here are the results of the interview.

- P : "What is the important information that you know from the question?"  
 R8 : "Questions answered correctly are worth 4, wrong questions are worth -1, and not answered 0. Out of 50 questions, Nafa was able to answer 39 questions correctly, 5 were not answered. The passing score for the Olympiad is 142"  
 P : "What steps will you take to solve the problem?"  
 R8 : "I can't solve this problem because I don't have enough time, ma'am"  
 P : "If given more time, would you be able to solve it?"  
 R8 : "No, ma'am"

**Analysis Based on Polya Problem Solving Steps**

In problem number 1, students have not been able to understand the problem well as in the following picture.

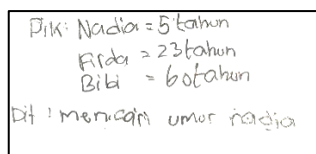


Figure 8. Display of student answer number 1

Figure 8 shows a student who misunderstood important information in the problem. Furthermore, the plan he made was not appropriate. This caused him to be unable to answer the problem. Based on interviews with respondents, the assumption that math is difficult makes them afraid and difficult to understand the problem.

In number 2, most students can understand the problem well. However, there are also students who are still not careful about the important information in the problem. This can be seen in Figure 9(a).

Rind sedang sakit itu dan berobat ke dokter di rumah hitung  
 dan berak banyak jadi makan kina

(a)

Jadi antibiotik di kaitkan terlebih dahulu dan

(b)

Antibiotik  $3 \times 1 = 3 \times 3 = 9$   
 Parasetamol  $3 \times 2 = 6 \times 3 = 18$   

$$\begin{array}{r} 19 \\ 18 \\ \hline 27 \end{array} +$$

(c)

$3 \times 3 = 9$   
 $6 \times 3 = 18$   
 $= 27$

(d)

Figure 9. Display of student answer number 2

In Figure 9(b), students are also still not perfect in writing the steps to be done. However, the student can solve the problem correctly according to Figure 9(c), although at the rechecking stage the student is still not perfect. Based on the results of interviews with students, he stated that he was not used to working on story problems by writing things that were considered important in the problem.

In number 3, students can write down important information contained in the problem. This can be seen in figure 10.

①. Jadi 3 hari 9 antibiotik  
 ②. Jadi 3 hari 18 parasetamol

Figure 10. Display of student answer number 3

However, students could not plan and work on the problem properly. This is due to lack of time. Based on the results of the interview, students stated that they could work on the problem if they had the time to do it longer. The factor that causes this student to take a longer time is because he is still not used to working on problem exercises.



In question number 4, there were only 3 students who could answer the question correctly. This can be seen in figure 11.

Dik: Jika soalnya dijawab benar : 4 nilai  
 Jika soalnya tdk dijawab : 0  
 Salah : -1 nilai  
 39 dijawab benar  
 5 soal tdk dijawab

(a)

- 
- ① mencari hasil nilai yang benar, salah dan tdk dijawab
  - ② mencari soal yang salah
  - ③ mencari nilai nafa

(b)

$39 \times 4 = 156$  nilai yang benar  
 $6 \times -1 = -6$  nilai yang salah  
 $5 \times 0 = 0$  nilai yang tdk dijawab  
 $156 + (-6) = 150$  nilai olimpiade Nafa  
 $39 + 5 = 44$   
 $50 - 44 = 6$  soal yang salah  
 $\therefore$  Nafa lulus, karena nilai Nafa lebih dari 142

(c)

$156 : 4 = 39$   
 $44 + 6 = 50$   
 $150 - (-6) = 156$

(d)

Figure 11. Display of student answer number 4

In problem number 4, the student can understand the problem correctly and can plan the steps to solve the problem. Furthermore, he can also find the right answer to the problem, and can check the answer again has obtained. This shows that his mathematical ability is good so that he can solve this problem by using the right Polya steps.

## DISCUSSION

Good learning requires well preparation from both teachers and students (Munna & Kalam, 2021). Teachers must be ready to plan various preparations before carrying out the learning process. Likewise with students, they must prepare themselves well both physically and mentally. It is hoped that students can understand the learning well without any significant difficulties or obstacles. This is in accordance with (Harefa & Harefa, 2023) which states that the readiness of teachers and students is very necessary in the learning process so that the learning process can be carried out well.

Students must always be confident to solve the problems given. This will have an impact on his study as he will continue to study hard. On the other hand, if students often feel insecure and believe that they are not capable, this can reduce student motivation and they will experience difficulties in the learning process. This is supported by (Widyaningrum, 2016) who stated that the negative impression experienced by students makes it difficult for them to understand mathematics.

The positive impression created during the learning process can create motivation for students (Yeh et al., 2019). So, students will continue to try to learn and understand the topic being taught. Motivation is very important during the learning process. In accordance with (Lestari, 2013) which states that motivation can influence student learning development.

In a learning process, students will be given problems that are appropriate to the topic being taught. This is to see the students' ability to understand the topic. In this process, students are expected to be calm in solving these problems. This calm can be obtained from within the student and from the surrounding environment. This calm can be obtained easily if students often work on the problems given. This is in accordance with Fatahillah et al. (2017) who stated that students who are not used to working on questions tend to rush, resulting in them not being able to write what they know and what is asked in the question.

This student's hasty attitude is usually the result of little time or insufficient remaining time to solve the problems given (Uyen et al., 2021). In this condition, students often do not focus on the problems given. Apart from sufficient time, a problem can be solved quickly if students are used to working on similar problems (Darling-Hammond et al., 2020). This makes students trained to determine important information in the problem, plan a solution and execute the plan. In the final stage, students can also easily check the correctness of their answers. This is in accordance with Akbar et al. (2018) who stated that students are still not used to working on questions so they have difficulty answering the questions quickly.

The student's habit of solving a problem makes him more able to understand the topic (Gulacar et al., 2013). So, students' abilities towards the topic can also increase. In accordance with Sulistiani et al. (2019) who stated that students with high mathematical abilities can perform arithmetic operations correctly so that the correct answer can be obtained.

## CONCLUSION

This research contains an analysis of students' answers based on Polya's problem-solving steps. Researchers concluded that students' problem-solving abilities obtained based on these four steps are in the form of students who can determine important information in the problem and can plan solutions resulting in them being able to solve problems more regularly, namely by executing the plans they have planned. After that, students who understand the problem well can also check the correctness of the answers they have obtained. Therefore, it is hoped that this research can help teachers to implement a learning process that can develop problem solving abilities. This research can be a reference for teachers to create a learning process that can develop students' problem-solving abilities.

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