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The Students' Mathematical Problem Solving Skills in Solving HOTS Problems

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Abstract. Problem-solving skills have a vital role in students' daily lives. This research aims to describe the students' problem-solving skills in solving HOTS problems. This research is a descriptive study. The research subjects used were 33 eleventh-grade students at one of the senior high schools in Musi Banyuasin, South Sumatera. A problem-solving test with the HOTS problems level was used as a data collection instrument. The results of this study depicted that the students have medium problem-solving skills. The students' problem-solving skills are inconsistent in solving HOTS questions. In understanding the problem stage, students have been able to write down the information obtained from questions, but some have not been able to write down complete and ideal information. While in determining plans and strategies stage, students have been able to make mathematical models based on the information obtained in the previous stage. The students are weak in solving problems stage because students are still not complete in solving problems according to the commands of the questions. The students also have weak in rechecking stage. So, teachers must optimize students' problem-solving skills. The teachers need to optimize students' problem-solving skills through exercises in solving HOTS problems using Polya's steps.

Keywords: HOTS Problems; Mathematical Problem Solving; Problem-Solving Skills

Abstrak. Keterampilan pemecahan masalah memiliki peran penting dalam kehidupan sehari-hari siswa. Penelitian ini bertujuan untuk mendeskripsikan kemampuan pemecahan masalah siswa dalam menyelesaikan soal HOTS. Penelitian ini merupakan penelitian deskriptif. Subjek penelitian yang digunakan adalah 33 siswa kelas XI di salah satu SMA di Kabupaten Musi Banyuasin, Sumatera Selatan. Tes pemecahan masalah dengan level soal HOTS digunakan sebagai instrumen pengumpulan data. Hasil penelitian ini menggambarkan bahwa siswa memiliki kemampuan pemecahan masalah yang sedang. Kemampuan pemecahan masalah siswa tidak konsisten dalam menyelesaikan soal-soal HOTS. Pada tahap memahami masalah, siswa sudah mampu menuliskan informasi yang diperoleh dari soal, namun sebagian belum mampu menuliskan informasi yang lengkap dan ideal. Sedangkan pada tahap menentukan rencana dan strategi, siswa sudah mampu membuat model matematika berdasarkan informasi yang diperoleh pada tahap sebelumnya. Siswa lemah dalam tahap pemecahan masalah karena siswa masih belum tuntas dalam menyelesaikan masalah sesuai dengan perintah soal. Siswa juga memiliki kelemahan dalam tahap pemeriksaan ulang. Jadi, guru harus mengoptimalkan kemampuan pemecahan masalah siswa. Guru perlu mengoptimalkan kemampuan pemecahan masalah siswa melalui latihan soal HOTS menggunakan langkah-langkah Polya.

Kata kunci: Kemampuan Pemecahan Masalah; Pemecahan Masalah Matematis; Soal HOTS;

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INTRODUCTION

Learning mathematics is essential at every level of education to establish students who are experts in dealing with change (Suryani et al., 2020). The role of mathematics is vital since it is needed in every aspect of life. Therefore, mathematics must be studied (Sumartini, 2016). Given the importance of mathematics, it is evident that mathematics is a beneficial and vital subject to be learned and mastered by students. One of the mathematical abilities that students must possess is problem-solving ability (Peranginangin et al., 2019).

Problem-solving is an efficient activity that can be done individually or in small groups, carried out cooperatively or in groups using the discussion method (Suryani et al., 2020). Students must possess and develop this ability in learning mathematics (Mulyati, 2016; Amalia & Hadi, 2021). Similarly, Gunantara said that one of the abilities that exists in an individual is the ability to solve problems (Imamuddin et al., 2019; Gunantara et al., 2014). The stages of Polya in problem-solving are understanding the problems, determining plans and strategies, resolving the problems, and rechecking the answers (Pulungan & Reflina, 2022; Davita & Pujiastuti, 2020; Hadi & Radiyatul, 2014). By solving problems, students can benefit themselves and those around them. This ability allows students to connect abstract concepts and understand real problems (Araiku et al., 2022).

The advantages of problem-solving include students learning various ways of solving problems, developing communication skills, raising social values, and thinking logically (Sani, 2016). Considering the benefits of problem-solving, which can help students with diverse characteristics, each student has their way of solving problems, so open-ended problems can be used as an alternative to making it easier for them to solve problems (Imandiyani, 2018). However, several factors can affect students' problem-solving skills, including initial experience, desire, and mathematical background (Subaidi, 2016). Students who have low problem-solving abilities are usually caused by a lack of interest, inappropriate learning methods, and limited learning facilities (Sumartini, 2016).

Mathematical problems given to students can train them to think because this ability is primarily determined by students' thinking skills (Imandiyani, 2018). One of them is higher-order thinking ability (HOTS). It is necessary to provide mathematics to all students starting from elementary school to equip them with logical, analytical, systematic, critical, and creative thinking and problem-solving skills (Pradani & Ilman, 2019). The indicators in HOTS are *analyzing*, which is dividing the material into several parts, connecting each part in a comprehensive and structured manner; *evaluating*, which is to re-examine based on criteria and standards; and *creating*, which is combining various parts to create new things in the form of original products (Imandiyani, 2018). On the other hand, Brookhart defines HOTS into a variety of viewpoints, including 1) analyzing,

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evaluating, and creating, 2) reasoning logically, 3) making decisions and thinking critically, 4) solving problems, and 5) doing creativity and creative thinking (As'ari et al., 2019).

Previous research on problem-solving based on HOTS shows different results. Students' high-level thinking abilities may be spread relatively evenly between high, medium, and low abilities (Hasyim & Andreina, 2019; Fauziah et al., 2019; Ayuningtyas & Rahaju, 2013). Other research shows different results, namely that only a tiny percentage of students have advanced thinking abilities at a high level (Murodda et al., 2022). Other research reveals that students generally need help understanding problems and choosing the right solution (Losi, 2020). These studies discuss more about HOTS in solving open-ended problems. Meanwhile, researchers researched students' problem-solving abilities in solving HOTS questions.

Based on the results of an interview with a mathematics teacher at a rural high school in South Sumatra, only a few eleventh-grade students have relatively good problem-solving skills. Only a few students can solve problem-solving problems well. Researchers must examine students' problem-solving abilities in solving and describing HOTS questions.

METHODS

This research is a descriptive study to describe the students' mathematical problem-solving skills in solving HOTS problems. The participants in this study were 33 students of a science group in one of the senior high schools in Musi Banyuasin, South Sumatera. Meanwhile, the method of taking the research subjects was carried out with the nonprobability sampling technique.

Problem-solving test with HOTS problems was used as a data collection instrument. The HOTS problem used in this study has been developed by Ilmiyana (2018) and consists of two problems about the Linear Equalities System of Two Variables material. Each question was conducted using polya stages, which consist of 4 steps. Thus, the researcher directly used the questions in the study without conducting retests for the validity and reliability level. The validity of the questions has been tested using the correlation of moment products, so the test is classified as valid. The test was a reliability test using the Cronbach alpha formula, so the test was reliable. Here are the problems.

Problem I:

The age gap between a father and his daughter is 26 years old. Five years ago, the sum of their ages was 34 years old. Sum up the aging of the father and daughter in the next two years!

Problem II:

A rectangular garden has a perimeter equal to 44 meters long. If the width is 6 meters shorter than the length, find the length and width of the garden!

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The data analysis technique is in the form of quantitative descriptive analysis. Furthermore, the results of students completing the HOTS problems referring to the Polya steps are described. The collected data was divided into several groups, including students who answered correctly and completely, correct but incomplete, there were errors, and the answers were not written down.

Table 1. The Test Scoring Guidelines

Polya's Stages	Scores	The Descriptions of Students' Answer
Understanding the Problems	0	No answer
	1	Incorrect answer
	2	Correct answer but incomplete
	3	The correct and complete answer
Determining Plans and Strategies	0	No answer
	1	Determining plans but incorrect
	2	Correctly determining plans
Solving the Problems	0	No answer
	1	Incorrect answer
	2	Correct answer but incomplete
	3	The correct and complete answer
Rechecking the Answers	0	No answer
	1	Interpret the results, but no conclusion
	2	A correct and complete conclusion

Table 2. Student Skills Categories Based on Total Score

Student Skills Categories	Value Range
High	$X \geq 12$
Medium	$6 \leq X < 12$
Low	$X < 6$

RESULTS AND DISCUSSION

Table 3. The Percentage of Students Who Give Correct Answers on Each Step

Polya's Stages	Total Students (%)	
	Problem I	Problem II
Understanding the problems	24 %	9 %
Determining plans	49 %	15 %
Resolving problems	9 %	3 %
Rechecking answer	3 %	0 %

Based on the data shown in Table 3, the percentage of students who meet the stage of understanding Problem I is more excellent than Problem II. When preparing a plan for Problem I, the percentage of students completed at this stage is more significant than Problem II, with a large enough difference. The percentage of student completion at the stage of solving Problem I is also more significant than that of Problem II. It also happens at the stage of re-examination. The percentage of students who meet at this stage is small. Even for Problem II, there are no students who meet this stage. Thus, it can be seen that it is weak at the stage of understanding the problem, solving the problem, and re-examining, as well as the inconsistency of mastery of the Polya stage on two different questions.

The following is related to the ability to solve mathematical problems based on the polya stages associated with the HOTS problem-solving ability test results.

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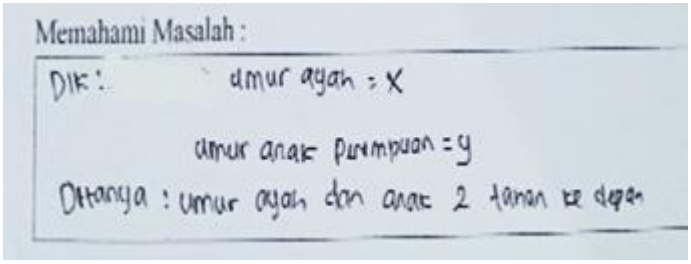
Understanding the Problem



Understanding the Problem:

Given: The father's age = x

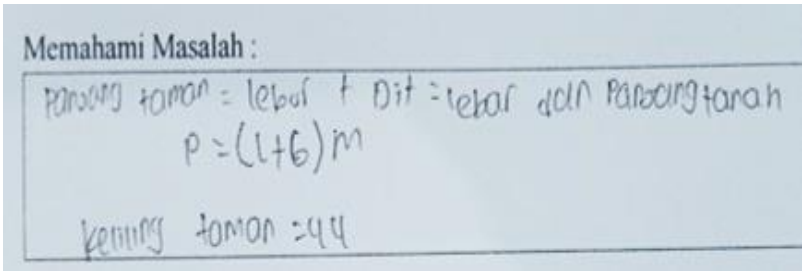
The daughter's age = y

Solve: The ages of the father and the daughter will be in the next two years.

Figure 1. Students do not Form an Equation for the Relationship Between the Father's Age and the Daughter's Age

Based on Figure 1, it can be seen that at this stage, students can write down the information obtained from the question in the form of information that is known from the problem by assuming x = father's age and y = daughter's age, then write down what is asked by the question. However, the written information is incomplete because of the difference in the ages of the father and daughter and the age of the two five years ago.

This stage is the stage that most students do, but some of them have not shown their ability to understand the information obtained from the questions in solving problems. The students have not been able to describe the information provided by the questions. Moreover, some students have not been able to determine the completeness of the information on the questions on the test, which they then wrote down on the test answer sheet. For Problem II, some students have difficulty understanding information from the question, such as not assuming the length and width with a variable, not including the formula for the perimeter of a rectangle, and not writing down what the question is asking, as shown in Figure 2.



Understanding of the Problem:

The garden length = width + 6
p = (l + 6) meters
The perimeter of the garden = 44 meters
Find the length and the width of the garden.

Figure 2. Students do not Equate Length and Width with Some Variables

However, some students understand the problem, as evidenced by some students who can convey the information by writing down what is known from the problem and what is meant by the question. Newman argues that students who can read the words in the problem are not necessarily able to understand each of these words (Utami & Wutsqa, 2017). This condition involves understanding language and mathematical modeling that all students have mastered. According to Geary, the ability to process mathematical information is something that students need to improve (Geary et al., 2012). This situation is a fact that is often found (Utami & Wutsqa, 2017). Several factors hinder students from answering correctly, namely the problem of interpreting theory, which is related to understanding the meaning of the problem, and the

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ability of the mathematical process, which consists of transformation, skills, and processes (Prakitipong & Nakamura, 2006), and student's interest in learning (Angraini et al., 2022).

Determining Plans and Strategies

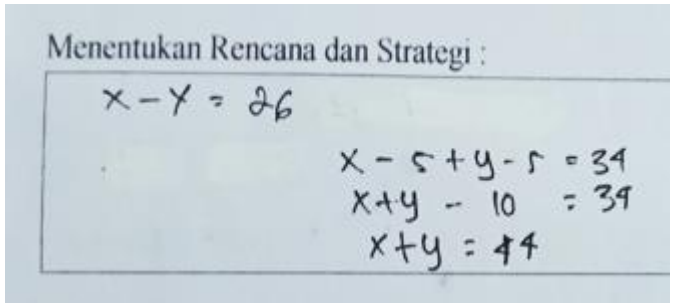

Figure 3. Students Determine the Plan and Strategy of Problem I

Based on Figure 3, students have been able to plan and determine the strategies that will be used to solve problems. The plans and strategies used by the students were to make a mathematical model based on the information obtained from the problem, such as a mathematical model of the difference in the ages of father and daughter, namely $x-y = 26$, then a mathematical model of the sum of their ages five years ago, namely $(x - 5) + (y - 5) = 34$.

The stages of determining plans and strategies are in the moderate criteria based on the percentage table of Polya steps. Some students need help determining plans and strategies, which they use to solve problems, especially in Problem II. Only a few students can do this.

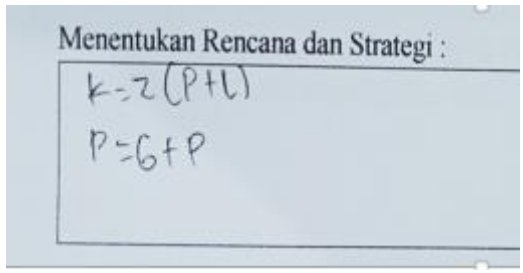

Figure 4. Incomplete Plan and Strategy of Problem II

Based on Figure 4, it can be seen that students have difficulty in determining the plans and strategies that will be used in solving questions. Students only write the formula for the perimeter of the square without entering the information obtained from the problem, such as the perimeter of the garden = 44 meters long, and the width of the garden is 6 m shorter than the length. This condition can occur because students who have been able to understand what the problem wants need help finding and determining the operations/equations needed to solve the problem (Utami & Wutsqa, 2017). This situation aligns with previous research that shows many students have difficulty deciphering the information in the questions to be associated with appropriate and relevant mathematical theories, so students are less precise in modifying the problem into a mathematical model (Sari & Wijaya, 2017). The limited ability of students to plan and determine

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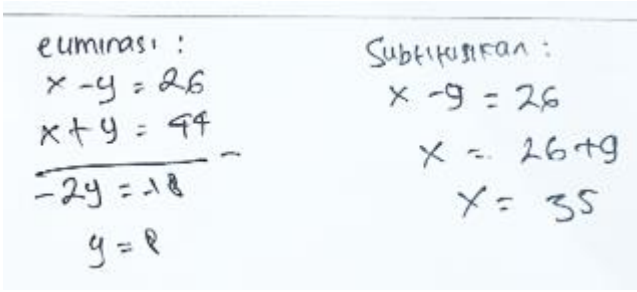
strategies can be seen when students are less precise in determining the theory used to solve problems (Utami & Wutsqa, 2017).

Solving Problems



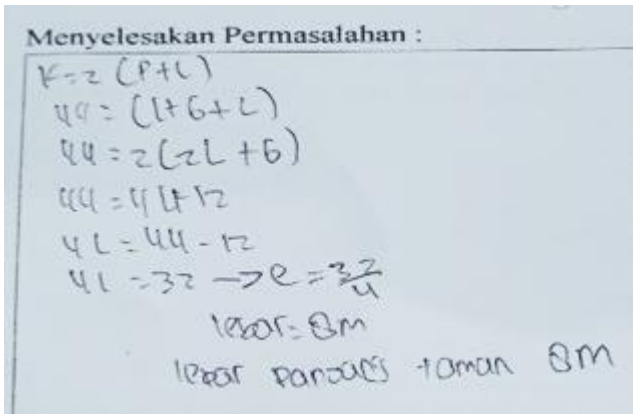
Eliminate y from two equalities to find y.

Substitute y = 8 into the first equality to find x.

Figure 5. Solving Problem Problem II

Based on Figure 5, students use the method of elimination and substitution. The elimination method used by students to find the value of y (daughter's age) is eight years old, then the substitution method is used by students to find the value of x (father's age), which is 35 years old. However, students have not been able to solve the problem to completion. Because students only managed to find the ageage of the father and daughter, while the questions on the questions have not been completed by students at the stage of solving the problem.

The inability of students to solve problem-solving is shown chiefly in Problem II because most students did not answer the stage of solving the problem of Problem II—the students who answered the stage of solving the problem of Problem II, in the following picture.



Solving the Problem:

Substitute K = 44 and p = l + 6 into the perimeter equation K = 2 (p + l).

Do algebraic manipulation to find l = 8.

It means the width = 8 meters long.

So, the width of the garden is 8 meters long

Figure 6. Incomplete Solution of Problem II

Based on Figure 6, students find the width by using the formula for the perimeter of a rectangle so that the width of a rectangular garden is 8 meters long. However, students only solved the problem once they got the length of a rectangular garden. This problem is because at least students can determine the relationship between the information in the question and the theory that needs to be used. Most students are confused when connecting what is known from the question and the steps for solving it, especially in Problem II. So, students are often incomplete and wrong in solving problems, even discrepancies between the formulas written at the stage of determining

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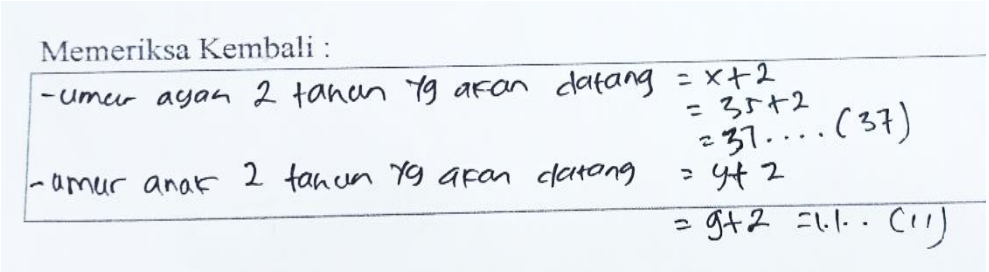
plans and strategies. It follows Newman's statement that it is possible to occur to students who are capable of recognizing operations on questions but are not able to solve problems (Utami & Wutsqa, 2017). It is reinforced by Elbrink's opinion, which states that the classification of students' mathematical errors includes calculation, procedural, and symbolic errors (Hasibuan et al., 2022). Students have not been able to solve problems by using different methods from the usual. However, students have been able to apply previously learned concepts to solve HOTS problems, such as using substitution, elimination, and mixed methods (Al-Mutawah et al., 2019).

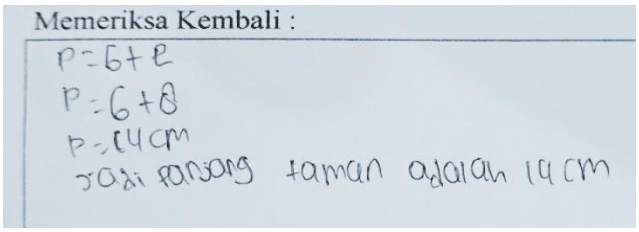
Rechecking



Rechecking:
The father's age for the next two years is more two than 35 or equal to 37 years old.

Figure 7. Students do not Recheck the Current Age of the Father and the Daughter

Based on Figure 7, students rechecked the father's age in the next two years by, e.g., $x + 2$, then substituted the father's age from the previous stage so that $35 + 2 = 7$. come up with, for example, $y + 2$, then substitute the ageage of his daughter obtained from the previous stage so that it is obtained $9 + 2 = 11$. Students still need to complete the rechecking stage because students do not recheck the ages of the father and daughter.



Rechecking:
So, the length of the garden is 14 cm

Figure 8. Students' Inaccuracy in Re-examining

Based on Figure 8, students do not recheck the answers obtained from the stage of solving the problem but look for the length of the plant. Students' ability in the rechecking stage can be shown when students substitute the results that have been obtained using other formulas or substitute the results into the equations written at the stage of determining plans and strategies. The percentage at this stage is the lowest when compared to other stages. Almost all students ignored

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the instructions on the question, needed help understanding how to re-examine, and were not even able to re-examine. The student feels enough of the final result he obtained without re-analyzing, and the student experiences confusion about substituting the results he obtained (Utami & Wutsqa, 2017).

Their ability to solve problems can be improved by getting used to solving non-routine problems (Utami & Wutsqa, 2017), using Problem-Based Learning (Nuraini et al., 2020), Guided Discovery learning (Tahir & Kurniawan, 2020), Missouri Mathematics Project learning model (Muhaimin & Mz, 2020), and Constructivism Learning Model (Asmar & Delyana, 2022). The more students with above-average self-directed learning, the better their problem-solving skills will be (Wulandari & Alyani, 2022).

CONCLUSION

Based on the results of data analysis and research results, students' problem-solving ability is inconsistent in solving two HOTS problems; in understanding the problem, students have been able to write down the information, but some students write down incompletely; in determining plans and strategies, students have been able to make mathematical models based on the information obtained in the previous stage, but some students complicated determine plans and strategies for problem II; some students are weak in solving problems like solving problems incompletely, do not answer according to the commands, and do not achieve the target to solve the problem; and students are weakly re-examining. The researchers suggest that teachers optimize training and improve students' problem-solving skills, especially in solving HOTS questions. The subsequent researchers are expected to conduct similar research using HOTS questions that meet all the indicators.

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