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Problem Solving Ability: Strategy Analysis of Working Backwards Based on Polya Steps for Middle School Students YALC Pasuruan

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Abstrak:
Tujuan penelitian ini adalah untuk menganalisis kemampuan pemecahan masalah matematika siswa berdasarkan prosedur Polya. Hal ini dapat meningkatkan kemampuan pemecahan masalah matematika siswa Kelas VIII SMP YALC Pasuruan. Data penelitian diperoleh dari analisis lembar jawaban siswa, lembar observasi, dan lembar aktivitas siswa berdasarkan indikator kemampuan pemecahan masalah. Jenis penelitian ini memiliki desain eksperimen semu dengan desain pre-test dan post-test. Uji-t dilakukan untuk memeriksa peningkatan pada setiap aspek keterampilan pemecahan masalah siswa dan semua aspek keterampilan pemecahan masalah matematika. Temuan utama dari penelitian ini adalah kemampuan pemecahan masalah siswa dalam matematika berdasarkan prosedur Polya mengungguli kemampuan pemecahan masalah siswa dengan pembelajaran reguler.

Kata Kunci: kemampuan pemecahan masalah, strategi bekerja mundur, langkah Polya, pembelajaran biasa

Abstract:
The purpose of this study was to analyze students' mathematics problem-solving abilities based on Polya's procedure. This may improve the math problem-solving abilities of Class VIII SMP YALC Pasuruan students. Research data were obtained from the analysis of student answer sheets, observation sheets, and student activity sheets based on indicators of problem-solving ability. This type of study has a quasi-experimental design with a pre-test and post-test design. A t-test was performed to check for improvements in each aspect of student problem-solving skills and all aspects of math problem-solving skills. The main finding of this study is that students' problem-solving ability in mathematics based on Polya's procedure outperforms students' problem-solving ability with regular learning.

Keywords: problem-solving skills, backward working strategies, Polya steps, ordinary learning

Introduction

In everyday life, we are often faced with various problems that often need to be resolved immediately (Nelson, 2013; Rahmawati et al., 2021). Problems arise when a person has a goal but does not know how to achieve it (Masfingatin et al., 2020; Utami et al., 2019). Indeed, not all the problems we face are mathematical problems, but to solve these problems many require mathematical thinking (Manalu et al., 2018; Zulyadaini, 2017). Mathematics learning in schools is not only intended to improve students' numeracy skills, but also to improve problem solving, both mathematical problems and other problems that use contextual mathematics to solve them (Desriyanti, 2014; Sari et al., 2018).

This is motivated by the direction of the development of Mathematics learning initiated

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by NCTM (2000) by stating that problem solving as a goal and approach. Solving problems means answering questions when the search method for solutions to unknown questions (Amam, 2017; Astutiningtyas & Wulandari, 2014; Pujiastuti, 2020). To find solutions, students must use previously learned things and work through the process by which they will develop new mathematical insights (Apriliani et al., 2016; Oktaviyanthi & Agus, 2019; Surya & Syahputra, 2017). Solving problems is not the goal of learning mathematics, but at the same time is the main tool for carrying out the learning process (Artika & Karso, 2019; Elsayed & ElSamanoudy, 2012).

It also highlights the different uses of problem-solving and recommends teachers encourage students to adopt these strategies. These strategies include manipulating, trialing, testing specific cases or special values, guessing and testing, calculating probabilities, collecting and organizing data and tables, finding patterns in tables, drawing diagrams, and working in reverse (NCTM, 1989 & NCTM, 2000). Implementing problem-based learning in schools is not as easy as one might think. Many factors hinder the optimization of the implementation of problem-solving learning, not only the teacher factor, but also the curriculum orientation factor, which is also the reason why teachers do not practice in a limited time.

In general, problems can be divided into two types, general questions and irregular questions. General questions are general factual questions that can be solved by procedures learned in class. Problems of this kind are found in many textbooks and are intended solely to train students to use the procedures learned in class (Ahdhianto et al., 2020). Meanwhile, unconventional questions are questions that need further thought to be solved because the procedures are not as clear or as clear as those learned in class (Meryansumayeka et al., 2021). In other words, these non-routine questions introduce new situations that students have never experienced before.

In a new situation, it is necessary to achieve a clear goal, but the way to achieve it has not yet appeared in the minds of students (Darmayanti et al., 2022). Asking unusual questions to students means training them to apply different mathematical concepts in new situations so that they can eventually use the different science concepts they have learned to solve everyday problems (Darmayanti & Sugianto, 2022). So that this irregular problem can be used as a solution to the problem. And problem-solving in mathematics education can be defined as the use of various mathematical concepts, principles, and skills that have been or are being learned to solve occasional problems (Herzon et al., 2018). However, many teachers have difficulty teaching children how to solve problems (often called non-routine questions), so many children also have difficulty learning them.

This difficulty may arise from the model that the final answer is the sole purpose of solving the problem (Hobri et al., 2020; Wahyudi & Anugraheni, 2017; Wiska et al., 2020). Children often use wrong techniques to answer problems because they focus too much on the final answer (Güner & Erbay, 2021). Meanwhile, we must realize that the problem-solving process, especially the way we solve problems, is much more basic and important. When the final answer comes first, the child may only learn how to solve a particular problem, but by focusing on the process, the child is likely to learn more about how to solve another problem (Herzon et al., 2018). Other factors are limited time, too many students in one class, and the teacher's lack of knowledge and experience (this makes it difficult to organize occasional questions) (Asmara et al., 2021). According to (Polya, 1973), the problem-solving solution consists of four stages of completion, namely understanding the problem, planning a solution, solving the problem according to the plan, and checking all the steps taken (Fadella et al., 2018).

Based on the description of the problem formulation, the purpose of this study is to describe the backward working strategy and how it is applied by analyzing students' mathematical problem-solving abilities based on Polya's steps which can improve students' mathematical problem-solving abilities in class VIII SMP YALC Pasuruan.

Method

This type of research is classified as quasi-experimental, depending on the questions considered. Data collection methods used in this study were pre and post tests based on indicators of problem solving abilities and student activity observation sheets to observe student activities during learning. To analyze the increase in students' mathematical problem solving abilities, t-test was used (Sudjana, 2011) and student activities during learning used student activity criteria with a given tolerance limit.

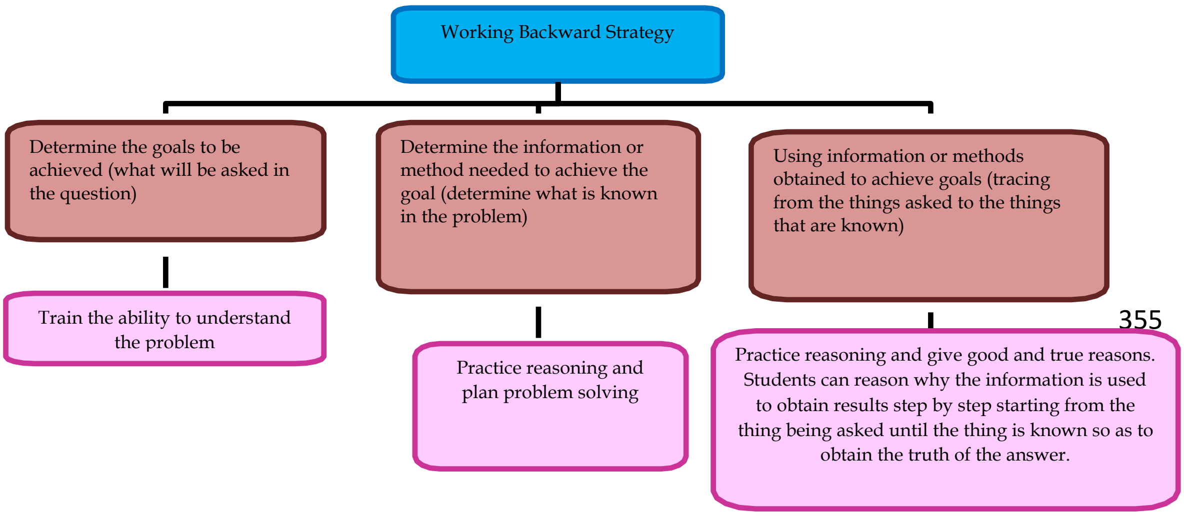
The working backward problem solving strategy contains three components as proposed by Eeden, namely: (a) First ask yourself What is my goal?; (b) Then you ask yourself What are the means to achieve this goal?; (c) Then solve or find as much means necessary to solve you goal(Yew et al., 2017; Enlow & Özgün-Koca, 2020; Ho et al., 2017; Ramful, 2015)

In other words, the three components referred to above are described in table 1 below:

Table 1. Indicators of working backward strategy

Aspect	Activity
Determine the goals to be achieved	Students are asked to determine what is being asked in the question, in this component the students' ability to understand the problem will be trained
Determine the information or means needed to achieve the goal	students are asked to determine what is known about the problem and think about how to solve the problem, in this component students are trained to reason and plan problem solving
Using information or methods obtained to achieve goals	tracing from the thing asked to the thing that is known (work backwards) so as to get the right answer, in this component students can be trained to give good and correct reasons for the answers they have got

For more details related to the components of the working backward strategy, you can see the following chart(Ho et al., 2017; Ramful, 2015):



Picture1. Components of Working Backward Strategy

Results and Discussion

Students' math problem solving ability before learning

The data in Table 2 were obtained based on the results of the pre and post tests given to students with the aim of analyzing students' mathematical problem solving abilities based on the Polya procedure.

Table 2. Data of pre-test and post-test results

Pre	Post	Information
63.77	79.84	Average
7.12	6.32	Standard Deviation
56.13	41.29	Variant
0.81		r_{xy}
15.17		t_{count}
2.01		t_{table}
$t_{count} > t_{table}$		Conclusion

Based on the calculations obtained from the pre-test and post-test, we found that the increase in students' scores was 15.2 based on the average score. The value of r is in a good range, but it means that there is a relationship between Polya's steps and students' problem solving abilities. Meanwhile, to test the increase in students' mathematical problem solving abilities were analyzed by t-test. Based on the results of the calculation of the overall aspect problem solving index, the t-count is 15.17 and the t-table value is 2.01, so it can be concluded that $t_{count} > t_{table}$ there is a significant difference between students. After learning math problem solving skills and step-by-step polya. Therefore, we conclude that the application of the Polya procedure in learning mathematics has an impact on improving students' mathematical problem solving.

Analysis of student response patterns based on polya. Stepping

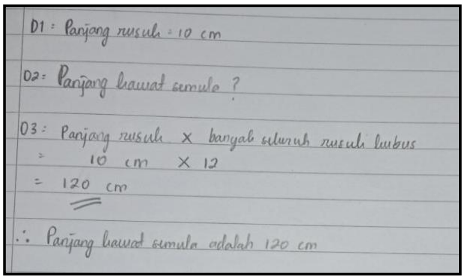
The pattern of answers/performance in understanding the problem on the pretest was better than the posttest of the students because the score on the writing aspect that was asked and which was known to be correct and complete in items 2,3,4,5 was higher than the final test. The aspect of the score of writing the adequacy of data correctly on the items numbered 1, 2, 3, 4 is higher than the results of the posttest answers. The pattern of answers/performance in planning the completion of the pretest is better than the posttest because the aspect of the score of writing the formula correctly and completely on items numbered 1 to 5 is higher than the student's posttest score.

The post-test answer pattern/calculation performance is better than the post-test. This is because the score for describing correctly and completely the accounting rules in items 1-5 is higher than the posttest class. The pattern/performance of students' responses to repeat the pretest was superior to that of the posttest students because the ratings for accurate and complete writing on items numbered 1 to 5 were higher than those in the posttest class. From the explanation above, it can be concluded that the response patterns of students who used the Polya step were more diverse than before using the Polya step and before using ordinary learning. The following is a description of students' questions and strategies in learning.

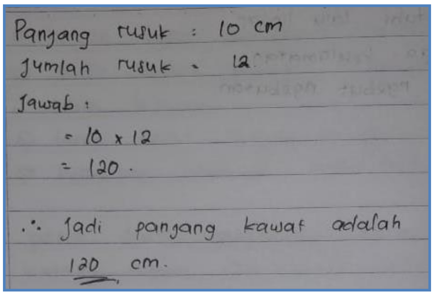
Problem 1

Andi and Budi want to frame a cube with a wire length of a cm. If the length of the side of the cube that can be made is 10 cm. What is the length of the wire again?

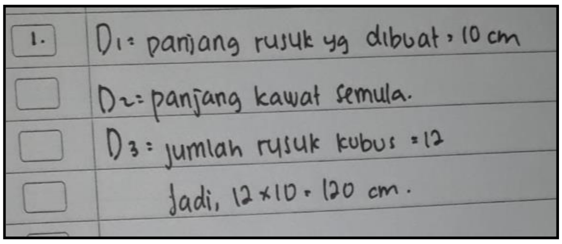
Student application results:


D1 : Panjang rusuk : 10 cm
D2 : Panjang kawat semula ?
D3 : Panjang rusuk x banyak seluruh rusuk kubus
= 10 cm x 12
= 120 cm
∴ Panjang kawat semula adalah 120 cm

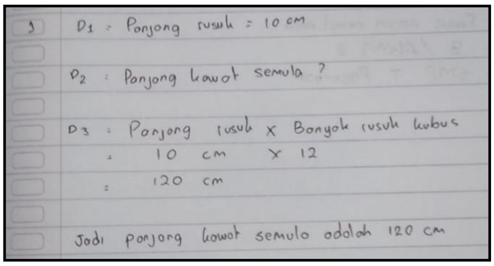
Subject 1


Panjang rusuk : 10 cm
Jumlah rusuk : 12
Jawab :
= 10 x 12
= 120 .
∴ Jadi panjang kawat adalah 120 cm.

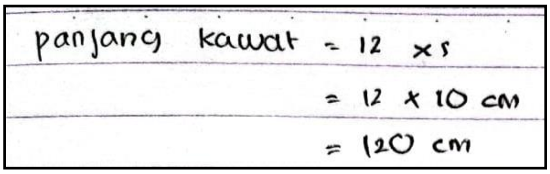
Subject 4


1. D1 : panjang rusuk yg dibuat : 10 cm
D2 : panjang kawat semula.
D3 : jumlah rusuk kubus = 12
Jadi, 12 x 10 = 120 cm.

Subject 2

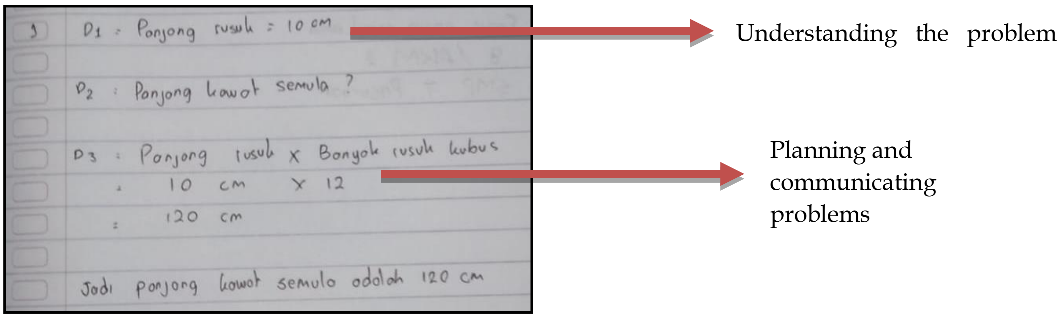

1) D1 : Panjang rusuk = 10 cm
D2 : Panjang kawat semula ?
D3 : Panjang rusuk x Banyak rusuk kubus
: 10 cm x 12
: 120 cm
Jadi panjang kawat semula adalah 120 cm

Subject 5


panjang kawat = 12 x s
= 12 x 10 cm
= 120 cm

Subject 3

Discussion and interview results from one of the subjects:



- ➔ Based on the picture beside, it can be seen that the initial step used by S-4 when working on the problem is to assume that it is something that is asked and the results will be sought. The subject makes a sketch of the information that is known from the problem in sequence.
- ➔ The length of the edge of the cube initially in the given problem will be used to make the skeleton of the cube, then the subject writes 10cm then multiplied by 12 because the number of edges of the cube is 12.
- ➔ It can be seen that what was asked in the question was the original length of the wire, the subject explained that he used the multiplication between the length of the rib and the number of ribs, so he worked backwards and sorted from the last thing known, 10cm times 12, the result is 120cm. Then the result is that the original length of the wire is 120cm

So, S-4 concludes at the end of the answer that the original length of the wire is 120. After that, S-4 does not correct or re-check the answer from the beginning to the end in writing about the answer he got.

Interview result :

Q: How many times have you read the questions?

S-4: Three to four times, ma'am, because you are still confused but after a while you don't get confused and
can do.

P : Oh I see, then when you receive the questions, what do you do first?

S-4 : That's ma'am, I read the problem then I thought about how to use it

Q: In what way, son?

S-4 : The analysis is yes, after reading the problem, I assume ma'am, this is a cube, so....... what he was l

P : So, what do you mean by that?

S-4 : Hmm, that's the initial length of the wire, ma'am.

Q: Did you re-check the questions you did?

S-4: I'm sure the answer is ma'am, so there's no need to check again

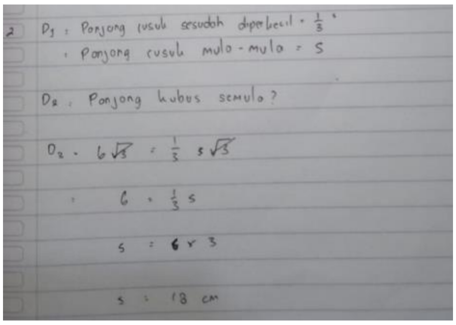
Furthermore, S-4 explained as in the interview excerpt S.4 that before working on the problem he analyzed the problem by assuming the thing being asked, because according to him, in working on the problem of building space, there would be, and that was what he was looking for. In the picture it is not seen it gives a description that he assumed as the length of the wire at first. But actually this is the condition that is being asked and the answer will be sought, it can be seen in the interview excerpt S.4 that S-4 stated that it was the length of the wire at first so he had started manipulating it as the length of the wire at first.

Thus, it can be concluded that S-4 has been able to determine the goals to be achieved in accordance with the working backward component and can manipulate the given problem even though he does not do the last step, which is to re-examine

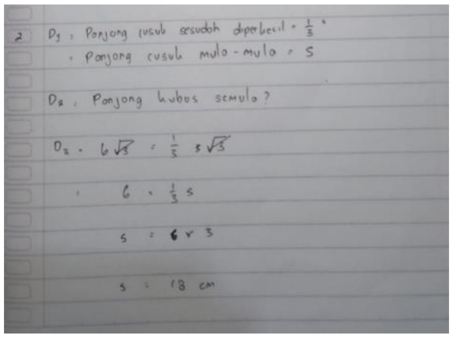
Problem 2

A cube with edge "S" is reduced to a 1/3S cube. the length of the diagonal of the small cube is 6√3. Determine the length of the original cube

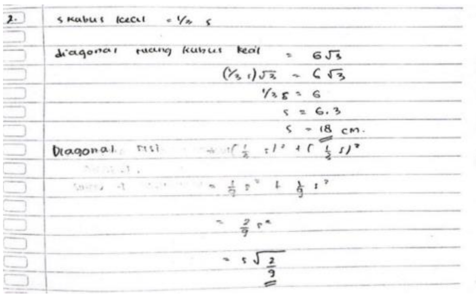
Student application results:



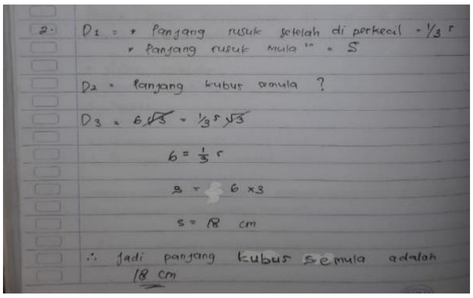
Subject 1



Subject 2

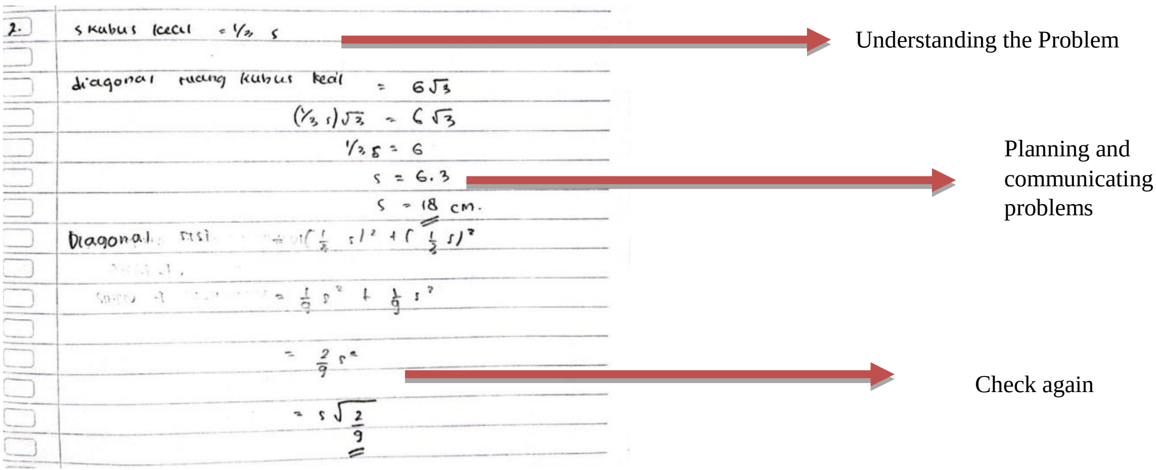


Subject 3



Subject 4

Discussion and interview results from one of the subjects:



- Based on the picture beside, it can be seen that the initial step used by S-3 when working on the problem is to write down the length of the reduced cube that is 1/3S and the diagonal of the small cube space is 6√3. Then S-3 finds the length of the side of the small cube using the diagonal space of the small cube and also directly finds the length of the original cube. The subject makes a sketch of the information that is known from the problem in sequence.
- It can be seen that what was asked in the question was the length of the original cube, the subject gave information that he sorted from the last thing known, namely 6√3 and then looked for the length of the side of the small cube, so that he got 6 and then multiplied by 3 because this cube was reduced by 1/3 so that To find the length of the first side, multiply by 3 and the result is 18 cm. Then the result is that the original length of the cube is 18cm
- S-3 did not conclude at the end of the answer that the original length of the cube was 18 cm, but S-3 tried to check again but the results obtained were not the same as the results when S-3 worked at the beginning.

Interview result :

P : How many times have you read the questions?

S-3 : Three times ma'am because I'm still confused but after a long time I'm not confused and can do.

P : Ohh*like that*, then when you receive the question, what do you do first?

S-3 : Itma'am, I read the problem and I wrote what I knew, then I looked for what was asked, ma'am.

P :Then what do you do?

S-3 : Yes, I'm looking for the length of the cube initially, bu

P :*Have you re-checked the questions you did?*

S-3 : yes ma'am, but the answer I got was not the same as the result of the question I was working on

P :Why do you think so?

S-3 :hey, don't know ma'am

Furthermore, S-3 explains as in the S-3 interview excerpt that before working on the problem he assumes things that are already known. In the picture it is not seen that he gives information about what is being asked of the given problem. But actually this is the condition that is being asked and the answer will be sought, this can be seen in the S-3 interview excerpt that S-3 stated that it was the length of the cube at first, so he had started manipulating it as the length of the cube at first. S-3 did not conclude at the end of the answer that the original length of the cube was 18 cm, but S-3 tried to check again using the side diagonal but the results obtained were not the same as the results when S-3 worked.

Thus, it can be concluded that S-3 has been able to determine the goals to be achieved according to the working backward component and can manipulate the given problem even though he tries to re-examine and gets results that are not the same as the results he is working on.

Conclusion

Based on the findings, the findings of the research data analysis, and the discussion of the research that has been described, several conclusions are put forward as follows. The troubleshooting ability after applying the Polyas step is better than before applying the Polyas step. Student response patterns with Polya's steps are more diverse than ordinary learning applications

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