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## Analysis of difficulties in solving mathematical problems categorized higher order thinking skills (HOTS) on the subject of rank and shape of the root according to polya stages

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# Analysis of difficulties in solving mathematical problems categorized higher order thinking skills (HOTS) on the subject of rank and shape of the root according to polya stages

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**Abstract.** Destination of this research is to identify difficulties faced by the students in solving mathematical problems HOTS categorized on the subject of rank and shape of the root. This research was classified as descriptive research with a qualitative oncoming. In this study, researc subjects numbered 115 students, after going through data reduction, the data focused on 4 students representing high, medium, and low abilities, to precede the process of looking deeper into the process of working on problems based on Polya's stages. Data collection techniques in this study were observation, tests, and interview. In this study, the authors used persistence observation techniques and data triangulation. Based the results and discussion of study showed so as 62.54% of students had difficulty understanding the problem, 70.62% of students had difficulty thinking of a plan, 79.68% of students had difficulty implementing the plan, and 87.16% of students had difficulty reviewing. Difficulty factors in solving mathematical problems categorized HOTS on the theory of rank and shape of the root is students do not understand what is called a problem, students aren't able absorb information properly, weaknesses prerequisite concepts owned by the student, the student aren't careful and thorough the process, lack experience students working on math problems categorized HOTS, and lack student experience in working on story problems.

## 1. Introduction

Education in the era of industrial revolution 4.0 is directed at developing 21st-century competencies, which consist of three main components namely competence of thinking, acting and living in the world. The thinking component includes critical thinking, creative thinking, and problem-solving skills. Acting components include communication, collaboration, data literacy, technology literacy, and human literacy. The components of life in the world include initiative, self-direction, global understanding, and social responsibility.

The success of students in the component of thinking competence can be seen from the final sults of learning. Teachers can use questions to find out students' success in learning. Questions are used to measure the skill, knowledge, intelligence, and abilities possessed by individuals or groups. HOTS stands for Higher Order Thinking Skills, which means Higher Level Thinking Skills. HOTS questions can be interpreted as questions that can stimulate thinking skills that are not merely recalling, restating, or referring without doing processing (recite) but also being able to think critically and creative.



The dimension the thought process in Bloom's Taxonomy perfected by Anderson & Krathwohl [1], consists the ability to: know (knowing-C1), understand (understanding-C2), apply (aplyingC3), analyze (analyze-C4), evaluate ( evaluating-C5), and creating (C6). HOTS questions generally measure ability realm of analyzing (C4), evaluating (evaluating-C5), and creating (C6-creating).

Mathematics subjects at junior high school level include several aspects, namely numbers, algebra, geometry, statistics, and opportunities. HOTS learning for numbers, especially in the material Departure and Root Forms can be developed in the classroom is not possible only by memorization, exercises that are routine, as well as ordinary learning, but with exercises that are not routine questions.

The HOTS problem that is a problem for students is the HOTS problem which has 3 indicators. Students will go through a process step to complete the problem. Many stages of problem-solving are stated by several figures, but the stages of problem-solving from Polya can be used in general. Therefore the HOTS problem solving is appropriate using Polya's problem-solving stages.

Problem-solving in teaching and learning is an effort made by students to look for and determine alternative activities in bridging a situation at the moment and the desired state [2]. According to Polya [3], there are several activities or stages that be done by students to solve problems, namely understanding the problem (understanding the matter), devising a plan (devising a plan), carrying out a plan (carrying out a plan), and checking (looking back).

Broadly speaking, the stages of problem-solving according to Polya [4] can described as follows:

#### 1. Understanding the Problem

According Polya to able understand a problem that must be done is:

- Understand language or terms used in problem
- Formula what is nown, what is asked, whether the information obtained is sufficient
- What conditions must be met
- State or write the problem in a more operational form making easier solved.

#### 2. Planning a Solution

What students have to do at this stage is students can:

- Look for concepts or theories that support one another.
- Looking for the formulas needed.

#### 3. Implement the Plan

Students are ready to do calculations with all kinds of data needed inclding concepts and formulas or equations that are appropriate. At this stage, students must be able to carry out strategi made with diligence and accuracy to get a solution.

#### 4. Look Back

Students in solving problems for this stage are students who must try to double-check and re-examine carefully every step of the solution it does.

According to Ahmadi and Supriyono [5], learning difficulties are "a condition where students or students cannot learn as they should, this is not always caused by intelligence factors, but can also be caused by non-intelligence factors."

Factors cause error when viewed from students learning difficulties and abilities according to Rohmah & Sutiarso [6], namely: (1) Students aren't able to Absorb Information Well, (2) Lack of Student Experience Overcoming Problems, (3) Weak Ability Prerequisite Concepts, and (4) Student Negligence or Carelessness.

## 2. Research Methods

This researc is included in type of descriptive researc with a qualitative approach. The data obtained in this study are the results of HOTS problem-solving data which will then be analyzed and concluded. From these conclusions, a description of the Difficulty in Solving Mathematics Problems in the Higher Order Thinking Skills (HOTS) category will be obtained for the Departure Material and Root Forms According to Polya Stages.

The steps in this research procedure consist of preparation for conducting research, analyzing data and making reports. The research subjects in this study were students in class IX. A through IX.D, totaling 115 students in the academic year 2019/2020. Through data reduction, the data is focused on 4 students representing high, medium, and low abilities, to explore the process of looking deeper into the process of working on problems based on Polya's stages. Data reduction is an analysis process for selecting, focusing, simplifying, abstracting and transforming data that emerges from field notes [7].

Subjects in this study were taken using purposive sampling technique. Purposive sampling is a data source sampling technique with certain considerations [8]. Purposive sampling is intentional sampling by required sample requirement. The researchers determined the sample taken because there was a consideration, the sample wasn't taken randomly, but determined by the researchers themselves. The subjects used in this study were four students from class IX. A to IX.D SMPN 11 Pesawaran odd semester in the academic year 2019/2020. Four students are students who have difficulty in solving HOTS categories. This research was conducted by the writer at SMPN 11 Pesawaran because this school has never researched the analysis of difficulties in solving mathematical problems categorized higher order thinking skills (HOTS) on the subject of rank and shape of the root according to Polya stages.

The main data source in this study is written test data and interview data based on research subjects are students of SMP Negeri 11 Pesawaran grades IX. A through IX.D. Data collection techniques in this study are:

#### *Observation*

The author in this study chose observation technique passive participation because the writer would only observe and record student activities in solving mathematical problems categorized by HOTS and not involved in student activities in solving mathematical problems.

#### *Test*

The test used in this study is an essay test to find out the completeness of students in a problem. The type of the test was an instrument is diagnostic. In determining the validity of this test, the authors use content validity. Content validity is a validity test using the instrument lattice where there are indicators as benchmarks and the number of questions that have been explained by the indicators and to test further validity then consult to someone who is considered an expert in the field [8]. In this research, the validator instrument was mathematics education college teacher at the University of Lampung.

**Table 1.** Guidelines for assessing students ability in problem solving.

No.	Analysis of Polya	Stages of Students Reactions to reserves	Score
1	Understanding the problem	● Write it down what is known and asked as requested	3
		● Write down what is known and asked not according to request	2
		● Incorrect in determining what is known and what is asked	1
		● Not answer	0
2	Planning a Solution	● Think about what steps should be done correctly	3
		● Thinking about what steps should be done isn't all right	2
		● Thinking about the steps that should be done but wrong	1
		● Not answer	0
3	Implement the Plan	● Carry out the calculation process in accordance with the plan	3
		● Carrying out the calculation process is not according to plan	2
		● Incorrect in carrying out the calculation process	1
		● Not answer	0
4	Judicial Review	● Check the truth of calculation results according to the	3

No.	Analysis of Polya	Stages of Students Reactions to reserves	Score
		answers	
		● Check the truth of calculation results do not match the answers	2
		● Not checking the truth of the calculation results	1
		● Not answer	0

*Interview*

The interview will be used in this study is a semi-structured interview. With semi-structured of interview is included the in-depth interview category, which its implementation is freer when compared to structured interviews. The list of interviews in this research contains questions that will be adjusted to the test questions. The follow-up questions are adjusted the results of students answers. The implementation of the framework and the global of the planned question for the interview process are manifested in the form of interview guidelines.

The author uses persistence observation techniques and data triangulation. Observation of persistence, the researcher must show his persistence in chasing the data that has been obtained to be more deepened and that does not yet exist continue to be pursued. Increasing perseverance or persistence means researchers make observations more closely and continuously. This way, data certainty and sequence of events will be obtained definitively and systematically. Triangulation is a data validation technique that uses other things in comparing the results of interviews with research objects (Moloeng, 2004: 330)[9]. Triangulation can be using different techniques (Nasution, 2003: 115)[10], namely interviews, observation, and documents.

**Table 2.** Interview guidelines.

Problem Solving Aspects Polya	List of Interview Questions
1. Understanding the problem	1. Please mention what is known about problem? 2. Try to mention what was asked about this problem? 3. Are there important conditions that need attention in this matter?
2. Planning a Solution	1. Try to find concepts or theories that support each other? 2. Try to find the formulas needed in this problem? 3. Try to think about the steps to do this problem correctly?
3. Implement the Plan	1. Can you carry out the calculation process according to plan? 2. Explain how what is used to solve this problem? 3. Are there any difficulties in carrying out the process and calculation?
4. Judicial review	1. Can you research every step of the solution? 2. Can you check the truth of the calculation results? 3. Are you sure you answered with the final result?

**3. Results and Discussion**

Problem-solving based Polya's theory have 4 stages of problem-solving, namely understanding the problem, think of a plan, implementing a plan, and reviewing it. Of 115 students it was seen that 37.46% of students were able to understand of stage 1 Polya problem solving, 29.38% of students were able to understand of stage 2 Polya problem solving, 20.32% of students were able to understand of stage 3 Polya problem solving, and 12, 84% of students can understand of stage 4 Polya problem solving. From 115 students, 4 students were chosen who represented high, medium, and low abilities.

The following is a presentation the results of analysis each subject about Polya's theoretical problems, namely:

The subject of researc I was named Erna Pratiwi with initials EP. Problem 1, the subject has fulfilled the indicator of understanding problem, the subject specifies what is known and the subject determines what is asked of the problem. The subject didn't think of a plan so it was incomplete and wrong in working on the problem, this happened cause the subject wasn't careful and thorough in doing answer process. The subject didn't review, this happened because of the lack of experience of students working on story problems.

Problem 2, subject to determine what is already known about the problem, but the subject doesn't determine what is asked, this is due to by the omission and slovenliness the subject. The subject didn't fulfill the indicators to understand the problem. The subject didn't review, this means that the subject didn't understand the material entirely.

Problem 3, the subject doesn't fully understand the field of study so that the subject can't fulfill the indicator of understanding the problem. The subject directly resolves problem without making a plan in advance so that the subject is incomplete doing the calculation, this happened cause of negligce and carelessness in the implementation without a plan. The subject can't conclude, this is due to omission and slovenliness in conducting review.

Problem 4, the subject doesn't answer question number 4, this happens cause subject doesn't understand problem, the subject doesn't think a plan, subject doesn't carry out the plan, and the subject doesn't conduct a review, this happens because the subject doesn't carry out the calculation process.

#### *Problem 1:*

In a traditional market, the estimated velocity of money that occurs every minute is around Rp.81,000,000.00. On Monday-Friday the trading process takes place on average 12 hours each day. Whereas for Saturday and Sunday the buying and selling process takes place an average of 18 hours every day. How much money is circulating in the traditional market for 1 week? (state your answer in the form of rank).

The image shows a student's handwritten solution on lined paper. The student lists 'Is known' as 'Velocity of Money = 81.000.000,00' and 'All amounts = 12 hour' for weekdays and 'Saturday - Sunday = 18 hour'. The 'Asked' is 'Money Circulation For 1 week?'. The 'Answer' shows calculations:  $12 \times 5 = 60 \times 60 = 3.600$  and  $18 \times 2 = 36 \times 60 = 2.160$ . These are summed to  $3600 + 2160 = 5760$ . The final calculation is  $81.000.000,00 \times 5760 = 646560 \times 10^7$ .

**Figure 1.** Students answering EP in problem 1.

Research subject II named Setio Hidayat with initials SH. Problem 1, the subject doesn't make an example what is known and what is asked of the problem means that the subject can't fulfill the indicators understand the problem. The subject did the calculation process but not correctly, this happened cause of omission and slovenliness in carrying out a plan because previsly the subject didn't think a plan. The subject didn't do the review, this happened because of the lack of experience of students working on story problems.

Problem 2, the subject doesn't fulfill the indicators to understand the problem, this happens cause the subject doesn't fully understand. The subject didn't think of a plan so it was incomplete and wrong in working on the problem, this happens because the subject isn't careful and thorough in doing the answer process. The subject didn't conclude, this happened cause the subject didn't conduct a review.

Problem 3, the subject doesn't determine what is known and what is asked in the problem, this is due to the omission and slovenliness the subject. The subject didn't fulfill th indicators to understand

the problem. The subject didn't conduct a review, this happened because of the lack of experience of students working on story problems.

Problem 4, the subject doesn't answer question number 4, this happens caused the subject doesn't understand the problem, the subject doesn't think a plan, the subject doesn't carry out the plan, and the subject doesn't conduct a review, this happens because the subject doesn't carry out the calculation process.

*Problem 2:*

Pak Asep has a cylindrical swimming pool behind his house. The diameter of the pond is  $14\sqrt{3}$  meters with a depth of  $150\sqrt{2}$  cm. If Pak Asep wants to fill the pool to the full, how many liters of water does Pak Asep need? Write your answer in the simplest form of rank.

2. Answer:  
 Tube Volume =  $\pi \times r^2 \times h$   
 $= \frac{22}{7} \times 700^2 \times \sqrt{3} \times (700\sqrt{3})$   
 $\times 150\sqrt{2}$   
 $= 22 \times 100 \times 700 \times 150 \times (\sqrt{3} \times \sqrt{3})$   
 $= 321.000.000 \times 3 \times \sqrt{2}$   
 $= 693.000.000 \sqrt{2} \text{ cm}^2$   
 $= 693.000 \sqrt{2} \text{ L}$

**Figure 2.** Students answering SH in problem 2.

Research subject III named Raditya Kurnia with initials RK. Problem 1, the subject doesn't understand the problem, the subject doesn't write down what is known and what is ask of the problem, this is because the subject matter isn't fully understood. The subject is wrong in counting, this happens because the subject doesn't plan carefully and doesn't carry out a thorough calculation process. The subject didn't review, this happened because of the lack of experience of students working on story problems.

Problem 2, the subject doesn't fulfill the problem understanding indicator and has no plans to solve it first, this is because the subject problem is not fully understood. The subject is negligent, careless, and not careful in doing the answer process so that the subject's answers are incomplete and wrong in working on the problem. The subject didn't conclude, this happened caused the subject didn't conduct a review.

Problem 3, the subject doesn't understand the problem and the implementation of a plan, this happens caused the subject doesn't understand the material as a whole. The subject is incomplete and wrong in counting, the subject is wrong in using the formula that should be the Pythagorean form, this happens because of omission and slovenliness in the implementation of the subject that is not careful and thorough in doing the calculation process. The subject didn't conduct a review, this happened because of the lack of experience of students working on story problems.

Problem 4, the subject doesn't meet the plan thought indicator, so that in practice the subject is incomplete and incorrect in calculation. The subject is wrong in using the ball volume formula, this happens because the subject is not careful in doing the calculation process. The subject didn't conduct a review, this happened because of the lack of experience of students working on story problems.

*Problem 3:*

A wind powerboat like the picture on the side. Estimate the length of the sail to draw the ship at an angle of  $45^\circ$  and a sail height of 150 m.



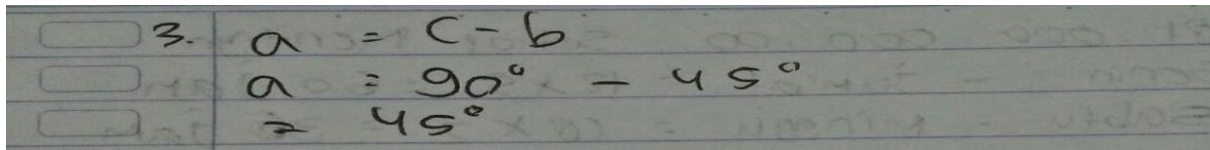


Figure 3. Students answering RK to problem 3.

Research subject IV named Vina Mariana with initials VM. Problem 1, the subject determines what is know about the problem, but the subject doesn't decisive what is ask in the problem, this is because of the omission and slovenliness of the subject. The subject didn't fulfill the indicator to understand the problem. The subject does the calculation process but not correctly, this happens because of omission and slovenliness in carrying out a plan because previsly the subject didn't think a plan. The subject didn't do the review, this happened because of the lack of experience of students working on story problems.

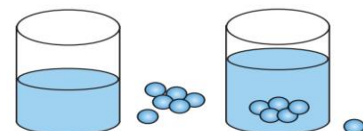
Problem 2, the subject has fulfilled the indicator of understanding the problem, the subject specifies what is known and the subject determines what is asked of the problem. The subject didn't understand in making plans and the implementation of the solution, so the subject was wrong in working on the problem, this happened because the subject in the process of answering is not careful and thorough. The subject didn't conclude, this happened because omission and slovenliness in reviewing.

Problem 3, the subject doesn't fulfill the indicators of thought a plan, The subject hasn't planned to be made what from the matter, this happens because the subject problem isn't fully understood. The subject is incomplete and wrong in counting, this happens because of omission and slovenliness in the calculation process. The subject didn't do review, this happened because of the lack of experience of students working on story problems.

Problem 4, the subject determines what is known from the problem, but the subject doesn't specify what is asked in the problem, this is due to the omission and slovenliness of the subject. The subject didn't fulfill the indicator to understand the problem. The subject incorrectly wrote ball volume formula, this happened because of omission and slovenliness in the implementation the subject was not careful and thouroug in carrying out the calculation process. The subject didn't do review, this happened because of the lack of experience of students working on story problems.

*Problem 4:*

A rubber ball with a diameter of 7 cm is soaked in a vessel filled with kerosene for 3 hours. If the diameter of the rubber ball is increased by 0.002 mm/sec, what is the volume of the rubber ball after the soaking process?



Sumber: Dokumen Kemdikbud  
Gambar 1.2 Bejana berisi minyak tanah dan bola karet

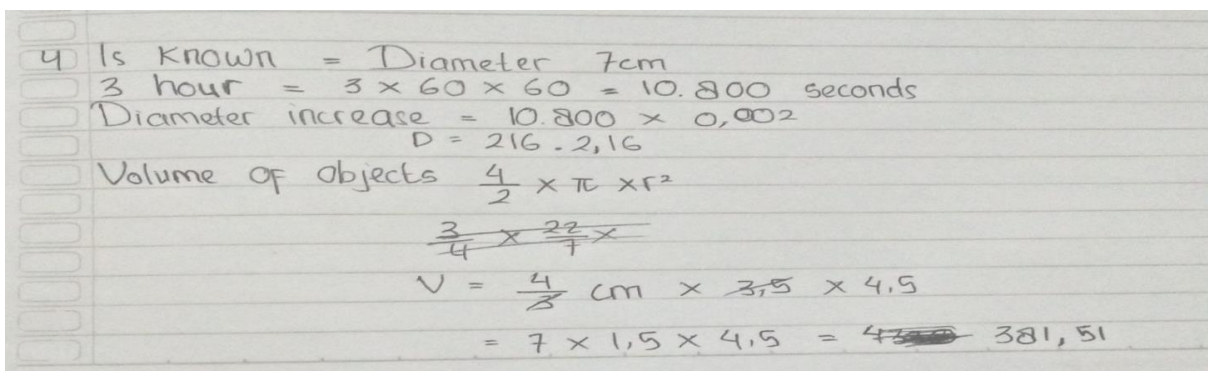


Figure 4. Students answering VM on problem 4.



Based results the subject description above, all four students have not been able to meet the problem solving of all indicators based on Polya's theory.

In the stage understanding problem, EP subjects can fulfill this indicator, the subject thinks about what is known and the subject determines what is asked the problem. SH Subjects and RK Subjects on issue item number 1, number 2, number 3 and number 4 cannot fulfill this indicator, the subject didn't assume what was known and what was asked of the problem, this happened because of the omission and slovenliness of subject.

At stage thinking of a plan, EP subjects have not planned completion of items number 1, number 3 and number 4, because the subject matter is not fully understood. SH subjects and RK subjects could not fulfill this indicator in problem item number 2 and number 4, because they did not fully understand the subject matter. The subject of VM also cannot fulfill the problem indicators item number 2 and number 3 because the subject matter is not fully understood.

At the implementation stage of the plan, EP subjects cannot fulfill this indicator, in problem items number 3 and number 4, subject SH cannot fulfill this indicator in problem item number 1 and number 4, RK subjects and VM subjects cannot fulfill this indicator on the problem point number 1, number 2, number 3, and number 4, the subject is not able to understand the problem must be like what, because the subject cannot absorb the information properly.

In review, EP subjects, SH subjects, RK subjects, and VM subjects did not make a review of the problems in item number 1, number 2, number 3, and number 4, because of the lack of experience of students working on story problems.

#### 4. Conclusions and Suggestions

Based the results and discussion of the study showed that 62.54% of students had difficulty understanding the problem, 70.62% of students had difficulty thinking of a plan, 79.68% of students had difficulty implementing the plan, and 87.16% of students had difficulty reviewing.

The difficulty factor in solving HOTS categorized math problem in the material of rank and root form is that students do not understand what is called a problem, students aren't able to absorb the information right, weaknesses in the prerequisite concepts owned, students aren't careful and thorough the process, lack experience students working on math problems categorized HOTS, and the lack of student experience in working on story problems.

This research is expected to provide insight into teachers and other researchers in the field of education to use appropriate models, strategies, and media and apply HOTS-based test questions as a reference for teachers to find out their success in developing their students' high-level thinking skills on learning models in the learning process especially the material of rank and root form, so that students' mistakes can be minimized.

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