Student’s ability in solving higher order thinking skills (HOTS) mathematics problem based on learning achievement

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Abstract. Higher Order Thinking Skills (HOTS) mathematics problem is non-routine mathematics problem that contains elements of analysis, evaluation, and creation. This research uses problem-solving based on Krulik and Rudnick to analyze student’s ability in solving HOTS problem. Problem-solving has a role in learning achievement. This research aims to describe the student’s ability in solving HOTS mathematics problem with high and low learning achievement. This research used a qualitative descriptive method, with research subjects consisting of 4 students of class VIII in Junior High School which is this school is one of the best schools in Surakarta which selected using purposive sampling. Based on the findings, subjects with high learning achievement can solve HOTS problems well, can do the problem-solving process correctly and with the right answers. Subjects with low learning achievement can only understand what is known in the problem, so they cannot continue the next step and cannot find the right answer.

1. Introduction

Mathematics is essential for the individual to learn. According to Chen mathematics is very important for various fields with real-life applications, including natural sciences, engineering, medicine, and social sciences [1]. Mathematics can be used to develop skills that involve logical, systematic, critical, careful and creative reasoning skills in communicating ideas or solving problems [2]. Mathematics problems are useful for training students to reflect and analyze mathematics [3]. Therefore students must be taught how to solve problems with an appropriate problem-solving.

Problem-solving is an essential part of mathematics. Problem-solving is one way to give students the opportunity to develop a deeper understanding of mathematical concepts, English, and various ways to represent mathematical solutions [4]. Students must be encouraged to reflect on their thoughts during the problem-solving process so that they can implement, adjust and modify appropriate strategies to find solutions, so students need opportunities to formulate, solve, and solve complex problems [5]. Therefore NCTM (1989) made changes by recommending a mathematics curriculum that emphasized problem-solving abilities [6]. Based on Krulik and Rudnick there are five stages of problem solving, namely: (1) Read and think, at this stage the problem is analyzed, the question is identified, the relationship of each
information in the problem is determined, and the problem is changed into the language that is easy to understand; (2) Explore and plan, at this stage, the data is analyzed whether there is enough information that can be used for problem-solving, then the data can be arranged in tables, images, graphs, models, etc. So that a plan was developed to get the answer; (3) Select a strategy, at this stage a strategy is estimated that can be used, such as finding a pattern, working backward, guessing and testing and simulating or experimenting so that it can provide direction for solving problems that must be done in finding the answer; (4) Find an answer; this stage includes solution estimation, use of computational capabilities, and the use of algebra and geometry skills; (5) Reflect and extend, the solution that has been obtained from the previous stage is reexamined, then determines the alternative solution and makes an expansion or general [7]. Problem-solving occurs when students can think toward the expected solution [8]. Thinking ability has a role in interpreting the situation in the problem-solving process so that when students face unusual problems, it takes high-level thinking skills [9]. High Order Thinking Skills (HOTS) is a concept of education reform based on Bloom's Taxonomy with the idea that some types of learning require more cognitive processing than others, but also have more general benefits and involve complex judging skills such as problem-solving [10]. Table 1 describes the dimensions of HOTS based on Bloom's Taxonomy revised by Anderson and Krathwohl namely, analyze, evaluate, and create [11].

Table 1. Dimensions of HOTS cognitive processes based on Bloom's Taxonomy revised Anderson and Krathwohl [11].

| Analyze          | a. Specifies the elements needed in problem solving | b. Verb: compare, check, test |
|------------------|-----------------------------------------------------|-------------------------------|
| Evaluate         | a. formulate a decision                             | b. Verb: evaluation, assess, refute, decide, choose, support |
| Create           | a. Create your own ideas / ideas.                   | b. Verb: construct, design, create, develop, write, formulate. |

HOTS is essential to be understood in all sectors, especially in the context of mathematics learning to improve student performance [12]. The many types of research about HOTS indicated this, but their implementation in school learning was not optimal. HOTS's assessment to measure students' abilities in the field of Mathematics and Science internationally has been carried out by Trends in the International Mathematics and Science Study (TIMSS) and the Program of International Student Assessment (PISA) [10]. Based on the results of the PISA study in 2015, Indonesia was ranked 69th out of 76 countries [13]. The results of the 2015 TIMSS study show that Indonesia is ranked 45th out of 50 countries in the field of mathematics [14]. This shows the low learning achievement of students, especially on the scale of international education. Therefore, to improve the quality of Indonesian education, especially in the field of mathematics which refers to international education, it can be done by training students' skills in solving HOTS mathematical problems. In HOTS mathematical problem research is a non-routine mathematical problem that contains elements of analysis, evaluation, creation. Furthermore, to describe students' ability to solve HOTS mathematical problems, the problem-solving phase will be used based on Krulik and Rudnick.

Problem-solving has a role in student learning achievement. Sun & Wu revealed in their research; students learn independently to acquire basic knowledge, which helps identify problems when conducting learning activities in the classroom so that collaboratively can practice how to apply knowledge to problem-solving activities that can improve student learning achievement [15]. Learning achievement includes the knowledge and abilities of individuals produced by the learning process that has been arranged by the teacher following a predetermined plan for a specified period [16].
Based on the previous explanation, the researchers need to do research related to solving HOTS mathematics problems. The purpose of this study was to describe student’s ability to solve HOTS mathematics problems with high and low learning achievement.

2. Methods
This research uses the descriptive qualitative method in the form of case studies. The results of the study illustrate the ability of students to solve mathematical problems of Higher Order Thinking Skills (HOTS) based on student learning outcomes. The subjects in this study were four students of class VIII in Junior High School which is this school is one of the best schools in Surakarta. The subject was taking using purposive sampling. Subjects are chosen based on the results of learning mathematics. In this study students' mathematics learning achievement are the results of the Midterm Examination. Based on learning achievement, two students with the highest learning achievement were taken and two students with low learning achievement. Subject retrieval is also based on consideration of the mathematics teacher.

Techniques Data collection in this research includes tests and interviews. The test in this study uses geometry problems that contain HOTS elements. The results of the test are students' ability to solve HOTS problems of geometric material analyzed based on Krulik and Rudnick's problem-solving. Interviews are conducted on selected subjects. Each subject is given an in-depth question based on the results of their work in solving HOTS problems of geometrical material. Data analysis techniques in this study are data triangulation. Data triangulation is done by comparing test results with interviews. After the triangulation process, it is seen that there is continuity between the results of the analysis of the student's work and the results of the interview.

3. Results and discussion
Researcher conducted interviews related to the answers of subjects based on their learning achievements. Interview activities are conducted to determine student’s ability to solve Higher Order Thinking Skills (HOTS) mathematics problems. Analysis of student’s ability in solving HOTS mathematics problems based on Krulik and Rudnick's problem solving of each subject is shown as follows.

3.1. Student's ability in solving HOTS mathematics problem with high learning achievement

3.1.1. Read and think. At this stage, the problem is analyzed, the question is identified, the relationship of each information in the problem is determined, and the problem is changed into the language that is easy to understand.

![Figure 1](image)

As shown in figure 1, information from the problem has not been written all. Based on interviews that have been done, it can be seen that the subject understands the problem well and be able to know information about problems.
3.1.2. Explore and plan.

Figure 2. The answers of Subject with high learning achievement on explore and plan the problem.

Figure 2 shows that the subject is able to present a problem with the picture. The interview results show that the subject understands well the instructions of HOTS's mathematics problems. Therefore, the subject can plan the next step to determine the length of PQ.

3.1.3. Select a strategy. I at this stage, a strategy is estimated that can be used, such as finding a pattern, working backwards, guessing and testing and simulating or experimenting so that it can provide direction for solving problems that must be done in finding the answer. (R = Researcher, S= Subject with high learning achievement).

R: what strategy did you choose to solve this problem?
S: first I look for the height of the triangle ACD, then use the Pythagorean theorem, then calculate the length of the PQ.
R: How can you make that plan to solve the problem?
S: I understand the problem, so I find the relationship of every information that I then use to determine the length of the PQ.

Figure 3. The answers of Subject with high learning achievement on select a strategy.
Figure 3 shows that the subject chose the strategy by determining the area of one triangle from the parallelogram that had been drawn. The next strategy is to determine the height of the triangle. Subjects use the Pythagorean theorem, so as to get new information from the problem to determine the length of the PQ. This is in line with interviews conducted that the subject is able to design the strategy correctly.

3.1.4. *Find an answer.* This stage includes solution estimation, use of computational capabilities, and the use of algebra and geometry skills.

![Figure 4](image)

**Figure 4.** The answers of Subject with high learning achievement on select a strategy.

Figure 4 shows that the subject does the calculation correctly, so the subject can determine the PQ length correctly. This is reinforced by the results of interviews that the subject can explain in detail about his answers.

3.1.5. *Reflect and extend.* The subject checks the answer again, then determines an alternative solution and makes an expansion or general.

The results of the interview with S are as follows.

R: are you sure your answer is correct?
S: Yes, I'm sure.
R: What is the reason you are sure your answer is correct?
S: I'm sure the answer is correct because the formula and calculation are correct.

Based on the results of the interview, it appears that the subject is sure of the answer and the steps are right. The subject can explain each step well and check the calculation.

3.2. *Student’s ability in solving HOTS mathematics problem with low learning achievement*

![Figure 5](image)

**Figure 5.** The answer of Subject with low learning achievement.

3.2.1. *Read and think.* Information from the problem has not been written all as seen in figure 5. Subjects can understand problems and be able to know information from problems. This was reinforced by the results of interviews that the subject was able to understand the problem well.
3.2.2. Explore and plan. Figure 5 shows that the subject is able to express information from the problem in the form of images. The subject represents information from the problem into a figure of parallelogram.

3.2.3. Select a strategy. The interview results are used to determine the strategy chosen by the subject in solving the problem. The following are the results of interviews with subject on select a strategy to solve HOTS problem. (R = Researcher, T = Subject with high learning achievement).

R: What strategy did you choose to solve this problem?
T: First I look for the height of the triangle, then use the Pythagorean theorem, but I was confused in implementing the plan, so I did not find the height of the triangle.

Based on the results of the interview can be seen that the subject is not able to choose the right strategy. The subject feels confused to continue his work and unable to determine the next step.

3.2.4. Find an answer. At this stage, the subject cannot find the right answer as seen in figure 5.

Based on the interview results the subject does not have the right strategy so that he experiences confusion in processing information. Subject felt that there was information had not found to find answers.

3.2.5. Reflect and extend. Figure 5 shows that the subject cannot solve the problem and unable to reflect and extend. Based on the results, subjects with high learning achievement can solve HOTS mathematics problems well. The subject can solve the problem correctly at every stage of the problem solving based on Krulik and Rudnick. The subjects with high learning achievement are able to understand problems, plan, create formulas by connecting each information from problems. In the stage of finding an answer, the subject is able to find the right answer. In the reflect and extend stage, the subject is able to explain and check all calculations properly. This makes the subject sure that the answer is correct. The results have in accordance students who have high HOTS tend to get high academic achievement in mathematics learning [17].

The results on subjects with low learning achievement indicate that the subject is able to understand what is known in the problem. in the select strategy stage, the subject is confused and unable to determine the right strategy to find answers. Subjects experience obstacles in determining the right answer and also cannot understand the concept of parallelogram. This makes it difficult to determine the next step. Subjects are not able to continue their work, so subjects with low learning achievement cannot solve HOTS math problems. The results have in accordance with Zohar, Degani and Vaaknin’s statements [18]. The teacher believes that students with low learning achievement were unable to work on HOTS math problems.

4. Conclusion

Based on data analysis that has been done by researchers about the ability of students to solve Higher Order Thinking Skills (HOTS) mathematics problems with high and low learning achievement, it can be concluded that subjects with high learning achievement have the ability to solve HOTS mathematics problems well, able do the problem solving process correctly and with the right answer. Subjects with low learning achievement are having the ability to solve HOTS mathematics problems with the wrong steps and cannot continue the next step, so the subjects with low learning achievement cannot find the right answer.

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