Students' misconception of HOTS problems in teaching and learning of mathematics

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Students' misconception of HOTS problems in teaching and learning of mathematics

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Abstract. The purpose of the research was to analyze the opinions of mathematics education students about HOTS questions. The method used in this research was a qualitative research method, using a descriptive approach. The subjects in this study were 21 students, were selected purposively. The data collection instrument is open-ended set of questions using the Google classroom application. Triangulation was conducted through interviews with four lecturers was conducted in order to increase the validation of the research. The results showed that there were two groups of student opinions about the HOTS question; difficult questions and three top-level levels of Bloom's taxonomy. However, there are misconceptions of the students interpreting difficult problems and Bloom's taxonomy level about HOTS problems. Not all difficult problems can be classified as HOTS problems, nor all problems on three top-level questions of Bloom's taxonomy be categorized as HOTS problems.

1. Introduction

Mathematics instruction is needed for students to possess higher-order thinking skills (HOTS) to enable them to compete in the industrial revolution 4.0. Therefore, this led to the Indonesian government's use of the HOTS math test in the 2018 national exam. Unfortunately, the majority of the students stated that the test was too difficult for them to comprehend. However, their unfamiliarity with the questions in the test led to complexity and inability to determine solutions [1].

Students are not familiar with the HOTS problems, so the question is a difficult one. Many factors make it difficult for students to solve HOTS issues, one of which is their ability to read and understand [2]. The other explanations are the students' lack of understanding of questions and incompleteness in reading questions [3], the difficulty in constructing a mathematical model [4], and the difficulty in generating ideas in such a way that they are unable to think beyond the box and build ideas intuitively and spontaneously [5].

On the other hand, HOTS is defined as the widespread use of thinking skills when students discover new challenges. This tends to occur when the information and knowledge stored in their memory are rearranged and developed to achieve a goal or determine a solution to a difficult situation [6]. Therefore, experience in learning mathematics is the key to students' ability to solve HOTS related problems.

What does the problem of HOTS mean? Is it true that students in Indonesia are not familiar with HOTS questions? Why don't they familiar with HOTS problems?

The HOTS problem is a problem that requires some mathematical concepts to be solved. For example, in order to solve the 'Sailing Ship' task, students must use four mathematical concepts: triangle isosceles, theorem Pythagoras, irrational numbers, and rounding [7]. Therefore, a student must be able to generalize some of the information in the test item in order to develop new strategies to solve the

problems [1]. Students should understand mathematical concepts, not just memorize them. Students will then have to analyze and link the relationship between concepts. Both of these are two crucial stages in the solution of HOTS problems

Furthermore, based on the level of ability in the PISA problem, the HOTS problem was a matter of levels 4, 5, and 6. The higher the level of ability in PISA, the more complicated the problem [7]. For instance: students at Level 4 of PISA work effectively with explicit models for complex concrete situations that consist of constraints. They select and integrate different symbolic representations, linking them directly to real-world situations. Furthermore, at this level, students tend to utilize well-developed skills with some insight in these contexts. They are also able to construct and communicate explanations, as well as arguments based on their interpretations and actions [8].

Moreover, in terms of assessment, half of the teachers identified HOT problems as contextual problems with difficulty and a long story-line [9]. HOTS problems are related to higher level of Bloom' taxonomy, analysis, synthesis, and evaluation [10, 11], the highest level in the hierarchy of cognitive processes [5].

However, various opinions about the HOTS problems are those of experts, researchers, and lecturers, while those related to students have never been studied. On the other hand, student opinion is important in learning. According to [12], teaching and learning must start from the known to the unknown. Based on these findings, the lecturer can design an appropriate learning method. Therefore it is necessary to analyze the opinions of mathematics education students about HOTS problems. The results of this study can be used to develop HOTS-based mathematics learning.

2. Method
The research was conducted using a qualitative research method with a descriptive approach, used for setting research objectives, selecting subjects, collecting data, verifying data, analyzing data, and drawing conclusions. The main procedure of the research presented in Figure 1.
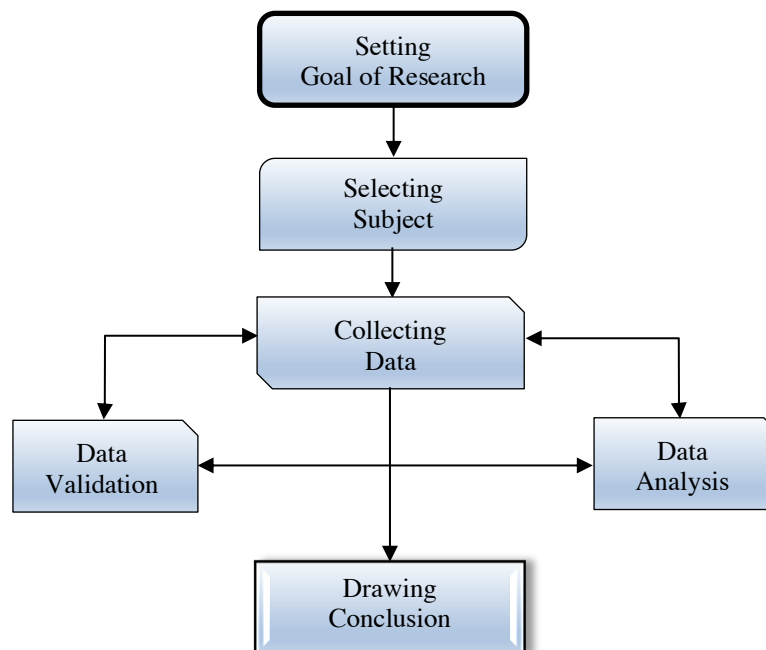
Figure 1. Flowchart of Research Procedure

The subjects of the research were 21 students of mathematics education, selected purposively. The main criterion used for the selection of subjects is that they are students of the sixth semester. They studied several lessons related to the concept of HOTS, such as the mathematical analysis of junior high school, the mathematical analysis of senior high school, and the variables in mathematics education

research. They, therefore, know about teaching-learning mathematics, in particular the types of mathematics problems in secondary schools.

The instrument used for gathering students' opinions is an open-ended question submitted using the Google classroom application. The first question posed to students is: "How do you recognize a problem related to HOTS?" The questions then continued when the answers obtained have not answered the question. Students are also required to present an example and a counter-example to clarify their point of view. Furthermore, students were asked to analyze problems in mathematics textbooks based on Bloom's taxonomy.

In addition, the triangulation method, with a structured interview with four lecturers in mathematics education, was used to validate the research. They were lecturers, teaching the subjects. The questions were asked to the lecturers to clarify the opinions of students using the WhatsApp application.

Finally, the data from students and lecturers were analyzed in order to obtain their perspective on HOTS-related problems by compiling a table that is divided into different categories. If the data still needs to be clarified during the data analysis, interviews with lecturers or students will be conducted. The table is intended to classify the opinions of students in a number of categories. The results of the data analysis shall be presented as the results of the research.

3. Result and Discussion

Higher-Order Thinking Skills (HOTS) problems are measurement instruments used to determine student' abilities to solve mathematical question, exercises, or examples relate to higher-order thinking skills. The questions used for foster critical thinking [13], problem-solving, and decision making [11]; to promote higher-order thinking [14]. Therefore, questions, both exercises or examples in mathematics textbooks, are the principal objects to explain the HOTS of students. There are two keywords on the item of problems associated with HOTS, namely, difficult problems and top level of taxonomy Bloom. The difficult problem is an item of question that cannot be solved, while Bloom's top level of taxonomy is cognitive abilities for analysis, evaluation, and creation. The students' opinions and the discussion are detailed as follows

3.1. Difficult Problems

As far as HOTS is concerned, three different groups have stated that the problems are difficult. The first opinion concludes that difficult issues are problems that cannot be resolved. The difficult question is of a subjective nature. It might be a difficult problem for a person, but it's easy for others. One of the reasons why these problems are difficult to classify is due to a lack of knowledge of the concept of the question. The concept in question has never been learned, or students have learned it, but have not yet fully understood it

The second group of students describes a difficult problem as a type of subject without an example, despite having been previously studied. This is because most students are used to solving problems using an algorithm. They are, therefore in a position to memorize procedures, with the inability to use their thinking skills to provide solutions. Students memorize procedures, but they do not use their thinking skills to solve the problem. Therefore, according to [15], to improve the student's HOTS, the teacher always has to use novelty questions; these questions that they never did before. The novelty of the assessment material is under the control of the teacher.

The most common learning methods in mathematics used in Indonesia are traditional teaching methods [16]. The teacher uses the teaching-learning process by introducing verbal formulas, concepts, and examples. Students will only listen, imitate, or copy what the teacher gives without the initiative to develop their thinking skills. Students are not used to optimizing their potential to develop their thinking skills [17]. The learning model causes students not to be able to solve problems that are slightly different from examples. Students are not used to mathematics thinking. They 're accustomed to memorizing a problem-solving procedure.

In addition, some other students say that the difficult question was a problem that could not be done immediately, but that requires some thought before the problem is resolved. Not all questions can, however, be classified as problems with the HOTS. Students solve problems as a problem before with

an algorithm. Students do not utilize the ability to think optimally but use standard procedures to respond to these problems.

On the other hand, higher-order thinking is a complex, non-algorithmic way of thinking that often generates multiple solutions. This thinking involves uncertainty, the application of multiple criteria, reflection, and self-regulation [11]. The student weakness in the solution of the HOTS type test is, therefore, due to the lack of competence of the student to generalize some of the information in the test item in order to develop new strategies to solve the problems[1].

Based on the previous description, a difficult problem is not directly categorized as a HOTS issue. On the other hand, not all HOTS issues can be classified as difficult issues. Difficult problems are problems that cannot be directly addressed. The problems requiring analysis to solve them can be classified as HOTS problems. But with one condition, students do not solve these problems using standard procedures, but thinking skills to design strategies to construct a solution. Students link different concepts to both mathematical concepts and other learning concepts and then solve HOTS questions.

3.2. Three top cognitive levels of Bloom taxonomy

Bloom's taxonomy is a set of three hierarchical models used to classify educational learning objectives that are cognitive, affective, and psychomotor. The cognitive domain was the primary focus of most traditional education. In the original version, the cognitive domain consists of six levels of objectives: knowledge, understanding, application, analysis, synthesis, and evaluation. The levels are slightly different: remember, understand, apply, analyze, evaluate and create as a result of the revised edition of Bloom's taxonomy in 2001[18].

To find out which items are grouped into which aspects of the cognitive domain can be done by using a verb in the task items. Verbs used to know what action defines each stage of the Bloom taxonomy. The verb is an indicator of cognitive groupings. The verb is used to determine the cognitive level needed to solve the item. Evaluation, for example, involves making judgments on the basis of criteria or standards by checking and criticizing them. Based on the definition, it is still difficult to determine which items are classified at the level of the evaluation. It needs a verb as an indicator, therefore. Some verbs are used to determine the cognitive level of evaluation, including: arguing, evaluating, checking, criticizing, commenting, concluding, considering, debating, grading, revising, and scoring [19].

However, not all problem items explicitly contain verbs. The verb is not directly, but implicitly, for some objects. The word is not written explicitly on the implicit verb but can be determined by examining the process of resolving the issues. According to [20], sometimes it is not possible to determine HOTS questions directly on the basis of verbs. Researchers need to carry out further research on how to address these issues. So even though it doesn't have a verb, the cognitive level of the object can be defined.

On the other hand, even if it has a corresponding verb, an item cannot be directly grouped as a HOTS problem. In that case, the item cannot be classified as a HOTS problem, because it is solved by students using a memorized algorithm. They were used to solve similar problems. Students do not use their thinking skills to respond to these problems. These issues are therefore grouped together as routine issues. A routine test, according to [21], is a type of question that students are familiar with. In this situation, students do not need high-level thinking skills to solve problems. Students only use low-level thinking skills to solve problems, i.e. imitative reasoning (IR).

IR is students' thinking skills in mathematics reasoning, in addition to the CMR - Creative Mathematically founded Reasoning [22, 23]. IR consists of Memorized Reasoning (MR) and Algorithmic Reasoning (AR). The MR strategy is based on recalling, by memory, an answer, and the strategy implementation consists only of writing it down. The AR strategy is to remember an algorithm, which is a sequence of rules for solving a particular task type. In contrast, the three characteristics of CMR are novelty, plausibility, and mathematical foundation [24]. Therefore, IR classified as LOTS, while CMR is the HOTS.

4. Conclusion

Difficult questions and three top-level Bloom taxonomy levels are two keywords used by students of Mathematics Education to describe HOTS questions. There are, however, some misconceptions associated with the interpretation of these keywords. For example, not all difficult problems are classified as HOTS, nor are verbs at the top three levels of Bloom's taxonomy. These problems are classified as difficult due to students' lack of knowledge of the problem, the frequent use of algorithms, and certain ideas. Similarly, an item is not directly grouped as a HOTS problem regardless of the presence of the corresponding verb.

5. Acknowledgements

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