Analysis of student’s thinking ability to solve higher-order thinking skills (HOTS) math problems

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Abstract. This study aims to describe students’ thinking skills in solving mathematical problems which are Higher-order Thinking Skills (HOTS) problems. The thinking process used in this study refers to Bloom’s Taxonomy was modified by Anderson and Krathwohl. It was a qualitative descriptive study conducted at SMP Xaverius 1 in Palembang. There were 30 students of grade IX involved as subjects in this research. The data collection techniques used were tests, documentation, and interview. All students involved were given two HOTS questions. Based on the analysis of student answers and interviews, the results obtained stated that only 6.67% had reached the create stage in completing HOTS questions, the rest did not even reach the analysis stage.

1. Introduction

High order thinking skills have become one of the main topics in Indonesia developing the quality of education. In the curriculum of 2013, the government encouraged educators to develop learning strategies and HOTS ratings. Therefore, many HOTS type questions are needed so that the development of HOTS questions has been done a lot [1]. HOTS assessment includes logical reasoning, judgment and critical thinking, problem solving, creativity and creative thinking [2]. However, based on Kohar, Wardani & Fahrudin research results, most students have low-level cognitive abilities [3]. According to Zulkardi, the PISA question was very demanding of cognitive abilities [4]. At this time the thinking ability of students in Indonesia is still low. Based on the results of the PISA (Program for International Student Assessment) survey in 2015, Indonesia ranked 62 out of 70 countries [5]. As claimed by Haniffah & Manoy, the low ability of students to solve problems needs to be improved by providing exercises that are different from the examples given by the teacher [6]. One of them is by using the Higher-order Thinking (HOT) problem. This is in line with the ministry of education and culture, in the 2013 thematic curriculum integrated technical thematic learning guide, explaining that teachers must practice higher-order thinking skills or what is often referred to as Higher-order Thinking Skills (HOTS) students from elementary level, with the goal is to improve students' ability to reason and answer complex questions [7]. On the report of Clonkin, the levels of thinking are differentiated by the complexity of mental processing required. Some equate the idea of difficulty with complexity [8].

HOTS is a program developed by the government as an effort to improve the quality of learning and the quality of graduates in Indonesia. The provision of HOTS problems is one of the government's efforts to train students' high-level thinking skills [9]. Currently, HOTS questions have begun to be applied in the 2017 National Examination, and are increasingly being expanded in the 2018 National Examination.
In 2001 Anderson & Krathwohl had classified the higher-order thinking stages in Bloom's taxonomy, from C4 to C6 contained in the following table [10-12].

**Table 1. Classification of Higher-Order Thinking Stages of C4-C6 by Anderson & Krathwohl**

| HOTS     | Creating                                      | Evaluating                                      | Analyzing                                      |
|----------|-----------------------------------------------|-------------------------------------------------|------------------------------------------------|
|          | - Creating your own ideas.                    | - Make your own decisions.                      | - Specifying aspects/elements.                 |
|          | - Verbs: construct, design, create, develop,  | - Verbs: evaluation, rate, refute, decide,      | - Verbs: compare, examine, criticize, test.    |
|          | write, formulate.                             | choose, support.                                |                                                 |

Several researchers already documented their research about developing instruments of higher-order thinking skills. The limited knowledge and time of the lecturers of mathematics in developing valid and reliable instruments for measuring HOTS become the obstacles less attention to the achievement of the basic goals of mathematics lessons [13, 14]. Some studies have discussed the important of higher-order thinking skills for students and applying it in learning activities [15, 16]. Based on their studies, we can conclude that the thinking ability of students is still low. Human thinking skills can be classified into two, namely the low level thinking skills/ lower order thinking skills (LOTS) and high-level thinking skills or higher-order thinking skills (HOTS).

This research will discuss more deeply about how students' abilities in solving higher-order thinking skills problems. Based on the results of Wicasari and Ernaningsih's research in 2016, most students have reached the stage of analysis and evaluation. However, from the total students, only a few students reached the creative stage. This is because the answers given have not shown the element of student creativity on new ideas [17].

As claimed by Brookhart, creating means reordering existing elements to form new structures/ideas, including generating, planning, and producing [2]. Kusuma et al, argued that the ability to think at a higher level is created is the ability to create conceptual knowledge, create procedural knowledge, and create metacognitive knowledge [18]. Widana stated that creating is the ability to formulate new problem solving strategies [11]. Also, some experts assert that creative or innovative thinking skills are increasingly tested in the domain of creation [1, 19].

From various experts' opinions, it can be concluded that creating is a thought process at the highest level in Bloom's Taxonomy which has been revised by Anderson and Krathwohl, namely finding new ideas/ideas in solving a complex problem by bringing up its creativity. If students can unite different things in new ways or solve problems by producing several solutions it means that students have achieved the ability to "create" [2]. According to Krathwohl, indicators of creating are as follows [11].

- Generalize the idea or way of looking at something.
- Designing a way to solve the problem.
- Organizing elements or parts into new structures that have never existed before.

Based on the description above, the purpose of this study is to find out and describe students' thinking skills in solving HOTS mathematical problems which create stages. To find out the extent to which students' thinking abilities in completing mathematical problems of the HOTS domain create type, it requires a thought process that refers to Bloom's taxonomy.

### 2. Method

This research was conducted in a qualitative descriptive by analyzing the results of student work. Students were given tests which related to HOTS problems, then students were given time to find the solutions according to the knowledge they have. After that, researchers analyzed of the results of student work. The analysis carried out is seen from the stages of completion outlined by students. Data
collection techniques used were tests, documentation, and interviews. This research was conducted at Xaverius 1 Junior High School Palembang. Students involved as the subjects were students from class IX I as many as 30 students. The data collected in this study was in the form of students' answers which were described and documented during the study.

3. Result and Discussion
The 30 students from SMP XAVERIUS 1 Palembang were asked to find the solution of two mathematics HOTS problems domain create. These questions have been validated that has been done in previous studies. The following two items are displayed along with some of the answers given by students.

Item Number 1:
A community held an art performance, the committee chose a performance building where the audience seating was in the form of a circular sector as shown below.

Ticket prices in the blue area are the most expensive tickets. The ticket price difference between one area and another area is IDR 10,000. It is assumed that all of the spectator seats are filled and the number of seats in the red and white areas follows the pattern of the number of seats in the previous areas. If the community wants to get an income of Rp. 22,500,000.00. How much is the ticket price that must be sold in each area? Explain your reasons.

Several variations of answers to question 1:

Figure 1. question 1

Figure 2. CJ's Answer

Figure 3. KY's Answer

Figure 4. V's Answer

Figure 2 is the result of the answers of students with the initials CJ, it showed that CJ knew that the problem contains the concept of number patterns. But in its operation, CJ made a mistake so that CJ did not seem to understand how to determine the next number. CJ also did not finish solving the problem until it was completed. This shows that CJ does not have a new idea in determining the existing problem solving strategies. Thus it can be said that the CJ thinking process in Bloom's
Taxonomy has only reached stage C1 which is knowing (remembering). As many as 6.67% of students are only able to think up to stage C1.

For Figure 3, the answer given by KY. In the process, it is seen that KY has been able to determine the numbers that do not yet exist, namely many seats in the red and white areas. However, KY does not complete the answer so it appears that KY has no ideas / strategies to solve the problem. KY also looks confused deciding the strategy he will do is shown from the arrows he wrote on the answer sheet. As many as 16.67% of students experienced the same thing. In Bloom's Taxonomy, they have just reached stage C2, which is understanding.

Next, Figure 4 is the answer V which represents 46.67% of the answers of Xaverius 1 Junior High School students in Palembang. Demonstrating that they are trying to solve problems with problems that are not procedural but by following mathematical calculation rules, this is permissible. First of all V can determine the number of seats in the red and white areas. After that, V determines the number of all the audience seats in the performing arts building. In the next step, V makes a mistake, which is V considers the price of all seats in each area is the same. This is seen because V divides the number of seats in the blue area by the number of all seats in the building. This causes the answers given by V to be inaccurate, so that V does not get the maximum score. V has not been able to analyze the existing situation, so in Bloom's Taxonomy it has only reached stage C3, which is applying.

Figure 5. FW’s Answer

Different from V, FW provides answers with very procedural steps. Figure 5 shows that FW is able to determine the number of seats in the red and white areas. In addition, FW is also able to make mathematical models of the existing situation appropriately. However, FW made a mistake in the calculation, so the answers given were not right and did not get the maximum score. In this case FW has been able to reach the analyzing stage, namely C4 in Bloom's Taxonomy. Of the 30 students who were the subjects in this study, there were 23.33% of students in the same stage of thinking.

The last is the answer given by WS, which can be seen in the 5th picture. It turns out that WS also uses non-procedural steps such as the answer given by V in Figure 4. However, it appears that WS does not determine the number of all spectator seats in the performing arts building. The WS strategy is to find a number which, if multiplied by the number of seats in each area, when added together results in an income of Rp. 22,500,000. This shows that FW is able to evaluate a situation or concept based on certain criteria, so that it can conclude something complex with logical reasons. In addition, FW was very careful in its calculations so that FW managed to solve the problem in mathematical problems of the HOTS domain create type correctly and obtained a perfect score. The idea or strategy
provided by WS is very simple and simple, so there is no need to use mathematical formulas or models. Therefore, in Bloom's Taxonomy it can be said that WS has reached the stage of creating, namely C6. Where there are only 6.67% of students who are able to reach this stage.

Figure 6. WS's Answer.

Item Number 2: Batik is one of the identities and pride of the Indonesian people.

A batik craftsman will make batik painting with a circular motif as shown next. If 1 m\(^2\) fabric requires 1.5 liters of textile dye solution, how much brown color solution is needed to make the batik.

Source: https://goo.gl/images/nzFKNz

Figure 7. Question 2.

Figure 8 is the answer given by PAN which represents 40% of students' answers to problem number 2. This problem is also a HOTS mathematics problem which create stages. Figure 6 shows that PAN has good basic knowledge and mathematical calculations. However, PAN only determines a lot of solution for fabrics that are sized (98 \times 98) cm\(^2\). PAN tends to ignore existing information, it focuses more on numbers. PAN also has not been able to analyze the existing situation. Therefore, the answer given is not right. In Bloom's PAN Taxonomy with 40% other students are at stage C1, namely remembering.
Compared to the PAN answer, the answer given by ES is not much different. ES also has good basic knowledge and calculations. What PAN does not do is analyze the image in the problem. In Figure 9 it is seen that ES counts the number of circles in the image that form a motif. The picture shows that ES does not focus on numbers alone. However, ES also does not analyze images in great detail. So, the answer given is not right. As many as 23.33% of students who gave answers similar to ES can be classified as at stage C2, that is understanding.

Figures 10 and 11 are the correct answers with different completion steps. Figure 10 is the answer given by the PC, while answer 9 is the answer given by the MV. It appears that the PC and MV have mathematical knowledge and calculations with a good level of accuracy. The first step taken by PC and MV is to break batik motifs into one whole picture. The PC succeeded in obtaining a triangle image which was added with a can on the tilted side. Whereas the MV obtains a circle image which has a square shape inside it. Both have obtained basic patterns from batik motifs. After that, the strategy carried out by the PC is to determine the width of the canister and the area of a right triangle. Whereas MV determines the area of a circle and area of a square. PC and MV look very focused on the picture and do not ignore the information provided. The ability to analyze the situation and evaluate the concepts contained in the batik motif is done well by PC and MV. In Bloom PC and MV Taxonomy has reached stage C6 which is creating.
Although PC and MV can solve this problem correctly, there are 73.33% of students who give incorrect answers and do not finish until the end. In addition, there are 20% of students who clear the answer sheet for question number 2. Based on the results of the interview, this is due because students are confused about determining the initial strategy that will be carried out. They only focus on numbers, and are unable to analyze the situation and the information in the picture.

HOTS mathematics problems are questions that demand a high-level thinking process. The thought process is included in bloom's taxonomy which consists of the process of remembering, understanding, applying, analyzing, evaluating, and creating. Where the last 3 processes explain the extent to which students' thinking abilities in achieving HOTS.

From the results of research conducted at Xaverius 1 Junior High School in Palembang and involving 30 students of class IX I, it can be seen that in solving mathematical problems of the HOTS which create stage even though few, there are students who have reached the stage of creating. Some students arrive at the analysis or evaluation stage only. This shows that the students' higher-order thinking skills have been seen. However, there are still many students who are only able to reach the stage of understanding and applying. This is consistent with the results of research by Hugerat & Kortam [20].

Students who arrive at the analysis stage are students who can analyze the situation precisely. Students are able to recognize the information contained in the stimulus provided. Students know the concepts and strategies that need to be done. In addition, students are also able to connect existing information in a simple form. Although students at this stage sometimes still make mistakes. Students who reach the evaluation stage, have been able to do the previous stage, namely the analysis phase. In addition, students carry out these activities carefully and precisely. Students at this stage rarely make mistakes such as misinterpreting or deciding on an existing comparison, they are more likely to draw conclusions well. While students who reach the analysis stage are able to analyze the situation and the stimulus provided. They have also been able to identify the elements in the problem. But still making mistakes, such as wrong calculation, misinterpreting a given situation, not careful in concluding an answer, and not completing a strategy of completion, and less creative in determining a solution strategy.

From the previous description, it appears that students who are able to analyze (C4) means that they have passed through the stages of remembering (C1), understanding (C2), and applying (C3). Likewise for students who reach the evaluation stage (C5) are students who have been able to go through the analysis phase (C4). This is in accordance with the opinion of Kurniati [21], which states that the requirements of students are able to do the creation, if he has been able to do an analysis and evaluation first. Of the 30 students who were the subjects of the research, there were students who were able to produce creative ideas using a procedural process. This shows that students have done the thinking process from a low level to a higher level, which is to create. Students who only arrive at the
thought process of applying (C3) cannot yet be said to be able to think at a high level, because they have not been able to analyze the situation or the stimulus provided.

4. Conclusion
As many as 30 students from Palembang Xaverius 1 Middle School have completed mathematical problems for the HOTS domain type create. All students involved were given two HOTS questions. Based on the analysis of student answers and interviews, the results obtained stated that only 6.67% had reached the create stage in completing HOTS questions, the rest did not even reach the analysis stage. It can be concluded that there are students who are able to reach the creating stage. However, from all students it can be said that most students are only able to reach the analysis stage. This shows that students still need to be trained in higher-order thinking skills using HOTS questions.

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