Analysis of higher order thinking skills 8th grade students in math problem solving

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Abstract. This study aims to describe the higher order thinking skills of 8th grade students in mathematics problem solving. The sample used was one class consisting of 29 students and the class was selected based on purposive random sampling. Data collected through tests and interview. Data analyzed by descriptive analysis. The students are given mathematics problem solving test which includes HOTS level of analyze, evaluate and create. The result in the analyze level as many as 86.2% of students be able to differentiating, 48.3% of students be able to organizing, and 48.3% of students be able to attributing. In the Evaluate level as many as 72.4% of students be able to checking and 68.9% of students be able to critiquing. In the Create level, as many as 37.9% of students be able to generating, 31% of students be able to planning and 27.6% of students be able to producing.

1. Introduction

Education has a very important role in improving the quality of human resources in order to compete in the era of globalization and modernization [1]. One of the abilities that must be possessed by students to face this era is higher order thinking skills (HOTS). HOTS are important aspects of learning and are useful tools to help students learn, improve performance, and reduce student weakness [2]. HOTS can be taught in various ways, one of which is through mathematics learning. Mathematics learning plays a big role in developing human thoughts, bringing strategic, systematic reasoning processes used in problem analysis and problem solving [3].

HOTS are conceived as students being able to relate their learning to other elements beyond those, they were taught to associate with it [4]. Higher order thinking skills (HOTS) are thinking on a level that is higher than memorizing facts, expressing facts, or applying rules, formulas, and procedures. HOTS require that we do something about facts, make connections between facts, categorize them, manipulate them, place them in new contexts or ways, and be able to apply them to find new solutions to problems [5]. HOTS are abilities and skills that include the use of complex thinking that goes beyond basic recall of facts, such as evaluation and invention, enabling students to retain information and to apply problem solving solutions to real-world problems [6].

Stein and Lane state that high order thinking as the use of complex, non-algorithmic thinking to solve a task in which there is not a predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instruction, or a worked-out example [7]. HOTS have some general characteristics, according to Resnick these characteristics include: non-algorithmic, complex and yielding multiple solutions, requires the application of multiple criteria, self-regulation, and often involves uncertainty [8]. Based on some of these opinions, it can be concluded that HOTS are non-algorithmic thinking skills not...
just memorizing facts, expressing facts, or applying rules, formulas, and procedures, but can apply the knowledge and skills that have been developed in learning at new context.

In education, there is a taxonomy of thinking that is often used in defining HOTS, Bloom’s taxonomy. Bloom in [9] divides the taxonomy of thinking into six levels: (1) knowledge; (2) understanding; (3) application; (4) analysis; (5) synthesis, and (6) evaluation. The first level to the third level is lower order thinking skills and the fourth to six levels are higher order thinking skills. This taxonomy was revised by Krathwohl and Anderson [10], which gave rise to a new taxonomy of being (1) remember; understand; (3) apply; (4) analyze; (5) evaluate, and (6) create. Level of higher order thinking skills in the new taxonomy include analyze, evaluate, and create.

HOTS in mathematics can be defined as the ability to perform mathematical processes or complex tasks or math problems involving connection, problem solving, and mathematical reasoning [11]. In the classroom, HOTS can be taught by familiarizing students with problem solving on a given problem. Polya [12] state that problem solving is the process of accepting challenges (problems) that cannot be solved by routine procedures and require a lot of effort to solve the problem.

Solving problems can be seen as a process where students find combinations of rules that they have learned in advance that they use to solve new problems [13]. Krulik and Rudnick define problem solving as a method by which a person uses knowledge, skills, and understanding to meet the demands of a non-routine situation [14]. From some of the definitions above, it can be concluded that problem solving is a method used to solve problems that cannot be solved using routine procedures, but must be resolved to achieve goals using the knowledge, skills, and understanding possessed.

Referring to the results of the PISA (Program for International Student Assessment) in mathematics Indonesia ranked 63 out of 72 participating countries. The average math score of Indonesian students is only 386 which is still far compared to the average mathematics score of all participants which is 490 [15]. Therefore, the government seeks to improve the education system in Indonesia by always making improvements to the current curriculum, the 2013 curriculum.

The 2013 curriculum has been implemented in Indonesia for several years, one of the schools that has implemented it, is SMPN 1 Pecangaan. SMPN 1 Pecangaan has implemented the 2013 curriculum since the curriculum was implemented until now. The 2013 curriculum has now been refined, one of which is assessment in learning using HOTS questions. So that now students are familiarized with HOTS questions, especially in problem solving. From the above descriptions, the aim of this research is to describe the higher order thinking skills of 8th grade students in mathematics problem solving at SMPN 1 Pecangaan.

2. Method
In this research the method used was descriptive analysis method to determine the profile of high order thinking skills of 8th grade students of SMPN 1 Pecangaan. From the population one class was chosen consisting of 29 students to represent the population. Selected students have mathematical abilities that range from low to high abilities. Students are selected based on several criteria: 1) students have learned by using the revised 2013 curriculum; 2) students have received mathematics learning material from 7th grade to 8th grade semester 1; 3) students selected for interviews are students who are able to speak and explain well. Retrieved data using tests and interviews. The question consists of 3 questions which include levels of Analyze, Evaluate and Create. Questions are tested based on the mathematical knowledge that has been given to students. Interviews are used to find out how students get these answers.

3. Result and discussion
Higher order thinking skills as explained before, have 3 levels and 8 indicators refer to revised Bloom’s Taxonomy by Anderson and Krathwohl. In some of higher order thinking skills indicators, the percentage of students who have higher order thinking skills that reaches more than 50% include differentiating, checking, critiquing. Can be seen from the following table.
### Table 1. HOTS test result.

| HOTS Levels | Indicator     | Student right answer (%) |
|-------------|---------------|--------------------------|
| Analyze     | Differentiating | 86.2                     |
|             | Organizing    | 48.3                     |
|             | Attributing   | 48.3                     |
| Evaluate    | Checking      | 72.4                     |
|             | Critiquing    | 68.9                     |
| Create      | Generating    | 37.9                     |
|             | Planning      | 31.0                     |
|             | Producing     | 27.6                     |

Students who answer correctly are students who have answers with correct and logical arguments and supporting evidence. Based on table 2 it can be concluded that higher order thinking skills of students are good enough, where there are no indicators that are not met.

Will be discussed more deeply the differences in student answers that meet the indicators of higher order thinking skills and students who have not met the indicators of higher order thinking skills.

#### 3.1. HOTS level: analyze

Consider the following picture.

**Figure 1.** HOTS level analyze.

Scales 1 and 2 contain balls, cylinders and cubes with perfect balance. How many cylinders do you need to balance 3 scales? Explain!

**Figure 2.** Student with wrong answer (1a).

**Figure 3.** Student with right answer (1b).

Based on figure 2, subject 1a cannot answer the question correctly. Subject 1a is not able to determine the relevant information that can be used to solve the problem. Based on the interview with subject 1a, it is known that students are confused to determine the right way to solve the problem so that students only provide answers in origin. In Figure 3, subject 1b can say well what information is relevant for solving the problem (differentiating). Subject 1b can determine the correct equation and can also be able to associate the relationship between equations (organizing). Subject 1b can find out the point of view
of the question being asked by giving a correct, clear and good solution (attributing). Based on interview with subject 1b, it is known that subject understood clearly what must be done to solve the problem by forming a system of equations from the scales 1 and 2 then making substitutions to solve the equations on the scales 3. Based on that explanation subject 1b be able to differentiating, organizing and attributing in analyze level.

3.2. HOTS level: evaluate
In a city there are two online motorcycle taxi companies namely Ok Jek! and Siap to Jek! The company offers motorcycle taxi fares like the following table.

| Table 2. HOTS level evaluate.          |
|---------------------------------------|
| Cost (Rp)   | Distance (km)       |
| Start (0)  | 1   | 2   | 3   | .... | 15   |
| Oke Jek    | 7.000 | 9.500 | 12.000 | 14.500 | .... | .... |
| Siap Jek   | 10.000 | 12.000 | 14.000 | 16.000 | .... | .... |

Dani wants to go to the bookshop which is 15 km from his house. In order to get a lower cost, which ojek should be used by Dani? Explain!

Based on figure 4. Subject 2a does not check to be able to determine the correct conclusion. Subject 2a only concludes based on the criteria of price per km. Based on interview with subject 2a determine the answer based on the difference in price of each company, subject 2a chooses the cheapest price without regard to the distance traveled. In figure 5, subject 2b writes information that is relevant and needed. Then subject 2b checks each company to find out the company that provides the lowest price (checking). After getting the results subject 2b determines one company based on the specified criteria (critiquing). Based on interview with subject 2b determine the per-km rate for the two companies, then determine the general equation then perform calculations on the two companies. Next subject 2b concludes the company is Siap jek in response to the problem. Based on that explanation subject 2b be able to checking and critiquing in evaluate level.

3.3. HOTS level: create
Consider the following picture.

Figure 4. Student with wrong answer (2a). Figure 5. Student with right answer (2b).
If the pattern continues until the n pattern, determine the right formula to determine the number of small triangles that are formed.

Based on Figure 7, subject 3a cannot formulate or determine the right steps to solve the problem. Based on the results of interview subject 3a confusion in determining how to solve the right for the problem. Subject 3a did not find an idea to solve the problem. In figure 8, subject 3b can determine the resolution of the problem by finding the pattern equation based on the three existing patterns (Generating). Then find out how the relationships between patterns and determine the general equation of the pattern (Planning and Producing). Based on the results of the interview with subject 3b, he knew that to solve the problem must form equations between patterns, then look for the similarity of the pattern to finally write the general form of the corresponding equation. Based on that explanation subject 3b be able to generating, planning and producing in create level.

From that explanation, there are some students who are able to reach the create level although many other students have difficulty at this level. Higher the HOTS level, the fewer students will be able to achieve it. In line with Budiysa, who has conducted research to measure HOTS in high school students in Jayapura, the result is higher the level of HOTS, the fewer students are able to achieve it, even no student reaches the create level in that research [16]. This shows that very few students have high mathematical abilities.

Having high mathematics abilities can help students solve problems better. Bakry stated that students’ thinking skills with high mathematical abilities, moderate mathematical abilities, and low mathematical skills in solving HOTS problems were different [17]. According to Bakry the student who has high math ability is able to create meaning, make opinion and can conclude. And the otherwise the student who has low math ability is not able to create meaning and cannot conclude.

In this research, although there are still many students who have difficulty at the create level, there are still some students who are able to solve the questions at the create level correctly. In addition, several indicators from HOTS even exceeded 50% of students were able to achieve it.

4. Conclusion
Based on the analysis of the data, it can be concluded that the high order thinking skills of the 8th grade students of SMP Negeri 1 Pecangaan in mathematics problem solving are good enough, where in the analyze level as many as 86.2% of students be able to differentiating, 48.3% of students be able to organizing, and 48.3% of students be able to attributing. In the Evaluate level as many as 72.4% of students be able to checking and 68.9% of students be able to critiquing. In the Create level, as many as 37.9% of students be able to generating, 31% of students be able to planning and 27.6% of students be able to producing.

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