Content Analysis of Higher Order Thinking Skills (HOTS) in Mathematics National Exam

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Abstract. Higher Order Thinking Skills (HOTS) is a hot topic in education world. It is important for students because they can learn some skills of HOTS to solve their real life problems. However, some previous researches show that there were only a few samples of HOTS questions found in national exam. Knowing that national exam is one of assesment standard in national scale, the researchers are going to analyse the content of HOTS in national exam kit, especially on the last three years of senior high school mathematics exam: 2017, 2016, 2015. This is a qualitative research. The steps taken to analyse are as follows: 1) unitizing (distinguish units according to the characteristic of HOTS), 2) recording (collect data based on the instruments and give additional description about the data) 3) reduction (reduce irrelevant things about HOTS) 4) inferring (present the percentage of HOTS content and make a conclusion of the result). The result revealed that there were only 3.33%, 2.5%, 4.17% of HOTS content in mathematics national exam in the year of 2015, 2016, and 2017, resepectively. The distribution of each category of HOTS content was less evenly distributed.

1. Introduction

The 21st century demands people to have the ability to compete in the world. Some of these skills include critical and creative thinking [1]. People need critical and creative thinking to solve problems in real life. Creative and critical thinking can be categorized into higher order thinking skills [2][3]. Thomas and Thorne said that higher order thinking skills are high level skills where a person is able to understand facts, conclude, and connect between facts and other concepts. It requires understanding, deducing, and relating facts to other concepts, categorizing, manipulating, and putting the facts together in new ways and applying them to problem solving [4].

King et al said that higher order thinking skills appear when students are faced with non-routine problems [5]. This indicates that a problem is needed that does not only rely on memory of certain knowledge to solve it, but also needs the ability to process and connect knowledge to solve these problems. If the problem can be solved only by using previously owned understanding (prior knowledge) without associating between knowledge, this ability is classified as lower order thinking skills (LOTS) [6]. In line with that opinion, Lopez & Whittington states that higher order thinking skills appear when a person can obtain new information, he/she will store that information in memory then associates and returns information to reach a goal or finds a possible solution in configuring conditions [7]. In other words, higher order thinking skills (HOTS) is the ability to personalize and categorize a fact and then relate it to other concepts to solve a problem using certain manipulations.

According to Bloom's revised taxonomy, the taxonomy of learning goals based on the cognitive process dimension, HOTS includes the ability to analyze (C4), evaluate (C5), and create (C6) [8]. Meanwhile, when viewed from the dimension of knowledge, HOTS includes conceptual, procedural, and metacognitive knowledge. The categorization of HOTS is based on the slices of these two dimensional knowledge components, including C4-conceptual, C4-procedural, C-4 metacognitive, C5-conceptual, C5-procedural, C-5 metacognitive, C6-conceptual, C6-procedural, and C-6 metacognitive [9].

Anderson & Krathwohl defines analyzing is the ability to break a unity into parts and determine the part and then relate to one another back [9]. At the analytical level, one is able to break down information into more complex sections to recognize patterns, causes and effects of a thing. Categories analyzing, among others, differentiating, organizing, and attributing. Diferentiating occurs when able to discriminate important and unimportant, relevant and irrelevant. In differentiating involves organizing, while organizing itself is the ability to identify the elements together into related structures [9]. While evaluate is the ability to make a judgment about something. The judgment is based on other experts' thinking. The categories include checking and criticize. Creat is about generalize a new idea, product, or new perspective from an occurance. It involves creativity. The categories include generate hypotheses, make a plan, and produce.

The ability to analyze, evaluate and create constructs dimension of cognitive process. The other dimension, dimension of knowledge, consists of factual, conseptual, procedural, and metacognitive knowledge. Jaelani & Sugiman state that conceptual knowledge is knowledge about category, classification, and relation between two categories or among categories and classification of complex knowledge. This knowledge is used to make the phenomenon related to any science being systematic. Procedural knowledge is about how to use algorithm, using methods to solve problem, and choose the best procedure based on specific criteria. The highest level of cognitive dimension, metacognitive knowledge, is the human ability to control their thinking. Someone can monitor or control themselves [4].

Given the importance of higher order thinking skills for students, the government strives to improve the quality of education through various curriculum reformation, including the mathematics curriculum. The implementation of the 2013 curriculum form of efforts to improve the quality of education. The content of 2013 curriculum has been oriented towards the achievement of higher order thinking skills (HOTS). This makes higher order thinking skills a main goal in learning, including mathematics learning. This is in line with the National Council of Teacher of Mathematics which defines problem solving as a standard process which requires HOTS in its completion [10]. Thus, students need to be trained to enhance their higher order thinking skills. Teachers can present the questions containing HOTS content. They can take several references, including questions of mathematics national exams. Nevertheless, there is a study that states that the questions of mathematics national exams of senior high school in 2010 almost entirely are in knowledge level: 72 %, 23 % at the level of application, and only 5 % at the level of reasoning, while the mathematics national exams of senior high school year 2011 is at the reasoning level of 8 % [11]. The low percentage of reasoning level indicates that only a small part of the mathematics national exams of senior high school contains HOTS. Although the government has included a HOTS loaded issue in the mathematics national exams of 5 %, the number is still small enough [12]. The national exam is a national assesment standard. The questions in this exam have a great opportunity to become teachers' references to facilitate students enhancing HOTS. Therefore, it is necessary to analyze the content of HOTS in the mathematics national exams.

In order to know the content of HOTS in national exam kit, we carried out an analysis of HOTS in the mathematics national exam kit especially the questions of mathematics national exam from year 2015 to 2017. The exam kit consisted of 40 questions with multiple choices, so that there were 120 questions. Following Krippendorf, the steps taken in this research were unitizing (distinguish units according to the characteristic of HOTS), recording (collect data based on the instruments and give additional description about the data), reduction (reduce irrelevant things about HOTS), and inferring (present the percentage of HOTS content and make a conclusion of the result) [13].

We selected some of 120 questions that will be analyzed, recall it as units. We distinguish units that potentially contained HOTS content (unitizing). The selection based on the characteristics/indicators of

HOTS. These were the slices of cognitive process dimension and dimension of knowledge. The selected questions would be included into the instrument for this research.

There were 15 units in the instrument. We collected data about the classification of HOTS from 5 coders (recording). The two of them were the experts and the others were mathematics teachers in senior high school. The coders decided the category of HOTS for each unit in the instrument. They could write down additional information in the column "Additional Information". Table 1 was the content of the instrument with one sample of math exam questions. The indicators of HOTS were shown in Table 1.

Table 1. Instrument of content analysis of HOTS

Instrument of HOTS Content Assesment in Science High School Mathematics National Exam Questions of 2017, 2016, & 2015

Name of Coder:
Instruction :
Give the HOTS category based on the indicators and knowledge dimensions in each of the following questions

Indicators of HOTS

Indicators of HOTS	Sub Indicators of HOTS	Cognitive Dimension
1. Analyze (C4)	1. Distinguish 2. Organize 3. Attribute	
2. Evaluate (C5)	1. Checking 2. Criticize	Conceptual Procedural Metacognitive
3. Create (C6)	1. Modelling 2. Planning 3. Produce	

No	Questions	HOTS Category	Additional Information
1	Every day a bag craftsman produces two types of bags. The capital for the first model bag is IDR 20,000 with a 40% profit. The capital for the second type of bag is IDR 30,000 with a 30% profit. If the available capital every day is Rp1,000,000.00 and at most can only produce 40 bags, the biggest advantage that can be achieved by the bag craftsmen is ... . A. 30% B. 34% C. 36% D. 38% E. 40%		

We reduced some irrelevant units from the instrument (reduction). The unit was stated irrelevant towards HOTS if the coders did not consider it as HOTS question. After reducing units, we counted the percentage of HOTS content based on two dimensions of Bloom's taxonomy and the percentage of

HOTS content for mathematics national exam year 2015, 2016, and 2017 (inferring). Besides, we would present sample of questions that contained HOTS content. The formula used for counting the percentage of HOTS content was shown below.

$$p_H = \frac{q_H}{q_E} * 100\%$$

p_H = the percentage of HOTS content
q_H = the number of HOTS questions
q_E = the numer of mathematics national exam questions

2. Result and Discussion

As the previous study shown, the content of HOTS in mathematics national exam in 2010 and 2011 was still low [11]. Enhancing higher order thinking skills' student can be facilitated through giving them exercises contained of HOTS content. The standard assesment in national scale, mathematics national exam, can be considered. Though the government had included some HOTS questions in national exam in 2013, we still need to anaylize the content of HOTS in the next national exam, such as in 2015, 2016, 2017.

Our analyses revealed that there were only a few questions in mathematics national exam measuring HOTS. Most of questions measured Low Order Thinking Skill (as opposed to HOTS) because students do not need to associate the related concepts to solve the problem [6]. The percentage of HOTS content was presented in Table 2.

Table 2. Percentage of HOTS content

Year	Percentage of HOTS content for each indicator			Percentage of HOTS
	C4	C5	C6	
2015	7.5 %	2.5 %	0 %	3.33 %
2016	0 %	5 %	2.5 %	2.5 %
2017	10 %	0 %	2.5 %	4.17 %

In 2017, the largest HOTS content was at C4-analyze with organizing indicator. There were 3 questions included in category of C4 with organizing indicator and one question of C4 category with attributing indicator. One of questions was like: *"known regular hexagonal limes T.ABCDEF base rib 6 cm and pyramid height 6√3 cm. The sine value of the angle between the upright rib and the base of the base plate is ... . "*. To solve this question students needed to know the concept related to three dimension material. This indicated that the question needed conceptual knowledge[4]. Students needed to know the sketch or picture representing the problem. After that, they would aplicate the formula of trigonometry to find the solution. The procedure used to solve the problem was non routine and the question could not be solved in one way [5]. This was suitable to the characteristic of HOTS with attributing indicator [9].

Another sample question for C4 was presented in figure 1. In figure 1, the question included in organizing indicator. In solving problem, students needed to find the relevance of information with a concept[4]. They had to organize one information to others in order to make a plan to solve the problem [7]. This was a non-routine problem. Problems with such characteristics and procedures required higher order thinking skills in their resolution [9].
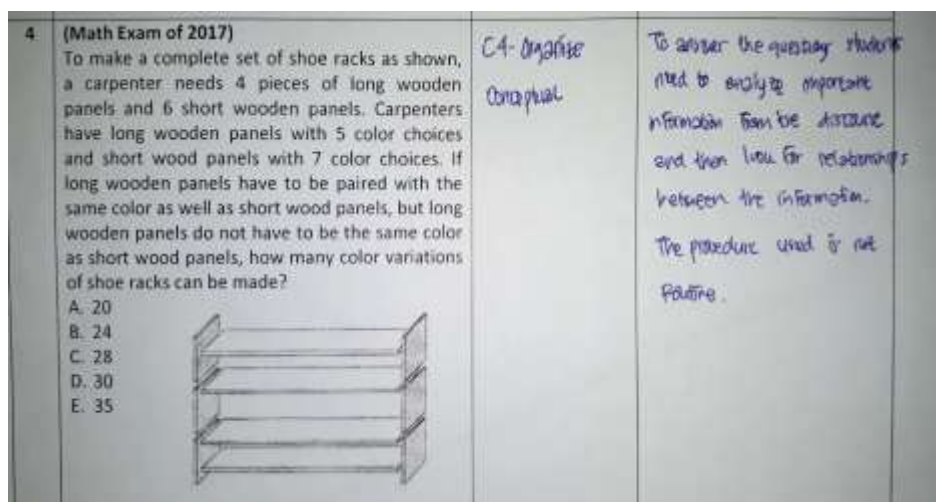
FIGURE 1. Sample of C4-analyze

While the percentage for C6-create was 2.5% which meant there was only a question containing HOTS with planning indicator. The sample question and the result of the assesment of one of the coders was shown in figure 2. The HOTS problem with creating category required a strategy of formulation, planning, and production. In this case, students needed to do mathematics modelling, then draw a set of completion areas. Not to stop at modelling linear programming, students needed to formulate how to determine the biggest gain (optimum value) in the form of percent. This was suitable to the characteristics of HOTS in creating category[9]. The steps taken to solve the problem were more than one way, so students needed to use procedural knowledge[4].

FIGURE 2. Sample of C6-create

In 2016, the content of HOTS with analyzing indicator was not found in the question. While the HOTS with evaluating indicator existed with a percentage of 5% which meant there were two questions with analyzing indicator. Category C5 (evaluate) was encountered also with checking indicator.

While in 2015, there was HOTS content in three questions with category of analyzing and two questions with category of evaluating (C5). C5 question was shown in figure 3. In that question, we could see that students needed to check the integrity of the option based on the presented image/curve. This was suitable to characteristic of evaluate. To evaluate this, students needed to know the concept of integral [9]. They had to know the function that would be integrated and how to integrate that function. It was conceptual knowledge [4].
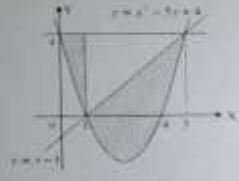
FIGURE 3. Sample of C5-evaluate

Broadly speaking, the HOTS content on the mathematics national exam for senior high school was at the cognitive level of conceptual knowledge. The distribution of HOTS content for each category was less evenly distributed. If we looked according to the percentage of HOTS, i.g. in 2017, there was only 3.33% of questions contained HOTS, while 96.67% of mathematics national exam did not contain HOTS. Most of questions in national exam did not need analyze, evaluate, and create skill to solve them. It just used some skills like memorizing and aplicate the formula to solve the questions. It should be proportional between HOTS and LOTS question in the mathematics national exam for senior high school.

3. Conclusion
The results of our analysis of mathematics national exam kit (especially on the last three years: 2017, 2016, 2015) provide evidence the lack of HOTS content in national exam kit. This conclussion adds to earlier study that showed the lack of HOTS content. The distribution of HOTS content for each category was less evenly distributed. The mathematics national exam in 2017 consists of HOTS with analyze and create indicator without evaluate indicator. The exam in 2016 consists of HOTS with evaluate and create indicator without analyze indicator. The exam in 2015 consists of HOTS with analyze and evaluate indicator without create indicator. Mostly, the domain cognitives that be involved are conceptual and procedural knowledge. There is no metacognitive knowledge found in these exams.

Based on our finding, we recommend including more the content of HOTS in mathematics national exam. It should be proportional between HOTS and LOTS content. And it should be evenly distributed for every category of HOTS, analyze, evaluate and create. National exam is assesment standard in national scale. It is potential to be used by teachers as references to facilitate students enhancing their HOTS.

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