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# Teachers understanding about cognitive level on science test items

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**Abstract.** This study aims to describe science teachers understanding about cognitive level on science test items. Subjects of the study were 30 secondary school science teachers from 4 districts in Banten Province, Indonesia. Data were collected from online survey about teacher's ability to determine cognitive levels on five science test items from TIMSS 2013. Teacher's professional development on assessment and higher order thinking skills (HOTS) item development were asked in the survey as well. Blueprint and test booklet from X district were analysed to get information about teachers skills in developing HOTS items. The results showed that the teachers tended to assume items with lower cognitive level as a higher cognitive level items. Teachers from X district claimed that 4 items from summative test were in the level C4. Meanwhile, referred to the item analysis in item construction, it was showed that those 4 items were still classified in the level C2. From the survey results, the average duration for teacher's professional development programs on assessment and HOTS item development is only 5-6 hours at district level (MGMP). The activities in those programs were still lack of direct practice on developing a valid and reliable assessment especially in developing HOTS items. Intensive teachers professional development programs are really needed to improve teachers skills in developing HOTS items.

## 1. Introduction

Some references of science learning standards, such as the National Science Education Standard (NSES) or the Next Generation Science Standard (NGSS) were emphasizing on students ability to solve problems in various situations. Those standards also illustrate that higher level thinking is an important aspect in science learning [1]. In Indonesia, curriculum 2013 has adopted Bloom's taxonomy revision, which starts from the level of knowing (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5) and creating (C6). The higher level of thinking demanded on the students is reflected in the Graduate Competency Standard (SKL) [2].

In fact, students are not drilled or trained to think critically in solving problems. Classroom instruction are mostly still teacher centered, dominated with written assignments, lack of inquiry activities that provide students with the opportunity to share their ideas and knowledge [3]. Learning Science is only about learning a knowledge of facts without any opportunity for students to develop their inquiry skills [4]. The survey results towards teachers in California showed that 89% teachers claimed that critical thinking was a goal in their teaching and learning process. However, only 19% of



those teachers could explain what critical thinking is and only 9% of them used critical thinking in their classroom [5].

Another important part of developing higher order thinking skills is assessment. To develop students skills require appropriate selection of assessment techniques in order to provide meaningful information to improve the learning process [6]. The dominance of assessment practices that focus on lower order thinking has become a serious concern among researchers [7, 8]. The 2015 TIMSS results showed that Indonesian students only master a routine, simple computing, and knowledge about day-to-day facts. Indonesian students need to strengthen their ability to integrate informations, draw conclusions, and generalize their knowledge to solve the problems [9].

Due to the importance of teachers' questions in the teaching and learning process, the analysis of these questions has been researched extensively. It has been shown that teachers at all levels of education tended to ask mostly questions requiring recall and rarely ask questions requiring reflection. Inamullah (2011) conducted a research in Pakistan secondary school and found that most of the questions asked are low order thinking from the total of 267 questions, 67 percent were dominated by knowledge based questions [10]. A survey research conducted by Iskandar and Senam (2015) found that 15 chemistry teachers in senior high schools infused only 13, 9% higher order thinking questions in their summative assessment [11]. Hill and Flynn (2008) reveal that remembering factual records is what many teachers mostly employ when they test the students. This practice focusing in lower order level questions might not contribute to the development of students' cognitive skill in reasoning and analysing. The absence of higher level thinking tests, especially at the school level affected students' ability to think critically [12].

From the results above, it is necessary to conduct a study which focuses on the teachers' understanding about cognitive levels in Bloom's taxonomy. Their understanding will be measured by examining teachers' ability to correctly determine cognitive levels of TIMSS questions. In addition, analysing level cognitive of questions from summative test that has made by teachers will be conducted as well. This will give information about teacher's ability in designing appropriate item test related to its cognitive level of taxonomy. This study is a preliminary research for designing teacher professional development program especially in developing science item bank for higher order thinking items.

## 2. Method

The research subjects in this study were 30 middle school science teachers. They were representatives from 4 districts in Banten Province (Lebak, Serang, Cilegon and Tangerang). Data were collected through questionnaires and document studies. All data obtained in this study will be analyzed quantitatively by calculating the percentage of each measured aspect.

The Questionnaires were distributed via online media. They contained five questions taken from TIMSS 2013. Teachers were asked to determine the cognitive levels of the questions. In addition, the teachers were asked to provide data about their professional development activities which were related to the assessment and test item development.

Document study was done to analyze the cognitive level of questions from summative test booklet for secondary school in December 2017. Those documents were taken from district X in Banten Province. In this district, the test booklet was used for all district-wide secondary school, whereas in other districts, they used different test booklet for each school. The test items were developed by science teachers who are members of MGMP IPA (Science Teacher Working Group) in X district. For the analysis, researcher uses Bloom's revised taxonomic benchmark [13] for 40 multiple choice questions. However, the analysis will be more focused on higher cognitive level items. The result of the analysis will give information about teacher's ability in developing appropriate test items that matched to their cognitive levels in Bloom's taxonomy. This study is a preliminary research for designing teacher professional development program especially in developing science HOTS item bank.

### 3. Results and discussion

#### 3.1. Teachers' determination of cognitive level on test items

Five questions from TIMSS 2013 were used in the survey. These items consisted of several different cognitive levels as shown in Table 1. This table also describes teachers' judgment about cognitive level of those questions.

**Table 1.** Teacher's judgment about cognitive level on TIMSS questions.

Item number.	Cognitive level	Teachers' judgment (%)	
		match	mismatch
1	Remembering	37	63
2	Applying	53	47
3	Understanding	7	93
4	Analyzing	40	60
5	Evaluating	27	73

Item number 1, students were asked to explain the purpose of cell respiration. This required students to remember the function of cell respiration. This item was categorized to be at the remembering level (C1). Only 37% of respondents categorized this item into C1 levels, while 63% categorized this item into other cognitive levels. Interestingly, teacher categorized this item to a higher cognitive level. More than half of teachers (53%) categorized this item into C2 level (understanding), 3% of teachers classified this item at C4 level (analysing) and 7% of teachers considered this item belongs to the category of evaluating (C5).

Item number 2 was categorized into C3 level (applying). In this questions, students were asked to apply certain procedures to describe the effect of temperature on the solubility of sugar in water. The first step in solving this problem, students must know how different temperatures can affect the solubility of a substance. Students should identify the dependent variables and independent variables as well as how the variables relate each other. Students should make a graphic to describe these relationship. Most teachers (53%) rated this item belong to C3 level. However, 30% of teachers classified this item at C4 level and 10% of teachers categorized it into C5 level.

Item number 3 was categorized at level C2 (understanding). Students were asked to construct the meaning of pictures and components that were shown in this item. One of the cognitive processes of understanding level is explaining. The explanatory cognitive process takes place when students can use causal models in a system [13]. Results showed that only 7% of teachers classified this item into C2 level. A total of 93% of teachers classified this item to a higher cognitive level of C3 (3%), C4 (70%) and C5 (3%). Level C4 (analysing) involves the process of breaking the material into small parts and determining how the relationships between parts and the overall structure. Analysing includes learning to distinguish relevant pieces of information, organizing pieces of that information and attributing the purpose behind the information [13]. Such a process is not seen in this item. In this case the students were only asked to explain the cause of the sodium bicarbonate and vinegar reaction to the balloon expansion.

Item number 4 was classified into C4 level (analyzing). Students were given plant images and asked to design experiments to prove that water goes out into the air through plants. To answer this question, students must understand the concept of water transport in plants as well as the experiments to prove it. Students should analyze each option that best describes the process of transport in plants. Only 40% of teachers classified this question into C4 level. Meanwhile, 60% of teachers rated this item into C1 (7%), C3 (30%) and C5 level (13%). These differences showed that most teachers have not been able to distinguish the questions based on their cognitive level.

Item number 5 was categorized into C5 level (evaluating). Students were asked to give their judgement on mayor's actions to prevent pollution through planting trees. In this case, students must master the concept of photosynthesis, pollution and the factors that influence photosynthesis and

pollution. At the evaluation stage, students should be able to make judgments and decisions about the idea [13]. The teacher's response showed that 40% of teachers classified the item into C5 level (evaluating) and 27% into C4 level. There were also teachers who classified this item to the level of C1 (7%), C2 (10%) and C3 (17%).

### 3.2. Analysis on summative test items

From the summative test blueprint that the teachers have made, only 4 questions showed as C4 levels. The four items were item number 2, 7, 11, and 39. The analysis focused more on these four items. Level C4 describes the ability of students to be able to break down a problem into smaller parts. Students also should be able to specify the factors causing it as well as to understand the relationships between these factors [2]. In question number 2 students were asked to classify samples of plants based on buds reproduction. The verb "classifying" are included in level C2. The process of thinking that must be passed by students to solve this problem is that they must know the differences in plant breeding and also the examples. Students were not asked to describe the components and understand the relationships between components which are the characteristic of the C4 level. So, the researchers classified this item in level C2.

Item number 7 can be classified into C3 level. To answer this item, students must understand the concept of dominant and recessive. Furthermore, students apply the cross breeding procedures between organisms that have dominant and recessive genes. Item number 11 has a similar procedures for students to answer the question. Therefore, item number 11 was categorized into C3 level as well. Item number 39 was still classified at level C2. Students were only asked to classify the types of animals with the same morphological functions. These results indicated that the four questions are not classified as higher cognitive level in Bloom's Taxonomy.

From the results above, most teachers have not understood about the characteristics of cognitive levels in Bloom's taxonomy. Teachers tended to judge items with lower cognitive levels as the higher ones. The questions that have been developed by the teachers still belong to lower cognitive level, although they claimed that some of the questions were already in the higher cognitive level.

Questioning was employed to encourage students to use higher order thinking processes [14]. In the teaching and learning process, the effective use of questions depends on the teacher's ability to determine Bloom's cognitive level of the question he asks. Unfortunately, many researches on teachers' use of questioning have shown that this skill was typically less effective than it could be [15]. This can be attributed to the lack of knowledge about questioning taxonomies [16]. The survey results about teachers' professional development activities supported this assumption. It showed that 57% of teachers have received information about how to develop higher order thinking skills (HOTS) questions. This information is generally obtained through MGMP (teacher working group) activities. But this activity is just a delivery of information about HOTS. In other words, it is only about the theory or the concept about HOTS. They are not deeply trained on how to make HOTS questions. In addition, the duration of this activity only about 5-6 hours in average. Loucks-Horsley et al states that the teacher's professional development activities that is merely informational is not effective in improving the learning practices in classroom. Professional development for teachers should be rooted in school practice [17, 18]. Therefore, it is necessary to design an intensive teacher's professional development program to improve teacher's skills in developing HOTS items by using Intensive guidance and coaching strategy.

## 4. Conclusion

Most teachers have not been able to determine the appropriate cognitive level of the questions presented to them. They tended to judge items with lower cognitive levels as a higher cognitive levels. Teachers from X District have not been able to develop higher cognitive level questions. The teachers professional development programs related to assessment and test item development were still lack of direct practices in developing HOTS items. It is necessary to develop teachers' professional development program to improve teachers' skills in developing HOTS items by using guidance and coaching strategy.

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### References

- [1] Abosalem A M 2016 *Int. J of Secondary Educ* **4** 1
- [2] Kemdikbud 2013 Standar Kompetensi Lulusan (Jakarta: Kemendikbud)
- [3] Susilo A B and Supartono Wiyanto 2012 *Unnes Science Education Journal* **1** 12
- [4] Fitz Patrick B and Schulz H 2015 *Canadian Journal of Sci. Math and Tech. Education* **15** 136
- [5] Lemons P P and Lemons J D 2013 CBE-Life Sciences Education 12 47
- [6] Abosalem A M 2016 *Int. J of Secondary Educ* **4** 1
- [7] Chen X, Jiang M, Cai L, Liang L L, Du J and Zhou Y 2017 *Contemporary Trends and Issues in Sci. Ed* 45 p 235
- [8] Osborne J and Dillon J 2008 *Science education in Europe: Critical Reflections*
- [9] Rahmawati 2016 *TIMSS 2015 Report Analysis* (Jakarta: Puspendik)
- [10] Inamullah H M 2011 *Asian Social Science* **9** 149.
- [11] Iskandar D and Senam S 2015 *Innovation of Science Education Journal* **1** 65
- [12] Hill J D and Flynn K 2008 *Journal of Staff Development* **29** 46
- [13] Anderson L W and Krathwohl D R 2001 *A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives* (New York: Longman) chapter 5 pp 94-139
- [14] Gall M D 1970 *Review of Educational Research* **40** 707
- [15] Graesser A C and Person N K 1994 *American Educational Research Journal* **31** 104
- [16] Zohar A 2004 *Higher Order Thinking in Science Classroom: Students' Learning and Teachers' Professional Development* (New York: Springer)
- [17] Loucks H S Hewson P W Love N and Stiles K E 1998 *Designing professional development for teachers of science and mathematics* (CA: Corwin Press)
- [18] NRC 2001 *Classroom Assessment and the National Science Education Standards* (Washington DC: National Academy Press)