Items analysis of physics assessment based on cognitive level of high order thinking skills in bloom taxonomy

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Abstract. There are many challenges faced by some countries which lead them to revise their educational curriculum, including in Thailand. In Thailand, the revised of curriculum in science learning field with Science and Engineering Practices (SEPs) is indirectly demands teachers to include High Order Thinking Skills in their teaching and learning as well as in assessment process. By concerning this phenomenon, this study was aimed at describing the realization of the cognitive levels from bloom taxonomy used by Physics teachers. Six classifications of the cognitive levels in bloom taxonomy were divided into two order thinking skills, namely Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS). To achieve the aforementioned objectives, this study employed qualitative research design. Accordingly, the subjects of this study were a Physics teacher in Matthayom Siriwanwari II Songkhla Secondary School and students in two classes, covering matthayom 5th and matthayom 6th. As stated earlier, there were three types of analysis in this study, the analysis of level, the evaluation of level, and the creation of level. Besides, the reasons which prevent the teacher to use cognitive level of bloom taxonomy High Order Thinking Skills were also investigated. The results showed that according to the analysis of matthayom 5th and 6th physics final examination items the cognitive levels used were 0% of remembering, 3.3% of understanding, 33.3% of applying, 50% of analyzing, 3.3% of evaluating, and 3.3% of creating. Meanwhile, matthayom 6th had 0% of remembering, 0% of understanding, 25.7% of applying, 51.4% of analyzing, 5.7% of evaluating, and 17.1% of creating. By referring to these results, it is known that the physics test items used small portion of evaluating and creating aspects. Based on these findings, it is known that the portions of evaluating and creating aspects are still low. However, these results actually can be a starting point in fulfilling the demand of the revised curriculum by the ministry of education in Thailand.

1. Introduction
Education is the necessary aspect to logic shaping and intellectual developing also to continuing the values, ideas, and perfecting thinking skills. In modern concepts, education becomes one of the means for preparing students to encounter every challenge of the contemporary era as responses to global problems. The students are taught to have logical, structural, systematic thinking with HOTS. Based on Brookhart, High Order Thinking Skills is (1) the high order thinking which is placed on the highest order of bloom cognitive taxonomy, (2) high order thinking skills is a goal behind the cognitive taxonomy to prepare the students to transfer the knowledge, and (3) the ability to think, meaning that
the students could apply the knowledge and the skills that are developed by them once they learn new contexts. New context means any applications of knowledge which have not yet been done by students derived from the concepts they have obtained before. Similarly, high order thinking requires students’ skills to connect the learning materials to the new things that have not to be taught before [1]. HOTS based on the revised version of bloom taxonomy have three dimensions that are: analyzing, evaluating, and creating. Evaluation is a thinking skill in making a decision based on facts or information, and creation is the thinking skills to build ideas [2]. In Indonesia, HOTS test items are not only tested in learning activities, but also tested in the Indonesia secondary school’s National Exam (UN), although in some cases, the achievement of the HOTS test items is far from satisfactory [3]. This shows the urgency of HOTS that is not only the main goals of the educational process.

Currently, Southeast Asia countries make an educational revolution. Hallinger & Bryant state that since the 1990s, Thailand, like other developing countries in Southeast Asia, has focused on expanding education access for its youth, and in 2018, Thailand even revised the curriculum, so it could support the development of critical thinking education [4]. Reeve also points out the importance of the 21st century and critical thinking skills needs by Thai students for their technical and vocational education and training (TVET) [5]. In the revised 2008 curriculum of Thai, Thai science curriculum document was the backbone of STEM learning and teaching [6]. This curriculum aimed to develop students’ ability to apply knowledge for their higher education and daily lives. In relation to these, Lertdechapat proposes four strands of science learning areas, namely biological areas, physical science, earth science and space, and technology. Various indicators used to measure progress in these areas are aimed to help teachers implement the revised science curriculum in practice. These indicators can be referred as Science and Engineering Practices (SEPs) which by NRC is related to cognitive level of Higher Order Thinking Skills in Bloom Taxonomy. In this way, students are expected to have the higher thinking skills by using the assessment with analyzing, evaluating, and creating levels [7]. Based on these descriptions, the researchers conducted a research with an aim to know the cognitive level of Higher Order Thinking Skills in Bloom Taxonomy. In this way, students are expected to have the higher thinking skills by using the assessment with analyzing, evaluating, and creating levels [7].

2. Method
This study attempted to know the realization of the cognitive level of High Order Thinking Skills in Bloom Taxonomy in physics final examination items for matthayom 5th and matthayom 6th only based on the indicators from revised bloom taxonomy by Anderson and Krathwohl without has a further research about the identification of the items to measure the difficulties of the items, distinguish factors, and the items pattern. To pursue this objective, the researchers conducted the research design with a descriptive analysis in Matthayom Siriwanwari II Songkhla School with total 42 boys and 83 girls in range of age 17 until 18 years old for Matthayom 5th as well as 24 boys and 88 girls in range of age 18 until 19 years old for Matthayom 6th. The document was taken with purposive sampling due to the criteria that was given by the revised Thai curriculum. Further, the data were obtained by collecting the documents of physics final examination items by matthayom 5th and matthayom 6th in the academic year of 2561/2019. From these data, the items were analyzed through several steps, namely: (1) transcribing, (2) identifying, (3) classifying, (4) summarizing, (5) comparing, (6) conclusions drawing. Besides, to validate the data, the researchers used triangulation in the form of interview with a Physics teacher. This interview covered several perspectives, namely the examination test items makers, the procedures in the test items making process, whether the teacher initially analysed the items or not, whether there were standardized items used by the teacher, and whether there was a follow up after the exam or not.
3. Result and Discussion
The cognitive analysis of High Order Thinking Skills items used by physics teacher was done by using cognitive processes in revised Bloom’s Taxonomy by Krathwohl in 2001, which including Low Order Thinking Skills (C1: remembering, C2: understanding, and C3: applying) and High Order Thinking Skills (C4: analyzing, C5: evaluating, and C6: creating) [8].

![Graph showing percentage of cognitive levels of High Order Thinking Skills items regarding to Bloom Taxonomy](image)

**Figure 1.** Graphic percentage of cognitive level of High Order Thinking Skills items regarding to Bloom Taxonomy

Furthermore, based on the data percentages, it was known that Matthayom 5th final assessment gained higher percentage of High Order Thinking Skills than the Low Order Thinking Skills. The subsection of Low Order Thinking Skills in Matthayom 5th physics final assessment were 0% C1, 3.3% C2, and 33.3% C3. Meanwhile, for the subsection of High Order Thinking Skills were 50% C4, 3.3% C5, and 3.3% C6. The total percentage of the items was not 100% because there were two invalid items, namely item number 5 and 7. The next data of Matthayom 6th physics final assessment showed that the percentage of the Low Order Thinking Skills items was lower than the High Order Thinking Skills. The subsection of Low Order Thinking Skills in Matthayom 6th physics final assessment were 0% C1, 0% C2, and 25.7% C3. Meanwhile, for the subsection of High Order Thinking Skills were 51.4% C4, 5.7% C5, and 17.1% C6.

The triangulation of this study was regarding the reasons of using cognitive level of High Order Thinking Skills in Bloom Taxonomy on physics final examination test items. As explained earlier, to deal with this matter, the researchers used interview with the Physics teacher herself. After the interview was done, the researcher found some reasons constraining the use of cognitive level of High Order Thinking Skills in Bloom Taxonomy on physics final examination test items in the following:

1. All of the assessment including but not limited to the final examination items was made by the physics teacher herself.
2. The procedures of items making process started with the teacher made a grid based on the indicators from the syllabus of curriculum before it was checked by the school director. Then, the teacher made the test items, and lastly the items were re-checked by the school director.
3. The physics teacher analyzed the items using PISA standard and Bloom Taxonomy.
4. The teacher divided the standard of the test items into 3 parts with the following percentages: 25% difficult items, 50% medium items, and 25% easy items. These distributions were used due to capacities of the students while adapting to the revised curriculum.
The teacher usually tells the students about their scores and if half of them do not reach the half of the standard score, the teacher will hold a remedial test.

![Graph of items distribution based on Cognitive Levels of Depth Knowledge PISA 2015](image)

**Figure 2.** Graphic percentage of items distribution by depth knowledge PISA 2015 and the comparison with the matthayom 5th and 6th physics final examination items.

Figure 2 showed that even though the low level of matthayom 5th was still far from the PISA 2015 items distribution standards, it was already lower than the amount of the PISA 2015 result of Thailand. Hence the matthayom 6th already reached the PISA 2015 items distribution. Additionally, for the medium level, the analysis results of matthayom 5th and matthayom 6th were almost similar to the PISA 2015 standards, so did the PISA 2015 results of Thailand. Even though, the percentage of high level from the distribution of matthayom 6th was close to the PISA 2015 items distribution standard, the percentages of matthayom 5th final examination items were still far from it. However, it obtained higher results than the PISA 2015 results of Thailand. This comparison happened due the consideration whether the items that were made by teacher have fulfilled the demand from the revised curriculum in scientific learning area to make the items based on the PISA standard or not.

**Table 1.** The comparison between the Thailand’s PISA result 2015 and the items analysis of matthayom 5th and 6th

| Cognitive Levels | Thailand PISA Results in 2015 | Matthayom 5th | Matthayom 6th |
|------------------|-------------------------------|--------------|--------------|
| Low              | 46.70%                        | 36.6%        | 25.7%        |
| Medium           | 50.00%                        | 50%          | 51.4%        |
| High             | 4.30%                         | 6.7%         | 22.9%        |

These results were actually in line with the triangulation that obtained from the interview, that the teacher was demanded by the education department due to the revised curriculum of Thailand to make the assessment that at least similar to the PISA 2015 distributions standards with 25%, 50%, and 25% distribution of low, medium, and high level. Hence, this distribution was actually to normalize the standard distribution graph, so the students grades proportion would stand still, but also still could challenge the 21st-century demand on education. Even though the matthayom 5th has not reached to the PISA 2015 distributions standard items for low and high level, it was still okay due to the actual priority of the revised curriculum was actually for the matthayom 6th and the matthayom 5th as the trial-classes, meanwhile the matthayom 4th was only the habituating class due to the this level was a transient class from the junior high school to the senior high school.

From the above reasons, it is known that the reason that was underlined the teacher in using the cognitive level of High Order Thinking Skills on their final examination items based on the demand of the revised Thai curriculum 2018 to increase the thinking skills of its students justified by the
Lertdechapat’s studies. The cognitive level of the items referred to the revised Bloom Taxonomy and also PISA 2015, although it hasn’t reached the exact similarities. In addition, the teacher was also demanded to always include the development of students study processes which only could be done by having the follow up activities after the result of the exam came out.

4. Conclusion
Taking everything in consideration, the physics examination for matthayom 5th and matthayom 6th already used the analysis, evaluation, and creation level from bloom taxonomy that categorized as High Order Thinking Skills. Furthermore, according to the data analysis, the items used of cognitive levels were various. The first most often used types of cognitive level by the physics teacher on their assessment were analysis level (C4). Then for the second level that used the most by the physics teacher on matthayom 6th final examination items was creating (C6) and followed by evaluation level (C5), while for matthayom 5th, both evaluation and creation has the same number of items. The first suggestion that was taken from this study was the need of the further research is to considering the previous items before the revised curriculum as an effort to achieve meaningful understanding towards the differences that shown after implementing the HOTS items more in the examination. The second suggestion for further research was to invoke the results from the examination and the relatable efforts that have been done by the ministry of education in Thailand so there would be additional research findings.

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