Applying CBT in physics learning to measure students' higher order thinking skills

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Abstract. Development in science and technology that exist today can be optimized to be used as media in learning process, one example is in assessment of learning using computer based test (CBT). Higher order thinking skills (HOTS) are important aspects in physics learning. CBT is used to measure the HOTS (PhysTeHOTS-CBT). The subjects of the study are 251 students of class XI science program. The students' HOTS by using PhysTeHOTS-CBT show 4.78% of students have very low category; 13.1% have low category, 60.9% have medium category, 9.16% have high category, and 11.9% have very high category. Based on the result of the study, the students' HOTS are dominated in the medium category.
Keywords: *CBT, HOTS, PhysTeHOTS-CBT, reasoning multiple choices*

1. Introduction

The curriculum is a component of the education system that contains lesson plan that is given over a period of education. The use of curriculum is done to understand the competencies in the learning process and to train students in higher-order thinking skills (HOTS) [1]. So, students become more accustomed to HOTS on the learning process.

One of the success factors of the educational process is determined by scoring system that used. Appropriate assessment of learning outcomes will provide accurate information about achievement of competence of students and the quality of learning that is used by the teacher [2]. Assessment is also a process for obtaining information on the performance of students [3]. Proper assessment system is necessary given regarding to the importance of assessment in the learning process. Proper assessment is provide accurate information, encourage students to learn, motivating teachers to teach, improve the performance of the institution, and improve the quality of education [4]. In a preparing the assessment must consider many aspects to comply with existing standards.

One effort in assessment is to use the test. Tests conducted to determine the cognitive obtained students during the learning process. Tests increasingly varied forms of development along with the development of science and technology [5]. Previous tests were only done on paper, now use computers as media tests to address the weakness in paper based test [6]. In addition, using computer based test is also able to eliminate shortage of tests on paper that is not environmentally friendly.

Tests that are used in high school to know the learning outcomes of physics so far is limited to the assessment of low-level of thinking and have not yet been developed to measure HOTS [7], this resulted in need to create a test to measure the ability of HOTS. Development of high-level test can be done by varying multiple choice or use the constructed response questions and essays [8]. Multiple choices reasoned have been chosen because the assessment process is more objective and more easily

processed by computers. Computers have been used due to the development of science and technology and also have many advantages [9]. Computer Based Test (CBT) have recently emerged as a viable form of alternative assessment used around the world [10]. For that, a CBT test is developed to provide accuracy and measure the ability of each student.

The development of a reasoned multiple choice format to cover multiple choice shortcomings has been investigated in [11] and the study used it for scoring students' answer and reason. An assessment score can be seen in table 1.

Table 1. Assessment Score in PhysTeHOTS-CBT.

Score	Criteria
4	Answer and Reason are right
3	Reason is right, but answer is wrong
2	Reason is wrong, but answer is right
1	Answer and Reason are wrong

2. Research method

This research was conducted at senior high schools class XI Science Program in Kota Yogyakarta, Yogyakarta Province. The research subjects are 251 students selected by stratified random sampling technique, namely by choosing high schools with high and low physics scores. The research subjects are asked to carry out physics tests using CBT that are able to measure the HOTS, i.e.: PhysTeHOTS-CBT.

PhysTeHOTS-CBT is developed in accordance with the indicators of physics class XI Curriculum 2013 and in accordance with indicators of HOTS. PhysTeHOTS-CBT consists of five subject matters that are rigid body equilibrium, elasticity and spring, static fluid, dynamic fluid, and temperature and heat. The questions consist of 4 packages with each package consists of 45 questions with 8 anchor items.

The question test in PhysTeHOTS-CBT meets the requirements of a good test item. These requirements are 1) content validation obtains V Aiken of 1.00, which means that all test items are valid to assess HOTS; 2) based on empirical validation seen from the suitability of items to the model, all items are in the range of 0.77 to 1.30, which means that all items match with the PCM model; 3) the difficulty of items in the PhysTeHOTS-CBT are in the range of -0.54 to 1.00, so it can be said that all items are in good condition; 4) the results of the reliability tests found that PhysTeHOTS-CBT is suitable for measuring students with abilities of -2.2 to 2.0.

Scoring PhysTeHOTS-CBT used the partial credit model (PCM) which is a development of 1-PL. The test is taken using PhysTeHOTS-CBT and the results are categorized in five levels of HOTS adopted from the distribution method by Azwar [12]. The category of HOTS can be seen in Table 2. Based in table 2, the category of HOTS can be ilustrated in table 3

Table 2. Interval equation and category of HOTS.

No.	Interval Equation	Category
1.	$\theta > M_i + 1{,}5\ x\ sb_i$	Very high
2.	$M_i + 0{,}5\ x\ sb_i < \theta \leq M_i + 1{,}5\ x\ sb_i$	High
3.	$M_i - 0{,}5\ x\ sb_i < \theta \leq +0{,}5\ x\ sb_i$	Medium
4.	$M_i - 1{,}5\ x\ sb_i < \theta \leq M_i - 0{,}5\ x\ sb_i$	Low
5.	$\theta\ \leq M_i - 1{,}5\ x\ sb_i$	Very low

Table 3. The result and category of HOTS.

No.	Interval Equation	Category
1.	$\theta > M_i + 1{,}5\ x\ sb_i$	Very high
2.	$M_i + 0{,}5\ x\ sb_i < \theta \leq M_i + 1{,}5\ x\ sb_i$	High
3.	$M_i - 0{,}5\ x\ sb_i < \theta \leq +0{,}5\ x\ sb_i$	Medium
4.	$M_i - 1{,}5\ x\ sb_i < \theta \leq M_i - 0{,}5\ x\ sb_i$	Low
5.	$\theta \leq M_i - 1{,}5\ x\ sb_i$	Very low

Information: θ = the students' HOTS; M_i = ideal mean skills = ½ $(\theta_{max} + \theta_{min})$ = ½ $(3 + (-3)) = 0$; and Sb_i = ideal standard deviation = 1/6 $(\theta_{max} - \theta_{min})$ = 1/6 $(3 - (-3) = 1$.

3. Results and Discussion

The instrument of HOTS developed is 160 items with 8 are anchor items. The HOTS test that has been developed is packaged into PhysTeHOTS-CBT. The students that are measured using PhysTeHOTS-CBT represent schools with HOTS in low and high categories. The PhysTeHOTS-CBT home page can be seen in figure 1.

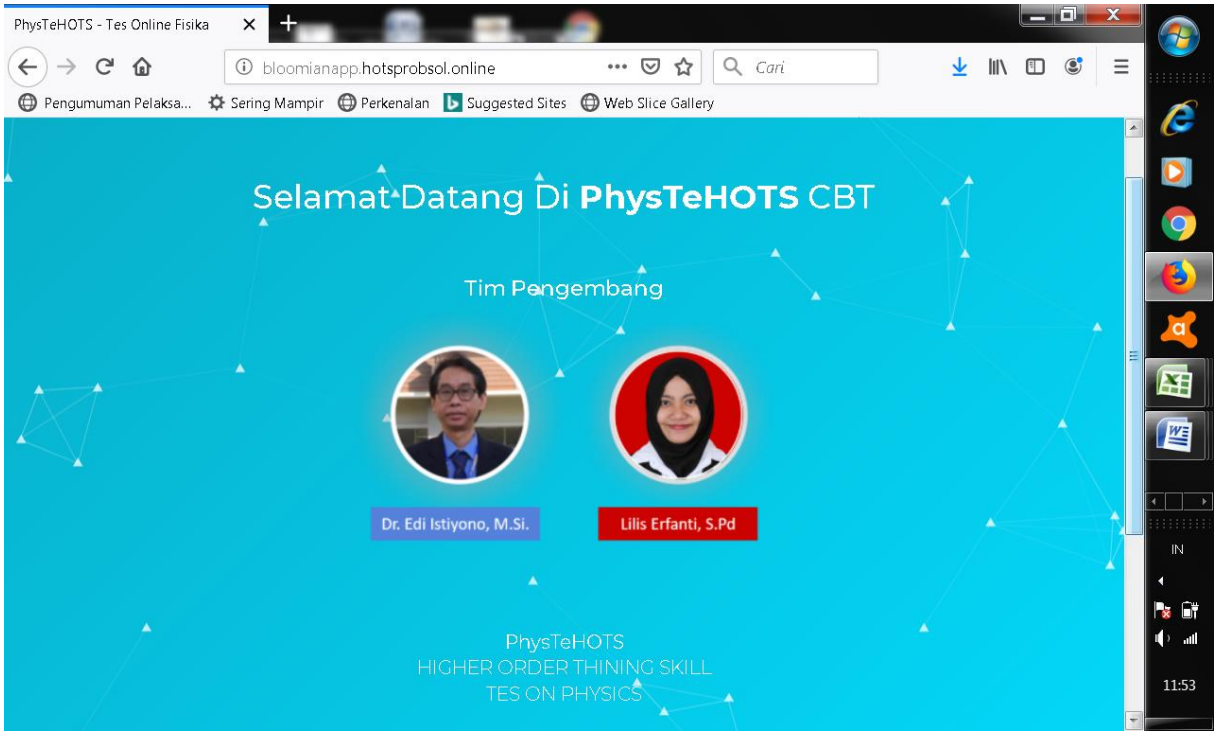

Figure 1. Home page of PhysTeHOTS-CBT.

The results of students' HOTS measurements can be seen in the statistics menu showing $\boldsymbol{\theta}$ calculations and categories of HOTS and conversion value from 1-100. The statistics menu display can be seem in figure 2. PhysTeHOTS-CBT are conducted for high school grade XI students. The test implemented is to measure the students' HOTS using CBT. The ability (θ) of each student can be categorized in the predicted ability from very high to very low based on the ideal score and standard deviation [12] which is shown in table 4. The result of categorizing the abilities (θ) of students are shown in completing the PhyTeHOTS using CBT in table 5

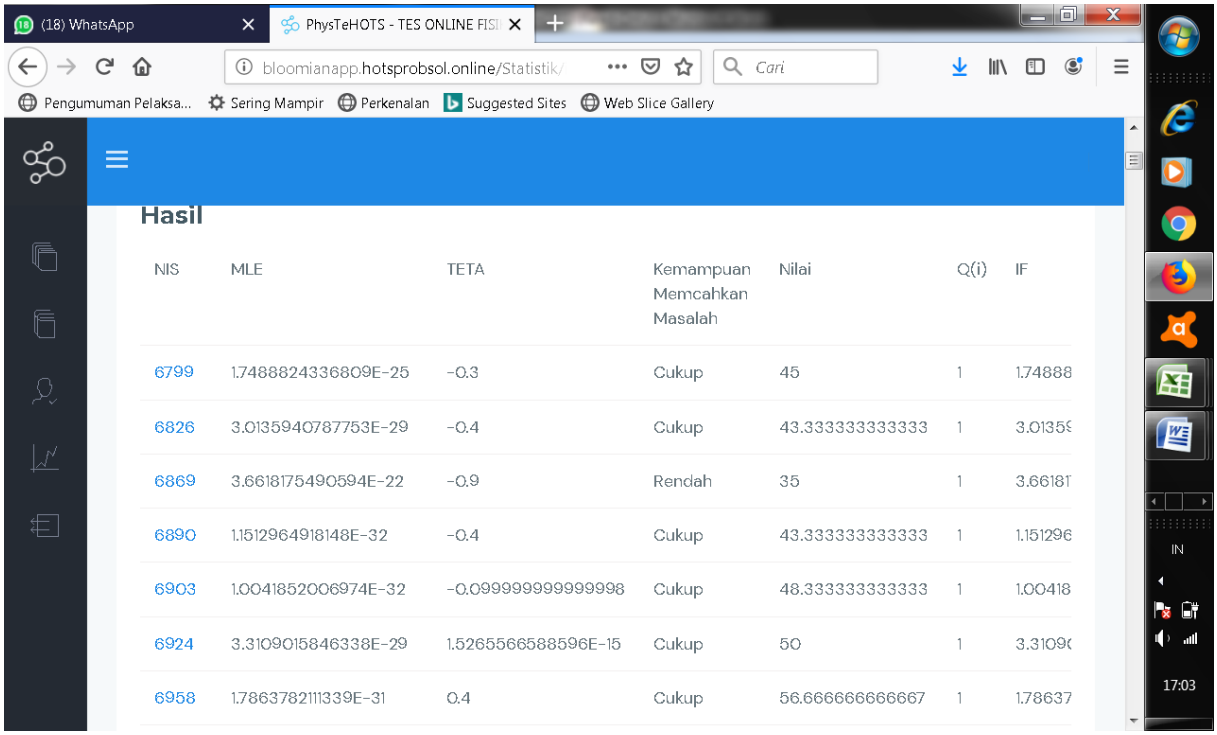

Figure 2. Statistics menu

Table 4. Students' ability interval.

No	Ability Intervals	Categories
1	$\theta \leq -1{,}5$	Very high
2	$-1{,}5 < \theta \leq -0{,}5$	High
3	$-0{,}5 < \theta \leq 0{,}5$	Medium
4	$0{,}5 < \theta \leq 1{,}5$	Low
5	$\theta > 1{,}5$	Very low

Table 5. Category of HOTS by using PhysTeHOTS-CBT

No	Category	Sum	Percentage (%)
1	Very high	30	11,9
2	High	23	9,16
3	Medium	153	60,9
4	Low	33	13,1
5	Very low	12	4,78

Table 5 shows the distribution of HOTS category in the PhysTeHOTS-CBT. From the table , it can be concluded that the majority of students have HOTS in the medium category. Figure 3 shows that students' HOTS in physics learning can be measured by CBT. Students with very high HOTS category is only 11.9%. The use of CBT also has many advantages, e.g.: paperless and time efficient. The result comes out as soon as the students finish the test. This is in line with the results of the research conducted in [13] that CBT has the advantage of faster test distribution, time-efficient benefits, and fast feedback. Also, in line with the results in [14], CBT is able to provide faster test results.

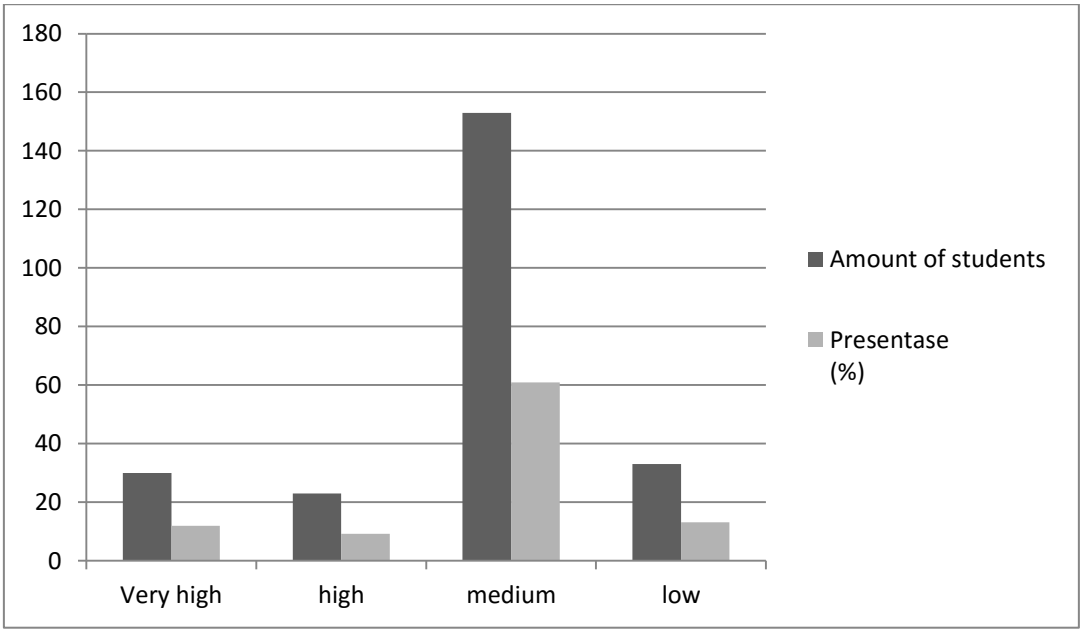

Figure 3. The distribution of HOTS in PhysTeHOTS-CBT.

4. Conclusions

Based on the results of the study, it is found that PhysTeHOTS developed based on the IRT algorithm can measure the students' HOTS. From 256 students of grade XI, there are 11.9 % that have very high ability, 9.16% high ability , 60.9% medium ablity, 13.1% low ability, and 4.78% very low ability. It is conclude that the majority of students have the ability in the medium category.

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