www.bircu-journal.com/index.php/birci
Budapest International Research and Critics Institute-Journal (BIRCI-Journal)
Humanities and Social Sciences
ISSN 2615-3076 Online)
ISSN 2615-1715 (Print)
Budapest Institute

Physics Higher Order Thinking Skills Analysis: Motion at Secondary School

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Abstract

This study aimed to analyze students ability to solve Higher Order Thinking Skills (HOTS) problems in physics, especially in motion in one of Pontianak' Senior High School. The methods used in this research was descriptive method with qualitative approach. The subjects in this research is 125 students of class XI MIPA. The data-collecting instruments in this research was twenty multiple choices problems, consists of analyze, evaluate, and create step of thinking. According to the data result of this research, it can be seen that the average of students ability in solving higher order thinking skills problems is 32.27%. Specifically, in each dimension of HOTS problems are analyze problems 43,13%, while evaluate ability are 41% and create ability are 12.67%. Those results show that students abilities of solving high order thinking problems still categorised as low. The result of mann-whitney were asymp. Sig. (2-tailed) score of 0,170 (>0,05), so H0 are accepted and H1 are denied. It means that there are no significant difference between male and female students in term of ability to accomplish higher order thinking problems. Therefore, learning activities in order to increase students high order thinking skills are needed at secondary school in Pontianak.

Keywords
analysis; higher order thinking skills; motion

I. Introduction

According to law number 20 (2003), "the aims of national education are to develop the potential of students become human beings who believe and are devoted to God Almighty, have a noble character, are healthy, knowledgeable, capable, creative, independent and become democratic and responsible citizens in the context of enriching the life of a nation."

As implied in the law, one of the students' potentials that need to be improved is intelligence. One of the ways to improve students' intelligence is by dev students' intelligence skills in solving problems. Thinking skills are essential in describing and explaining physical phenomena. There are many concepts studied in physics that can be found in real life in everyday life, one of which is the concept of vibration. Characteristics of motion concepts that are abstract so that they require high thinking skills to understand theories and compare them with symptoms in everyday life.

According to Astuti et al (2019) Education is an obligation of every human being that must be pursued to hold responsibilities and try to produce progress in knowledge and experience for the lives of every individual. Education is one of the efforts to improve the ability of human intelligence, thus he is able to improve the quality of his life (Saleh and Mujahiddin, 2020). Education is expected to be able to answer all the challenges of the times and be able to foster national generations, so that people become reliable and of high

quality, with strong characteristics, clear identities and able to deal with current and future problems (Azhar, 2018).

According to Bloom's taxonomy, which has been revised, thinking skills are divided into lower-order thinking skills (LOTS) and Higher Order Thinking Skills (HOTS). Higher-order thinking skills are an approach to think critically, logically, reflectively, metacognitively, and creatively. The 2013 curriculum currently being implemented by the government also requires students to think at a higher level. It is indicated by the presence of several active verbs that indicate students' higher-order thinking skills in the core competencies (KI) of the 2013 curriculum.

This thinking skill will appear when individuals or students are faced with problems that they have not encountered before. In addition, higher-order thinking skills can encourage students to think broadly and deeply about the subject matter (Directorate of High School Development, 2017). Therefore, higher-order thinking skills are an essential aspect of learning and are valuable tools to help students learn, improve performance, and reduce students' weaknesses (Heong, 2011).

Bloom's taxonomy is considered as the basis for higher-order thinking skills. This thinking is based that some types of learning require more cognitive processes than others but have more public benefits (Heong, 2011). Based on Bloom's taxonomy, three aspects in the cognitive domain are part of higher-order thinking skills. Those three aspects are analyzing aspect (C4), evaluating aspect (C5), and creating aspect (C6) (Anderson, 2001).

Analytical ability is a person's ability to determine the parts of a problem and show the relationship between these parts and the material as a whole. Evaluation ability is an activity to assess based on specific criteria and standards (Anderson, 2001). The ability to create is the ability to combine elements to form a new and unique structure, design ways, and find more than one answer (multiple solutions) (Brookhart, 2010).

An assessment is needed to determine a person's higher-order thinking ability. To carry out the assessment, teachers need an assessment instrument in the form of questions to test knowledge, attitudes, and skills. The assessment instrument used by the teacher to test student learning outcomes in the knowledge aspect is usually taken from various books or a collection of exam questions. Questions can be in the form of descriptions, multiple-choice, short entries, and others.

In reality, the questions usually tend to test more aspects of memory to analysis in the field. Even though many books present material by inviting students to learn actively, concepts are very systematic. However, it often ends with evaluation questions that do not train students' higher-order thinking skills. The teacher can train students to practice questions that invite students to think of analysis, evaluation, and creation.

Based on several studies that have been carried out, the ability of students to solve HOTS questions is still relatively low. Permatasari (2017), in his research, found that the average higher-order thinking ability of students on each indicator was 0.38 for C4 (analyzing), 0.26 for C5 (evaluating), and 0.21 for C6 (Creating). 68.24% of students have high-order thinking skills in analysis, 3.53% of students have higher-order thinking skills in evaluating, and 0% of students have higher-order thinking skills in creation (Budiarti, 2017). In addition, in his research, Kurniati (2016) found that 18 students were able to solve HOTS questions with a medium level, and there were 12 students able to solve HOTS questions in the low category.

HOTS assessment can also be seen through national exams and school exams. This can be seen from the increase in the percentage of HOTS questions inserted in the national exam questions in recent years. The Indonesian government maintains the national exam as a form of final assessment at a level of the educational institution to determine the

graduation of students. Based on the average value of the national exam in recent years for physics subjects in high school, there are several schools in Pontianak whose test scores are relatively high, one of which is SMA which scored 61.15 (2016) 69.15 (2017), and 72.63 (2018). Based on the national exam results, Pontianak High School students can have reasonably good skills in solving HOTS questions.

For this reason, it is necessary to research higher-order thinking skills in SMA Pontianak. The measurement of this ability is done by giving HOTS questions. This study aims to measure students' ability to solve HOTS questions on the physics of motion material.

II. Research Method

This study is a descriptive study that aims to analyze the ability of students to solve HOTS questions on physics of motion material in class XI students of Natural Science Specialization in one of the junior high schools in Pontianak. The method used is survey research with a qualitative approach.

The population in this study were all students of class XI Specializing in Natural Sciences at one school in Pontianak in the 2021-2022 school year who were taught by the teacher of the same subject and had attended physics lessons on motion material. The sampling technique in this study was done by random sampling. The sampling method in this study was by looking at the number of students in each class, considering the small number of male students. Therefore, 60 students were selected, consisting of 60 male students and 65 female students as samples in this study.

The data collection technique used in this study is a measurement technique. The measurement technique in this research proposal uses a written test in the form of an essay. The data collection tool in this study was in the form of a multiple-choice test with a total of 20 questions in the cognitive domains of analyzing (C4), evaluating (C5), and creating (C6).

Then the results obtained were analyzed qualitatively to obtain a profile of students' ability to solve higher-order thinking skills in motion material. Furthermore, to determine whether there are differences in the ability to solve HOTS questions between male students and female students, a non-parametric analysis was carried out.

III. Results and Discussion

3.1 Results

a. The Level of Students' Ability in Solving Physics HOTS Questions on Motion Material

Data on students' ability is measured based on the ability of students to solve problems that contain criteria for meeting higher-order thinking skills. The following is a summary of the data on the level of students' ability to solve the problems presented in Table 1.

Table 1. Percentage level of students' ability in solving problems

Aspects	score	Percentation (%)	Level
Analyze	10,78	43,13	Low
Evaluate	8,2	41	Low
Create	0,63	12,67	Low

From Table 1, it can be seen that the average score obtained by students at the analyzing level is 47.85. In contrast, the average percentage obtained by students is 38.28% with low criteria, for the level of evaluating the average score obtained by students is 51.87 or the average percentage is 41.5%, while the average score obtained by students for the level of creating is 28.8, or the average percentage is 23.04 %. This fact shows that the level of students' ability to solve HOTS questions is relatively low.

The following is a description of the grouping of students based on test results can be seen in Table 2.

Table 2. Grouping of students based on test scores

Score	Criteria	Number of Students Based on HOTS Criteria					
		Analyze	%	Evaluate	%	Create	%
x > 75%	High	0	0	0	0	2	1,6
45 ≤ x ≤ 75%	Middle	23	18,4	68	54,4	4	3,2
x < 45%	Low	102	81,6	57	45,6	119	95,2

Based on Table 2 shows that the HOTS scores of students in the cognitive domain of analyzing (C4) with moderate criteria are 23 students (18.4%) and low criteria are 102 students (81.6%). The HOTS score of students in the cognitive domain evaluates (C5) with moderate criteria as many as 68 students (54.4%) and low criteria as many as 68 students (54.4%).

57 students (45.6%). While the HOTS value of students on the ability to create (C6) has a high criterion of 2 students (1.6%) and a moderate criterion of 4 students (3.2%), while the low criterion is 119 students (95.2%).

b. Differences in students' abilities based on gender in solving physics HOTS questions on motion material

To find out the differences in the abilities of students based on the type of gender in solving HOTS questions on the physics of motion material requires a statistical prerequisite test, namely the normality test, to find out whether the data is normally distributed or not. If the data is normally distributed, proceed with parametric statistical tests, namely the unpaired T-test. If the data are not normally distributed, proceed with non-parametric statistical tests, namely the Mann-Whitney test.

This study used the Shapiro-Wilk test for data normality. Based on the normality test results, a significance value of 0.357 for males and 0.01 for females was obtained. The data can be normally distributed if the two significance values are > 0.05 so that the male and female data are not normally distributed.

Furthermore, a non-parametric statistical test was carried out, namely the Mann-Whitney test, because the data were not normally distributed. The test results are presented in Table 3.

Table 3. Mann-Whitney test

	Ability to solve HOTS Problems
Mann-Whitney U	1624.500
Wilcoxon W	4109.500
Z	-1.372
Asymp. Sig. (2-tailed)	.170

Based on Table 3, the asymp value is obtained. Sig. (2-tailed) or the asymptote significance for the two-tailed test was 0.170, above 0.05 (0.170 > 0.05). So it can be concluded that there is no significant difference between the HOTS ability of male students and the HOTS ability of female students.

3.2 Discussion

The research was conducted at the Emmanuel Christian High School on students of class XI. The form of research used is a survey. This research was conducted once by giving HOTS questions to students. The number of students who worked on the HOTS questions was 60 people, with 30 males and 30 females. The purpose of this study was to analyze the ability of students to solve problems of Higher Order Thinking Skills (HOTS) physics on motion material at SMA Pontianak. Specifically, following the objectives of this study, the level of students' ability to solve HOTS physics questions on motion materials and the differences in students' abilities based on gender in solving physics HOTS questions on motion materials was discussed.

Data analysis found that the average percentage of students' abilities in solving physics HOTS questions on motion material was low (39%). These findings are in line with research conducted by Ramadhan (2018), which shows that the profile of students' higher-order thinking skills is in a low category and (Erfan 2018) found the same thing (100% HOTS ability of students is in a low category).

Based on the answer sheet analysis of 5 questions in the cognitive domain to analyze (C4) given to students, the average ability to solve questions was 43.13% in the low category. Only 26 students (43.33%) were able to answer questions in the low category. Medium and 34 students (56.67%) were able to answer questions in the low category. One of the question indicators with the lowest score in the cognitive domain of analyzing is question number 6. The question's indicator is examining the pendulum's speed in different areas with the same treatment. In this indicator, analysis can be done if students can determine the parts that make up a particular form, object, or problem so that students can show their relationship to one another. However, indicator students' skills in connecting between different concepts have not been seen, such as the relationship between frequency and gravity and the relationship between frequency and pendulum velocity. Students are only able to analyze the effect of gravity in the two areas.

In the cognitive domain evaluating (C5), the average ability to solve questions is 41% in the low category, only 28 students (46.67%) can answer questions in the medium category, and 32 students (53.33%) can answer questions with low category. Of the four questions in the cognitive domain to evaluate students, the number of questions with the lowest score is number 7. The indicator of the question is to prove the time required for one vibration. In this indicator, there are no students who can answer correctly. Students can only decipher the information by writing down what is known and asking what is meant by the question. Students are also wrong in writing formulas and less precise in doing calculations. The ability of students to solve category evaluation questions is lower than the ability of students to solve analytical category questions because not all students can provide an assessment of the solutions provided based on suitable criteria. Evaluating can be done if students can plan and carry out problem-solving plans appropriately, understand the question's intent correctly, and provide the right reasons/evidence so that the written answer will answer the question in question.

In the cognitive domain of creating (C6) from 1 question given to students, the average ability to solve questions is 12.67% in the low category. All students in the low category (100%). The indicator of the question in the cognitive realm of creation is

designing and arranging experiments on the motion. In this indicator, there are no students who can answer correctly. The average student is wrong in determining the purpose of the experiment and the steps of its work. The ability of students to solve problems in the category of creating is the lowest compared to the other two categories, namely analyzing and evaluating. This is because not all students can arrange experiments systematically and adequately, as research conducted by Prasetyani et al. (2016) states that the aspect of analyzing has the highest value compared to evaluating and creating. After all, analyzing is the lowest level of higher-order thinking skills so that more students succeed on these indicators than indicators of higher-order thinking.

In addition, it was found that there was no significant difference in the ability of students to solve physics HOTS questions on motion material based on gender, indicating that there was no difference in the ability to solve problems between male and female students. This is supported by research by Ramos et al. (2013), which states that the HOTS ability of male and female students is the same, and (Abubakar et al., 2012) also says the same thing (there is no significant gender difference in the academic achievement of students).

The explanation above shows that, on average, students have not been able to solve problems with more complex characteristics (high criteria). Therefore, students need to be given questions at the HOTS level to be trained to develop their cognitive abilities. Students who have difficulty answering usually do not practice doing the questions. Students need to be trained to work on practice questions during the learning process. According to (Kusuma, UU, Abdurrahman, & Suyatna, 2017), the teacher's gradual provision of HOTS questions can improve thinking skills. In addition, there is a need for strategies in the learning process that can stimulate students' thinking activities repeatedly, such as problem-solving learning, assignments, inquiry learning, cooperative learning, and so on. Students must be actively invited to develop their skills to think about answers or identify and explore scientific examinations of existing facts (Thitima & Sumalee, 2012).

IV. Conclusion

Based on the study results, in general, it can be concluded that the ability of students to solve HOTS questions on physics in motion material at SMA Pontianak is still relatively low, with an achievement percentage of 39% of the ideal score. Specifically, the study were concluded that the students' ability levels in solving identification problems was 43.13%, students' ability levels in solving evaluation questions were 41%, and 12.67% for create dimension. On the results of the Mann-Whitney test, the asymp value is obtained. Sig. (2-tailed) 0.075 (> 0.05), so that H0 is accepted and H1 is rejected. There is no significant difference between the average test results for the ability to solve questions for male students and the ability to solve questions for female students.

Based on the results of the research that has been done, it is indicated that there is a need for learning that can improve students' HOTS abilities. In addition, further researchers are expected to be able to overcome the weaknesses in this study, including: (1) using a balanced proportion of questions for each cognitive domain; (2) The provision of test questions is carried out before the students finish reviewing the material related to the research or right after the material is delivered. This is done to increase the objectivity of the test result data.

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