

HOTS profile of physics education students in STEM-based classes using PhET media, Journal of Physics

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Submission date: 05-Jan-2021 10:16AM (UTC-0600)

Submission ID: 1483326854

File name: Yusuf_2019_J._Phys.__Conf._Ser._1157_032021_1.pdf (958.3K)

Word count: 2661

Character count: 14575

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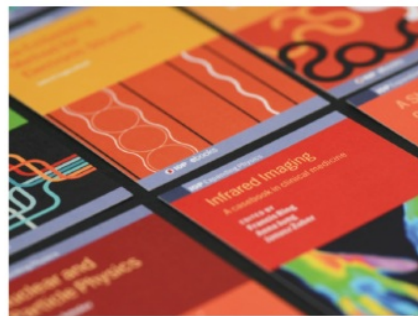
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To cite this article: I Yusuf and S W Widyaningsih 2019 *J. Phys.: Conf. Ser.* **1157** 032021

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HOTS profile of physics education students in STEM-based classes using PhET media

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Abstract. The development of information and communication technology is currently overgrowing. The utilization of this technology has become an opportunity for educators to be creative to improve the ability of high-order students or Higher Order Thinking Skills (HOTS) which is still a problem. The integration of Sciences, Technology, Engineering, and Mathematics (STEM) in learning especially in physics courses is essential because it consists of various abstract concepts and complex mathematical calculations. This study was aimed to find out the HOTS profile of students after the application of Physics-based lectures STEM using PhET Media. This quasy-experiment research with one group pretest-posttest design model through data analysis technique uses Rasch modeling concept. The results of the assessment indicate an increase in HOTS students' ability after applied STEM-based Physics learning using PhET media, with the medium category at the normalized gain. The results of the research will be continually developed in other courses in Jurusan Pendidikan Fisika Universitas Papua.

1. Introduction

Science and technology today has an essential role in the advancement of education. The utilization of information and communication technology in learning can be a solution to improve high-level thinking skills or Higher Order Thinking Skills (HOTS) learners. Critical thinking skills are very developed mainly in science subjects including physics so that learners can analyze and create a variety of more complex concepts. Learners with high ability HOTS tend to be more successful in learning compared with learners with low HOTS ability [1,2]. HOTS ability of learners can be observed based on their ability to analyze, evaluate, and create various problems given according to the level of thinking according to Bloom's Taxonomy [3].

The ability of HOTS students in Jurusan Pendidikan Fisika Universitas Papua has been relatively low. It can be seen based on the results of the initial HOTS student analysis obtained an average value of $18.7 \pm SD 3.9$. The low ability of HOTS to be an indication that their thinking ability has not been trained since the beginning or during their elementary and secondary school. Therefore it is necessary to develop an appropriate solution to improve the ability of HOTS. Integration of Science, Technology, Engineering, and Mathematics (STEM) in physics course become one of a solution to improve student HOTS capability. STEM learning, especially in prospective teachers, is essential because they are expected to facilitate STEM lessons and integrate materials effectively [4]. The ability of teachers in applying STEM is one indicator of the success of learners to generate innovative ideas to overcome various problems [5].



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Physics course consists of various abstract concepts, so that needed a media in learning one of them is PhET media that simulates the material directly. The integration of STEM by using PhET media is the right solution and needs to be developed continuously so that the learning objectives can be achieved. PhET media is available to support STEM learning such as PhET simulations on Faraday's Law material, learners can simulate directly and analyze various physical quantities by utilizing PhET technology [6]. The use of computer simulations such as PhET media in physics learning, can explain in more detail the concept of abstract physical matter and improve the thinking ability of learners [7,8,9]. Based on the problem, the purpose of this research is to know the application of physics learning based on STEM using PhET media, measure students' HOTS capability after learning, and analyze student perception after application of STEM-based physics learning using PhET media.

2. Experimental method

This quasy-experiment research with one group pretest-posttest design model. Population, as well as samples in this research, were students in Jurusan Pendidikan Fisika Universitas Papua programmed the second-semester Physics II course, which numbered 12 people. The instruments used are student HOTS ability tests consisting of five essay that includes the realm of analyzing, evaluating and creating the appropriate Bloom's Taxonomy. Assessment of student perceptions was done by using a shared perception questionnaire at the end of the lesson. The data analysis technique used gain normalization test [10]. Normality test was used to determine the level of student HOTS ability differences before and after the learning.

To know the effect of physics learning based on STEM using PhET media was done by using SPSS program. Before determining the difference test used, first test prerequisite analysis was tested normality and homogeneity. If the data were normally distributed and homogeneous then continued using parametric testing, but if not then be tested with a non-parametric technique. Analysis technique uses Rasch modeling concept to describe the result of the questionnaire of student perception during STEM-based physics learning using PhET media.

3. Result and discussion

This research was initiated by administering a pretest to measure student understanding of prior knowledge HOTS. Pretest implementation smoothly so that it can be used as an accurate reference regarding the level of previous knowledge HOTS students. The next lesson is done by applying STEM concept using PhET media on electrical and magnetic materials. The situation of learning implementation can be seen in figure 1.



Figure 1. Physics-based STEM learning situation using PhET media.

Figure 1 shows that the integration of STEM using PhET media can develop students' learning activities in the form of direct involvement in simulating and determining a wide range of physical quantities related to electricity and magnetism. The use of simulations directly for learners can improve their performance in learning [11,12]. Computer simulations can facilitate students in learning, especially in

the matter of physics that abstract [13]. The use of simulation in learning can be done in groups to develop cooperation among learners [14]. In this study, the implementation of the learning is done in groups. Each group of students each runs PhET simulations. Some students run the simulation, record the results of measurements, and discuss each other related learning done. The use of PHET simulations by the group can enhance learners' cooperation in learning [15].

The measurement of HOTS capability of students before and after learning as in table 1 shows that the normalized gain value is 0.5 in the medium category, then this learning is sufficient to improve students' HOTS capability. Although the average HOTS student's ability is still low, there is an increase of pretest value. The low pretest results indicate that so far HOTS capability is still not a concern and has not been trained especially at the secondary school level [16]. Sources of reading available in secondary schools also generally do not require high-order thinking skills for learners so that they have difficulty answering questions that require analysis, evaluation, and creation [17]. In addition to textbooks, other learning tools in the form of computer media need to describe the thinking ability of learners so that they can create various problems faced [18]. The students' HOTS skills need to be trained and continuously developed so that they can be creative and innovative in solving problems [19].

Table 1. The result of HOTS student ability test before and after STEM-based physics learning using PhET media.

	Pretest	Posttest	g	N-g	N-g Criteria
Average	18.7	33.7	15.0	0.5	Medium
Standard Deviation	3.9	12.1	10.2	0.3	

Before testing to determine the real effect of learning on the ability of HOTS students, then first tested the prerequisite. Based on the prerequisite test results obtained that the pretest and posttest scores were normally distributed. However, on homogeneity test, non-homogeneous data were obtained so that non-parametric testing technique is Wilcoxon test as in table 2.

Table 2. Wilcoxon test results of HOTS capability of students before and after STEM-based physics learning using PhET media.

	N	Mean Rank	Sum of Ranks		Posttest - Pretest
Negative Ranks	0 ^a	0.00	0.00	Z	-2.936 ^b
Posttest - Positive Ranks	11 ^b	6.00	66.00	Asymp. Sig. (2-tailed)	0.003
Ties	1 ^c				
Total	12				

Table 2 shows that asymp. sig. (2-tailed) for the 2-tailed test is 0.003. Because in this study is a one-sided test, then the probability becomes $0.003/2 = 0.0015$. It appears that a probability value of less than 0.05 indicates that STEM-based learning using PhET media has a marked effect on improving students' HOTS capabilities. STEM-based physics learning using computer media can enhance students' understanding of abstract material concepts, and it was difficult to explain directly [20]. STEM learning using ICT efficiently used to explain the subject matter as well as to create active learning and provide the understanding of the concepts to the learners [21].

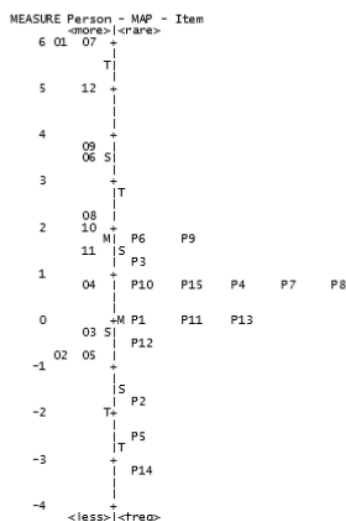


Figure 2. Overview of student perception through Rasch modeling.

Based on figure 2 on the map to the left appears, there are seven students (01, 07, 12, 09, 06, 08, and 10) whose high ability rate is approving all statement items on the given perceptual questionnaire. At the bottom left of the map, there are two students (02 and 05) with low abilities or the lowest level of approval compared to other students. Both students also have low HOTS capabilities compared to others. Based on figure 2 on the right map, it is also seen that the most challenging statements of perception questionnaires to be approved is the P6 and P9 statements about learning independence and participation in learning. It is because at the time of student learning is divided into several groups and they work in groups, so there are some students whose only pay attention and record the observations made. Assessment of students' perceptions agrees on the lessons learned. The use of PhET media on STEM-based learning can improve the learner's positive response to the learning [22].

4. Conclusion

Physics-based STEM learning using PhET media used to develop the capabilities of students HOTS. Students' perceptions of the learning done in general show that students agree on the learning. Physics-based learning STEM using PhET media will continue to develop in various subjects in Jurusan Pendidikan Fisika, Universitas Papua to increase student HOTS ability.

Acknowledgments

We would like to extend our gratitude to the dean of Fakultas Keguruan dan Ilmu Pendidikan and chairman of Lembaga Penelitian dan Pengabdian pada Masyarakat of Universitas Papua for the support given during this research.

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