TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 15, Özel Sayi, Aralik 2018

Journal of
TURKISH SCIENCE EDUCATION
Volume 15, Special Issue, December 2018

http://www.tused.org

Implementation of E-learning based-STEM on Quantum Physics Subject to Student HOTS Ability

Irfan YUSUF[1], Sri Wahyu WIDYANINGSIH[1] and Sri Rosepda Br. SEBAYANG[1]

[1] Jurusan Pendidikan Fisika, Fakultas Keguruan dan Ilmu Pendidikan, Universitas Papua, Indonesia

Received: 20.06.2018 **Revised:** 20.09.18 **Accepted:** 15.12.2018

The original language of article is English (v.15.n. Special Issue December 2018, pp. 67-75, doi: 10.12973/tused.10258a))

ABSTRACT

E-learning media is one effective solution as a learning tool that could be implemented anytime and anywhere. Science, Technology, Engineering, and Mathematics (STEM) approach through the use of e-learning is expected to develop students Higher Order Thinking Skills (HOTS). This study aimed to measure students HOTS abilities through the use of e-learning based-STEM media in quantum physics courses. Through purposive sampling technique set sample research that is students who are in the program of quantum physics courses for ten people in the even semester 2017-2018 in Jurusan Pendidikan Fisika Universitas Papua. The instruments used are eight numbers of HOTS questions in the form of essays and questionnaires of student responses given after the lesson. The data analysis technique used was gain test to see if there was the improvement of HOTS student ability and hypothesis test through SPSS to know the difference of HOTS ability before and after learning, while student response questionnaire analysis is done through Rash modeling using the Winstep program. The results showed that the value of N-gain (0.7) high category and Wilcoxon test significance value (0.004) indicating that learning of quantum physics through e-learning based on the STEM can improve students HOTS capability. Rasch modeling showed that in general the students strongly agree on the learning done. Therefore, the implementation of e-learning based on the STEM in quantum physics course could be used as one of the references to develop students HOTS capability.

Keywords: e-learning, HOTS, response, STEM

INTRODUCTION

The development of science and technology has penetrated in various aspects of life including education. Science and technology today have an essential role in education, in particular, to equip learners with challenges in the future. Science, Technology, Engineering, and Mathematics (STEM) is one alternative that can be applied in science learning to build a generation capable of facing various challenges in the 21st century. Science and technology cannot be separated from the concept of the STEM. Science can be found from the advent of technological products and the opposite, the development of science supports for the emergence of various cutting-edge technologies. The life skills of learners must meet the needs of today's world that they must be able to work with IT and develop their thinking skills (Wahyuni and Zainnuri, 2017).

The ability to think or known as HOTS is very important to train to learners who are able to develop their abilities in problem solving. The ability HOTS of students is still relatively low in Department of Physics Education, Faculty of Teaching and Education, University of Papua. The low ability of HOTS is affected by lack of student learning motivation (Yusuf and Widyaningsih, 2018). Innovation in learning is essential to be done by educators to improve the motivation to learn that affects the HOTS ability of students. The use of technology can be one of the innovations in learning that can foster the motivation of learners (Suryani, 2017). The use of technology in learning can help learners to understand the material and encourage their perception and motivation to learn (Yusuf and Subaer, 2013; Yusuf, et al., 2015; Iksan and Saufian, 2017).

One of the uses of technology in learning is through the use of e-learning. Learning through e-learning is one of the means of transforming conventional learning into digital form. Utilization of e-learning can eliminate the limits of space and time that happenedin education (Gunga and Ricketts, 2007). Learning through the use of e-learning can affect the ability of STEM learners and their interest in science lessons (Proudfoot and Kebritchi, 2017; Popovici and Mironov, 2015). Learning through e-learning can also create learning independence for learners and contribute positively to their learning experiences (Tubaishat and Lansari, 2011).

Therefore, it is necessary to apply e-learning based on the STEM in the quantum physics course to examine HOTS capability of students. The purpose of this study is to measure students HOTS capabilities through the use of e-learning based on STEM-media in quantum physics courses.

METHODOLOGY

This research was quasi-experiment research of one group pretest-posttest design. The purposive sampling technique was used to determine the sample of research which was the student of quantum physic program courses of 10 people in the even semester of 2017-2018 Department of Physics Education, Faculty of Teaching and Education, University of Papua. The instruments used were eight of HOTS questions in essays and questionnaires of student responses given after the lesson. Data analysis technique used was the N-gain test (<g>) to measure whether there was an improvement of HOTS student ability. The N-gain test equation according to Hake (1998) as in equation (1).

$$<g> = \frac{\% <S_f> - \% <S_i>}{100 - \% <S_i>} \tag{1}$$

Where, <g> was a normalized gain,<Si> was the average score of the pretest, and <Sf> is the posttest average score. N-gain improvement criteria are categorized according to Table 1.

Table 1. *Normalized average score criteria*

Value <g>	Criteria
<g> >0,7	High
0,3 < <g> ≤ 0,7	Medium
<g> ≤ 0,3	Low

The effectiveness implementation of e-learning based on STEM in the quantum physics course on students HOTS ability could be known based on the effect size value as in equation (2).

$$d = (m_A - m_B) / \left[\left(sd_A^2 + sd_B^2 \right) / 2 \right]^{1/2} \quad (2)$$

Where d was the effect size, mA was the mean value of posttest, mB was the average value of pretest, sdA was the standard deviation of postest, and sdB was the standard deviation of pretest (Hake, 2002). The effect size value was categorized based on the criteria as in Table 2 (Cohen, 1992).

Table 2. *Category of effect size*

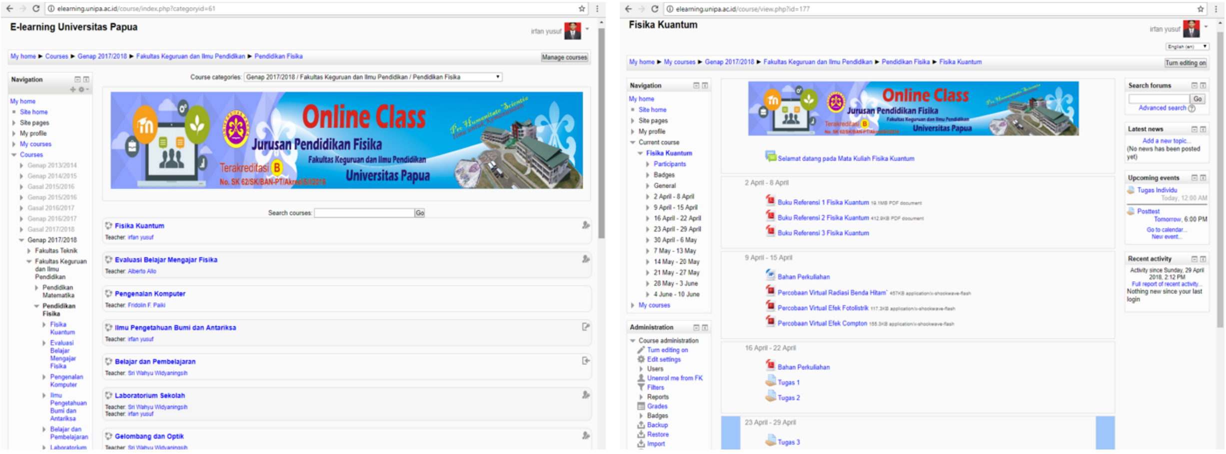
Effect size	Category
d < 0,2	Small
0,2 < d < 0,8	Medium
d > 0,8	High

Hypothesis testing was done using SPSS program to know the difference between HOTS ability before and after learning. Determination of hypothesis testing technique begins with normality test and homogenity test of data. If the data was normal and homogeneous distributed then the hypothesis tested through parametric technique. But, if not normal or not homogeneous then the hypothesis tested using non-parametric analysis. Student response questionnaire analysis was done through Rasch modeling using the Winstep program. Winstep provided various features that could help in analyzing respondent ratings. Rasch modeling could proceed more accurate analysis results that had so far been unrivaled by other analytical techniques (Boone, et al., 2014).

RESULT and DISCUSSION

This research begins with giving the pretest to students. Pretest aims to determine the first ability and difficulty faced by students, so hopefully can be done applying the appropriate learning. Preparation of learning begins with the preparation of learning materials into e-learning system includes Semester Learning Plan, material slides, assignments, and evaluation of learning. The material presented on e-learning consists of various reference books and virtual experimental facilities that can be run by students to understand more deeply related to the concept of quantum physics material being studied.

The course of quantum physics consists of abstract concepts and is difficult to describe directly because of its microscopic scope. One solution to explain the abstract material is to include virtual lab media into the e-learning system. The e-learning system can run a variety of media such as video, animation, and virtual experiment simulations that can be run directly by both teachers and learners (Gordillo, et al., 2013). The virtual lab media can be run directly by the learner to understand the experimental principle. Experiments that can be executed virtually by learners include black thing radiation experiments, photoelectric effects, and Compton effects. A virtual experiment can help learners to understand experimental principles like real experiments in a real laboratory. The virtual experiments were conducted with due to consideration to the limitations of laboratory facilities and infrastructure, the dangers posed when the experiments were conducted in a real laboratory, or simulations performed before the experiments were performed (Azis and Yusuf, 2013). Figure 1 shows the initial appearance of e-learning in Department of Physics Education, Faculty of Teaching and Education, University of Papua and the online classroom display of quantum physics courses.



(a) (b)

Figure 1. *The use of e-learning in learning (a) initial appearance of e-learning in Department of Physics Education, Faculty of Teaching and Education, University of Papua and (b) display of online classes of quantum physics*

The study of quantum physics through the utilization of e-learning allows learners to be able to explore and find themselves a concept. A wide variety of reference books and instructional materials are presented directly and accessible whenever and wherever they are both inside and outside the classroom. All students are actively involved in learning. This can be seen from the ongoing online discussions and their enthusiasm in completing the assigned task. Figure 2 shows the active involvement of all students in collecting their assignments online through e-learning.

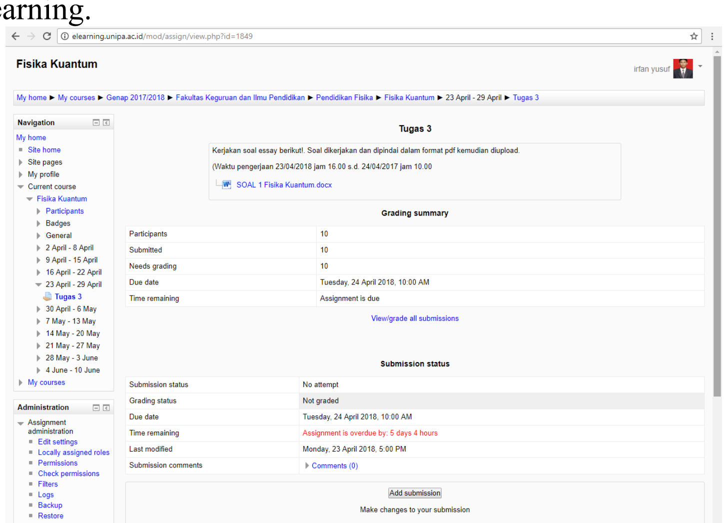


Figure 2. *Records of tasks completed by all students.*

Students, in general, are actively involved in learning. Involvement is visible on each task was given that they can complete all the tasks and upload them directly through e-learning as in Figure 2. Each student can interact directly with e-learning account given as a class participant. Lecturers can directly provide an assessment of each task so that students can know the results of the assessment of the tasks they do. Learning through e-learning is very effective, and there is no limit between lecturers and students as well as students with whom they can interact in learning (Zhanga, et al., 2006). The use of e-learning can also create the independence of learners learn that they can perform activities to complete the task independently through their respective accounts (J. K. Lee and W. K. Lee, 2008). Learning through e-learning can improve the thinking ability of learners because they are expected to seek and find themselves a concept (Saadé, et al., 2012; Muryani, et al., 2017)

Measurement of HOTS capability of students before and after learning through e-learning based on in quantum physics courses obtained the N-g value of 0.4 or is in the high category as shown in Table 3. This result shows that learning through STEM-based e-learning on the course of quantum physics is instrumental in improving students HOTS skills. HOTS demonstrate the learners' deep understanding of the learning material that has been studied (Tanujaya, 2016).

Table 3. *The result of HOTS student ability test before and after STEM-based physics learning using e-learning media*

	Pretest	Posttest	g	N-g	N-g Criteria
Average	33.3	72.0	38.8	0.7	High
Standard Deviation	13.4	40.4	21.1	0.3	

The effectiveness of learning through e-learning based on the STEM in quantum physics course on students HOTS capability is shown through the result of effect size test as shown in Table 4. The result of effect size calculation is obtained by 3.5 which shows that e-learning is effective in physics course quantum of students HOTS capabilities.

Table 4. *Results of effect size testing to find out how much the effectiveness of learning through e-learning based on the STEM in the subject of quantum physics*

Learning Outcame	Average	Standard Deviation	Effect Size	Category
Pretest	33.3	13.4	3.5	High
Posttest	72.0	20.4		

Table 4 also shows that the average of pretest and posttest learning outcomes of students has increased from 33.3 ± SD 13.4 to 72.0 ± SD 20.4. The improvement of learning outcomes indicates that the performed learning improves students HOTS capabilities, although the standard deviation of posttest high is 20.4. This is because there is one student with the same value when the pretest and the value are very low compared with other students who have increased. The low learning outcomes of students are due to lack of activity during learning and often do not follow lectures online. Student activity can be traced directly through the use of e-learning as each student has their account and is known when they are active (Blas and Fernández, 2009).

The result of normality test data obtained sig value. Pretest and posttest respectively are 0.025 and 0.007 less than 0.05 indicating that the data is not normally distributed. Homogeneity test results obtained sig value. 0.566 bigger than 0.05 indicating that the data is homogeneous. Based on the result of the prerequisite test, it is found that the data is not normal but homogenous so that the non-parametric testing technique is done through Wilcoxon test as in Table 5.

Table 5. *Wilcoxon test results of HOTS capability of students before and after STEM-based physics learning using e-learning media*

		N	Mean Rank	Sum of Ranks		Posttest - Pretest
Posttest - Pretest	Negative Ranks	0[a]	0.00	0.00	Z	-2.666[b]
	Positive Ranks	9[b]	5.00	45.00	Asymp. Sig. (2-tailed)	0.008
	Ties	1[c]				
	Total	10				

Table 5 shows that in the aymp sig (2-tailed) for the 2-sided test is 0.008. Since the case is a one-sided test, the probability becomes 0.008/2 = 0.004. Here comes the probability of below 0.05, then it can be concluded that the use of e-learning-based on STEM has a real effect on the ability to raise student HOTS. At the end of the study, perceptions were assessed on ten students to know their responses to the lessons learned. Student perceptions of learning using e-learning based on the STEM are shown in Figure 3.

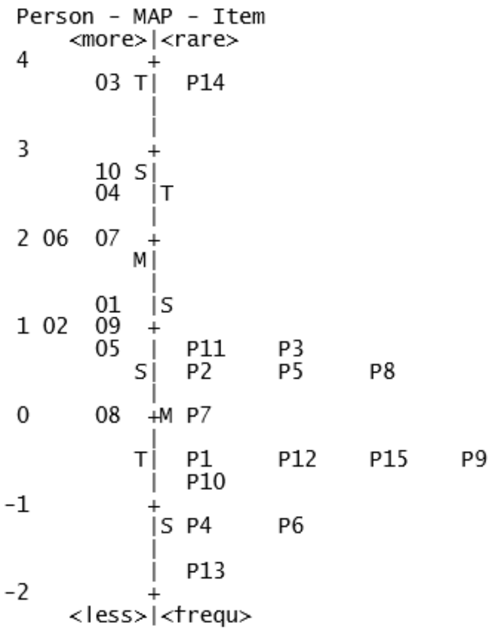


Figure 3. *Student Perceptions of E-Learning Implementation based on the STEM on Quantum Physics Subject to HOTS Ability*

Figure 3 shows that on the left map there are five students (03, 10, 04, 06, and 07) whose high ability rate is to approve all statement items in a given perceptual questionnaire except the P14 statement that is about the display of e-learning media that can see on the right map. This is because the display of e-learning media is an innate display of moodle programs provided by the Universitas Papua computer center which by default has been set up with a minimalist look. The minimalist look is due to the limited server of the Universitas Papua and also the consideration of large data capacity when accessed by users, but the view does not reduce the facilities provided in e-learning to support learning activities. The use of the Moodle Program as e-learning is perfect for online learning as it comes with a variety of exceptional features (Aydin and Tirkes, 2010; Limongelli, et al., 2011).

At the bottom left of the map, there is one student (08) with low abilities or the lowest level of approval compared to other students. The student also has a low HOTS ability compared to the others. This is because students do not regularly attend lectures and are often not active in online classes. Assessment of students perceptions generally agrees on the lessons learned. The use of e-learning media based on the STEM in quantum physics courses can improve the positive response of learners to the learning.

CONCLUSION

Implementation of STEM-based e-learning in quantum physics courses is instrumental in improving students HOTS skills. This can be seen based on the results of the N-gain test that is obtained results 0.7 (high). The effect size value is 3.5 (high), and the value of

Wilcoxon test probability is 0.004 (below 0.05), and the students perception is general learning well so it can be concluded that e-learning is effectively used in the quantum physics lecture and has the real effect to increase students HOTS capability. The study of quantum physics through the utilization of e-learning allows learners to be able to explore and find themselves a concept. A wide variety of reference books and instructional materials are presented directly and accessible whenever and wherever they are both inside and outside the classroom. All students are actively involved in learning. Learning through e-learning is very effective, and there is no limit between lecturers and students. The implementation of e-learning based on the STEM in quantum physics course could be used as one of the references to develop students HOTS capability.

ACKNOWLEDGMENTS

Our thanks to the Dean of the Fakultas Keguruan dan Ilmu Pendidikan, Universitas Papua for their help and support during the implementation of the activities. The author also expressed gratitude to the head of Computer Center in Universitas Papua for his help during the use of e-learning.

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