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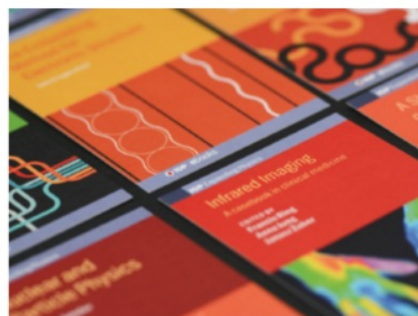
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Validity of physical learning module based on multiple representation and higher order thinking skills

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Abstract. This aims of research to determine the validity of multi-representation based physics learning modules that can improve higher order thinking skills (HOTs). Physics learning modules are very necessary to realize student-centered learning. A good physics learning module is a module that has been validated with certain criteria. This research is a development study using the McKenney model. Data collection techniques in this study are started from the needs analysis, then build a draft module so that it is ready to be validated by media and material experts using a validation questionnaire. This research produced a multi-representation based physics learning module to improve valid HOTs that are ready to be used in learning physics at school.

1. Introduction

Higher Order Thinking skills is very important for students in analyzing and solving problems encountered in daily life. HOT is also needed by students in facing 21st century challenges that demand quality human resources in order to compete on a global scale [1]. [2], revealed that in the 21st century like today tasks that require complex thinking skills are considered to be very important for everyone. HOT can encourage to think broadly and deeply and be able to connect knowledge with the real world. Therefore HOT is an important aspect of learning and is a useful tool to help students learn and improve performance.

HOT is an ability that must be present in every science subject, especially physics. This is in line with the purpose of physics in high school, namely that students have the ability to develop analytical thinking skills by using concepts and principles to explain various natural phenomena and solve problems [3]. Besides that HOT in physics is also needed because physics is the basis for all disciplines including engineering and technology making physics the basis for its development [4].

Some research that has been done shows that the average HOT of students tends to be low. [5] conducted a study of HOT high school students and obtained results that the average score of students was 27.9 from a scale of 100. [6] conducted a HOT analysis using two tier multiple choice instruments showing low results with an average value of 8 , 45 out of a maximum score of 30. [7] conducted a study of HOT using a virtual laboratory showing low results in the range of values of 34.7 to 58.3.

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This is also in accordance with the analysis of the results of the 2016/2017, 2017/2018, 2018/2019 high school UNBK high school subjects in physics which shows the average value between 28.9 - 55.7 for indicators of the ability to analyze (C4) and evaluate (C5).

HOT as one of the 21st century skills that students must possess will be more easily realized if using multi-representation as a basis in the learning process [8]. Shifting the 21st century education paradigm which includes changes from teaching to learning, from teacher-centered to student-centered, teachers are required to be able to present a learning process that is compatible with the 21st century education system [9]. The learning process that is compatible with 21st century education will be easily realized if the teacher includes appropriate teaching materials. One of the appropriate teaching materials for growing HOT is a module.

Modules as one of the teaching materials are quite effective to use because they are independent that focus on mastering the competencies of the study material that students learn with a certain time in accordance with their potential and conditions. A good module is prepared by presenting material in full and easily understood by students in accordance with the development of science and technology without restricting students to find more material presented, use simple and communicative language and provide information about references that support the material.

Module characteristics that can improve HOT are those that have writing patterns based on the writing procedures of teaching materials, namely: 1) analysis, 2) design, 3) development, 4) evaluation, and 5) revision. In addition to writing based on the procedure of writing the teaching material, the author of the teaching material needs to also pay attention to the division in each chapter, for example in each chapter is divided into 3 (three) parts, namely the introduction, presentation and closing.

Representation is an arrangement that can describe or symbolize objects and / or processes, represent or symbolize something in a certain way. States multi-representation as a form of representation that combines verbal (text), real images or graphics. [10] Define multi-representation as a way to express a concept through a variety of ways and forms including verbal, mathematical, pictures and graphics. [11] concluded that multi-representation is a combination of forms of representation, namely verbal, mathematical, image and graphic formats. The results of the study of [12] and [13] found that the use of multirepresentation approaches in physics learning can improve students' understanding of concepts and reasoning. Good understanding of concepts is the main asset of students to improve HOT.

Physics modules that exist today, not many that present a description of physics material in the form of a complete multi-representation ranging from verbal representations, images, mathematics and graphics. Related to the above view, this research has the main objective, which is to examine the characteristics of the FBM module to improve the HOT of high school students.

2. Research Method

This research is a survey research, with the emphasis of the study on: 1) the initial reference source books; 2) description of learning; 3) module initial conditions; and 4) previous research results related to HOT, representation, and module development. Based on the study activities carried out in the study, the study data tend to be descriptive qualitative data. The data was obtained by observation techniques, questionnaires, documents and literature studies on various sources, such as: books, scientific journals, articles, research reports and so on as secondary data. To obtain the results and conclusions of the study, the data obtained were analyzed by descriptive analysis.

The subject in this research is a multi-representation based physics module (FBM) which can improve HOT ability for high school students. While respondents in this study were high school students in Probolinggo.

3. Results and Discussion

3.1 Results of a theoretical review

3.1.1 The results of the reseach are related to the development of multi-representation based physics teaching materials

The results of previous research in several places relating to multirepresentation-based physics teaching materials obtained from scientific journals, articles, and research reports show that multirepresentation-based physics teaching materials can improve students' understanding of concepts. Some research results are shown in Table 1.

Table 1. The Result of Research Study of Concerning multi-representation based teaching materials

Year	Result	Author
1	2	3
2003	Learning by involving multiple representations provides a rich context for students to understand a concept being learned	Andrew Izsák, Miriam Gamoran Sherin
2012	The use of verbal representations, drawings, mathematics and graphics in mechanics teaching materials can make it easier for students to improve their multi-representation abilities	I Ketut Mahardika
2015	The use of multiple representations or multi-representations is an important skill that students must have in learning science, especially physics	M Hill, M D Sharma and H Johnston
2016	Learning by involving multiple presentations provides a rich context for students to understand a concept being learned	Siprianus L. Angin, Sutopo, Suparno
2017	The representation ability possessed by students can help students understand a concept that can ultimately make it easier to build higher order thinking skills (HOT)	Pasi Nieminen, Antti Savinainen, and Jouni Viiri
2017	the use of a multi-representation approach to learning physics can improve students' understanding of concepts and reasoning	Dyah Ayu Lestyanningtyas, Sutopo, Hari Wisodo

(Source: author)

3.1.2 The results of study related to HOT

The results of previous studies in several places related to HOT obtained from scientific journals, articles and research reports show that HOT Indonesian students tend to be low and HOT is good which can have a positive impact on students in facing global competition and challenges in the 21st century. Some research results are shown in Table 2

Table 2. The result of research study related to HOT

Year	Result	Author
1	2	3
2014	HOT is also needed by students in facing 21st century challenges that demand quality human resources in order to compete on a global scale. Robyn Collins	Robyn Collins
2015	By using the analogy approach in learning, the results are obtained that the HOT ability of students increases well.	Lindsey Engle Richland and Nina Simms
2015	By utilizing the media in the form of virtual laboratories in	Nicole Simon

Year	Result	Author
1	2	3
	learning activities can increase students' HOT ability 60%.	
2017	HOT siswa SMA cenderung rendah hal ini ditunjukkan dengan hasil bahwa skor rata – rata siswa adalah 27,9 dari skala 100.	Anggita Permatasari, Wartono, Sentot Kusairi
2018	HOTS-based science learning modules can improve students' critical thinking skills	Emi Rofiah, Nonoh Siti Aminah, Widha Sunarno
2018	HOT in physics is needed because physics is the basis for all disciplines	Roismayadi dan Suharto
2018	HOT students show low results with an average value of 8.45 out of a maximum score of 30.	Gilang Ramadhan, Pratiwi Dwijananti, Siti Wahyuni
2018	HOT evaluation using a virtual laboratory showed low results, namely in the range of values of 34.7 to 58.3.	Asrizal, Arnel Hendri, Hidayati, Festiyed
2017	HOT high school students tend to be low this is indicated by the results that the average score of students is 27.9 on a scale of 100.	Anggita Permatasari, Wartono, Sentot Kusairi

(Source: author)

3.2 The Result of Survey, Documentation, and Field Observation

The survey was conducted by means of interviews and questionnaires distributed to 30 high school students in class X, XI, XII science programs in Probolinggo district and analysis of UNBK and USBN physics high school results from 2017, 2018, and 2019 .. Survey activities were carried out in the period of time July - August 2019.

The results of interviews and questionnaires distributed to 30 students, approximately 25 students who experienced difficulties when faced with questions that demanded the ability to analyze (C4), evaluate (C5), and create (C6). Even though students are often trained in questions in class that require higher-order thinking skills (HOT), students still find it difficult when they have to study independently outside of class hours in class. This is due to the limited teaching material in the form of modules that regularly practice students' abilities in analyzing, evaluating and creating. Existing physics modules are generally not equipped with regular multi-representation ranging from verbal, drawing, mathematics and graphics.

Analysis of the results of the USBN and UNBK in the last three years, namely 2016/2017, 2017/2018, and 2018/2019 in physics subjects which show average values between 28.9 - 55.7 for indicators of ability to analyze (C4) and evaluate (C5). These results indicate that the average HOT ability of students tends to be low.

Based on these data it is necessary to design teaching materials in the form of physics modules that are able to increase HOT students based on in-depth analysis and study so that they are ready to be used by students. One of the physics modules that can improve HOT is one that is accompanied by multi-representation, ranging from verbal representations, pictures, mathematics and graphics. Multirepresentation-based physics modules (FBM) that will be compiled include verbal representations, drawings, mathematics, and graphs in each learning activity, both in the description of

the material and in the practice questions. By including multi-representation the predicted ability of HOT students will improve.

4. Conclusion

The study of the research showed that the physics module based on multi-representation (FBM) contained verbal representations of images, mathematics and graphs in the description of the material, sample questions, practice questions and evaluation questions. By presenting multi-representations in a set of learning activities, it is predicted that students' understanding of concepts will increase which will ultimately increase students' HOT.

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