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Systematic Review: The Effect of Using Virtual Laboratory On Physics Learning to Improve Student's Concept Understanding

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ABSTRACT

The 2013 curriculum requires teachers to be skilled in the learning process which makes students more active in learning activities. Physics learning does not only discuss theory, but also needs to do practical work so that students understand the concepts being taught, if schools have limitations regarding laboratory equipment, then they can use virtual laboratories instead. There are many research articles about the use of virtual laboratories in physics learning. However, there has been no systematic study that summarizes these studies, for this reason a systematic study is needed that will produce new information. This study aims to: (1) analyze the model/strategy/method of using virtual laboratories in learning physics, (2) analyze the effect of virtual laboratories in learning physics on increasing students' understanding of concepts. The method used in this study is a systematic review. The collected articles totaled 25 articles published in the last 10 years in national and international journals. Data analysis was performed using predetermined instruments and effect size formulas. The results of the study are learning models/learning strategies/learning methods for using virtual laboratories in physics learning to improve students' understanding of concepts, there are 7 learning models, and 2 learning approaches. The discovery learning learning model and inquiry learning model are the most widely used. momentum and impulse materials have a good effect on students' understanding of concepts. with an average effect size value of 1.95 with a high influence category.

Keywords :*Systematic Review, Virtual laboratory, learning physics, understanding concepts*

I. INTRODUCTION

In Indonesia, the curriculum has developed over time, for now the 2013 curriculum is used. The 2013 curriculum is one of the products of curriculum development and refinement in Indonesia which emphasizes a balance between knowledge, attitude and skill competencies. Learning devices have a role as a support for the implementation of learning and must be able to optimize the role of teachers and students by conditioning the learning atmosphere to be better, fun, and on target [1]. The 2013 curriculum currently used in Indonesia emphasizes the practical learning process that includes attitude competence, competence, knowledge, and skills competency. The implementation of the 2013 curriculum is in line with nature learning physics where in the process learning emphasizes practical activities [2].

Scientific method learning activities carried out in the laboratory. The laboratory is an infrastructure facility that must be provided by school administrators to support learning activities teaching one of which is the school physics laboratory [3]. The laboratory is one of the important facilities that should not be neglected, because to achieve competence in accordance with the demands of the curriculum, educational facilities in schools need to be managed properly so that laboratory use is more effective in increasing student competence. The effectiveness of practicum implementation is influenced by several factors, namely laboratory management, laboratory facilities, availability of tools and materials and students' attitudes towards practicum activities. Another factor, namely the time allocation given by the teacher also affects the effectiveness of practicum activities in the laboratory [4].

Advances in technology and information in Indonesia are currently experiencing a very rapid increase. As technology and information increase, educational experts have started using computer-based learning media, for example interactive videos (*e-books*), macro flash, and use of virtual laboratories [5]. One of the learning media that will be used in research is the PhET virtual laboratory. The choice to use the PhET virtual laboratory as a learning medium is because this simulation is designed to make it easier for teachers to guide students to develop their mastery of physics concepts. The PhET simulation used consists of objects that are not visible to the eye, for example small molecules, electrons, electric fields and photons [6]. PhET contains theoretical and experimental simulations that actively involve the user. Users can manipulate activities relating to experiments. So that besides being able to build concepts, PhET can also be used to bring up science process skills [7].

Learning physics directs students to be able to find out and practice directly because to understand physics material is not only fixated on the teacher's explanation but is further strengthened through experiments carried out so that the concepts being taught can be understood by students [8]. But in reality, learning physics in schools is still centered on the teacher. Students only get the concept informational concepts conveyed by the class teacher. Learning that fully conveys material without involving students directly in learning causes students to be less interested in learning so that it has an impact on reducing their motivation and activity during the learning process. This then has implications for the low mastery of students' physics concepts.

Implementation of practicum in schools still encounters many obstacles such as expensive laboratory equipment, limited laboratory facilities, and difficulties in carrying out practicums on abstract physics concepts. In abstract physics concepts, it is difficult to display physical processes directly through real laboratory activities, causing a low level of mastery of physics concepts and students' ability to think creatively. Practicum activities can also improve students' creative thinking skills and provide opportunities for students to practice the scientific method. Based on these problems the use of virtual laboratories is very important as a learning medium to support laboratory practicum activities.

A virtual laboratory is an interactive science situation with the help of an application on a computer in the form of a science experiment simulation. Virtual laboratories are sufficient to be used to assist the learning process in order to improve students' understanding of the material, and are also suitable for use to anticipate real laboratory unpreparedness [9]. [10] said that the virtual laboratory is an interactive experience in which students observe and manipulate the resulting system objects, data, or phenomena in order to fulfill learning objectives.

There are so many articles that reveal problems regarding the use of virtual laboratories, but no one has summarized this yet systematic review. By using systematic review it would be beneficial for more detailed information, because on systematic review it summarizes all the information on relevant topics, and the facts are presented more comprehensively.

Based on the explanation above, the researcher is interested in conducting research on the effect of using a virtual laboratory on physics learning. So I gave this research the title: Systematic Review: The Effect of Using a Virtual Laboratory on Physics Learning to Improve Students' Understanding of Concepts ".

II. METHOD

This type of research is qualitative and quantitative research. Qualitative research is research that can be used in examining natural conditions whose results are concerned with meaning. Meanwhile, quantitative research is research by collecting, analyzing, and displaying data in the form of numbers that are done objectively to investigate or examine something. The method used in this study namely systematic review. Systematic review is a research method that is carried out systematically to compare, assess and explain the results of relevant studies in order to produce a complete and thorough conclusion. according to Perry & Hammond a systematic review has several steps [11]: (1) Identifying research questions, determining the formulation and determining questions that cover the research topic. (2) Develop a systematic review protocol. This stage is carried out so that the research is more focused. (3) Determine the location of the data base used. In this step, the data used in the search is based on learning physics using the PhET virtual laboratory. (4) Relevant research screening. At this stage, the selection of articles is carried out based on predetermined criteria. (5) Choosing quality research results. All articles that met the requirements or criteria for further analysis. (6) Extraction of data from individual study results. At this stage data extraction is carried out to obtain important findings. (7) Synthesis of research results. Research synthesis uses descriptive analysis methods and meta-analysis (8) Data presentation. Based on the process of analysis and discussion of the findings.

The research data consists of 25 national/international indexed articles. The data analysis technique used in this study is descriptive statistical analysis and calculating effect size values. In descriptive statistics, it explains

that data analysis is carried out by giving descriptive data that has been determined without aiming to conclude something in general [12].
The calculation of the effect size value is carried out using the following formula:

$$ES = \frac{X_{posttest} - X_{pretest}}{SD_{pretest}} \quad (1)$$

$$ES = \sqrt[t]{\frac{1}{n_E} + \frac{1}{n_C}} \quad (2)$$

(Source: Ref [13])

After finding the effect size result based on the above formula, effect size criteria can be seen in table 1.

Table 1. Criteria effect size

ES (effect size)	Category
Effect size ≤ 0,15	Negligible
0,15 < Effect size ≤ 0,40	Low
0,40 < Effect size ≤ 0,75	Moderate
0,75 < Effect size ≤ 1,10	Hight
1,10 < Effect size ≤ 1,45	Very Hight
1,45 < Effect size	High Influence

(Source: Ref [13])

III. RESULTS AND DISCUSSION

The results of the study describe the formulation of the problems studied from 25 articles. The results of the first study explain the model/method for using a virtual laboratory in physics learning. The results of the second study influence the use of virtual laboratories in learning physics on increasing students' understanding of concepts.

The first analysis in this study is the learning model/learning method/learning strategy/learning approach for the use of virtual laboratories in physics learning. The following is presented in the table ... the results of an analysis of the learning model / learning method / learning strategy / learning approach for the use of virtual laboratories in physics learning.

Table 2. Learning models / learning methods / learning strategies / learning approaches for the use of virtual laboratories in physics learning.

Article Code	Learning Models / Learning Methods / Learning Strategies / Learning Approaches for The Use of Virtual Laboratories in Physics Learning.	Persentase
A1, A4, A15, A24	Discovery Learning Model	26,6
A2	Problem Besed Learning Model	6,67
A6, A18, A12, A19	Inquiry Learning Model	26,6
A8	Learning Model Assurance, Relevance, Assessment, dan Satisfaction (ARIAS)	6,67
A9	STEM (Science, Technology, Engineering, and Mathematic) Approach	6,67
A20	Predict-Observe-Explain (POE) Models	6,67
A21	Generatif Learning Model	6,67
A23	TGT Learning Model	6,67
A25	Interactive Conceptual Instruction (ICI) Approach	6,67

Based on the table above, it can be seen that there are 7 learning models that can be used in virtual laboratories in physics learning. Based on the table it can be seen that there are 2 learning approaches used in the use of virtual laboratories. Based on the research results, it can be seen that the use of learning models discovery learning and learning models Inquiry assisted virtual laboratory on students' understanding of physics concepts is most widely used with a percentage of 26.6.

The second analysis in this study is the effect or size of the effect (effect size) the use of virtual laboratories in physics learning to increase students' understanding of concepts. The following is presented in the table the results of calculating the effect of using a virtual laboratory on learning physics on increasing students' understanding of concepts.

Table 3. The effect of the use of virtual laboratories on learning physics on increasing students' understanding of concepts in terms of learning materials.

Subject Matter	Article Code	ES	ES Average	Category
Dynamic Electricity	A1 A2	3,54 0,013	1,78	High Influence
Hooke's Low & Elasticity	A3 A4 A8 A9 A22 A23	0,15 0,01 0,52 0,96 1,104 0,617	0,56	Moderate
Straight Motion	A5 A7 A13	0,32 0,89 0,48	0,56	Moderate
Static Fluida	A6	1,81	1,81	High Influence
Effort & Energy	A12	0,05	0,05	Negligible
Newton's Low of Gravity	A24 A25	0,4178 0,612	0,51	Moderate
Kinetic Theory of Gases	A14	0,16	0,16	Low
Simple Harmonic Motion	A15	0,175	0,175	Low
Vibrations & Waves	A16	0,557	0,557	Moderate
Heat	A17 A19	2,08 1,265	1,67	High Influence
Optical Tools	A18	1,052	1,052	High Influence
Momentum & Impulse	A20 A21	3,877 0,042	1,95	High Influence

Based on the virtual laboratory-assisted physics learning table, momentum & impulse material has value effect size average the highest is 1.95.

The first research results found in this study are the learning model/learning method/learning strategy/learning approach used in virtual laboratory-assisted physics learning. The total number of articles analyzed to answer the first research objective was 15 articles. The percentage obtained from the number of articles found divided by the total articles analyzed is then multiplied by 100%. Of the 15 articles on learning models/learning methods/learning strategies, there are 7 learning models and 2 learning approaches used. Discovery learning and inquiry learning models are most widely used in virtual laboratory-assisted physics learning. Discovery learning is a learning model that maximally involves all students' abilities to search for and find things (objects, people or events) systematically, critically, logically, analytically so that students can

formulate their own knowledge with confidence [14]. On learning discovery learning provide opportunities for students to learn to search and find themselves. The initial knowledge possessed by students is constructed through a process of discovery. The discovery is expected to produce concepts to gain meaningful experience and knowledge. Meaningful and lasting knowledge This length of time helps students improve their competence as evidenced by the increased learning outcomes of students after learning discovery applied [15].

There are several advantages of the learning discovery learning model. [16] explained its advantages include adding to students' experience in learning, providing opportunities to get closer to sources of knowledge, exploring creativity, being able to increase self-confidence and increasing cooperation between students. In addition, students can learn to solve problems independently and have critical thinking skills because they have to always analyze and handle information.

The inquiry learning model is an inquiry-based learning where students seek their own answers to the problems they face. According to [17], inquiry learning is a series of learning activities for students to seek and investigate systematically, critically, logically and analytically, so that they can formulate their own findings. Inquiry contains higher level mental processes, for example formulating problems, designing experiments, conducting experiments, collecting and analyzing data, drawing conclusions, having objective attitudes, being honest, curious, being open and so on.

The second research result found in this study is the effect of using a virtual laboratory in physics learning on increasing students' understanding of concepts in terms of physics learning material, namely the momentum & impulse material has a value effect size the highest average is 1.95 with a very high influence category. The limitation of this research is the virtual laboratory referred to in physics learning, namely Physics Education Technology (PhET) simulation and only includes 25 articles, consisting of 19 internationally indexed articles and 6 nationally indexed articles which have been published for the last 10 years (2012-2022). This research resulted in virtual laboratory-assisted physics learning that has an influence on students' understanding of concepts.

IV. CONCLUSION

Based on the research results obtained, it can be concluded that: learning models / learning strategies / learning methods for the use of virtual laboratories in physics learning to improve students' understanding of concepts there are 7 learning models, and 2 learning approaches. Each learning model functions to increase understanding of concepts according to the correct concept. Learning model discovery learning and inquiry is the learning model that is most widely used in the effect of using virtual laboratories on physics learning to increase students' understanding of concepts. This research resulted in virtual laboratory-assisted physics learning that has an influence on students' understanding of concepts.

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