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Students' Conceptual Understanding and Critical Thinking Skills Through Online Learning Using a Virtual Laboratory

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ABSTRACT
This study aims to analyze the understanding the concepts and critical thinking skills of physics students in online learning using a virtual laboratory. This study uses a causal associative relationship between variables. The subjects in this study consisted of 40 students from Muslim universities and Medan state universities who were programming physics laboratory courses. The sample collection technique uses random sample sampling. The instrument used in this study was a questionnaire to determine student responses to online learning using a virtual laboratory and student worksheets (LKM) to measure students' understanding of concepts and critical thinking skills. Based on the results of data analysis, it shows that online learning using virtual laboratories affects students 'understanding of concepts and critical thinking skills, with a significant value of understanding concepts and students' critical thinking skills of 0.000 <0.05, the correlation value of understanding concepts 81% and critical thinking skills of 84%. is in the very good category, so it can be concluded that there is a significant relationship between online learning using a virtual laboratory on students' conceptual understanding and critical thinking skills.

INTRODUCTION

The Covid-19 pandemic has had a huge impact on the world of education. All human activities follow health protocols to avoid the wider spread of Covid-19. The Minister of Education made a consideration by implementing the learning process from home through a distance learning system (online) as a way to prevent the spread of Covid-19 [1]. The process of teaching and learning activities, which is usually done face-to-face, now has to turn into distance learning that takes place online. Distance learning is an educational process that focuses on teaching methods and technologies to carry out the teaching process on students who are physically absent in traditional educational environments such as classrooms and laboratories [2]. Online learning during the Covid-19 pandemic has become a challenge in the world of education, especially higher education. Lecturers must continue carrying out the activities of the Tri Dharma of Higher Education, one of which is to carry

out the teaching and learning process and ensure their students can follow the learning well. However, there are many obstacles faced in the online learning process. One of them is like learning in practicum courses, especially in the physics education study program. This is in line with Totok Amien Soefianto's opinion [3] who said that "PJJ constraints in tertiary institutions depend on the field of study. For the social sciences, it does not appear to be of reduced quality. Reduced but not significant. In the fields of exact science, science, and technology, these are of relatively far less quality due to difficulties in practice and experimentation ".

Practicum is a must for students in the physics education study program because physics learning emphasizes providing direct experience to develop competencies. Providing direct experience is very effective if learning is carried out through practicum activities. However, the most felt obstacle is that students cannot do practicum because learning takes place online. Along with the times, researchers try to take advantage of one of the technological media that can help lecturers and students in the learning process so that the teaching and learning process can run conducive, namely by utilizing a virtual laboratory. According to Yusuf & Widyaningsih [4], the use of virtual laboratories as an alternative solution in overcoming the limitations of real laboratory facilities and infrastructure. Virtual labs make use of computers to simulate complex, expensive laboratory infrastructure or simulate experiments in hazardous environments [5]. Furthermore, Dobrzański & Honysz [6] stated that the virtual laboratory is a supporting factor for developing experimental skills activities. Science is a subject related to laboratory activities. It is a knowledge of natural phenomena involving inquiry and discovery through the hands-on and experiments under the guidance of the teachers [7]. In the science learning, the laboratory activity is much more important as providing opportunities for the students to perform various kinds of hands-on development of the digital age that can be utilized in the field of education is a virtual laboratory. The virtual laboratory offers exciting lab processing and simulation facilities, the ease of use of tools, and more accurate results [8]. The virtual lab is a learning medium that can provide direct experimental visualization, interactive virtual environments, practical experimentation, and conduct experiments more efficiently [9].

Gunawan, et al [10] said that virtual media is an interactive multimedia object which consists of various formats including text, hypertext, sound, images, animation, video, and graphics. One of the virtual laboratory applications is the Physics Education Technology (PhET) simulation. This virtual laboratory is used to assist the learning process to improve students' understanding of concepts and is also suitable for anticipating the unpreparedness of real laboratories [11]. Understanding the concept is something that has been patterned in the mind so that it can be expressed verbally or in writing [12]. Student involvement in the use of virtual laboratories will help students to understand the concepts of physics and at the same time their critical thinking skills towards physics practicum courses even though learning is done online. Hermansyah [13] stated that there are several advantages of using a virtual laboratory, namely: (a) increasing students' mastery of concepts; (b) improve critical and creative thinking skills and scientific problem solving; (c) develop skills in the field of ICT without neglecting knowledge of laboratories.

According to Yulianto et al [14], Critical thinking skills and conceptual understanding of students' science material can be built through practicum activities. Incomplete practicum tools cause the intensity of the practicum to below. The low intensity of the practicum can be helped by the use of media that can show practicum in virtual form. Understanding concepts is very important in the learning process because conceptual understanding is a stage in understanding abstract information which in the process of understanding it must classify an object or phenomenon [15]. There is a high-order thinking process, one of which is the ability to think critically to achieve a conceptual understanding. Through critical thinking skills, cognitive intelligence can be trained and developed, and the knowledge possessed by students can connect various facts or information to make predictions. Therefore, in learning physics, critical thinking skills are very important to be developed at every level of education, because it is one of the factors that can improve students' understanding of concepts [16].

According to previous research by Dewa, Mukin, & Pandango [10], that there is an effect of virtual laboratory assisted online learning on students' learning interest with a sig (2-tailed) value smaller than 0.05 (0.0063 <0.05) and there is an effect of online virtual laboratory assisted learning on student cognitive learning outcomes didi with a sig (2-tailed) value smaller than 0.05 (0.000 <0.05). Then according to research [13], It can be concluded that the use of virtual laboratories affects the mastery of concepts and students' creative thinking skills in the vibration and wave material of class VII SMPN 1 Alas Barat 2013/2014. Yulianti, et al [14] states that there is an effect of flash animation-based virtual laboratory on concept understanding and critical thinking skills. Further research conducted by Fischer, et al [17] with the results showed that there was significant difference in critical thinking skills between experimental and class control class. The results of students' critical thinking skills in inquiry discovery higher class than conventional learning classes. The results of the study recommend that teachers empower HOTS ability from students on inquirydiscovery class, so that meaningful learning and Learning learning can be created. Future research need to explore contribution from inquiry discovery model on students' critical thinking skills. This is also in line with Leasa, et al [18] with the results of his research which states that there was no learning style (LS) has a significant effect on CTS. The difference in how to receive and process information in learning is not a determine the developmental factors for CTS. This study recommends that teachers need to become teachers specially trained to teach CTS. In addition, it is necessary to create a constructivist learning environment using learning strategies or learning models that have the potential to develop student skills interpretation, analysis, inference, evaluation, and explanation. Further research is needed to investigate the influence of learning strategies, age, and student learning experiences on student development thinking ability.

METHOD

The research method used in this study is the research method of causal associative relationships between variables, namely understanding the concept and critical thinking skills which are the dependent variable, and online learning using a virtual laboratory which is the independent variable. Causal associative research is research that aims to determine the effect between two or more variables [19]. The subjects of this study were 40 students programming physics laboratory courses at Almuslim University and Medan State University. The sampling technique used simple random sampling. According to Sugiyono [20], simple random sampling is the taking of sample members from the population which is done randomly without paying attention to the strata in the population.

Data collection techniques used student worksheets (LKM) and questionnaires. Student worksheets are used to measure students' understanding of concepts and critical thinking skills with a level of understanding C1 to C6, while questionnaires are used to see student responses to online learning using a virtual laboratory Assessment of student worksheets use ordinal scale data which consists of 4 frequency categories, namely (1) very poor, (2) poor, (3) good, (4) very good [4]. Percentage of assessments using rating categories according to Tiduwan [21].

Table 1. Score Interpretation Criteria

Percentage (%)	Criteria
0 - 25	Very Less
26 - 50	Not Good
51- 75	Good
76 - 100	Very Good

Data were analyzed using Somers' test to determine whether there was a significant relationship between online learning using a virtual laboratory on concept understanding and critical thinking skills of physics students. The laboratory used in this research is the PhET simulation learning media. Level sig = 0.05. The results of data testing are presented in the form of a crosstabulation table.

RESULTS AND DISCUSSIONS

Based on research data that has been conducted by researchers, through a questionnaire it is known that all student responses to online learning using a laboratory show excellent results. This can be seen from the proportion of the answers to the trap questions made by the researcher, namely that during learning I did not like learning physics. The results of the proportion of answers to these questions can be seen in Figure 1.

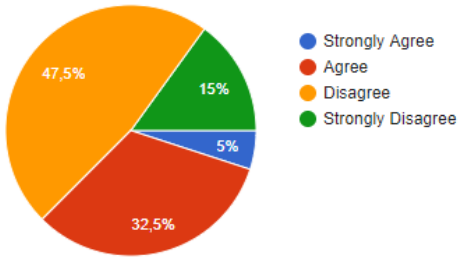

Fig 1. *Percentage of students who dislike learning physics online*

Based on the diagram in Figure 1, it shows that as many as 47.5% of students chose answers in the disagree category, as many as 32.5% of students chose answers in the agreed category, as many as 15% of students chose answers with the category of strongly disagree and the remaining 5% chose the category strongly agree. Even though the learning takes place online, students remain enthusiastic and enjoy learning physics. This can be seen from the percentage of answers given by students which almost reaches half of the total number of students. The answers given are not based on coercion, but on the students' own choices. So it can be concluded that students like physics learning even though learning is carried out online, more students are in the disagreeing category for disliking physics learning even though learning is done online.

The percentage of answers with the question that I used a virtual laboratory during bold learning can be seen in Figure 2.

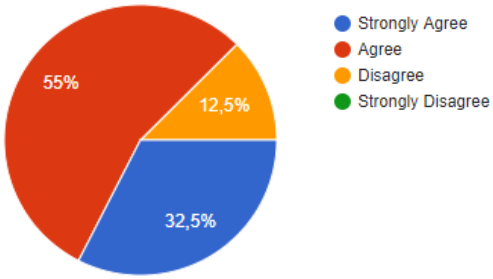

Fig 2. *Percentage of students who like using virtual laboratory on online learning*

Based on the diagram in Figure 2, there are 55% of students who use the use of virtual laboratories in online learning are in the agree with category, 32.5% in the strongly agree category, 12.5% in the disagree category. The use of virtual laboratories during a pandemic has no effect on student motivation to learn, although this shows that students use the use of virtual laboratories in physics courses even through online learning during a pandemic ecause they can see the material directly so that learning becomes easier to implement.

The percentage of answers to the question "through the virtual laboratory I can practice again independently even though the learning has ended so that I can refine my understanding of the

material", can be seen in Figure 3.

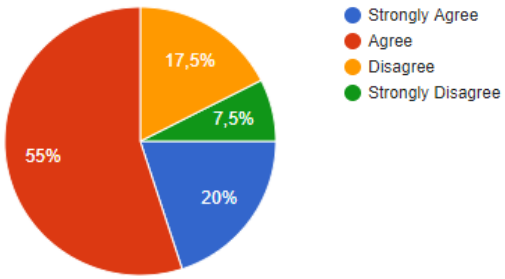

Fig 3. *Percentage of student answers*

Based on the diagram in Figure 3, there are 55% of students who choose the category agree that virtual laboratories can be practiced again independently even though the learning has ended so that students' understanding of the material can be honed again, as many as 17.5% of students choose the category disagree, as many as 20% are in the category Strongly agree and only 7.5% voted strongly against. Through the student's answers, it can be seen that most students have felt the benefits of using virtual laboratories. Although it cannot be denied that the use of virtual laboratories is only limited to virtual laboratories. But during a pandemic and for material that is abstract in nature, a virtual laboratory is the right choice. Students are very enthusiastic about online learning using virtual laboratories, because they can re-practice what they have learned before, and understand the material can be refined so that it can improve students' thinking skills.

Furthermore, the researcher gave another trick question to test the consistency of the students with the pre-selected answers, namely "I don't like the use of virtual laboratories for now". The results of the proportion of student answers to these questions can be seen in Figure 4.

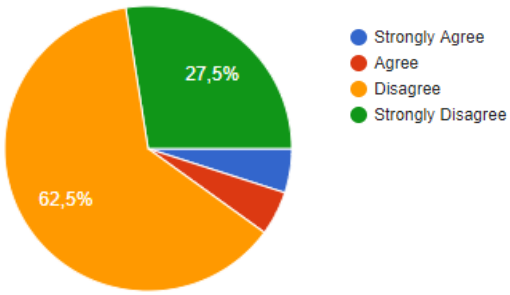

Fig 4. *Percentage of student answers*

Based on Figure 4, 62.5% of students chose the disagree category, namely 27.5% of the students chose the strongly disagree category, and the rest chose the strongly agree and agree category with a very small percentage. Trick questions are made to see the consistency of students in choosing the answers previously chosen. Because the answers given must come from the student's own choice, not coercion from others. Through these percentage results, it shows that students like the use of virtual laboratories in online learning for physics laboratory courses.

Based on the results of data collection student worksheets used to measure students' conceptual understanding and critical thinking skills, it was found that there was a significant relationship between online learning using a virtual lab on student concept understanding and online learning using a virtual lab on students' critical thinking skills. The results of the analysis of online learning data testing using a virtual laboratory on student understanding of concepts can be seen in Table 2.

Table 2. Online Learning Crosstabulation Using a Virtual Laboratory for Concept Understanding

		Concept Understanding			Total
		Not good	Good	Very Good	
Online Learning Using a Virtual Laboratory	Not good	2	1	0	3
	Good	0	16	4	20
	Very Good	0	0	17	17
Total		2	17	21	40

Table 3. Somers'd Test Analysis Results

			Value	Asymp. Std. Errora	Approx. Tb	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.830	.066	9.010	.000
		Lab_Virtual Dependent	.848	.069	9.010	.000
		Conceptual Understanding Dependent	.814	.070	9.010	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Based on the results of the Somers'd test analysis in Table 3, the sig value is obtained. students' understanding of the concept 0.000 <0.05 or sig <0.05. This shows that there is a significant relationship between online learning using a virtual laboratory and students' understanding of physics concepts. The value of understanding the concept is 0.814 or 81% with very good criteria [21].

The results of the analysis of online learning data testing using a virtual laboratory on students' critical thinking skills can be seen in Table 4.

Table 4. Crosstabulation of Online Learning Using a Virtual Laboratory for Critical Thinking Skills

		Critical Thinking Skills				Total
		Very less	Not good	Good	Very Good	
Online Learning Using a Virtual Laboratory	Very less	1	0	0	0	1
	Not good	1	2	0	0	3
	Good	0	2	11	0	13
	Very Good	0	0	6	17	23
Total		2	4	17	17	40

Table 5. Somers'd Test Analysis Results

			Value	Asymp. Std. Errora	Approx. Tb	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.792	.059	7.723	.000
		Lab_Virtual Dependent	.749	.069	7.723	.000
		Critical Thinking Skills Dependent	.841	.058	7.723	.000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Based on the results of the Somers'd test analysis in Table 5, the sig value is obtained. Students' critical thinking skills are 0.000 <0.05 or sig <0.05. This shows that there is a significant relationship between online learning using virtual laboratories and students' critical thinking skills. The value of critical critical thinking is 0.841 or 84% with very good criteria [21].

Based on the data obtained, it is known that bold learning using the laboratory affects students' concepts and critical thinking skills, this is supported by the results of the questionnaire responses and Student Worksheets (LKM) which are divided by 40 students. The results of the questionnaire responses showed very enthusiastic student responses, all the questions given showed positive results, even though the researchers gave some trick questions, the answers were given by students who were still consistent in online learning using virtual laboratories during a pandemic. Likewise, the results of the student LKM analysis showed that there was a significant relationship between online learning using the laboratory and students' understanding of concepts and critical thinking skills with a significance level of 0.000 <0.05 with the criteria obtained which indicated the category was very good. So it can be ignored that there is a significant relationship between bold learning using a virtual laboratory with understanding concepts and critical thinking skills of physics students, especially in physics laboratory courses. This is in line with Elsunni & Abdelwahed [22], which states that the use of Lab-Vir media is efficient in science lessons so that student skills can be developed in conducting virtual experiments. Furthermore, according to Yusuf & Widyaningsih [4, there is a significant relationship between laboratory application and students' critical thinking skills. The use of virtual laboratories is one solution to the limited laboratory facilities and infrastructure, especially during a pandemic like now. According to Suwarni, Sudarmin, & Kadarwati [23], practicum simulation through computer media can help the implementation of practicum for those who do not have adequate laboratory facilities. The advantage of using this software is that it can be used to visualize simulations and animations so as to create lifelike images.

CONCLUSION AND SUGGESTION

Even though online learning is carried out using a virtual laboratory, the ability of students to understand the concept of the material being taught is very good. This is evidenced by the results of research that has been conducted by researchers which show that students' enthusiasm in attending lectures and their ability to understand the material being taught is in the very good category. Also besides, students can understand the abstract material, because they can see the simulation of the material directly through a virtual laboratory that they have never studied directly in a real laboratory so that students' critical thinking skills also develop.

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