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Article

Virtual Laboratory and Its Effect on Student Learning Outcomes in Physics Education

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Abstract: This study aims to determine the effect of using a virtual laboratory on student learning outcomes in Kirchhoff's law material at the physics education study program at HKBP Nommensen Pematangsiantar T.A. 2020/2021 by utilizing a virtual laboratory. This type of research is a true experiment with the research sample, namely the physics education study program group A as the experimental class and group B as the control class. The research instrument test was composed of 20 multiple-choice questions, the content validity was tested by a team of experts as validators as many as 2 people and student activity observation sheets. From the data analysis, the average post-test value for the experimental class was 78.46 with a standard deviation of 11.25 and the average post-test value for the control class was 66.50 with a standard deviation of 13.78. Normality and homogeneity tests at the level of =0.05 stated normal and homogeneous and one-party hypothesis testing t-stat > t-table (2.99> 1.67). Thus, it can be concluded that the use of a virtual laboratory can improve student learning outcomes in the basic physics practical subject of Kirchoff law.

Keywords: virtual laboratory; student learning; physics education; Kirchhoff's law.

1. Introduction

Physics is a branch of natural science that studies symptoms, concepts, or phenomena that occur in nature. Like science, physics as one of its branches is formed and developed through a scientific process that must be taught to students in order to have a meaningful learning experience. In addition, there are two properties of physics, namely physics as a product and physics as a process (Newell, 1985). Online learning (in the network) is still an important alternative for teachers carrying out teaching tasks during the Covid-19 pandemic. Distance Learning (PJJ) has become a priority agenda since the government implemented a learning from home program (Learning from home). Teachers, students, and parents must adapt to the new policy and keep working together so that students can continue their study routines even in the midst of limitations. Of course, this is not easy, it takes a long time to learn how to make sure PJJ

can run smoothly. Physics cannot be separated from practical activities. Practicum is part of the teaching and learning process where students can find knowledge through investigation. So far, physics practicum is often carried out in the physics education laboratory of UHKBPNP. However, due to the Covid-19 pandemic, teachers/lecturers design virtual-based learning including how to design virtual practicum learning (virtual lab). One solution to continue to provide learning abilities within these limitations, or as an alternative material in overcoming the problem of implementing practicum due to limited laboratory facilities and requiring a lot of time and expensive costs, is virtual practicum. Virtual Practicum is a laboratory activity that is moved in front of a computer. This Virtual Practicum certainly requires a Virtual Laboratory as well or commonly called a Virtual Laboratory. Virtual Laboratory or commonly referred to as Virtual Laboratory is a series of laboratory equipment in the form of interactive multimedia-based computer software that is operated with a computer and can simulate activities in the laboratory as if the user was in a real laboratory. However, Virtual Laboratory cannot be used as a substitute for practicum in a real laboratory.

Virtual Laboratory has an important role in implementing practicum activities. Revealed by Ervina et al. (2019), virtual laboratories are used for demonstrations before the actual practicum takes place in the laboratory. This virtual laboratory can also meet the needs of students such as giving students the freedom to do or carry out practicums anywhere and anytime without having to be guided by the teacher. A virtual laboratory is a form of laboratory with observation or experimental activities using software that is run by a computer, all the equipment needed by a laboratory is contained in the software (Tüysüz, 2010). Computer simulations provide opportunities for students to learn physics dynamically and interactively. Simulation in the form of interactive multimedia-based computer software, which is operated by a computer and can simulate activities in the laboratory as if the user is in a real laboratory, is called a virtual laboratory. Virtual laboratories provide students with tools, materials, and laboratory equipment in computers to subjectively perform experiments anywhere and anytime (Ahmed & Hasegawa, 2014). Virtual/virtual laboratories are needed to strengthen the understanding of concepts in the learning process. Virtual laboratory is not a substitute but part of a real laboratory that is used to complement and improve existing weaknesses. Especially during the Covid-19 pandemic, virtual laboratories are an effective choice for teachers, especially science teachers, in conducting practical.

The things that teachers need to do to design virtual laboratory-based learning well are first, analysing the basic competencies of learning. In the physics education study program, FKIP University, Nommensen Pematangsiantar, there are several practicum courses, namely basic physics practicum, advanced basic physics practicum, basic electronics practicum, school physics practicum and advanced physics practicum. Especially for basic physics practicum, you can take advantage of the use of a virtual laboratory. This is so that the concepts that are owned are not only limited to memorization but are also able to understand more deeply the concept. It is important to do this research because of the current pandemic situation, which is still carrying out the online learning process. In addition, this research is also expected to be able to overcome problems from an economic point of view, where using a real laboratory requires a large amount of money. while the virtual laboratory only uses software media and the practicum data obtained is also not much different from the real laboratory. The purpose of this study was to determine how much influence the use of a virtual laboratory had to improve student learning outcomes of physics education at HKBP Nommensen Pematangsiantar University.

2. Literature Review

Virtual Laboratory is a place where experimental activities take place electronically using applications or simulations on a computer. Virtual Laboratory is a medium used to help understand a subject and can be a solution to the limitations or absence of laboratory equipment. Virtual Laboratory can be accessed via the web as a learning supplement. Virtual Laboratory is a series of laboratory equipment in the form of interactive multimedia-based computer software that is operated using a computer and can simulate activities in the laboratory so that users feel as if they are in a real laboratory (Wolf, 2009). Virtual Laboratories have the potential to provide significantly enhanced learning and a more effective learning experience. The use of this Virtual Laboratory is expected to be able to solve learning problems experienced by students and overcome cost problems in procuring tools and materials used to carry out practical activities for schools that have constraints on the procurement of facilities and infrastructure, so as to optimize the physics learning process for students (Irwanto, 2018).

Virtual word which means not real, which can be simulated at any time with computer software. The word Virtual is usually associated with the word Virtual Reality, which means "a set of image and sound produced by a computer, which seems to represent a place or a situation that a person can take part in". The word "Virtual Reality" can be interpreted as a realistic simulation of the environment, including three-dimensional graphics with computer systems that use interactive software and hardware (Zhou & Deng, 2009). The merging of the two words Virtual and Laboratory can be interpreted as something abstract represented by a visual model to assist the user in obtaining data in a simulation to make a hypothesis. In this case, the simulation is taken from the word "stimulatory" which means the media to test an experiment or experiment as if it were the original (Zhou & Deng, 2009). According to Thompson et al. (1996), simulation as a representation or model of events, objects or some phenomena. In the field of science education, according to Akpan & Andre (1999), computer simulation is the use of computers to simulate objects in the real world

or imagine the real world through dynamic systems. Virtual Laboratory is a virtual reality environment that simulates the real world for discovery learning purposes. In principle it aims to evaluate real-world operations and experiments due to time, safety, or cost constraints in a real-world environment and is usually used in learning (Muhamad et al., 2010).

Virtual Laboratory is also said to be equal in assessment for students, because Virtual Laboratory is flexible and is one of the efforts to address the differences in various student learning styles (Koretsky et al., 2008). Although the Virtual Laboratory cannot match the real practicum in total, the virtual laboratory is worth considering because this Virtual Laboratory has various benefits and advantages so that the learning process is easier to implement. The use of the Virtual Laboratory allows students to explore and design their own research laboratory and there are modules designed to provide students with real-world comparisons of scenarios when applying physics concepts (Daineko et al., 2017). The benefits of using the Virtual Laboratory program in the classroom in physics lessons are that students can explore their own Laboratory experiments, connect physics to real life and improve students' decision-making abilities. In general, people do business or work with the hope of getting a lot of results without spending a lot of money, energy and time, in other words efficient. Efficiency is a concept that reflects the best comparison between effort and result. Thus, there are two kinds of efficiency that can be achieved by students, namely the efficiency of learning efforts and the efficiency of learning outcomes (Ten Bruggencate et al., 2012). A learning activity can be said to be efficient if the results or achievements obtained by students are in accordance with the wishes and standards of results (eg minimum completeness scores) with efficient or minimal effort (Irmayani et al., 2018).

Effort in this case is everything that is used to get satisfactory results such as energy, thoughts, time, learning equipment, and other things that are relevant in learning activities. Furthermore, an activity can also be said to be efficient if with certain efforts it can provide high learning outcomes or achievements. It should also be noted that the use of this virtual laboratory does not mean that it should be used as a substitute for participation of students in conducting practical in real laboratories, but only as an alternative in helping students to easily understand the concept and application material. Virtual Laboratory is a computer-based learning media, as for the advantages of this media, namely:

- Computers can accommodate students who are slow to receive lessons, because they can provide a more effective climate in a more individual way, never forget, never get bored, very patient in carrying out instructions as desired by the program used.
- Computers can stimulate students to do exercises, do laboratory activities or simulations because of the availability of animated graphics, colours, and music that can add realism.
- Control is in the hands of students so that the level of student learning speed can be adjusted to the level of mastery. In other words, computers can interact with students individually, for example by asking questions and assessing answers.
- The ability to record student activity while using a teaching program provides better opportunities for individual learning and the progress of each student is constantly monitored.
- Can connect with and/or control other equipment such as CDs, video tapes, etc. with the control program from the computer.

While the weaknesses in the use of the Virtual Laboratory are:

- Students must be connected to the internet or use a computer to run a simulation of a practicum.
- Lack of experience in real laboratories, resulting in confusion for students in assembling and operating tools in the Virtual Laboratory.
- Virtual Laboratory does not provide real practical experience.

The development of Virtual Laboratory in the world is very fast. Currently, most of the largest Virtual Labs have been installed on a web-based or online basis, but many are still being developed offline. With the increasing number of Virtual Laboratory that can be accessed for free or can even be downloaded. One of the Virtual Laboratory displays of interactive Physics learning from the University of Colorado. How to take advantage of freeware from the University of Colorado in the form of phet.colorado.edu.

3. Materials and Methods

This research was carried out on students of the physics education study program at the HKBP Nommensen Pematangsiantar university which was carried out from September to November for 2021/2022. The population in this study were all physics education students of UHKBPNP for 2021/2022. The sample in this study consisted of two classes, namely the experimental class (class that uses a virtual laboratory) and the second class called the control class (class that uses a real laboratory). This research will involve two classes that are given different treatment and to find out student learning outcomes, it is done by giving tests to both classes before and after being given treatment. The design of this study used a true experimental design. The design of this study is shown in Table 1:

Table 1. Design of the Pre-test and Post-test

Class	Pre-test	Treatment	Post-test
Experiment	T1	X1	T2
Control	T1	X2	T2

Table 1 shows design of the pre-test and post-test. T1 is Initial ability test (pre-test) for the experimental class and the control class, T2 is Final ability test (post-test) for the experimental class and the control class, X1 is Learning using the Practicum Method, X2 is Learning using conventional learning methods. Data collection instruments used in this study were learning outcomes tests and questionnaires.

Table 2. Pre-test Data Normality Test

Data	Class	L stat	L table	Conclusion
Pre-test	Experiment	0.121	0.142	Normally Distributed
	Control	0.131	0.140	Normally Distributed

Table 2 captures that result of pre-test data for measuring the normal distribution of data. The result showed that an experiment class the value of L stats is 0.121 and control class L is 0.131. The value of L table for an experiment class is 0.142 and control class is 0.140. Thus, the value of L stats less than L table. Thus, we can conclude that data comes from a population sample is normally distributed.

Table 3. Post-test Data Normality Test

Data	Class	L stat	L table	Conclusion
Post-test	Experiment	0.107	0.142	Normally Distributed
	Control	0.084	0.140	Normally Distributed

Table 3 shows result of post-test data for measuring the normal distribution of data. The result showed that an experiment class the value of L stats is 0.107 and control class L is 0.081. The value of L table for an experiment class is 0.142 and control class is 0.140. Thus, the value of L stats less than L table. Thus, we can conclude that data comes from a population sample is normally distributed.

Table 4. Result of Homogeneity Testing

Data	Class	Varian**ce**	F stat
Pre-test	Experiment	222.17	1.08
	Control	206.09	

Table 4 shows the result of homogeneity testing. For pre-test data, this study indicates that the F stat of experimental class and the control class is less than F table (1.08 < 1.72) with a significant level of = 0.05. Thus, Ho is accepted. It means that the population sample comes from a homogeneous population.

Table 5. Result of Hypothesis Test (Pre-test)

Data	Class	Mean	t stat	t table
Pre-test	Experiment	32.31	1.382	1.994
	Control	38.75		

Table 5 describes the result of pre-test hypothesis. The result showed that an experiment class mean value is 32.31 and control class is 38.75. The value of t stat is 1.382 and t table is 1.994. Thus, the value of t stats is less than t table. Thus, we can conclude that the initial abilities are the same.

Table 6. Result of Hypothesis Test (Post-test)

Data	Class	Mean	t stat	t table
Post-test	Experiment	78.46	4.218	1.667
	Control	66.50		

Table 6 indicates the result of pre-test hypothesis. The result showed that an experiment class mean value is 78.46 and control class is 66.50. The value of t stat is 4.218 and t table is 1.667. Thus, the value of t stats is higher than t table. Thus, we can conclude that there is a significant effect of using virtual laboratories on student learning outcomes of physics education program.

4. Results and Discussion

This study conducted at the UHKBPNP physics education study program. We use a different learning model, where one class as an experimental class uses a Virtual Laboratory and the other class as a control class uses a real laboratory. The researcher gave an instrument in the form of a test of 20 items in the form of multiple choice with five options that had been tested for content validity with a validity value of 3.66 and were included in the valid category. Based on the results of the study, it showed that using virtual laboratory media carried out on the subject matter of Kirchhoff's Law, student learning outcomes in the experimental class were greater than the control class with an average post-test value of 78.46 in the experimental class with a standard deviation of 11.25 while the average value the average post-test control class is 66.50 with a standard deviation of 13.78. From the one-party hypothesis test, it was obtained that t stat > t table (2.985 > 1.667). From the data that has been presented, by applying virtual laboratory media, it can improve student learning outcomes. This is because the virtual laboratory media is more interesting and simpler so that the material practiced is easier for students to understand (Balamuralithara & Woods, 2009). Thus, there is a significant effect by using virtual laboratory media whereby using virtual laboratories, student learning outcomes will increase in basic physics practicum courses.

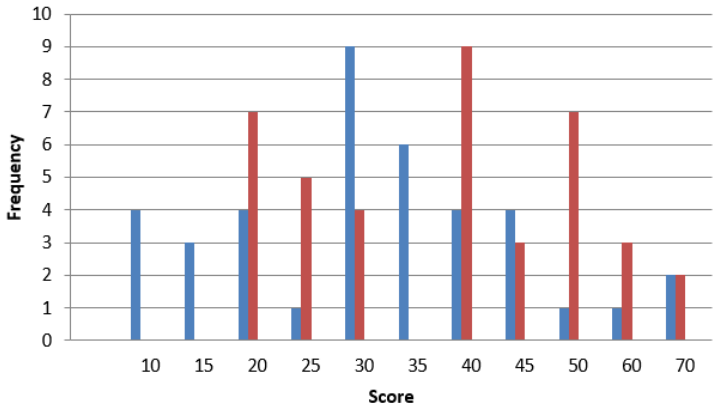

Figure 1. Result of Pre-test

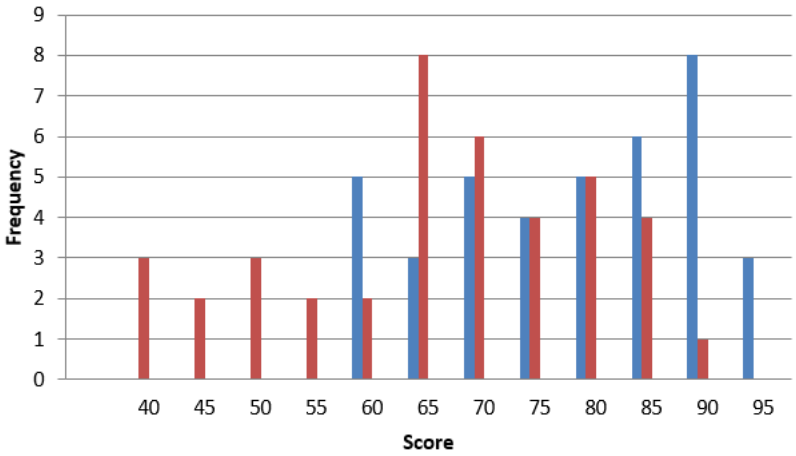

Figure 2. Result of Post-test

5. Conclusions

In conclusion, this study indicates that there is an effect of using Virtual Laboratory media on student learning outcomes. The results of the data analysis showed that student learning outcomes using a virtual laboratory on Kirchhoff's law material in the physics education study program for 2020/2021 the average for the experimental class is 78.46 and the control class is 66.50. Also, there is a significant effect of using virtual laboratories on student learning outcomes on Kirchoff law material in physics education study program with t stat higher than t table i.e., 2.985 > 1.667 at the significant level = 0.05. The correlation between the effect of using virtual laboratory and increasing student learning outcomes is 0.0614 (6.14%). It indicates that the use of Virtual Laboratory media is attractive to students or has a positive impact and gives enthusiasm in learning so that it affects student learning outcomes.

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