THE EFFECT OF VIRTUAL LABORATORY IN BASIC ELECTRONICS SUBJECTS ON STUDENT LEARNING OUTCOMES OF THE ELECTRICAL ENGINEERING EDUCATION DEPARTMENT

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ABSTRACT

Some facilities for basic electronics practicum in the electrical engineering education laboratory are not yet available. Therefore, a substitute practicum effort is made to use a virtual laboratory to achieve predetermined competencies. The research model for this is a quasi-experimental design with a design type nonequivalent control group design. The data review methodology utilized the t-test to detect variations in student learning results. The findings showed that the learning outcomes in a class using a virtual laboratory had an average value of 73.5 and a standard deviation of 9.66 with the highest trend level of 18.75%. Meanwhile, the class that did not use a virtual laboratory obtained an average value of 67.84, and the standard deviation was 10.00, with the highest tendency level of 6.25%. The populations in this study were all first-semester students in the 2020/2021 academic year majoring in electrical engineering education at Universitas Negeri Medan. The results of the t-test on learning outcomes in basic electronics subjects obtained tcount> ttable (2.3>1.999), meaning that there was a positive influence or improvement on student learning outcomes in classes using virtual laboratories on basic electronics subjects

Keywords

Virtual Laboratory, Basic Electronics Practicum, Learning Outcomes

Introduction

The laboratory as a practicum place is the spearhead in improving the competencies of students [1]. The laboratory is one of the educational facilities and infrastructure that must be owned by an educational institution that has a major in science and technology. Serves as a place for a practice-based or experimental learning process that contains various kinds of practicum tools, measuring instruments, components, or other materials to support learning objectives [2].

The management of education, especially concerning the laboratory, is identical to the complex problems [3]. Problems with resources (tools and materials) are often obstacles in managing the course of education in the laboratory [4]. Ideally, a student should get adequate facilities in doing practicum, but often limited resources make students have to take turns doing a practicum in the laboratory with limited time [5].

Based on observations made at the Department of Electrical Engineering Education, State University of Medan, in doing introductory electronics practicum, traditional laboratories are still used. One of the electronics laboratory obstacles in the electrical engineering education department is limited equipment and practicum materials. Several studies have been carried out related to efforts to overcome the obstacles faced by traditional laboratories, including the effectiveness of learning through developing simple industrial control simulations using Proteus software and LabView [6]. Further research is on the impact of the simulation program technique on student learning outcomes in microcontroller systems [7]. Next is the use of proteus as a simulation software in digital electronic experiments [8]. Then develop teaching modules with the support of Proteus software to enhance student skills [9]. On the basis of the study that has been conducted, it can be inferred that one of the options for learning to still be felt by students or as an alternative to actual practicum is to carry out practicum exercises in a simulated way [10][11][12].

The virtual laboratory is among the innovations in computing technology as a form of immersive multimedia object designed to simulate real laboratory experiments as if users were in real laboratories [13]. In a virtual lab, students have the ability to replicate the experiment many times; it is reliable, cost-effective, and prevents students from the risks that could occur when conducting actual experiments [14][15]. The use of virtual laboratories in practicum activities can also increase student interest and learning outcomes because it can make teaching content intuitive and straightforward to motivate students to do more practice [16][17][18][19].

An alternative virtual laboratory for introductory electronics courses is to use proteus software. Proteus software is a software that can be used to design and simulate electronic circuit schematics, both analog and digital. The proteus library can be said to be complete, starting from passive components, transistors, SCR, FET, types of buttons, types of switches, digital ICs, amplifier ICs, programmable ICs (microcontroller), and memory ICs. Besides being supported by a complete range of measuring instruments such as a voltmeter, ampere meter, oscilloscope, signal analyzer, and frequency generator [20][21].

Based on explanations provided, this study uses Proteus software as a virtual laboratory. Proteus software is used as an approach to having students carry out practicum exercises as well as in actual laboratories. The purpose of this research is to evaluate the impact of using proteus software on student learning outcomes.

Methods

This study used a Quasi-Experimental Design research design with the design type Nonequivalent Control Group Design [22][23], while the research design can be seen in Table 1. This design is almost the same as the Pretest-Posttest control group design [24]. Only in this design, the research participants were not selected randomly [25][26]. This research was conducted in the electrical engineering education department with a sample of all students in the first semester of the 2020/2021 academic year where the class is divided into two, class A as the experimental class and class B as the control class [27].

Table 1. Nonequivalent desain of control group

The experimental class	O_1	X	O_2
Control class	O_3	-	O_4

Where O1 is the measurement result of the pretest in the experimental class; O2 is the measurement result of the pretest in the control class; O3 is the measurement result of the final test (posttest) in the experimental class; O4 is the measurement result of the final test (posttest) in the control class; X is the class that is treated using proteus software media (the experimental class); Moreover (-) is a class that does not use the proteus software media (the control class).

Based on the research design in Table 1, there are two analyzes. The first analysis is to test the initial capacity between the experimental group and the control group. (O1:O3) by giving a pretest [28]. The second analysis is to test the posttest scores between the experimental class and the control class (O2:O4). The data collected from the pretest and posttest were processed using the t-test, the t-test formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_4^2}{n_2}}}$$

Where t is the result of the t-test; X ̅_1 is the average pre-test/post-test score in the experimental class; X ̅_2 is the average pre-test/post-test score in the control class; S_1 is the standard deviation in the experimental class; S_2 is the standard deviation in the control class; n_1 is the number of samples in the experimental class; n_2 is the number of samples in the control class.

Furthermore, testing the hypothesis with a significant level of α = 5% (0.05). If the tcount is greater than the ttable, there is a significant difference between the pretest and posttest results in the experimental group and the control class. Then these results can be said that there is an effect of using proteus as a virtual laboratory on learning outcomes in basic electronics subjects.

Results

At the beginning of the study, the experimental class and the control class were given a pretest to see the extent to which students understood concepts before applying the virtual laboratory. Based on the pretest results in the experimental class obtained an average score = 40.84; variance = 102.27; the highest score = 70 and the lowest score = 30, with a sample size of 32 students. Data on the frequency distribution of the experimental class pretest is presented in Table 2. Based on the results of the control class pretest, it was obtained an average score = 41.16; variance = 120.33; the highest score = 77 and the lowest score 30, with a sample size of 32 students. The data on the frequency distribution of the control class pretest is presented in Table 3.

Table 2. Frequency distribution of the experimental class pretest.

Class	Interval	$F_{observaion}$	$F_{relative}$ (%)
1	30-36	11	34.38
2	37-43	12	37.50
3	44-50	5	15.63
4	51-57	1	3.13
5	58-64	2	6.25
6	65-71	1	3.13
Total		**32**	**100**

Table 3. Frequency distribution of the control class pretest

Class	Interval	$F_{observaion}$	$F_{relative}$ (%)
1	30-37	14	43.75
2	38-45	9	28.13
3	46-53	6	18.75
4	54-61	1	3.13
5	62-69	1	3.13
6	70-77	1	3.13
Total		**32**	**100**

Hypothesis testing used to prove that the two research classes are not much different are summarized in Table 4. After doing the calculation, it turns out that tcount is between ttable, namely: -1.999 <-0.144 <1.999. So that H0 is accepted, namely the results of the students' pretest ability in the experimental class and the control class are the same.

Table 4. Pre-test experimental class and control class results.

Statistics	Class	
	Experimental	Control
N	32	32
Highest Score	70	77
Lowest Score	30	30
Average	40.84	41.16
$\sum x$	1307	1317
$\sum x^2$	56553	57993
S	10.11	10.97
S^2	102.27	120.33

Table 5. Post-test learning results of the experimental class and control class

No. Student	Eksperimental class	Control Class
1	80	67
2	77	57
3	83	60
4	67	60
5	67	70
6	77	57
7	70	70
8	80	67
9	77	80
10	73	57
11	57	70
12	60	67
13	80	80
14	77	50
15	67	60
16	70	67
17	50	50

18	77	80
19	60	60
20	83	73
21	90	77
22	83	50
23	77	70
24	60	77
25	80	67
26	90	90
27	70	77
28	77	83
29	83	67
30	73	67
31	77	77
32	60	67
$\sum x$	2352	2171
$\sum x^2$	175762	150393
$\sum \frac{X_1}{n}$	73.5	67.84
SD	9.66	10.00

Based on the data in Table 4, then:

$$S^2_{total} = \frac{(n_1-1)S_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$$

$$S^2_{total} = \frac{(32-1)\,102.27+(32-1)120.33}{32+32-2}$$

$$S_{total} = \sqrt{111.3} = 10.55$$

$$t = \frac{\bar{X}_1-\bar{X}_2}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

$$t = \frac{40.844-41.16}{10.55\sqrt{\frac{1}{32}+\frac{1}{32}}} = -0.144$$

At the end of the study, a post-test with 30 multiple-choice items was offered to the experimental class and control class. The table of learning outcomes in the experimental class and control class is shown in Table 5. Based on the posttest results of the experimental class, it was obtained an average score = 73.5; variance = 93.23; highest score = 90; and the lowest score = 50. Frequency distribution data of the experimental class posttest results can be seen in Table 6. Based on the results of the posttest control class, the average score is 67.84; variance = 100,136; highest score = 90; and the lowest score = 50. Frequency distribution data of the control class posttest results can be seen in Table 7.

Table 6. Frequency distribution of the experimental class posttest

Class	Interval	$F_{observaion}$	$F_{relative}$ (%)
1	50-56	1	3.13
2	57-63	5	15.63
3	64-70	6	18.75
4	71-77	10	31.25
5	78-84	8	25.00
6	85-91	2	6.25
Total		**32**	**100**

Table 7. Frequency distribution of the control class posttest.

Class	Interval	$F_{observaion}$	$F_{relative}$ (%)
1	50-56	3	9.38
2	57-63	7	21.88
3	64-70	12	37.50
4	71-77	5	15.63
5	78-84	4	12.50
6	85-91	1	3.13
Total		**32**	**100**

Furthermore, hypothesis testing is used to identify differences in learning results in the experimental class and control class. Then the standard deviation:

$$S^2_{total} = \frac{(n_1-1)S_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$$

$$S^2_{total} = \frac{(31)\,93.23+(31)\,100.136}{32+32-2}$$

$$S_{total} = \sqrt{96.68} = 9.83$$

so that it is obtained,

$$t = \frac{\bar{X}_1-\bar{X}_2}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

$$t = \frac{73.5-67.84}{9.83\sqrt{\frac{1}{32}+\frac{1}{32}}} = 2.3$$

At the significant level α = 0.05 and dk = n1+n2-2=62 in the t distribution level table, the value of ttable = t (0.05,62) = 1.999 is obtained. Then compared with tcount = 2.3, the value of tcount> ttable (2.3>1.999) is obtained. It can be concluded that there is an effect of using proteus software as a virtual laboratory on student learning outcomes in basic electronics subjects.

Discussions

Based on the data analysis of the pretest results in the experimental class and control class, it shows that the two classes have the same initial ability. The initial ability is the same based on the results of the t-test hypothesis testing; it is found that the tcount is between the ttable, namely -1.999 < -0.144 < 1.999. Because both the control class and the experimental class have same initial abilities, so that research can be carried out by teaching lessons about series, parallel, and mixed circuits.

The results of the study have shown that the class that used the virtual laboratory got an average score of 73.5, and the class that did not use the virtual laboratory got an average score of 67.84. Testing the t-test hypothesis on the posttest results obtained that tcount=2.3 > ttable=1.999. It can be inferred that student learning results in the experimental class or classes using virtual laboratories are better than those in the control class or classes that do not use virtual laboratories.

A virtual laboratory is a right model for virtual learning, according to research on the effect of simulation program methods on learning outcomes [7] and the use of Proteus software to improve student skills [9], indicating that a virtual laboratory-based approach can improve learning outcomes. Virtual laboratory-based learning can improve students' mastery of concepts on dynamic electricity topics. Virtual laboratory media can make it easier for students to do practical work directly with their respective groups. They were delivering using virtual laboratory media results in students being more innovative, creative, and useful so that the main principle is to increase the effectiveness of teaching and learning on campus in terms of the use of time, funds, facilities.

Conclusion

Based on the findings of the study and discussion that has been conducted, it can be inferred that the impact of the proteus software media as a virtual laboratory on student learning outcomes shows strong results relative to the learning outcomes of students who do not use the proteus software media as a virtual laboratory.

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