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The Effectiveness of Using Virtual Reality-Based Virtual Laboratories in the Internet of Things Course

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Abstract: The purpose of this study was to determine the effectiveness of using Virtual Reality-Based virtual laboratories on student learning outcomes in the Internet of Things Course in the Electrical Engineering Study Program, the average difference in student learning outcomes through the use of Virtual Reality-Based virtual laboratories in the Internet of Things Course in the Engineering Study Program Electrical Engineering, and student learning motivation through the use of Virtual Reality-Based virtual laboratories in the Internet of Things Course in the Electrical Engineering Study Program. This research is an experimental research approach that will be used is Quasi Experimental Design with the form of Nonequivalent Control Group Design. The validation test was carried out by measurement experts for post-test and pre-test questions, each aspect was tested by two experts. The results of the study show the effectiveness of using Virtual Reality-Based virtual laboratories to improve student learning outcomes in the Internet of Things Course in the Electrical Engineering Study Program. The increase in student learning outcomes analyzed using N-gain in the experimental class obtained an average value of 0.65 including the medium category, and the average N-gain for the control class was 0.15 in the low category. Meanwhile, the average difference in student learning outcomes through the effectiveness of using Virtual Reality-Based virtual laboratories in the Internet of Things Course in the Electrical Engineering Study Program is significantly and significantly different. The results of the experimental class data analysis obtained the t_count > t table value, namely 8,351 > 2,003 and the Sig. (2-tailed) 0.005 <0.05, then Ha is accepted, meaning that there is a difference in the average student learning outcomes after using a virtual reality-based virtual laboratory in the internet of things course in the Electrical Engineering Study Program. Student motivation through the use of Virtual Reality-Based virtual laboratories in Internet of Things Courses in the Engineering Study Program can increase very well

Keywords: Internet of things; Virtual labs; Virtual reality

Introduction

Technology in the current era of industrial revolution 4.0 which has the concept of human-centered society, artificial intelligence and human critical thinking skills by transforming big data collected via the internet of Things as a support for resolving or balancing social issues. This technological development makes Indonesia have to follow this pattern, especially the world of education.

The term Internet of thing technology during the pandemic due to Covid-19 has recently become popular to emphasize the vision of a global infrastructure that connects objects, using the same internet protocol enabling them to communicate and share information (Kassab et al., 2020). IoT applications are already being utilized in various domains such as medical services, smart energy, customer service, smart homes, environmental monitoring, education and so on. With the increasing use of IoT in the education domain, especially in higher education institutions, it is very

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important to incorporate these technological skills into the curriculum. To study how this technology with its different system functions such as sensing and decision making can support and challenge pedagogical processes for all interrelated actors (faculties, students and staff) and all assets involved (e.g. libraries, classrooms and laboratories) (Kassab et al., 2020). IoT in education has two aspects, the first is its use as a technology tool to improve academic infrastructure and the second as learning (Elyamany & Alkhairi, 2015).

Electrical Engineering is a study program that is closely related to experimentation or practicum. This practicum activity is carried out in the laboratory, where it is a place for students to acquire, train, and process skills while learning to concretize concepts that were originally abstract (Zwart, 2022). In this program IoT is a new conceptual paradigm and is still in its early stages, namely, IoT as learning or part of learning material. IoT learning is usually only given briefly, IoT material is general in nature and there is also no practicum. However, due to the broad scope of IoT, learning IoT requires an appropriate strategy and level of material depth. So, students can understand the concepts, uses, advantages and applications of IoT in various fields.

In this study, IoT will be studied to be practiced in the laboratory. However, the impact of Covid-19 in the past has resulted in the use of student hand-on laboratories experiencing psychological barriers in carrying out practical work. Besides being expensive in procuring materials and operational costs and less flexible. Practical objects or tools usually have a large physical size or are currently not easily available, so it is difficult or not easy to present them in front of the class. Practicum in the hand-on laboratory also makes students less comfortable working because of the fear of damage to the equipment used, as well as fear of endangering safety. This condition results in a decrease in student motivation so that it affects learning outcomes.

One of the most revolutionary tools to emerge during this rapid shift is Virtual Reality (VR). This technology is an artificial object that is not real, but users can feel that it has a real effect (Balsam et al., 2019). This technology helps create two- and three-dimensional images of abstract concepts from Electrical Engineering lessons. The use of technology in learning Electrical Engineering to support practicum is currently developing using virtual laboratory technology or E-lab based on Virtual Reality (VR). The use of this virtual laboratory is flexible and can be used repeatedly by students and can be used anywhere and anytime and is very useful for Engineering learning activities (Calvert & Abadia, 2020). Virtual Reality (VR) is a simulation similar to the real world. The use of this technology creates a simulated environment that can be explored in 360 degrees (Town & Islands, 2017). Virtual reality uses several input devices, for example joysticks and virtual reality headsets (Hui et al., 2022).

A virtual laboratory is a simulation of a practical laboratory that is packaged in a virtual form that is run using an electronic media device in the form of a computer or smartphone. In current technological developments, smartphones are part of technological developments, which are no longer luxury goods, but basic necessities for most people. Android is one of the operating systems that is currently widespread (Kanerva, 2021). The virtual lab can also strengthen practicum activities that cannot be carried out in real terms, meaning that the virtual lab can be an alternative practicum medium to replace the actual practicum, if it is not possible to do it (Rahmi et al., 2022). Therefore, an open use license (Open Source) allows educators and students to access it more easily.

The Electrical Engineering Study Program is one of the study programs of the Faculty of Engineering at Yogyakarta State University, which already has internet of things courses and has developed a Virtual reality-based E-lab. However, currently many of the students still have not fully utilized VR media and internet services in learning which have not been utilized optimally, have an impact on increasing the effectiveness of the learning process and create a lack of student interest and motivation in the learning process.

Based on this background, this study conducted research on the effectiveness of using a virtual laboratory or e-laboratory based on virtual reality to support internet of things courses in the electrical engineering study program. In the era of the industrial revolution 4.0, it is necessary to apply technology, especially virtual reality and the Internet of Things (IoT) to improve the learning process and laboratory practicum. With VR technology in learning the Internet of Things, students can see, select, and use sensor and actuator components as if they were. The data that is already in the microcontroller by the students is then sent to the middle device in the cloud. One of the android applications works to access sensor data in the cloud. Students besides being able to view sensor data can also control actuators with an Android application. According to Zulkifli et al. (2022) Virtual class or e-learning is a form of using the internet that is able to facilitate students in the learning process. In addition, the presence of several virtual laboratories can be a learning medium besides that it can also replace face-to-face practicum activities (Clarinda et al., 2022). Even interactive science situations that use computer programs to simulate science experiments are known as virtual laboratories (Fatayah, 2023). The use of virtual classes is currently an interesting thing for many users, especially educators, who almost all use Android-based smartphones.

VR-based IoT learning media is expected to increase the attractiveness of students to study IoT. In addition, this learning media can increase the efficiency and effectiveness of IoT learning because there is no need to build or add physical facilities and infrastructure in the lab to practice IoT.

Method

This study uses a quantitative approach with a quasi-experimental research type. The quasi-experimental method was designed using the Nonequivalent Control-Group Pretest Posttest design. The design of the research design can be seen in table 1.

Table 1. Quasi Nonequivalent Control Group Design (Sugiyono, 2018)

Group	Pre-test	Treatment	Post-test
Experiment (E)	O_1	X	O_2
Control (K)	O_3	-	O_4

Information: E = Experimental group, K = Control group, X = Treatment of the experimental group in the form of learning using Virtual reality, O1 = Initial test of the experimental group, O2 = Initial test of the control group, O3 = Final test of the experimental group, O4 = Final test of the control group.

The population in this study were students of the Electrical Engineering study program in semester VI who were taking Internet of Things courses. The samples taken in this study were students of the Electrical Engineering study program in semester VI of class H and K who were taking Internet of Things courses. Class H as the experimental class consists of 29 students and class K as the control class consists of 25 students. The instruments used in this study were tests, namely the pretest and posttest. Meanwhile, to obtain response data, a questionnaire in the form of a Likert scale was used.

Testing the butur test instrument in this study consisted of validity, reliability, item difficulty level, and discriminating power. While the non-test instrument testing consists of validity and reliability tests. Analysis of test item test data and non-test items using the help of the SPSS software application. Data analysis techniques in this study consisted of the t test (independent sample t test), N-gain, and percentage analysis.

Result and Discussion

This study aims to determine the increase in the effectiveness of using Virtual Reality-Based virtual laboratories on student learning outcomes in Internet of Things Courses in the Electrical Engineering Study Program, followed by differences in the average student learning outcomes through the effectiveness of using Virtual Reality-Based virtual laboratories in Internet of Things Courses In the Electrical Engineering Study Program, as well as student learning motivation through the effective use of Virtual Reality-Based virtual laboratories in the Internet of Things Course in the Electrical Engineering Study Program.

Before testing the hypothesis, N-gain analysis, the test instrument is tested first. Instrument testing consists of tests and non-tests. The test instrument analyzes multiple choice items through validity, reliability, difficulty index testing, and differential power tests. The non-test instrument analyzes the questionnaire through validity and reliability testing.

The results of the trial analysis of the Internet of Things subject before implementing learning using virtual reality and conventional learning media. This test consists of 25 multiple choice questions. Based on data analysis, the results of the validity test show that all questions are included in the valid category and the reliability test is 0.731, including the reliable category. Then the difficulty index test obtained 11 easy questions, and 14 moderate questions. Furthermore, the results of the different power test obtained 7 good and sufficient questions, and 18 questions in the sufficient category. Based on the test results, all questions can be accepted and used as test instruments in the research to be carried out.

After analyzing the results of testing the test instrument, the next step is to test the non-test instrument. The number of non-test instruments that will be tested in this study consists of 6 statement items in the form of a Likert scale. The validity level was carried out by a significance test by comparing the rcount value with the rtable value. As for the degree of freedom (df) = n-2, so n is the number of samples. So, in this case the amount of df can be calculated as 54-2 or df = 52 with $\alpha = 0.05$, then the rtable is 0.2681 if rcount is greater than rtable and the r value is positive, then the statement item is said to be valid. To find out the results of the validity test analysis in more detail, it can be seen as follows.

Table 2 shows the results of the analysis of the validity test as a whole corrected item total correlation or rcount > rtable, meaning that all statement items of student learning motivation are included in the valid category. After carrying out the validity test, reliability testing can be carried out on non-tests. The instrument reliability test can be seen from the Cronbach alpha value for each variable. Cronbach alpha is used to determine the consistent reliability of items or to test the consistency of respondents in responding to all items. An instrument for measuring motivation variables is said to be reliable if it has a Cronbach alpha value > 0.6. The results of data analysis can be performed using SPSS Version-22. Based on the results of data analysis, it was obtained that the reliability test value obtained the Cronbach's Alpha value of 0.927 > 0.6. It can be concluded that all instruments in this study are reliable or reliable. This means that all items in the learning motivation variable have a good level of reliability, so that they can be used as instruments in research.

Table 2. Results of the Questionnaire Instrument Validity Test (Non Test)

Variable	Question item	r-count	r-table	Declaration
Student learning motivation	P1	0.992	0.2681	Valid
	P2	0.883	0.2681	Valid
	P3	0.977	0.2681	Valid
	P4	0.965	0.2681	Valid
	P5	0.721	0.2681	Valid
	P6	0.948	0.2681	Valid
	P7	0.961	0.2681	Valid
	P8	0.957	0.2681	Valid
	P9	0.723	0.2681	Valid
	P10	0.914	0.2681	Valid
	P11	0.970	0.2681	Valid
	P12	0.909	0.2681	Valid
	P13	0.909	0.2681	Valid
	P14	0.514	0.2681	Valid
	P15	0.835	0.2681	Valid

The hypothesis test was carried out aiming to find out the average difference in student learning mastery in the experimental class and the control class. The hypothesis testing used is in the form of independent sample t t-test. The prerequisites for testing the hypothesis consist of a normality test and a homogeneity test.

The normality test aims to determine whether the data used is normally distributed or not. The normality test used is the Kolmogorov-Smirnov test. Ruli As'ari, (2018) says that "Data normality test, using the Kolmogorov-Smirnov test with the criterion if the value is asymp. Sig (p) > α, then the distribution of data is normally distributed ". The results of the Kolmogorov-Smirnov normality test in the experimental class and control class before and after applying the learning treatment can be seen in table 3.

Table 3. Kolmogorov-Smirnov Normality Test

Classes	Sig.
Experiment Pretest	0.965
Posttest Experiment	0.335
Pretest Control	0.647
Posttest Control	0.793

Table 3 shows the results of the Kolmogorov-Smirnov normality test in the experimental class and control class before and after applying the learning treatment. The results of the pretest and posttest analysis of the normality test for the experimental class and the control class were obtained by Monte Carlo Sig. (2-tailed) > 0.05. The results obtained show that the pretest and posttest data in the two classes are normally distributed.

The data homogeneity test is a test that provides information that the research data for each data group comes from a population that does not differ much in diversity (Ismail, 2018). The results of the pretest homogeneity test in the experimental class and control class obtained a significance value of 0.460. The results obtained prove that the significance value is > 0.05, so it can be concluded that the two classes come from populations that have the same or homogeneous variance. The results of the posttest homogeneity test in the experimental and control classes obtained the value of Sig. 0.808> 0.05, meaning that the data is homogeneous. The results of the pretest and posttest data analysis for the experimental class and control class obtained a significance value of > 0.05, so both data are included in the homogeneous category.

The results of the prerequisite test test, namely the normality test and homogeneity test on the pretest and posttest data of the experimental class and the control class are normally distributed and homogeneous. Based on the test results, it can be carried out to the next testing stage, in the form of an independent sample t test.

The independent sample t-test is a parametric test used to find out whether there is a mean difference between two independent groups or two unpaired groups with the intention that the two data groups come from different subjects. If the probability on the t-test shows a value greater than 0.05, then it can be it was concluded that there was no difference between the two groups. However, if the t-test probability value showed less than 0.05, then there was a difference between the two groups (Ghozali, 2018). The hypothesis test aims to determine the average difference in student learning outcomes in the Internet of Things course before and after applying the learning treatment to the experimental class and the control class. The hypothesis test used is an independent sample t-test.

Table 4. Independent Sample t-test Results for Pretest and Posttest Experiment Classes

Group Experiment Data	Mean	t	Sig.	Declaration
Pretest	60.55	8.351	0.000	Significant
Posttest	85.93			

Table 4 shows the results of the independent sample t test on experimental class data obtained by t-count = 8.351. Then look for the t-table with df = (29+29-2) = 56 at a significant level α = 0.05, so from the t distribution table we get t (0.95) (56) = 2.003. Because t-count > t-table is 8.351 > 2.003 and the value of Sig. (2-tailed) 0.005 < 0.05, then Ha is accepted, meaning that there is a difference in the average student learning outcomes after using a virtual reality-based virtual laboratory in the internet of things course in the Electrical Engineering Study Program. This is in line with research conducted by Ramadhani et al. (2021) the purpose of this virtual laboratory is to increase understanding of the material and anticipate real laboratory unpreparedness. Through a virtual laboratory as well as a learning experience that simulates an authentic laboratory (Kristanty, 2023).

This is because the implementation of virtual laboratories is able to provide interactive experiences where students can observe and manipulate the resulting system objects, data, or phenomena in order to fulfill learning objectives. Based on the results of the data analysis above, it can be concluded that the effectiveness of using virtual reality-based virtual laboratories in internet of things courses in electrical engineering study programs can improve student learning outcomes. Furthermore, the results of the analysis of the independent sample t test in the control class can be seen in table 5.

Table 5. Independent Sample t-test Results for the Control Class Pretest and Posttest

Group Control Data	Mean	t	Sig.	Declaration
Pretest	60.16	1.600	1.116	Not significant
Posttest	65.76			

Table 5 shows the results of the independent sample t test on the control class data obtained by t count = -0.611. Then look for t-table with df = (25+25-2) = 48 at a significant level α = 0.05, so from the t distribution table we get t (0.95) (48) = 2.010. Because t-count > t-table is 1.600 < 2.010 and the Sig. (2-tailed) 1.116 > 0.05, so there is no significant difference between student learning outcomes before and after carrying out conventional learning in the internet of thing course. This proves that learning activities in Internet of Things courses carried out through conventional laboratory activities are not significantly different before and after learning activities. Therefore, it can be concluded that conventional laboratory use is not effective in improving student learning outcomes. Furthermore, the results of the independent sample t test analysis can also be analyzed through pretest data in the experimental class and control class. The results of the data analysis can be seen in table 6.

Table 6 shows the results of the pretest data analysis in the experimental class and control class obtained t-count = 0.113 and t-table with df = (29+25-2) = 52 at a significant level α = 0.05 so from the distribution table t is obtained t (0.95) (54) = 2.005. Because t-count > t-table is 0.113 < 2.005 and the Sig. (2-tailed) 0.911 > 0.05, then Ha is rejected, meaning that there is no difference in the average student learning outcomes before applying the learning treatment in both the experimental class and the control class. After knowing the difference in the average learning outcomes before applying the learning treatment, the next step is to test the hypothesis after the learning treatment is given in the experimental class and the control class.

Table 6. Independent Sample t-test Results for the Experimental Class and Control Class

Group Experimental and Control Data	Mean	t	Sig.	Declaration
Pretest	60.55	0.11	0.91	Not
Posttest	60.16	3	1	significant

Table 7. Independent Sample t-test Posttest Test Results for Experimental Class and Control Class

Group Experimental and Control Data	Mean	t	Sig.	Declaration
Pretest	85.93	6.667	0.000	Significant
Posttest	65.76			

Table 7 shows the results of posttest data analysis in the experimental class and control class with tcount = 6.667 and ttable = 2.005. Because t-count > t-table is 6.667 > 2.005 and the value of Sig. (2-tailed) 0.000 <0.05, then Ha is accepted, meaning that there is a difference in the average student learning outcomes after applying the learning treatment. The results of the analysis prove that the use of virtual reality-based virtual laboratories in internet of things courses is better than the use of conventional media. Furthermore, to find out the analysis of increasing student learning outcomes for each student through the effectiveness of using virtual reality-based virtual laboratories in internet of things courses in the Electrical Engineering Study Program, it can be seen from the average N-gain results. For more details about the average N-gain for each student, it can be seen in table 8.

Table 8 shows an increase in student learning outcomes using the N-gain equation. Based on the test results obtained an average N-gain value of 0.65 is included in the medium category. The results obtained prove that the effectiveness of using virtual reality-based virtual laboratories can improve student learning outcomes. This is in line with research conducted by Fadli et al. (2022) who said that the use of virtual laboratory media is attractive to students or has a positive impact and provides enthusiasm for learning so that it influences student learning outcomes. The availability of practical instructions in the virtual laboratory is very helpful for students in using the virtual laboratory. This proves that the use of virtual reality-based virtual laboratories is effective in improving student learning outcomes, so that this learning media can be used as a learning medium capable of supporting the improvement of student learning outcomes. In addition, the results of the N-Gain analysis on the average student learning outcomes in the control class applying learning activities through conventional laboratories can be seen in table 9.

Table 9 shows the increase in student learning outcomes in the control class using the N-gain equation. Based on the test results, the average N-gain value for the control class is 0.15, which is included in the low category. The results obtained prove that through the effectiveness of conventional laboratory use the average student learning outcomes are still in the low category. Therefore, learning activities through conventional laboratories are not effective in improving student learning outcomes compared to experimental classes using virtual reality-based virtual laboratories.

Table 8. Results of Experiment Class N-Gain Analysis

Students Code	Pretest	Posttest	N-gain	Categories
X1	72	100	1.00	High
X2	44	84	0.71	High
X3	60	96	0.90	High
X4	64	80	0.44	Middle
X5	56	88	0.73	High
X6	60	96	0.90	High
X7	60	96	0.90	High
X8	48	72	0.46	Middle
X9	80	80	0.00	Low
X10	72	100	1.00	High
X11	40	72	0.53	Middle
X12	64	100	1.00	High
X13	68	92	0.75	High
X14	40	80	0.67	Middle
X15	52	76	0.50	Middle
X16	48	72	0.46	Middle
X17	72	92	0.71	High
X18	68	100	1.00	High
X19	40	80	0.67	Middle
X20	56	76	0.45	Middle
X21	80	92	0.60	Middle
X22	48	84	0.69	Middle
X23	64	76	0.33	Middle
X24	68	100	1.00	High
X25	56	80	0.55	Middle
X26	92	96	0.50	Middle
X27	52	72	0.42	Middle
X28	68	84	0.50	Middle
X29	64	76	0.33	Middle
Average	61	86	0.65	Middle

After analyzing the hypothesis testing and N-gain average student learning outcomes, the next step is to look at the level of student motivation in the experimental class and the control class. The level of student learning motivation is reviewed after applying the learning treatment to each class. Analysis of student responses in terms of perceptions of student learning motivation is summarized according to the theory put forward by Davis (1986) which consists of four indicators including; usability, convenience, attitude (behavior), and behavioral intention. The following is the result of an analysis of increasing student learning motivation in the experimental class and the control class.

Table 9. Results of Control Class N-Gain Analysis

Students Code	Pretest	Posttest	N-gain	Categories
X1	52	60	0.17	Low
X2	68	72	0.13	Low
X3	60	64	0.10	Low
X4	48	52	0.08	Low
X5	64	68	0.11	Low
X6	44	48	0.07	Low
X7	60	60	0.00	Low
X8	80	84	0.20	Low
X9	76	80	0.17	Low
X10	52	56	0.08	Low
X11	84	88	0.25	Low
X12	56	64	0.18	Low
X13	48	60	0.23	Low
X14	56	68	0.27	Low
X15	64	76	0.33	Middle
X16	40	44	0.07	Low
X17	52	60	0.17	Low
X18	68	72	0.13	Low
X19	80	84	0.20	Low
X20	60	60	0.00	Low
X21	76	80	0.17	Low
X22	48	56	0.15	Low
X23	72	76	0.14	Low
X24	44	48	0.07	Low
X25	52	64	0.25	Low
Average	60	66	0.15	Low

Figure 1 shows the results of the analysis of the level of student learning motivation in the experimental class and the control class. Based on the results of data analysis, it proves that student learning motivation in the experimental class is higher than in the control class. The average result of student learning motivation in the experimental class was > 90 in the very good category, while the average student motivation in the control class was < 50 in the sufficient category. It can be concluded that through the effectiveness of using virtual reality-based virtual laboratories in the internet of things course in the Electrical Engineering Study Program, it is able to increase student learning motivation compared to conventional laboratory use. In line with the research results put forward by Buchori et al. (2020) that the Virtual Laboratory greatly influences student motivation and behavior. Other research results put forward by Purwaningtyas et al. (2022) that virtual laboratories are able to motivate student learning, due to students' interest in images, videos, and text, which is different from traditional practices that use modules.

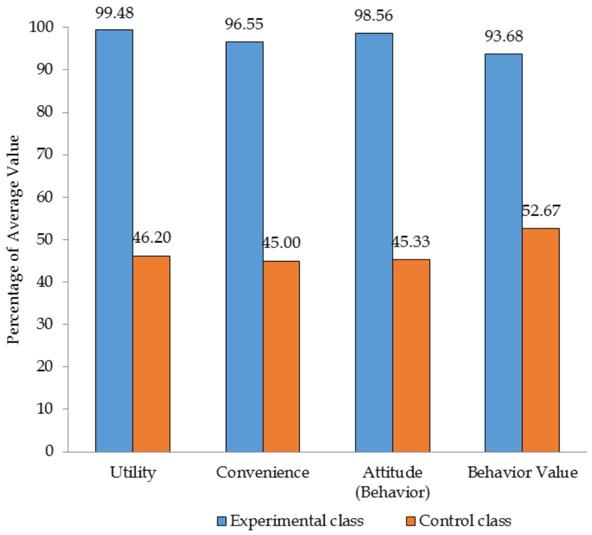

Figure 1. Results of the percentage of motivation analysis student learning

This is in line with research conducted by Sapriati et al. (2023) who said that the Virtual Laboratory (VLab) was designed with the aim of, among other things, preparing students to recognize the laboratory environment before being involved in real conditions. In addition, it is designed as a solution to overcome the problems encountered when conducting experiments in traditional classrooms. The intention to develop VLab is strengthened by the descriptions of educators in various articles which state that its implementation is more economical, time-saving, and able to reach more detailed experimental activities. In addition, Triatmaja et al. (2018) said that the use of a virtual laboratory (VLab) for digital electronics practicum is necessary for students to improve their digital electronics practice skills. Virtual laboratories for digital electronics can motivate students to do more practice than using real laboratories.

It can also be concluded that through the effectiveness of using virtual reality-based virtual laboratories in the internet of things course in the Electrical Engineering Study Program, it is able to increase student learning motivation compared to conventional laboratory use. In line with the research results put forward by Buchori et al. (2020) that the Virtual Laboratory greatly influences student motivation and behavior. Other research results put forward by Purwaningtyas et al. (2022) that virtual laboratories are able to motivate student learning, due to students' interest in images, videos, and text, which is different from traditional practices that use modules. In addition (Ilyas et al., 2022) virtual labs have many advantages such as being able to improve students' abilities to manipulate test variables correctly, improve concept learning, and can be accessed anytime and anywhere.

Students use virtual reality-based virtual laboratories in Internet of Things courses because the learning media are interesting, utilize virtual lab media as a means of completing assignments, and have the desire that virtual reality-based virtual laboratories can be used at any time without any time limits. In line with what was stated by Ramadiani et al. (2022) that virtual practicum activities can be carried out in a computer laboratory or virtual lab using certain applications that can support learning.

The results of the analysis of student learning motivation in the control class after applying learning through conventional laboratory use. The results of data analysis prove that attitudes and behavioral intentions are included in the sufficient category. This is because learning activities that are applied conventionally are still not able to increase student learning motivation.

The application of a conventional laboratory is one of the learning activities that is carried out directly without the existence of a specific learning method or model to identify problems in the subject matter of learning such as in Internet of Things courses. Learning activities in conventional laboratories focus more on direct activities without identifying problems as accurately as possible in the learning process.

Conclusion

Based on the results of the research that has been done, it can be concluded that increasing the effectiveness of using Virtual Reality-Based virtual laboratories can improve student learning outcomes in the Internet of Things Course in the Electrical Engineering Study Program. The increase in student learning outcomes analyzed using N-gain in the experimental class obtained an average value of 0.65 including the medium category, and the average N-gain for the control class was 0.15 in the low category. The average difference in student learning outcomes through the effectiveness of using Virtual Reality-Based virtual laboratories in Internet of Things Courses in the Electrical Engineering Study Program is significantly different. The results of the experimental class data analysis obtained the $t_{count} > t_{table}$ value, namely 8,351 > 2,003 and the Sig. (2-tailed) 0.005 <0.05, then Ha is accepted, meaning that there is a difference in the average student learning outcomes after using a virtual reality-based virtual laboratory in the internet of things course in the Electrical Engineering Study Program. While the results of the analysis of the control class data obtained the value of t_count > t_table, namely 1,600 <2,010 and the value of Sig. (2-tailed) 1.116 > 0.05, so there is no significant difference between student learning outcomes before and after carrying out conventional learning in the internet of thing course. Student learning motivation through the effective use of Virtual Reality-Based virtual laboratories in the Internet of Things Course in the Engineering Study Program can improve very well from the four indicators measured. The results of the analysis of student learning motivation in the experimental class obtained an average percentage of attitude (behavior) indicators reaching 98.56, and behavioral intentions reaching 93.68, while student learning motivation in the control class obtained an average percentage of attitude (behavior) indicators reaching 45.33, and behavioral intentions reached 52.67. The results of the analysis prove that students are more motivated to learn using Virtual Reality-Based virtual laboratories than conventional laboratories in Internet of Things courses.

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Author Contribution

Conceptualization: Sri Safiatuddin & Rustam Anawi, Data Curation and data acquisition: Sri Safiatuddin, methodology Sri Safiatuddin & Rustam Anawi, Visualization: Sri Safiatuddin, author of original draft: Sri Safiatuddin.

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Conflict of interest

No Conflicts of interest.

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