



The Effect of Using Virtual Laboratories on Dynamic Electricity Topic on Student Learning Outcomes

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Abstract: A virtual laboratory is an interactive science media assisted by computer applications in the form of science experiments. This research aims to determine the effect of using virtual laboratories on dynamic electricity topic on student learning outcomes. This type of research is quasi-experimental design research with a pretest-posttest control group design. The population in this study were all Class IX students of SMP Negeri 1 Wonosari in the current odd semester. The research results show that there is an influence on student learning outcomes. This is based on the hypothesis testing criteria, where t-count 2.09 is greater than t-table 2.02, and it can be concluded that hypothesis testing is t-count greater than t-table. The N-Gain test produced in the experimental class showed an N-Gain value of 1.18, which was included in the high criteria, while in the control class, the N-Gain value was 0.42, which was included in the medium criteria. The N-Gain value in the experimental class is included in the high criteria because the learning process uses a virtual laboratory in the experimental class. Virtual laboratories on dynamic electricity topic have an effect on student learning outcomes.

Keywords: Dynamic electricity; Learning outcomes; Virtual laboratories.

Introduction

Education in schools does not just teach learning content but also encourages students to discover and build their knowledge to develop life skills and be ready to face the challenges they will face. Education does not only emphasize the acquisition of grades but also the acquisition of skills (Kivunja, 2015). Students must also be able to do something with the procedures and scientific principles they have learned, and learning to know and to do must be achieved in teaching and learning activities (Abdjul & Ntobuo, 2019).

Learning outcomes are changes in a person's behavior that can be observed and measured through knowledge, attitudes, and skills. This change can be interpreted as a better improvement and development than before, and not knowing becomes knowing.

Learning outcomes can be interpreted as the maximum results that a student has achieved after experiencing the teaching and learning process in studying certain subject matter. Learning outcomes are not absolutely in the form of grades but can be in the form of changes, reasoning, discipline, and skills, which lead to positive changes (O'connor, 2017). Understanding learning outcomes is a process for determining student learning values through assessment activities or measuring learning outcomes (Mustaghfirah, 2022).

Along with the current development of science and technology, there is a strong need to develop human resources who can master science and technology. Education is a systematic, planned, and continuous effort both at the most concrete level as a short-term learning process goal and at the most abstract and general level in the sense of the "whole person" who will try as hard as possible to achieve

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educational goals. Which plays a role in nation-building and human development (Tolas et al., 2024). Every lesson requires strategies, methods, and learning media that give students a positive impression of the learning process. This is to ensure student achievement increases and the expected national education goals are achieved. As with science learning, almost all teaching materials require experimental activities to support the achievement of learning objectives (Fatimah et al., 2020).

One of the learning methods that requires experimental activities is science learning. Science learning is a part of education with great potential and a strategic role in developing quality human resources. The high school science curriculum focuses on giving students hands-on experience studying the environment, daily life, and events that occur in a society filled with modern technology. Therefore, with the guidance of innovative teachers, learning is needed that can increase student creativity (Mu'minah, 2022)

One way to encourage students' creativity when studying science is through practicums. Practicums provide students with the opportunity to prove theories, discover theories, and explain theories. Through these activities, students' understanding of the lesson rationalizes this phenomenon. Many science learning concepts and principles can be formed through a generalization process from facts observed in practical activities (Nurhasanah et al., 2023).

Based on the initial observations on interviews conducted at SMP Negeri 1 Wonosari, the school already has a laboratory. However, the laboratory is not used optimally due to lacking laboratory facilities and infrastructure, so they rarely do practical work. The limited laboratory facilities and practicum equipment in secondary schools in Indonesia inhibit science learning, which requires practicums. One effort that can be made to overcome various obstacles, especially the problem of laboratory facilities, is by utilizing computer application programs (courseware) in the form of virtual laboratories, which are currently widely available, either in the form of ready-made packages in the form of compact disk or using download from the internet (Setiadi & Muflika, 2020)

Virtual laboratories are an alternative to the limitations of real laboratories. A virtual laboratory is an interactive science media assisted by computer applications in the form of science experiments. Virtual laboratories can be used in the learning process to improve students' understanding of the material being studied and are very suitable for anticipating the unavailability of real laboratories (Aljuhani et al., 2018). The advantages of the Virtual Laboratory are that the learning process becomes more interesting and more

interactive, the amount of teaching time can be reduced, the quality of learning can be improved, and the teaching and learning process can be carried out anywhere and at any time (Nirwana, 2020), this is supported by research results (Meilina et al., 2023) that the use of the Virtual Laboratory is quite effective in having a good impact on students improving science process skills, creativity, mastery of concepts, motivation, and interest in learning of students so that learning outcomes also increase. Efficiency in funds, time, and facilities in virtual laboratories can be an alternative to the limitations of school laboratories. One of the virtual laboratories that has been developed is the virtual e-laboratory for dynamic electrical topic.

Various efforts have been made to develop virtual laboratories to overcome the problem of a lack of laboratory facilities and infrastructure. One of the virtual laboratories that has been developed and is used as a reference for this research is the dynamic electricity virtual e-laboratory. Based on this, researchers feel it is important to conduct experimental research on the effect of using a virtual laboratory on dynamic electricity topic on student learning outcomes at SMP Negeri 1 Wonosari by comparing the application of dynamic electricity virtual e-laboratories with other learning media.

Method

This type of research is quantitative with experimental research methods to see the differences in students' learning independence based on the Dynamic Electrical Virtual Laboratory with learning that uses PowerPoint (PPT) on dynamic electricity topic in Figure 1. This research was carried out at SMP Negeri 1 Wonosari, located at Jatimulya Village, Wonosari District, Boalemo Regency, in the odd semester of the 2024/2025 academic year. This type of research is quasi-experimental design research with a pretest-posttest control group design. The population in this study were all Class IX students of SMP Negeri 1 Wonosari in the current odd semester. In this research, the sampling method used is cluster random sampling. The details on how to take samples are by drawing lots using paper. The researcher prepared three rolls of paper, and the draw was carried out twice with the agreement that the roll of paper that fell first was used as the control class and the roll of paper that fell second was used as the experimental class. The sample results used are class IX-3 as a control class using PPT and class IX-2 as an experimental class using Virtual Laboratory-based learning media.

The data collection method used in this research is the test question technique. The test questions were

given twice, namely a pretest, which was carried out at the first meeting to determine the initial knowledge possessed by students in the experimental and control classes before receiving learning. Then, a posttest was carried out at the end of the meeting to determine whether there was an increase in student learning outcomes after the learning process. Research

instruments are used to measure the value of the variables studied. Thus, the number of instruments to be used for research will depend on the number of variables studied (Soegiyono, 2013). The instrument used in this research is a student learning test given to students as a learning outcomes test.

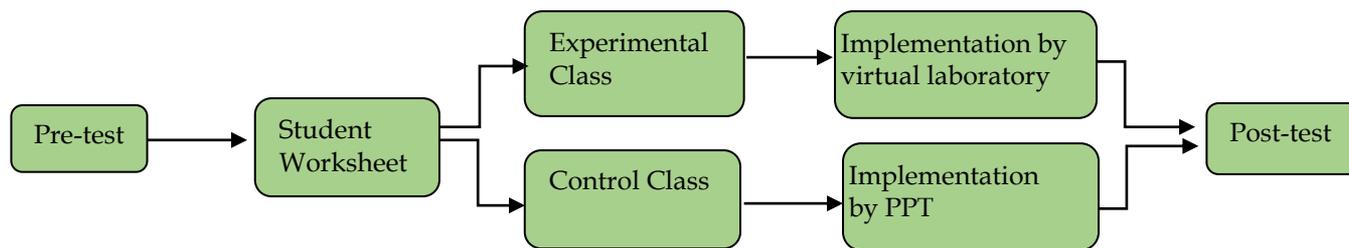


Figure 1. The flow chart of research

Result and Discussion

The data on student learning outcomes analyzed in this research consisted of two classes, namely the the experimental and control classes. In the experimental class, learning uses the Virtual Laboratory; in the control class, it uses PPT; both classes use the JIRE Collaborative learning method. To find out the students' initial abilities, the researcher first gave a pre-test to the experimental and control classes. Then, after being given a pre-test, the experimental class was given treatment in the form of learning using a virtual laboratory, and this treatment or treatment took place over three meetings in the experimental class. 3 meetings in the control class according to the Teaching Module listed on the attached page. Next, a post-test was given to determine the extent of success in learning using the Virtual Laboratory in the experimental class and PPT in the control class in Table 1.

Table 1. Scores for Experimental and Control Classes

Class	Pre-test	Pos-test
Experimental	36.96	83.04
Control	34.78	68.70

The average pre-test and post-test scores between the experimental and control classes are based on Table 1, which shows that the average points obtained are different; the average pre-test points obtained for the experimental class is 36.96 while the average post-test points for the experimental class were 83.04, and for the control class the average score for the pre-test was 34.78. The average post-test score for the control class was 68.70. The graph comparison experimental and control classes in Figure 2.

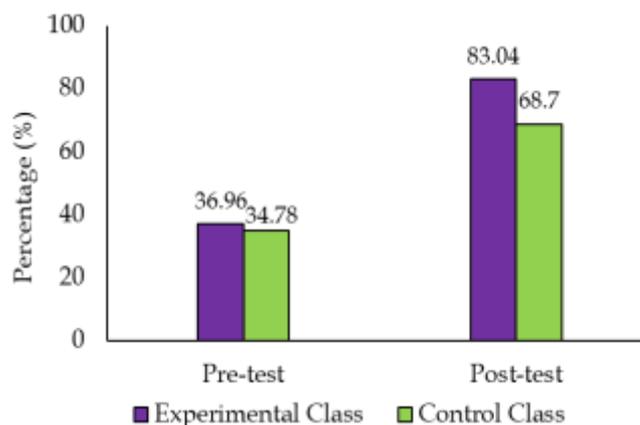


Figure 2. Average Pretest and Posttest Scores

Based on Figure 2, the post-test average score was better than the pre-test average for each experimental and control class. So, it is concluded that virtual e-laboratory learning media influences student learning outcomes. This is in line with research conducted by (Abdul & Ntobuo, 2019), which states that learning using virtual laboratories has an effect on student learning outcomes where there are differences in student learning outcomes who are taught using virtual laboratory learning media compared to those who are taught using teaching aids. The Virtual Laboratory influences student learning outcomes because it helps students better understand the concepts in learning dynamic electrical topic. Apart from that, learning with the Virtual Laboratory can make students more active in learning because students can carry out experiments directly. This is supported by research (Ariyanto et al., 2022) stating that the use of virtual laboratory media can help students understand concepts and increase learning activity, increasing student learning output.

This research aims to see the effect of the dynamic electricity virtual laboratory on student learning outcomes in dynamic electricity topic. Students being able to achieve cognitive competence is the goal of the results of the learning process. Students'

cognitive learning outcomes are obtained through the results of working on questions in the form of pretest and posttest, which include the ability to explain (C2), apply (C3), and analyze (C4). The results of students' cognitive abilities are shown in Figure 3.

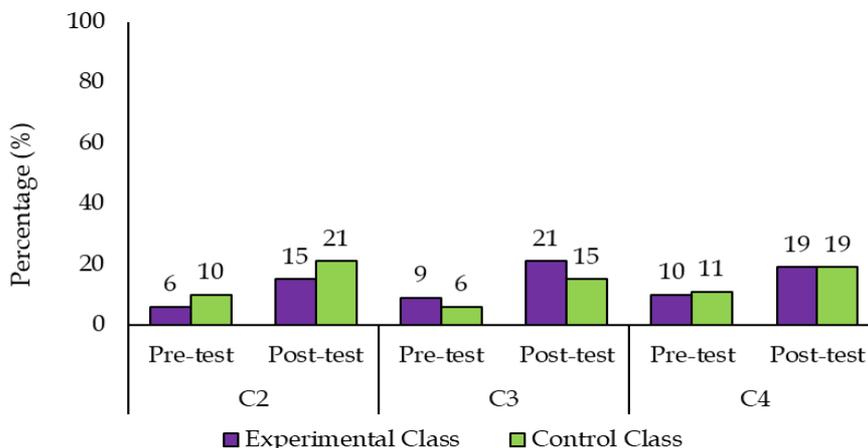


Figure 3. Cognitive Achievements of Experimental and Control Classes

Based on the percentage from Figure 3 of cognitive achievements in the experimental class regarding student learning outcomes obtained from the average post-test score, the cognitive presentation of the experimental class increased, where this increase occurred at all cognitive levels. However, the most visible increase was at cognitive level C3 (applying). An increase in student learning outcomes based on cognitive achievement results also occurred in the control class, which showed that C2 (explaining) had a high percentage. The average cognitive achievement of post-test scores in the experimental class increased significantly compared to the control class. Student activities and implementation of learning in the experimental class also influence cognitive improvement because learning uses a virtual laboratory where students must be actively involved in conducting dynamic electrical circuit experiments. This aligns with research conducted by (Abdjul & Ntobuo, 2019). Their research stated that in learning using a virtual laboratory, students must actively discover abstract wave concepts that cannot be seen with the naked eye and can prove these concepts through existing reference books.

Learning implementation data shows that the level of implementation in the experimental class and control class is higher than the level of non-implementation in the experimental class and control class. Student activity shows that the level of student activity in the experimental class is higher than in the control class. As seen in the table above, the success level of student activity meets three criteria: high,

medium, and low. The average success rate gets a high score from the first meeting to the third meeting.

Normality Test

In this research, the Smirnov Colmogrof normality test formula was used using Microsoft Excel to test the normality of data in both experimental and control classes. The data normality test results are in Table 2.

Table 2. Normality Test Results

Class	F_i	K	Status
Experimental	0.47	0.28	Normally distributed
Control	0.47	0.28	Normally distributed

Normality testing is a prerequisite test before hypothesis testing is carried out. According to Narlan et al. (2018), the purpose of normality testing is to find out whether the distribution of selected samples originating from a population is declared normal or abnormal. The results of data normality testing show that $F_i \geq K$ for the $\alpha = 0.05$ level.

Normality test data shows in Table 2 that the experimental classes, replication 1 and replication 2, have a F_i value of 0.47, while the K value for the three classes is 0.28. The results of data normality testing show that $F_i \geq K$ for the $\alpha = 0.05$ level. Thus, it can be concluded that the experimental and control classes' research data are normally distributed. This normal distribution is important because it supports the validity of the statistical analysis that will be carried out next and provides confidence that the research results

can be interpreted correctly in the learning context being applied. This is supported by research conducted by (Arumningtyas et al., 2022), where in his research the Kolmogorov-Smirnov normality test obtained a significance value of $\alpha > 0.05$ with a F_i of 11.7, indicating a normal distribution.

Homogeneity Test

In this research, the F test is used in the homogeneity test, with the test criteria being that if the value of T-count $<$ F-table value, then the data will be declared homogeneous using Microsoft Excel. The data from the F test results in Table 3.

Table 3. Homogeneity Test Results

F-count	F-table	Information
1.80	2.05	homogeneous

The variance homogeneity test aims to see whether the pre-test and post-test data have homogeneous variations. In this research, the F test is used in the homogeneity test, with the test criteria being that if the value of F-count $<$ F-table, then the data will be declared homogeneous using Microsoft Excel. The homogeneity test value in Table 3 obtained was 1.80 and F-table 2.05, so based on the analysis results, the data in the experimental class varied homogeneously. This is supported by research conducted by (Dalu et al., 2020), where in their research, it was discovered that for homogeneity calculations, a F-count value of $1.36 <$ F-table 2.56 was obtained, which means the data is homogeneous.

Hypothesis Testing

Hypothesis testing is carried out to analyze statements whose truth is still in doubt (not certain). This hypothesis test aims to determine whether using the Virtual Laboratory on dynamic electrical topic in the experimental class and using PPT in the control class has an effect. As for the results of hypothesis testing for the experimental class and control class, it was obtained that t-count $>$ t-table for the $\alpha = 0.05$ level. So H_0 is accepted, and H_1 is rejected, with t-count 2.09 greater than t-table 2.02, which can be seen in Table 4.

Table 4. Hypothesis Testing Results

t-count	t-table	Information
2.09	2.02	H_0 accepted

Table 4 shows differences in student learning outcomes in classes given the Dynamic Electrical Virtual Laboratory and classes that use PPT. This is because students can better understand concepts and directly carry out experiments when learning to use the

virtual laboratory, not just listen and observe. This is supported by research conducted by (Rihi & Bano, 2022) in their research stating that there are differences in learning outcomes between experimental classes that use conventional learning virtual laboratories where in learning using virtual laboratories, students understand the material better and do practical work without having to be in the laboratory.

N-Gain Test

The n-gain test measures the effectiveness of learning before learning (pretest) and after learning (posttest). The n-gain test results for the experimental class and control class can be seen in Table 5.

Table 5. N-Gain Test Results

Class	N-Gain	Criteria
Experimental	1.18	High
Control	0.42	Medium

N-gain or normalized gain in Table 5, which means normalized increase, is a method of measuring the effectiveness of learning or intervention in improving student learning outcomes (Sukarelawan et al., 2024). The n-gain test measures the effectiveness of learning before learning (pretest) and after learning (posttest). The N-Gain test produced in the experimental class showed an N-Gain value of 1.18, which was included in the high criteria, while in the control class, the N-Gain value was 0.42, which was included in the medium criteria. The N-Gain value in the experimental class is included in the high criteria because the learning process uses a virtual laboratory in the experimental class. This aligns with research (Arumningtyas et al., 2022) that virtual laboratory media can improve student learning outcomes in lessons. Science material on Archimedes' Law. This is proven by the pretest and posttest N-Gain test scores, which obtained a score of 0.8, an increase in the high category.

Conclusion

Based on the research results, the researcher concluded that learning using the Virtual E-Laboratory for Dynamic Electrical topic in class IX of SMP Negeri 1 Wonosari influenced student learning outcomes. This is based on the hypothesis testing criteria, where t-count 2.09 is greater than t-table 2.02. It can be concluded that hypothesis testing is t-count greater than t-table. The N-Gain test produced in the experimental class showed an N-Gain value of 1.18, which was included in the high criteria, while in the control class, the N-Gain value was 0.42, which was included in the medium criteria. The

N-Gain value in the experimental class is included in the high criteria because the learning process uses a virtual laboratory in the experimental class. This can be interpreted as the Virtual Laboratory of Dynamic Electrical topic having an influence on student learning outcomes in junior high school Negeri 1 Wonosari.

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