Received : 18 December 2023
Revised : 7 June 2024
Accepted : 17 June 2024
Published: 28 June 2024
Issued : 30 June 2024

DOI: doi.org/10.21009/1.10114

Impact of Using PhET and NI Multisim Simulation on Understanding Electrical Circuit Concepts

A. Halim[1,2,a)], Maiza Alinda[1], Elmi Mahzum[1], Agus Wahyuni[1], Ngadimin[1]

[1]*Department of Physics Education, Teacher Training and Education Faculty, Universita Syiah Kuala, Kopelma Darussalam-Banda Aceh 23111, Indonesia*
[2]*Centre of STEM Study, Universita Syiah Kuala, Kopelma Darussalam-Banda Aceh 23111, Indonesia*

✉: [a)]abdul.halim@usk.ac.id

Abstract

The lack of physics practicum equipment in schools is one of the reasons why practicum activities are rarely carried out, so many students still do not understand the physics concepts being taught. Therefore, one of the aims of this study is to apply two types of virtual practical media (PhET and NI Multisin simulations) and assess their effectiveness. This research uses a quasi-experimental approach with a non-equivalent control group design. In other words, the study utilized two experimental groups and one control group. All students in class 12 of high school from five localities comprised the research population, and a purposive sampling technique randomly selected a sample of three classes. So we got a sample of class 12-1 science for experimental group 1, class 12-2 science for experimental group 2, and class 12-3 science for the control group. After the testing prerequisites were met, the independent sample t-test at a significance level of 0.05 was used for data analysis. According to the data analysis results, there are significant differences in conceptual understanding between students in the control class, PhET class, and NI Multisim class. The research concludes that lecturers or teachers wishing to conduct virtual practicums in physics learning should utilize the NI Multisim simulation due to its ease of use and its more suitable facilities for the topic under study.

Keywords: PhET, NI Multisim, simulation, understanding concepts, physics practicum

INTRODUCTION

Education is an effort to create intelligent and quality human resources in the future. Education is also one of the government's efforts to realize the country's ideals, which have been formulated in the fourth paragraph of the 1945 Constitution, namely to make the life of the nation intelligent (Ramadani & Nana, 2020). However, in reality, Indonesia is still very far from national education goals. One of the problems facing the world of education in Indonesia is the weak learning process (Meishanti & Fitri, 2022). Students in the learning process only take notes, listen, are passive, and only memorize concepts from the material being taught. The aim of understanding concepts is so that students can remember the concepts of the material being studied (Maulidyah & Zainuddin, 2022).

Understanding is a person's ability to interpret, translate, or state something in his own way about the concepts he receives (Setyawati, Hidayati, & Hermawan, 2020). Understanding concepts is an important aspect of learning and is also the main goal of learning itself. A concept is a basic unit of cognition that is built from a fact or example, thus forming an abstract thought or image (Radiusman, 2020). In physics learning, many efforts have been made to increase understanding of concepts (Maulidyah & Zainuddin, 2022; Ramadani & Nana, 2020; Yulisa, Hakim, & Lia, 2020). Students who are able to build a good understanding of concepts will be able to construct knowledge and also be able to choose problem-solving methods well (Foster, 2021).

The low ability to understand concepts is caused by several things, one of which is the learning process in the classroom. In the learning process, teachers tend to convey information solely using the lecture method and do not use adequate learning models or media (Maulidyah & Zainuddin, 2022). Teachers only teach abstract physics through classroom learning and are not equipped with practical activities in the laboratory (Chania, Medriati, & Mayub, 2020). On the other hand, this practicum activity must be carried out because it has been proven to increase students' understanding of concepts (Nurwahidah & Sari, 2022; Mohyeden, 2021). In fact, practical activities are rarely carried out, even in schools that are categorized as good. One of the reasons is the unavailability of laboratories or a lack of facilities that support the implementation of practicums (Sari et al., 2023). However, along with the rapid development of technology, limited practical equipment is not a problem. There are many supporting simulations that can be used as substitute practical tools for conducting experiments.

A simulation that can be used to support learning and practical implementation is the PhET simulation. As a simulation software, PhET has a series of interactive simulations that are very beneficial in integrating computer technology into practicum and learning (Farida et al., 2020, November). Besides that, this simulation works on several computer operating systems and is easy to use (Putri, 2021). Apart from that, this simulation can also be used online or offline and presents various simulations on science material, including physics material (Arifin, Prastowo, & Harijanto, 2022). In the field of physics, PhET displays physics simulations that can explain various abstract concepts that are difficult to test in real laboratories.

The effectiveness of the PhET simulation medium has been proven through several research results that have been carried out, including that PhET simulation is very suitable for carrying out experiments that cannot be carried out in a real lab (Mardhatilla, 2021, December). Apart from that, the use of PhET is also able to help students discover or clarify the concepts being studied in a real and effective way to explain abstract physics concepts (Rizaldi et al., 2020). Besides that, PhET simulations can improve understanding of concepts or science learning outcomes with N-gain scores in the high category (Theasy et al., 2021). Other results show that PhET simulations can improve students' ability to understand physics concepts in the medium category, and there is a very large effect on the effect size score (Sasmita et al., 2023).

Apart from that, there is also the NI Multisim simulation, which can be used as a learning support, but it can only be used to simulate how an electronic circuit works (Alfikri & Rahayu, 2023). The NI Multisim program was first created by the Electronics Workbench company, is known as Electronics Instruments, and is used as a learning tool in the field of electronics. There are several advantages of NI Multisim simulation, including being able to model various circuit designs with a complete set of available components; almost unlimited combinations of circuit designs can be created; and its operation is quite easy to do (Azman & Ab Rahman, 2022).

Regarding the effectiveness of the NI Multisim media, a lot of research has been carried out, including that the NI Multisim media can be used as a virtual lab practicum facility for electrical classes conducted online (Azman & Ab Rahman, 2022). The results of other research show that the use of Multisim in the simulation and practicum process helps students understand the theory they have studied (Susilaningrum, 2022). Besides that, it shows that the implementation of NI Multisim in electrical engineering learning can increase students' knowledge, interest, and learning quality (Handayani et al., 2020). Likewise, the results obtained by Ridwan and Kembuan (2021) show that using the NI Multisim virtual application in learning electrical engineering can increase students' interest and make it easy to practice the material they have studied according to the actual physical form of the components.

Based on the results of observations and interviews with physics students and teachers at Unggul Darussalam State High School, Labuhan Haji, South Aceh, it is known that the average score for physics subjects on the concept of dynamic electricity is relatively low. One of the reasons is thought to be due to limited practical media, such as electrical kits. Students only receive the concept of dynamic electricity theoretically without carrying out trials or practicums, especially those related to electrical circuits, so they do not master the concepts in the dynamic electricity material taught. Based on the analysis of relevant research results and also based on observation results in target schools, the use of PhET simulation and NI Multisim simulation on the dynamic electrical concept is expected to be the right solution to this problem.

METHODS

Research Approach and Design

This research was carried out using a quantitative approach, because it is based on calculations using numbers starting from data collection, interpretation of the data to the appearance of the results. Meanwhile, the type of research used is quasi-experimental, because it is based on the research objective to determine the effects of a treatment.
Even though there is a control group, it does not function completely to control external variables that influence the implementation of the experiment. Furthermore, the research design that will be used is a nonequivalent control group design. Includes two experimental classes and one control class, namely the first experimental class is taught using the PhET simulation, the second experimental class is taught using the NI Multisim simulation and the control class without using supporting simulations. Before and after the treatment, the three experimental classes were given the same pre-test and post-test to obtain information on students' conceptual understanding. In detail the design of this research can be seen in TABLE 1 (Sugiyono, 2019).

TABLE 1. Design of Research

Sample	*Pre-test*	*Treatment*	*Post-test*
Experimental Group 01	Q_1	X_1	Q_2
Experimental Group 02	Q_1	X_2	Q_2
Control	Q_1	X_3	Q_2

Population and Sample of Research

Population is a generalization area consisting of subjects or objects that have certain characteristics and qualities selected by researchers who will then be studied and conclusions drawn (Sugiyono, 2019). The population in this research is all students in class XII Science at Senior High School, South Aceh in 2023.

Meanwhile, the research sample is part of the population that will be studied by the researcher. Sampling in this research was carried out using a saturated sampling technique, where all members of the population were used as samples (Sugiyono, 2019). The sample used in this research consisted of three classes, namely class XII Science 1 High School as experimental group 01 which was taught using the PhET simulation, class XII IPA 3 Senior High School as a control group.

Data Collection Instrument

The instrument used for data collection in this research is a written test in the form of an essay test which represents the indicators to be achieved. The essay test was prepared based on indicators of concept understanding developed by Anderson & Krathwohl (2000) then modified and adapted to the learning objectives of Dynamic Electrical concepts. Next, the essay test script is validated for content and criteria by experts.

Data Analysis

The data in this research is in the form of concept understanding test data before (pretest) and after (posttest) using PhET simulations and NI Multisim simulations in learning. Next, to determine the increase in students' conceptual understanding, data analysis was carried out using the normalized N-gain formula formulated by Hake (1999). In addition, a normality test was carried out using the Shapiro-Wilk test, while for the homogeneity test the Levene test formula was used with a significance level of 0.05 (Khatun, 2021).

Furthermore, once it is known that the data is normally distributed and comes from a population with homogeneous variance, hypothesis testing can be carried out using the independent sample t-test with a significance level of 0.05. The purpose of this test was to determine whether there were differences in students' conceptual understanding of electrical resistance circuit material for experimental group 1, experimental group 2 and the control group.

Data Analysis for Concept Understanding Test Results

The data in this research are the results of students' answers to the results of concept understanding tests before and after the experiment which will be analyzed using the N-gain formula. The scoring guidelines and answer criteria for measuring students' conceptual understanding can be seen in TABLE 2 (Abraham et al., 1992).

TABLE 2. Rubric for Assessment of Concept Comprehension Test in Description Form

Level of Understanding		Criteria of Answers
0	Didn't Answer (DA)	Didn't give an answer Answer Don't Know Answer: Don't Understand
1	Not Understanding (NU)	Completely a repetition The answer does not match the statement Unclear answer
2	Misunderstanding (Mis)	The answer given does not make scientific sense Answers that do not comply with scientific concepts
3	Partial Understanding (PU)	The answer is only correct in one aspect, other aspects are not given answers The answers given contain all the expected aspects, but not all of them are correct
4	Complete Understanding (CU)	The answers reflect all aspects and are all filled in correctly

Furthermore, the increase in conceptual understanding of each indicator tested before and after the experiment was calculated based on the normalized N-gain score using the Hake (1999) formula in EQUATION (1).

$$N - gain : \frac{Skor_{posttest} - Skor_{pretest}}{Skor_{max} - Skor_{pretest}} \tag{1}$$

Interpretation of calculation results using the N-gain formula refers to three categories, namely; high, medium and low, as shown in TABLE 3 (Hake, 1999).

TABLE 3. Criteria of N-gain score

N-Gain value range	Categories
(N-gain) > 0.7	High
0.3 ≤ (N-gain) ≤ 0.7	Middle
(N-gain) < 0.3	Low

Normality Test

The normality test aims to determine the normality of data distribution and to fulfill the statistical testing requirements for hypothesis testing. The normality test was carried out on students' concept understanding test data on dynamic electricity material in experimental group 1, experimental group 2 and the control group. The normality test used in this research is the Shapiro Wilk Test which is calculated using SPSS. The form of the hypothesis for the normality test is as follows:

H0: Data is normally distributed

H1: Data is not normally distributed

The criteria for testing are if the significance value (Sig.) > 0.05 then the data is normally distributed and if the significance value (Sig.) < 0.05 then the data is not normally distributed.

Homogeneity Test

The homogeneity of variance test is carried out to determine whether the samples taken come from a homogeneous population or not. This homogeneity test was carried out using the Levene test with a significance level of 0.05. The form of the homogeneity test hypothesis is as follows:

H0: Data variance is homogeneous

H1: Data variance is not homogeneous

The test criteria used in the Levene test are if the Wcount value is > 0.05 then H0 is accepted, meaning the data group has a homogeneous variance (Putra et al., 2019).

Hypothesis Testing

Hypotheses are possible answers to problems faced in research, which are actually still weak so they must be tested empirically (Hasan, 2011). If it is known that the data is normally distributed and homogeneous then a parametric test can be carried out, namely the Independent sample t-test. This test is used to determine the difference in the average of two independent populations/groups of data. The form of the independent sample t test hypothesis test is as follows:

H0: There is no difference in the average of the two groups

H1: There is a difference in the means of the two groups

The testing criteria used in this test are if the value thit > t-table then H0 is rejected and H1 is accepted, meaning there is a difference in the averages of the two groups (Nuryadi et al., 2017)

RESULTS

Research Result

This quasi-experimental research was conducted in class XII Science at Senior High School, Labuhanhaji, South Aceh on the topic of electrical resistance circuits. This research involved 3 different groups, consisting of 2 experimental groups and 1 control group. Experimental group 1 was taught using the PhET simulation while experimental group 2 was taught using the NI Multisim simulation, while the control group was taught without using media.

The data obtained in this research is pretest and posttest data which consists of 10 questions describing conceptual understanding. The data was analyzed to find out how students' understanding of concepts taught using the PhET simulation, NI Multisim simulation and without using media on electrical resistance circuits was compared.

Test Results of Concept Understanding

The students' concept understanding test data analyzed were data before (pretest) and after (posttest) treatment in experimental group 1, experimental group 2 and control group at Senior High School, South Aceh. Furthermore, the results of the N-gain calculation to determine the increase in students' understanding of concepts are obtained as shown in TABLE 4.

TABLE 4. N-gain of Concepts Understanding Test

Indicator	Experimental Group 1			Experimental Group 2			Control Group		
	Pretest	*Posttest*	N-gain	*Pretest*	*Posttest*	N-gain	*Pretest*	*Posttest*	N-gain
Ik01	3.9	4	1	3.8	4	1	2.9	3.1	0.2
Ik02	5.9	7.07	0.6	5.7	7.3	0.7	4.6	6	0.4
Ik03	3.87	7.4	0.9	4.4	7.4	0.8	3.5	6	0.6
Ik04	9	14.8	0.8	8.1	15.2	0.9	5.6	10.4	0.5
Ik05	2.27	3.6	0.8	3.1	3.8	0.8	1.2	2.5	0.5
Means			**0.82**			**0.84**			**0.44**

Based on TABLE 4, it can be seen the difference in the N-gain scores in students' conceptual understanding for each indicator. Based on the results of the analysis referring to the N-gain score criteria in TABLE 3, it can be seen that in Ik01, namely observing the differences in series and parallel electrical resistance circuits, it was found that the N-gain score for students' conceptual understanding in experimental class 1 was 1, which is in the high category. and the N-gain score for students' conceptual understanding in experimental class 2 is 1, which is also in the high category, while the N-gain score for students' conceptual understanding in the control class is 0.2, which is in the low category.

Furthermore, in Ik02, namely identifying the characteristics of electrical resistance circuits, it was found that the N-gain score of students' conceptual understanding in experimental class 1 was 0.6 which was in the medium category and the N-gain score of students' conceptual understanding in experimental class 2 was 0.7 which is in the medium category, while the N-gain score for students' conceptual understanding in the control class is 0.4, which is also in the medium category.

Meanwhile, in Ik03, namely classifying the relationship of quantities in series and parallel resistance circuits, it was found that the N-gain score of students' conceptual understanding in experimental class 1 was 0.9 which was in the high category and the N-gain score of students' conceptual understanding in experimental class 2 was 0.8 which was also in the high category, while the N-gain score for students' conceptual understanding in the control class was 0.6, which was in the medium category.

Then, in Ik04, namely analyzing questions about series and parallel resistance circuits, it was found that the N-gain score of students' conceptual understanding in experimental class 1 was 0.8 which was in the high category and the N-gain score of students' conceptual understanding in experimental class 2 was 0.9 which is also in the high category, while the N-gain score for students' conceptual understanding in the control class is 0.5 which is in the medium category.

Meanwhile, the Ik05 indicator, which summarizes the working principles of series and parallel resistance circuits, found that the N-gain score for students' conceptual understanding in experimental class 1 was 0.8 which was in the high category and the N-gain score for students' conceptual understanding in experimental class 2 was 0. .8 which is also in the high category, while the N-gain score for students' conceptual understanding in the control class is 0.5 which is in the medium category. A comparison of the increase in students' understanding of concepts can be seen in the N-gain scores of the three groups presented in FIGURE 1.

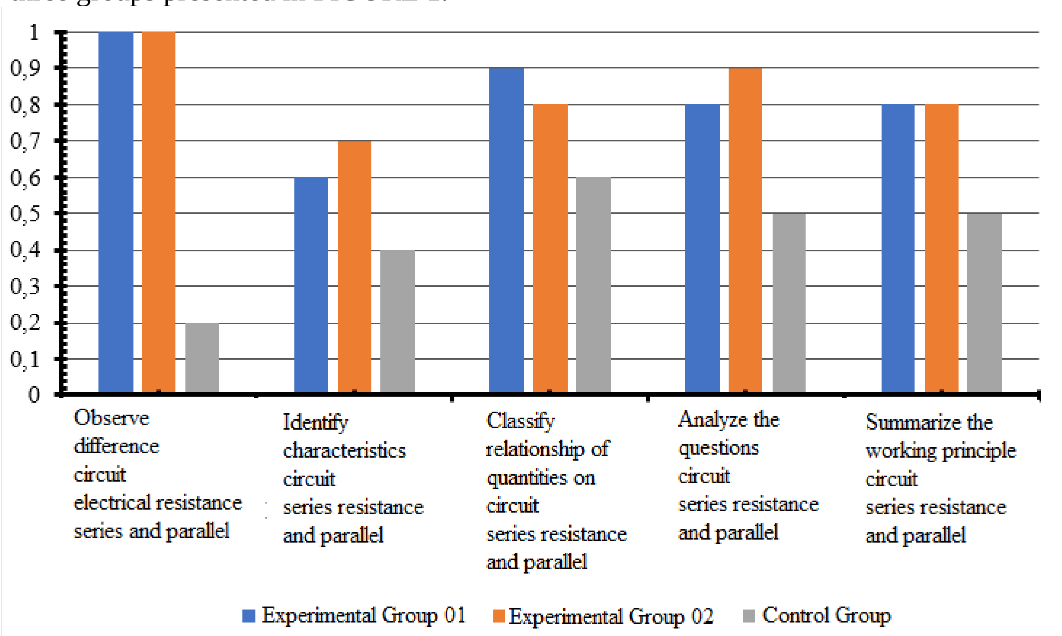

FIGURE 1. N-gain graph for experimental group 1, experimental group 2 and control group.

Based on FIGURE 1, it is known that there is a difference in the increase in students' understanding of concepts for each indicator in each group. The highest N-gain score is found in the first indicator (observing the difference between series and parallel electrical resistance circuits) with an N-gain score of 1 in experimental class 1 and experimental class 2. Meanwhile, the lowest N-gain score is also found in the first indicator with a score of N- gain of 0.2 in the control group.

Result of Normality Test

The normality test was carried out using the Shapiro-Wilk technique, a technique because the sample used was less than 100 respondents. The results of data analysis using SPSS for the normality test are shown in TABLE 5.

TABLE 5. Normality Test Results for Control Group and Experimental Groups

Shapiro Wilk	Normality Test		
	Experimental Group 1	**Experimental Group 2**	**Control Group**
Sig	0.407	0.159	0.682
α	0.05	0.05	0.05
Decision	Data is normally distributed	Data is normally distributed	Data is normally distributed

Based on TABLE 5, it can be seen that the significance level value (sig. > 0.05) was used for experimental group 1, experimental group 2 and also the control group. This shows that the data is normally distributed, this decision was taken based on the normality hypothesis testing criteria, namely if the significance value (Sig.) > 0.05 then the data is normally distributed.

Results of Homogeneity Test Analysis

The homogeneity test was carried out using Levene's test with a significance level of 0.05. The criteria for testing are if it is significant (Sig.) > 0.05 then H0 is accepted and if it is significant (Sig.) < 0.05 then H0 is rejected. Complete homogeneity test results are presented in TABLE 6.

TABLE 6. Result of Homogeneity Test

Levene Statistic	Homogeneity Test		
	Control Group – Experimental Group 1	**Control Group – Experimental Group 2**	**Experimental Group 1 – Experimental Group 2**
Sig	0.446	0.110	0.370
α	0.05	0.05	0.05
Decision	Homogeneous data	Homogeneous data	Homogeneous data

Based on TABLE 6, the results show that the significant value (Sig.) is 0.659 - 0.05 and H0 is accepted, so it can be assumed that the data comes from a homogeneous population.

Hypotesis Test

The hypothesis test used in this research is the independent sample t-test with a significance level = 0.05. With the test criteria, if the value of t-count is t-table then H1 is accepted. The results of the hypothesis test are presented in TABLE 7.

TABLE 7. Results of Hipotesis Test

Hypothesis Test	t_{count}	t_{table}	Decision
Control Group –Experimental Group 1	12.049	2.068	H_1 Accepted
Control Group –Experimental Group 2	13.931	2.068	H_1 Accepted
Experimental Group 1 –Experimental Group 2	4.369	2.048	H_1 Accepted

Based on TABLE 7, the results show that the t-count value in the independent sample t-test in the control group and experimental group 1 is 12.049 and the t-count value is 12.049 > t-table 2.068, so H0 is rejected and H1 is accepted, so it is known that there is a difference in understanding. concept of students in the control group and experimental group 1.

Furthermore, the results obtained were that the t value in the independent sample t-test in the control group and experimental group 2 was 13.931. Meanwhile, the t-calculated value is 13.9311 > t-table

2.068, so H0 is rejected and H1 is accepted, so it is known that there are also differences in students' conceptual understanding in the control class and experimental class 2.

Then the result was also obtained that the t value in the independent sample t-test in experimental group 1 and experimental group 2 was 4.369. Where the value of t-count is 4.369 > t-table 2.048, then H0 is rejected and H1 is accepted, so it is known that there is a difference in students' understanding of the concept in experimental group 1 and experimental group 2

DISCUSSION

Students' ability to understand concepts has a different average N-gain score for each class. In experimental class 1, students who received learning using the PhET simulation had an average N-gain score of 0.82 which was in the high category. This shows that the use of PhET simulations in learning can increase students' understanding of concepts. This is in line with research conducted by Sasmita et al., (2023) which states that the use of PhET simulations in learning can improve students' ability to understand physics concepts with an average N-gain of 0.68 which is in the medium category. Furthermore, this PhET simulation also influences students' ability to understand physics concepts with an effect size score of 0.83 which is in the high category. Apart from that, in research conducted by Sinulingga et al., (2016), the results showed that the use of PhET simulation media was able to improve student learning outcomes, where 85.29% of students succeeded in achieving the KKM with an average of 72.35 in the cycle. first and there were 89.47% of students who succeeded in achieving the KKM with an average of 76.97 in dynamic electrical material.

Furthermore, in experimental class 2, the average N-gain score was 0.84, which was in the high category. This shows that the use of the NI Multisim simulation can also improve students' ability to understand concepts. Because the use of the NI Multisim simulation in learning places more emphasis on students creating electronic circuits so that students are able to analyze each element used. In addition, the NI multisim simulation has more complete electronic measuring tools compared to the PhET simulation, making it very suitable for conducting virtual experiments on electronic materials. This is supported by research conducted by (Amiruddin, 2017) which states that the use of NI Multisim simulation in learning is effective in increasing understanding of dynamic electrical concepts with a percentage of 80%. Apart from that, based on research conducted by (Budiono & Rakhmawati, 2017; Frendi Bagus Septianto, 2015), the results showed that there was an influence of using the NI Multisim simulation on students' conceptual understanding.

Observe

The results of data analysis on the observing indicators in this research showed that the N-gain score in experimental class 1 and experimental class 2 was 1, which was in the high category, while in the control class, the N-gain score was 0.2, which was in the low category. Based on these results, it can be seen that the level of conceptual understanding of students in experimental class 1 and experimental class 2 is higher than that of students in the control class.

Students in experimental 1 and experimental 2 classes receive learning with the help of supporting simulations, namely in the form of PhET simulations and NI Multisim simulations, so that students can observe each part of the electrical circuit being studied. Students will better understand a concept if students directly observe what is being studied. This is in line with research conducted by (Nisa, 2017) which states that students who experience the learning process directly, for example through practicums, will find it easier for students to build knowledge and understand concepts about something in science more easily. and automatically students can memorize and remember the material given.

Identify

The results of data analysis on identifying indicators in this study, obtained an N-gain score in experimental class 1 of 0.6, in experimental class 2 an N-gain score of 0.7 was obtained and in the control class an N-gain score was 0.4. which is in the medium category. Based on these data, it can be seen that the level of conceptual understanding of students in experimental class 1, experimental 2 and control class is in the same category, namely the medium category with the highest N-gain score on this indicator in experimental class 2.

Experimental class 2 is a student class taught using the NI Multisim simulation. This simulation allows students to create an electrical circuit design that is similar to the original so that students can easily identify each part of the electrical circuit being studied. This causes students to be able to identify the characteristics of each series.

Classifying

The results of data analysis on identifying indicators in this study, obtained an N-gain score in experimental class 1 of 0.6, in experimental class 2 an N-gain score of 0.7 was obtained and in the control class an N-gain score was 0.4. which is in the medium category. Based on these data, it can be seen that the level of conceptual understanding of students in experimental class 1, experimental 2 and control class is in the same category, namely the medium category with the highest N-gain score on this indicator in experimental class 2.

Experimental class 2 is a student class taught using the NI Multisim simulation. This simulation allows students to create an electrical circuit design that is similar to the original so that students can easily identify each part of the electrical circuit being studied. This causes students to be able to identify the characteristics of each series.

Analyze

The results of data analysis on the analyzing indicators obtained an N-gain score in experimental class 1 of 0.8, while in experimental class 2 an N-gain score of 0.9 was obtained, which was in the high category, while in the control class it was found that the N-gain score was 0. .5 which is in the medium category. Based on these results, it can be seen that the level of conceptual understanding of students in experimental class 1 and experimental class 2 is in the high category, while students who do not receive learning with any supporting simulations are in the medium category with the highest N-gain score on this indicator being at experimental class 2.

The use of NI Multisim simulation in experimental class 2 really allows students to analyze various problems in electrical resistance circuit material, because this software provides analysis features, SPICE simulation and PCB tools to help students develop circuit designs quickly and effectively (NI Multisim, 2022). So by implementing this simulation in learning it is able to increase students' conceptual understanding of analyzing indicators.

Summarize

The results of data analysis on indicators summarize that the N-gain score in experimental class 1 and experimental class 2 was 0.8, which is in the high category, while in the control class, the N-gain score was 0.5, which is in the medium category. Based on these results, it can be seen that the level of conceptual understanding of students in experimental class 1 and experimental class 2 is higher than that of students in the control class.

The use of PhET simulations and NI Multisim simulations in learning is able to increase students' conceptual understanding of summarizing indicators, this can be seen from the N-gain scores obtained from the two classes. These results are in line with research conducted by (Sasmita et al., 2023) which shows that students' conceptual understanding of the summarizing indicators is in the medium category. Apart from that, increased understanding of this concept can occur because students are directly involved in the practicum activities carried out.

Based on this explanation, it can be seen that there are differences in the use of PhET simulations and NI Multisim simulations in learning regarding students' concept understanding abilities for each indicator of concept understanding. This result is strengthened by the results of hypothesis testing where the value of t-table > t-count means that the use of PhET simulation and NI Multisim simulation in learning can have a significant impact on students' conceptual understanding of electrical resistance circuit material.

Much research has been carried out on understanding concepts in physics learning, especially in relation to concepts that are laden or contain many misconceptions. For example, the development of Student Worksheets (SW) to improve understanding of concepts (Hasja et al., 2020; Halim et al., 2021), the GeoGebra application to increase understanding of physics concepts (Halim et al., 2021a), the use of PhET simulations for understanding concepts (Mizayanti et al., 2020; Arifullah et al., 2020), the effect of multi-representative videos on understanding concepts (Halim et al., 2021b), and the impact of E-Learning modules on understanding and misconceptions (Halim et al., 2021c).

CONCLUSION

Based on the analysis and discussion, it can be concluded that there are differences in students' conceptual understanding of electrical resistance circuits among the three classes at Unggul Darussalam Labuhanhaji State High School. The average N-gain scores are in the high category for both experimental classes and the medium category for the control class. The independent sample t-test results (t-count > t-table) confirm a significant difference in conceptual understanding among the classes. This research has certain limitations, including the scarcity of reading materials on the application of NI Multisim simulations in learning. Therefore, this study can serve as a reference for future researchers. Future research should provide guidance to students during practicum activities using PhET or NI Multisim simulations, as well as consider using these simulations for other physics topics.

REFERENCES

Abraham, M., Grzybowski, E., Renner, J., & Marek, A. E. 1992. 'Understanding and misunderstanding of eighth graders of five chemistry concepts found in textbooks'. *Journal of Research in Science Teaching*, vol.29, pp.105–120.

Adi, R. "Metodologi penelitian sosial dan hukum". (Yayasan Pustaka Obor, Jakarta, 2021), pp. 121-123

Alfikri, A. M., & Rahayu, S. 2023. 'Rancang Bangun Buck Converter Efisiensi Tinggi Dengan Pengendali Arduino Nano Berbasis Simulasi Multisim'. *KILAT*, vol. 12, pp. 148-159.

Amanda, F. D. 2021. 'Analisis Kemampuan Pemahaman Konsep Materi Tekanan Siswa Sman 2 Sungai Penuh Dengan Metode Pembelajaran Berbasis Video'. *Journal Evaluation in Education (JEE)*, vol. 30, pp. 55-58.

Anderson, L., & Krathwohl, D. "A Taxonomy for Learning, Teaching, and Assesing, A revision of Bloom’s Taxonomy of Education Objective". (Addison Wesley Lonman Inc, USA, 2000). pp. 102-113

Arifin, M. M., Prastowo, S. B., & Harijanto, A. 2022. 'Efektivitas penggunaan simulasi phet dalam pembelajaran online terhadap hasil belajar siswa'. *Jurnal Pembelajaran Fisika*, vol. 11, pp. 16-27.

Azman, A. H., & Ab Rahman, A. 2022. 'Pembangunan E-Modul Pembelajaran Asas Ni Multisim'. *Research and Innovation in Technical and Vocational Education and Training*, vol. 2, pp. 086-098.

Budiono, N. Y., & Rakhmawati, L. 2017. 'Pengaruh Penggunaan Software Multisim Sebagai Media Pembelajaran Terhadap Hasil Belajar Siswa pada Standart Kompetensi Teknik Elektronika di SMKN 1 Grati-Pasuruan'. *Jurnal Pendidikan Teknik Elektro*, vol. 6., pp. 104-108.

Chania, D. M. P., Medriati, R., & Mayub, A. 2020. 'Pengembangan bahan ajar fisika melalui pendekatan stem berorientasi hots pada materi usaha dan energi'. *Jurnal Kumparan Fisika*, vol. 3, pp. 109-120.

Devi, D. A. P. P. S., Widana, I. W., & Sumandya, I. W. 2022. 'Pengaruh penerapan ice breaking terhadap minat dan hasil belajar matematika siswa kelas XI di SMK Wira Harapan'. *Indonesian Journal of Educational Development*, vol. 3, pp. 240-247.

Dewi, N. M., Rosidi, R., & Yusyama, A. Y. 2022. 'Konsep Desain Welding Fixture K Horizontal Bracing'. *In Prosiding Seminar Nasional Teknik Mesin*, No. 2, pp. 1966-1975.

Farida, N., Melati, P., Ruqoyah, R., Yuristiansyah, V. P., & Antarnusa, G. 2020, November. 'Pengaruh amplitudo (A), frekuensi (f), dan tegangan gelombang pada tali berbasis Phet simulation'. *In PROSIDING SEMINAR NASIONAL PENDIDIKAN FISIKA UNTIRTA*, vol. 3, pp. 10

Foster, M. K. 2021. 'Design thinking: A creative approach to problem solving'. *Management Teaching Review*, vol. 6, pp. 123-140.

Frendi Bagus Septianto, N. K. 2015. 'Pengaruh Model Pembelajaran Kooperatif Tipe Stad Dengan Software Multisim Terhadap Hasil Belajar Siswa Pada Mata Pembelajaran Mengukur Besaran-Besaran Listrik Dalam Rangkaian Elektronika Di Kelas X Smk Sunan Drajat Paciran Lamongan'. *Jurnal Pendidikan Teknik Elektro*, vol. 04, pp. 415–422.

Hake, R. R. 1999. 'Analyzing Change/Gain Scores'. Dept. of Physics Indiana University. Unpublished.[Online] URL: http://www. Physics. Indiana. Edu/~ Sdi/AnalyzingChange-Gain. pdf

Handayani, A. S., Husni, N. L., Rumiasih, R., Sitompul, C. R., Soim, S., Nurdin, A., ... & Nurhaida, N. 2020. 'Pemanfaatan Aplikasi Simulasi Rangkaian Listrik Sebagai Media Pembelajaran Fisika'. *Aptekmas Jurnal Pengabdian pada Masyarakat*, vol. 3, pp. 13-17

Hidayati, N., & Abdullah, A. A. 2021. 'Penerapan Model Pembelajaran Contextual Teaching and Learning (CTL) Berbasis Etnomatematika terhadap Kemampuan Pemecahan Masalah Matematika Siswa Kelas VIII SMPN 1 Bambanglipuro'. *Jurnal Tadris Matematika*, vol. 4, pp. 215-224.

Khatun, N. 2021. 'Applications of normality test in statistical analysis'. *Open Journal of Statistics*, vol. 11, pp. 113.

Kristianto, K., Ama, O. K., & Dewa, E. 2023. 'Penerapan Simulasi PhET Sebagai Virtual Laboratorium Pada Materi Getaran, Gelombang Dan Bunyi Dalam Meningkatkan Pemahaman Konsep Dan Aktivitas Belajar Peserta Didik Kelas VIII SMP Negeri 3 Kupang'. *MAGNETON: Jurnal Inovasi Pembelajaran Fisika UNWIRA*, vol 1, pp. 37–44. https://doi.org/10.30822/magneton.v1i1.2046

Mardhatilla, Z. M. 2021, 'December). 'PhET simulation sebagai penunjang pembelajaran IPA secara online selama pandemi covid-19'. In PISCES: *Proceeding of Integrative Science Education Seminar*, vol. 1, pp. 441-448).

Maulidyah, R. L., & Zainuddin, A. 2022. 'Implementasi tes formatif berbasis multirepresentasi untuk analisis pemahaman konsep siswa'. *Jurnal penelitian pembelajaran fisika*, vol. 13, pp. 1-8.

Meishanti, O. P. Y., & Fitri, N. A. R. A. 2022. 'Pengembangan Rencana Pelaksanaan Pembelajaran (Rpp) Inspiratif Pendekatan TaRL Berbasis PjBL Melalui Pembelajaran Literasi Sains Materi Virus'. *EDUSCOPE: Jurnal Pendidikan, Pembelajaran, dan Teknologi*, vol. 8, pp. 1-13.

Mohyeden, J. 2021. 'Meningkatkan Pemahaman Konsep Cahaya Melalui Penerapan Metode Praktikum Pada Siswa Kelas V SDI Paupanda'. *Ekspektasi: Jurnal Pendidikan Ekonomi*, vol. 6, pp. 143-147.

Mukhid, A. "Metodologi penelitian pendekatan kuantitatif". (Media Publishing, Jakarta, 2021). pp. 123-125.

Nisa, U. M. 2017. 'Metode Praktikum untuk Meningkatkan Pemahaman dan Hasil Belajar Siswa Kelas V MI YPPI 1945 Babat pada Materi Zat Tunggal dan Campuran'. *Procceding Biology Education Conference*, vol. 14, pp. 62–68.

Nurwahidah, I., & Sari, D. S. 2022. Analisis Keterampilan Mahasiswa Pendidikan IPA Dalam Melakukan Praktikum dan Berkolaborasi. *EduTeach: Jurnal Edukasi dan Teknologi Pembelajaran*, vol. 3, pp. 1-10.

Putra, A. L., Kasdi, A., & Subroto, W. T. 2019. 'Pengaruh Media Google Earth Terhadap Hasil Belajar Berdasarkan Keaktifan Siswa Kelas Iv Tema Indahnya Negeriku Di Sekolah Dasar'. *Jurnal Review Pendidikan Dasar,* vol. 5, pp. 1034–1042. https://doi.org/10.26740/jrpd.v5n3.p1034-1042

Putri, R. A. 2021. 'Aplikasi Simulasi Algoritma Penjadwalan Sistem Operasi'. *(JurTI) Jurnal Teknologi Informasi*, vol. 5, pp. 98-102.

Radiusman, R. 2020. 'Studi Literasi: Pemahaman konsep anak pada pembelajaran matematika'. *FIBONACCI: Jurnal Pendidikan Matematika Dan Matematika*, vol. 6, pp. 1-8.

Ramadani, E. M., & Nana, N. 2020. 'Penerapan problem based learning berbantuan virtual lab phet pada pembelajaran fisika guna meningkatkan pemahaman konsep siswa sma: Literature review'. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*, vol. 8, pp. 15

Ramadani, E. M., & Nana. 2020. 'Penerapan Problem Based Learning Berbantuan Virtual Lab Phet pada Pembelajaran Fisika Guna Meningkatkan Pemahaman Konsep Siswa SMA : Literature Review'. *Jurnal Pendidikan Fisika Tadulako Online (JPFT)*, vol. 8, pp. 87–92.

Ridwan, R., & Kembuan, D. R. E. 2021. 'Efektivitas Penggunaan Simulasi dengan Multisim Berbantuan Virtual Laboratory untuk Meningkatkan Kemampuan Berpikir Kritis Mahasiswa Jurusan Pendidikan Teknik Elektro'. *Jurnal Kiprah*, vol. 9, pp. 39-47

Rizaldi, D. R., Jufri, A. W., & Jamaluddin, J. 2020. 'PhET: Simulasi Interaktif Dalam Proses Pembelajaran Fisika'. *Jurnal Ilmiah Profesi Pendidikan*, vol. 5, pp. 10–14.

Sari, I. P., Sulistiani, E., Syaifullah, A. P., Putri, R. A., Baruku, D., Anwar, A., & Sulaeman, N. F. 2023. 'Analisis Ketersediaan Fasilitas dan Alat Praktikum Laboratorium Fisika Untuk SMA di Kota Samarinda'. *Jurnal Literasi Pendidikan Fisika (JLPF)*, vol. 4, pp. 88-95

Sasmita, P. R., Hartoyo, Z., & Sutrisna, N. 2023. 'Pengaruh Media Simulasi Interaktif PhET terhadap Pemahaman Konsep Fisika Siswa. *Jurnal Ilmiah Wahana Pendidikan*, vol. 9, pp. 109–116.

Setyawati, E., Hidayati, I. S., & Hermawan, T. 2020. 'Pengaruh penggunaan multimedia interaktif terhadap pemahaman konsep dalam pembelajaran matematika di MTs darul ulum muhammadiyah galur'. *Intersections*, vol. 5, pp. 26-37.

Sinulingga, P., Hartanto, T. J., & Santoso, B. 2016. 'Implementasi Pembelajaran Fisika Berbantuan Media Simulasi PhET untuk Meningkatkan Hasil Belajar Siswa Pada Materi Listrik Dinamis'. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, vol. 2, pp. 57–64. https://doi.org/10.21009/1.02109

Sugiyono. "Metode Penelitian Kuantitatif, Kualitatif, dan R&D". (Alfabeta, Jakarta, 2019). pp.125-130.

Susilaningrum, A. 2022. 'Penerapan Media Pembelajaran Software Multisim dalam Menganalisis Komponen Dioda Semikonduktor. *Jurnal Penelitian Pendidikan Indonesia*, vol. 7, pp. 23-25.

Tahang, L. 2022. 'Penerapan Model Pembelajaran Ropes (Review, Overview, Presentation, Exercise, Summary) Untuk Meningkatkan Aktivitas Dan Hasil Belajar Fisika Siswa Kelas X SMA Negeri 4 Pasarwajo Pada Materi Hukum Gerak Newton'. *Jurnal Penelitian Pendidikan Fisika*, vol. 7, pp. 241-248.

Theasy, Y., Bustan, A., & Nawir, M. 2021. 'Penggunaan Media Laboratorium Virtual PhET Simulation untuk Meningkatkan Pemahaman Konsep Fisika Mahasiswa pada Mata Kuliah Eksperimen Fisika Sekolah'. *Variabel*, vol. 4, pp. 39.

Wang, G. 2007. 'Multisim The Teaching Digital System Design'. *Computers in Education Journal*, vol. 17, pp. 77.

Yennita, Sukmawati, M., & Zulirfan. 2012. 'Hambatan Pelaksanaan Praktikum IPA Fisika yang Dihadapi Guru SMP Negeri di Kota Pekanbaru'. *Jurnal Pendidikan*, vol. 3, pp. 1–11.

Yulisa, Y., Hakim, L., & Lia, L. 2020. 'Pengaruh video pembelajaran fisika terhadap pemahaman konsep siswa SMP'. *Jurnal Luminous: Riset Ilmiah Pendidikan Fisika*, vol. 1, pp. 37-44.