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IMPLEMENTATION OF PhET SIMULATION WITH DISCOVERY LEARNING MODEL TO IMPROVE UNDERSTANDING OF DYNAMIC ELECTRICITY CONCEPTS

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Abstract: This study describes the implementation of learning using PhET simulation with a discovery learning model, the effect on increasing understanding of dynamic electricity concepts in science subjects, and student responses after participating in the lesson. This type of research uses a pre-experiment in the form of a one-group pretest-posttest design. The research was conducted on class IX IJHS students at Al-Islahiyah junior high school. Collecting data using the test method, questionnaire method, and observation method, with instruments in the form of test sheets, student response questionnaire sheets, and learning implementation observation sheets. The results of this study are 1) the implementation of learning using PhET simulation media with discovery learning model at first to fourth meetings is categorized as very good with percentages of 95.05%, 94.78%, 99.47%, and 100%. 2) The average n-gain value of all sub-concepts in class IX-A and class IX-B of 0.68 and 0.66, respectively, in the medium category indicate an increase in concept understanding. 3) The students show a positive response to the implementation of learning with PhET simulation with a discovery learning model with an average percentage of 74.28%. Thus, PhET simulation learning with a discovery learning model can improve students understanding of concepts.

Keywords: *PhET simulation, discovery learning model, concept understanding*

INTRODUCTION

Technology is growing rapidly in the 22nd century and is shaping quality human resources. Education is a great place to print quality human resources that can face the advancement of science and technology in the era of globalization. The availability of space in learning to guide students in solving problems, monitoring the development of scientific attitudes, and knowledge of science and technology is the most appropriate in education [1]. Education in Indonesia has many subjects that must be mastered, one of which is science learning. Science learning has a place for students to practice solving problems and instilling a scientific attitude in students. Science learning should provide material connected with life and practiced so that students can understand and apply the concepts learned in everyday life [2]. Science is a science that discusses several facts and concepts directly related to real-life and based on the results of human experiments and observations[3]. The nature of science learning is finding and finding out all the facts, concepts, principles, events, or phenomena, both microscopic and macroscopic. It becomes a scientific product that can be applied in everyday life.

Science learning in junior high school is expected to train basic process skills and integrated processes in learners. Basic process learning skills include several abilities as follows, 1) observer, 2) able to classify, 3) able to measure, 4) ability to convey information, 4) ability to interpret data, 5) ability to predict, 5) ability to use tools, 6) ability to conduct experiments, 7) ability to make conclusions. There are several types of science learning process skills as follows; 1) skills to formulate problems, 2) skills to identify experimental variables, 3) the ability to explain relationships between variables, 4) the ability to explain variables operationally, 5) the ability to formulate hypotheses, 6) The ability to design research, 7) the ability to conduct research experiments, 8) the ability to search and present data, 9) the ability to analyze experimental data, 10) the ability to collect research results [4].

Information technology is growing very rapidly, that technology can be utilized in the world of education to face the era of globalization and facilitate students in learning. The effective use of technology in education is to use interactive learning media, namely PhET (Physics Education Technology) simulation media, an science learning application equipped with interactive learning simulations designed to conduct research and experiments on science learning. This PhET software contains science subjects, namely Physics, Chemistry, Biology, Mathematics, and Earth, that cannot be seen directly as the tools and materials for the research process [5]. This PhET software is equipped with virtually designed laboratory equipment, such as voltmeters, thermometers, stopwatches, etc.

Based on the observations that have been conducted at the School of IJHS Al-Islahiyah, information is obtained that students assume that science subjects, especially in the dynamic electrical topic, are difficult lessons. Laboratory use is also less than optimal. The factors that cause

students difficulty in understanding the material are 1) having many formulas, thus making students confused; 2) There is no laboratory equipment available to support electrical experiments, so teachers often air experimental videos to overcome the problem. These constraints cause the student's understanding of the dynamic electrical matter to be reduced.

Given the importance of understanding concepts for students, then ideally, the science learning process should be able to improve students' ability to understand and master the concept of science. The difficulty of students in science learning has many formulas and a lack of practicum activities, making science learning less meaningful and the level of understanding of concepts less. With practicum and research in the laboratory, students can find science concepts independently [6]. Based on this, teachers play the main role needed in determining learning models that can improve students' understanding of science concepts. Learning models applied by teachers can make students active when learning takes place (student-centered learning) So that students can discover and build concepts through their construction. In science learning, teachers can think creatively to address the application of science concepts to problems often found in everyday life so that the learning received by students can be meaningful [6].

The learning process that can be applied to help understand the concept in this research is by using PhET simulation media. PhET simulation media can help science learning in practicum activities. In addition, the right learning model is needed in supporting the learning process using PhET simulation media is a discovery learning model. The covered learning approach is a method of learning. Students are guided to understand material concepts and cooperate with teams through intuitive processes to collect the completion results together. The Discovery learning model involves students finding a solution to problems in a systematic, logical, critical, and analytical manner, the results of which can make students formulate their knowledge obtained in learning. Discovery learning assisted PhET simulation media can help students in finding the knowledge that has been obtained. Students actively conduct learning activities such as conducting experiments, asking and answering questions, solving a problem and finding basic learning concepts independently [7].

Based on the description that has been submitted, the study was conducted with the title "Application of PhET Simulation Media with Discovery Learning Model To Improve Understanding of Concepts in Dynamic Electrical Materials."

RESEARCH METHOD

In this research, the type of research applied is quantitative research, the pre-experimental design, which is simple experimental approach research that is practiced in experimental classes and replication classes. The design of this study is One-Group Pretest-Posttest. Design research is described in Table 1.

Table 1. One-Group Pretest-Posttest Design

Pretest	Treatment	Post-test
O_1	X	O_2

where O_1: Pretest assessment conducted before the application of media PhET learning with the discovery learning model; X: Application of PhET simulation media with the discovery learning model learning; O_2: The posttest assessment conducted after treatment Application of PhET simulation media with the discovery learning model learning

The study was conducted in two classes: class A for experimental classes and class B for replication classes, hoping that each class would be improved and consistent after being given the same treatment. Here are the research design patterns that will be used [8].

Table 2. Research Design

Class	Pretest	Treatment	Post-test
A	O_1	X	O_2
B	O_1	X	O_2

The study was conducted at IJHS Al-Islahiyah Sukobendu Lamongan. The subjects of this study were class IX-A students who numbered 21 students and IX-B, which amounted to 20 students of IJHS Al-Islahiayah in the odd semester in 2021-2022. This research data is collected through observation, test, and questionnaire methods. The instruments in this research are covered by observation sheets filled by science teachers by giving a checkmark on the column that contains a "Yes or No" with a score scoring scale of 0 to 4. Data obtained from the observer assessment when observing teacher activities are analyzed by calculating the percentage of scores using the following formula:

$$P = \frac{\text{totalobservationscore}}{\text{maximumscore}} \text{x } 100\ \%$$

The score is corrected according to the following categories [9]:

Table 3. Category of Observation of Implementation

Score	Category
25% ≤ P ≤ 43.75 %	Bad
43.75%< P ≤ 62.50%	Less Good
62.50%< P ≤ 81.25%	Good
81.25 %< P ≤ 100%	Very Good

In this study, the test method aims to measure the level of understanding of students' concepts before and after being given treatment on learning activities using a PhET simulation medium with a discovery learning model. The test sheet is a research instrument that aims to measure the improvement of understanding of students' concepts. In this study, test sheets were presented in pretests and posttests. The pretest problem is given at the beginning of the meeting of dynamic electrical materials to measure the student's initial understanding of the dynamic electrical material to be taught. In contrast, the posttest problem is given at the end of the dynamic electrical learning material to measure the level of understanding of the student's concept after learning from the teacher. The student in the experimental class fills out the test sheet. The test problem in this study is a written test in the form of multiple choices with a total of 20 questions with details of 5 questions about the concept of electric current, 5 questions about the concept of electric circuits (open circuits and closed circuits), 5 questions about the concept of obstacles and Ohm's law, and 5 questions about the concept of energy change. The data results are analyzed using IBM SPSS Statistics, version 26. Then the data will be analyzed using the N-Gain test, normality test, homogeneity test, unpaired t-test.

The N-Gain test aims to determine the effectiveness of PhET simulation media with discovery learning models in improving the understanding of student concepts. The N-Gain test in this study can be done using the following equations:

$$<g> = \frac{\text{posttestscore} - \text{pretestscore}}{\text{idealscore} - \text{pretestscore}}$$

The N-Gain Score criteria translate N-Gain values as in the following Table 4 [10].

Table 4. Criteria N-Gain score Pretest Posttest

Score	Category
N-Gain < 0.3	Low
0.7 >N-Gain≥ 0.3	Medium
N-Gain≥ 0.7	High

The normality test identifies whether the distributed data is normal or abnormal, conducted with the Kolmogorov-Smirnov test in the IBM SPSS Statistics version 26 program. The data is normally spread if the signification value > 0.05. It is said to be spread abnormally if the signification value is < 0.05. The variance homogeneity test aims to identify that the sample in the study has the same variance. The results of the sample study can also apply to the population [11].

The unpaired t-test was used to identify the effect of using PhET simulation media with discovery learning models on improving student concept understanding, conducted using the unpaired t-test on IBM SPSS Statistics version 26 program. Statistically, the hypotheses in this study are:

$$H_0 : \mu_1 = \mu_2$$
$$H_a : \mu_1 \neq \mu_2$$

Information :

H_0 = There is no difference in understanding concepts before and after the implementation of learning using PhET simulation media with the discovery learning model.

H_a = There are differences in understanding concepts before and after implementation of learning using PhET simulation media with the discovery learning model.

Suppose the signification value obtained is more than 0.05. In that case, H0 is accepted, and Ha is rejected, meaning that the average n-gain data on the concept of experimental students have the same ability as the average n-gain ability to understand the concept of replication classes [12].

Instruments using this questionnaire method aim to find out the student's response after obtaining learning using PhET simulation media with discovery learning model on dynamic electrical materials. Students will fill out the response questionnaire by giving a checkmark on the questionnaire column. This questionnaire contains 18 positive questions with details of 5 questions of the aspect of the ministry, 3 questions of usefulness, 2 questions of the concept of electric current, 3 questions of aspects of electrical circuits, 3 questions of Ohm's legal concept, 2 questions of the concept of energy sources. Data results are analyzed by converting them into quantitative data forms according to the Likert scale, as in Table 5.

Table 5. Questionnaire Filling Description

Category	Score	Description
SS	1	Strongly Agree
S	2	Agree
KS	3	Less Agree
TS	4	Disagree
STS	5	Strongly Disagree

Each answer to the response questionnaire will be calculated by the percentage of each question item using the following formula:

$$\%\ \text{NRS} = \frac{\sum_{i=1}^{n} \text{NRS}}{\text{NRSmaximum}} \text{x } 100\%$$

Information:
% N R S= Percentage of Student Response Scores
$\sum_{i=1}^{n}$ NRS= Number of Student Response Scores Obtained
N R S maximum = Number of Respondents and Maximum Score
The data is adjusted to the following Table 6 [13].

Table 6. Student response percentage category

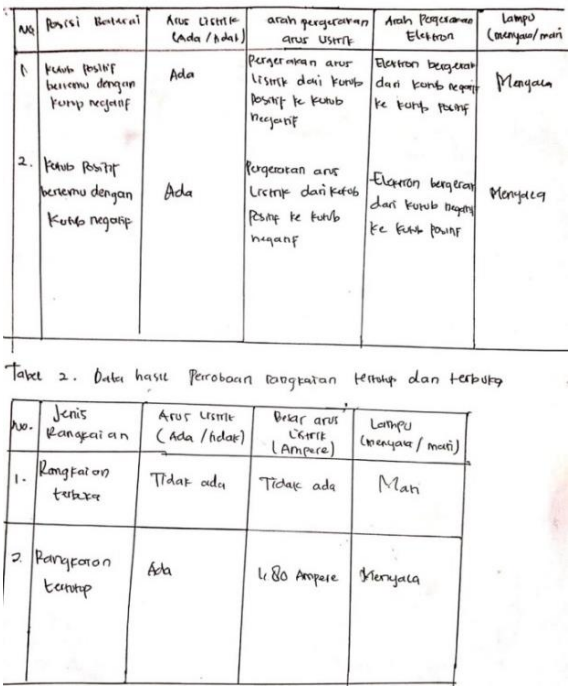
Response Value	Category
$25\% \leq \%NRS < 43\%$	Very Weak
$44\% \leq \%NRS < 62\%$	Weak
$63\% \leq \%NRS < 81\%$	Strong
$82\% \leq \%NRS \leq 100\%$	Very Strong

RESULT AND DISCUSSION

Science learning activities in IJHS Al-Islahiyah are conducted face-to-face with a limited time allocation of 4JP / week, which is allocated to two face-to-face meetings in the Covid-19 pandemic mass. This learning activity is carried out for 3 weeks with 6 meetings. The first meeting was held on Saturday with an allocation of time (2 x 30 minutes). At the first meeting, students are asked to pretest to measure the student's initial understanding of dynamic electrical matter. Here is documentation of the learning process that can be seen in the image below.

At the second meeting of learning activities using PhET simulation media with discovery learning model on electric current concept material, held on Monday with time allocation (2 x 30 minutes), here is the documentation of the learning process in the figure 1.

At the third meeting of learning activities using PhET simulation media with discovery learning model on ohm obstacle and legal concept material, conducted on Saturday with time allocation (2 x 30 minutes), the following documentation of student work data can be seen in the figure 2.

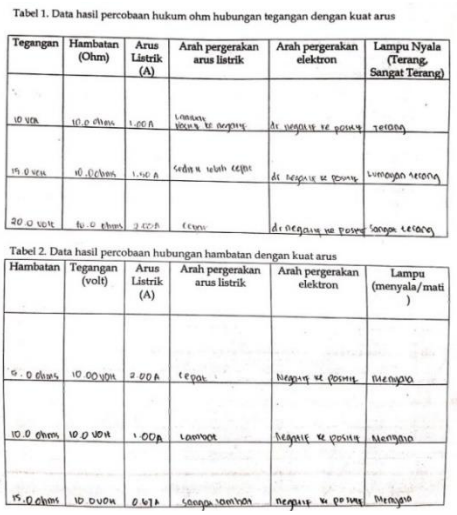


Translation:

No	Battery Position	Electric Current (There is/ No)	Electric Current Friction Direction	The direction of Electron Movement	Lamp (On/ Off)
1	Positive Pole meets negative pole	There is	Electric current moves from the positive pole to the negative pole	Electrons move from the negative pole	On

No	Series Type	Electric Current (There is/ No)	Large Electric Current (Ampere)	Lamp (on/off)
1	Open circuit	No	No	Off
2	Close circuit	There is	1.80 Ampere	On

Figure 1. Data on Student Work Results on Electric Current Concept Material



Tabel 1. Data hasil percobaan hukum ohm hubungan tegangan dengan kuat arus

Tegangan	Hambatan (Ohm)	Arus Listrik (A)	Arah pergerakan arus listrik	Arah pergerakan elektron	Lampu Nyala (Terang, Sangat Terang)
10 Volt	10.0 ohms	1.00 A	Lambat dari + ke -	Dr negatif ke positif	terang
15.0 volt	10.0 ohm	1.50 A	cepat dari negatif ke positif	Dr negatif ke positif	lumayan terang
20.0 volt	10.0 ohms	2.00 A	cepat	dr negatif ke positif	sangat terang

Tabel 2. Data hasil percobaan hubungan hambatan dengan kuat arus

Hambatan	Tegangan (volt)	Arus Listrik (A)	Arah pergerakan arus listrik	Arah pergerakan elektron	Lampu (menyala/mati)
5.0 ohms	10.00 volt	2.00 A	cepat	negatif ke positif	menyala
10.0 ohm	10.0 volt	1.00 A	lambat	negatif ke positif	menyala
15.0 ohms	10 0 volt	0.67 A	sangat lambat	negatif ke positif	menyala

Translation:

Voltage (Volt)	Obstacles (Ohm)	Electric Current (A)	Electric Current Friction Direction	The direction of Electron Movement	Lights on
10.0 Volt	10.0 Ohm	1.00 A	Slow, moving from positive to negative	negative to positive	Dim
15.0 Volt	10,0 Ohm	1.50 A	A little faster	negative to positive	Bright
20.0 Volt	10,0 Ohm	2.00 A	Fast	negative to positive	Very Bright

Obstacles (Ohm)	Voltage (Volt)	Electric Current (A)	Electric Current Friction Direction	The direction of Electron Movement	Lights on
5.0 Ohm	10.0 Volt	2.00 A	Fast	negative to positive	Bright
10.0 Ohm	10,0 Volt	1.00 A	Slow	negative to positive	Dim
15.0 Ohm	10,0 Volt	0.67A	Very Slow	negative to positive	Very Dim

Figure 2. Data on Student Work Results on Obstacle Concept Material and Ohm Law

At the fourth meeting of learning activities using PhET simulation media with discovery learning model on Ohm obstacle and legal concept material, conducted on Monday with time allocation (2 x 30 minutes), here is the documentation of student work data in the figure 3.

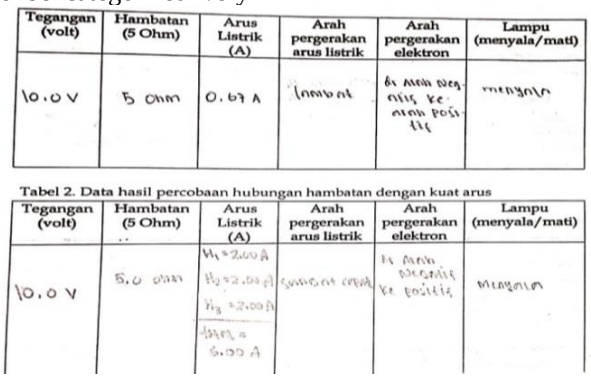
At the fifth meeting of learning activities using PhET simulation media with discovery learning model on the material. The understanding of energy source concepts, conducted on Saturday with time allocation (2 x 30 minutes), here is the documentation of student work data that can be seen in the figure 4.

Students were asked to work on posttest problems at the sixth meeting held on Monday with a time allocation (2 x 30 minutes). It measures the improvement of students' understanding of dynamic electrical materials. It fills out a response questionnaire sheet to see the student's response or response to the learning that has been done.

Based on research that has been done, the implementation of learning that uses PhET simulation media with the discovery learning model is carried out by observing teacher activities during learning. The results of the recapitulation of learning implementation observation data at the first, second, third, and fourth meetings are shown in Table 7.

Table 7 shows that the information was obtained that learning using PhET simulation media with discovery learning model at meeting 1 with an average score of 95.05% was carried out in an excellent category. At this first meeting, each stage of the learning process that was carried out to get a 100% score percentage was categorized very well. The appreciation stage, with a score of 93.75%, was categorized very well. The problem orientation stage with a score of 91.75% was categorized very well, and the verification stage with a score of 75% was categorized as good. The implementation of the 2nd meeting learning was carried out in an excellent category with an average score percentage of 94.78%, categorized as very good. At the second meeting, each learning process was 100% percentage, except at the problem orientation stage with a score of 83.3%, categorized

very well, and at the verification stage with a score of 75% categorized as good. The implementation of learning at the 3rd meeting with an average score percentage of 99.47% was categorized as excellent. At each stage of the learning process, get a percentage of 100%, except at the data collection stage with a score of 95.83%. It is categorized very well. The implementation of learning at the 4th meeting was carried out in a very good category, with an average score percentage of the overall stage of 100%. Each stage gets a percentage score of 100% at this meeting to be categorized very well. At the 2nd meeting, there was a decrease in the percentage score of learning implementation at the orientation stage of the time allocation problem at the second meeting is not enough, so in the orientation stage, the problem has not been implemented properly. One of the external factors that implement learning with less maximal learning model discovery is the mismatch of time allocation. Teachers spend more time at the stage of analyzing data so that the implementation of other stages is less maximal [14].



Tegangan (volt)	Hambatan (5 Ohm)	Arus Listrik (A)	Arah pergerakan arus listrik	Arah pergerakan elektron	Lampu (menyala/mati)
10,0 V	5 Ohm	0,67 A	(illegible)	(illegible)	menyala

Tabel 2. Data hasil percobaan hubungan hambatan dengan kuat arus

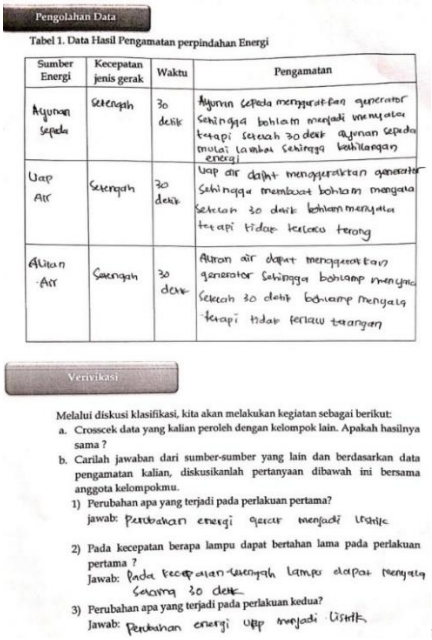
Tegangan (volt)	Hambatan (5 Ohm)	Arus Listrik (A)	Arah pergerakan arus listrik	Arah pergerakan elektron	Lampu (menyala/mati)
10,0 V	5,0 ohm	R_1 = 2,00 A R_2 = 2,00 A R_3 = 2,00 A Jadi a 6,00 A	(illegible)	(illegible)	menyala

Translation:

Voltage (Volt)	Obstacles (Ohm)	Electric Current (A)	Electric Current Friction Direction	The direction of Electron Movement	Lamp (on/off)
10,0 V	5,0 Omh	0,67 A	Slow	negative to positive	On

Voltage (Volt)	Obstacles (Ohm)	Electric Current (A)	Electric Current Friction Direction	The direction of Electron Movement	Lamp (on/off)
10,0 V	5,0 Omh	R_1 = 2,00 A R_2 = 2,00 a R_3 = 2,00 R_{total} = 6,00 A	Very Fast	negative to positive	On

Figure 3. Data on Student Work Results on Electrical Circuit Concept Materials
Source: Personal Documentation



Pengolahan Data

Tabel 1. Data Hasil Pengamatan perpindahan Energi

Sumber Energi	Kecepatan jenis gerak	Waktu	Pengamatan
Ayunan Sepeda	Sedang	30 detik	Ayunan sepeda menggerakkan generator sehingga bohlam menjadi menyala terapi sekecah 30 detik ayunan sepeda mulai lambat sehingga kehilangan energi
Uap Air	Sedang	30 detik	Uap air dapat menggerakkan generator sehingga membuat bohlam menyala sekecah 30 detik bohlam menyala terapi tidak terlalu terang
Aliran Air	Sedang	30 detik	Aliran air dapat menggerakkan generator sehingga bohlamp menyala sekecah 30 detik bohlamp menyala terapi tidak terlau terang

Verivikasi

Melalui diskusi klasifikasi, kita akan melakukan kegiatan sebagai berikut:
a. Crosscek data yang kalian peroleh dengan kelompok lain. Apakah hasilnya sama ?
b. Carilah jawaban dari sumber-sumber yang lain dan berdasarkan data pengamatan kalian, diskusikanlah pertanyaan dibawah ini bersama anggota kelompokmu.
1) Perubahan apa yang terjadi pada perlakuan pertama?
jawab: Perubahan energi gerak menjadi listrik
2) Pada kecepatan berapa lampu dapat bertahan lama pada perlakuan pertama ?
Jawab: Pada kecepatan sedang lampu dapat menyala selama 30 detik
3) Perubahan apa yang terjadi pada perlakuan kedua?
Jawab: Perubahan energi uap menjadi listrik

Energy Sources	Speed of Motion Type	Time	Observation
Bicycle swing	Half	30 seconds	The bike swing moves the generator so that the bulb becomes on, but after 30 seconds, the bike swing starts slow, so it loses energy.
Water vapor	Half	30 seconds	Water vapor can move the generator so that it makes the bulb light up. After 30 seconds, the bulb lights up but not too brightly.
Water Flow	Half	30 seconds	The flow of water can move the generator so that the bulb turns on. After 30 seconds, the bulb lights up but not too brightly.

Figure 4. Data on Student Work Results on Energy Source Concept Materials

Table 7. Learning Results

Stages	Percentage Score (%)			
	First Meeting	Second Meeting	Third Meeting	Fourth Meeting
Orientation	100	100	100	100
Apperception	93.75	100	100	100
Problem Orientation	91.67	83.3	100	100
Determining Research Questions	100	100	100	100
Collecting Data	100	100	95.83	100
Verification	75	75	100	100
Formulating conclusions	100	100	100	100
Cover	100	100	100	100
Average Score Percentage (%)	95.05	94.78	99.47	100

To find out the improvement of students' conceptual understanding on learning using PhET simulation media with discovery learning model on dynamic electrical materials is done by providing pretest and posttest, students are asked to work on pretest and posttest problems. The following Table of average results of n-gain tests in classes IX-A and IX-B can classically be seen in Table 8.

Table 8. Average Results of N-Gain Test

Average Value	IX-A	IX-B
Pretest	51.42	58
Post-Test	82.85	85.5
N-gain	0.68	0.66
Category	Medium	Medium

Based on data from Table 8 shows an increase in the ability to understand students' concepts. In class, A experiments and class B replication improved understanding of medium categorized concepts, which showed N-gain values in class IX-A and IX-B were 0.68 and 0.66, of 0.66, were 0.68 and 0.66, of 0.66, million, of 0.68, million, of 0.68, million, among others.

In research, applying PhET simulation media with discovery learning models can improve students' understanding of dynamic electrical materials. Improved understanding of the concept can be seen from the results of pretests and posttests that have been done. This statement is also reinforced by the research results from [7]. The use of discovery learning models with PhET simulation media can affect the level of understanding of student concepts assist students in experimental discovery activities in learning. Students are also given the freedom to find things themselves so that students will better understand the concept of learning in-depth. Based on the results of the Pretest and Post-Test of each student in grades IX-A and IX-B can be used as a normality test presented in the table 9.

Table 9. Normality Test Results Data

		Normality Test		
		Kolmogorov-Smimov[a]		
Pretest and Posttest Results		Statistic	Df	Sig.
	Pretest	.155	41	.014
	Post-Test	.130	41	.077

Based on normality test results in Table 9, sig scores on the Kolmogorov-Smimova test were 0.011 in pretest results and 0.077 on posttest results of 0.077. Pretest and Posttest data are normally distributed based on Kolmogorov-Smirnova test results because sig > value of 0.05. After knowing the pretest and posttest data distributed normally, homogeneity tests can be done to determine the homogeneity in the study sample using N-Gain.

Table 10. Homogeneity Test Results Data

Homogeneity Test	IX-A Sig.	IX-B Sig.
Based on average	.551	

Based on the data in Table 10. Sig value of 0.551, n-gain data in the experimental class and control class can be declared homogeneous with a value of Sig>0.05. Based on the n-gain of each class that has met the homogeneity test, the data of the test results can be analyzed with unpaired t-tests

that aim to be the average difference in the ability to understand concepts in class IX-A and IX-B. The results of the unpaired t-test analysis are t-paired in Table 11.

Table 11. Unpaid t-test results N-gain Class IX-A and IX-B

Unpaid t-test	IX-A	IX-B
T count	1.400	
Sig. (2-tailed)	.691	

Based on Table 11 of the sig values listed in the sig column. (2-tailed) of 0.691, then sig value > 0.05 and t count of 1,400 so that H0 is accepted, which means the average n-gain understanding of student concepts in the experimental class is the same as the replication class.

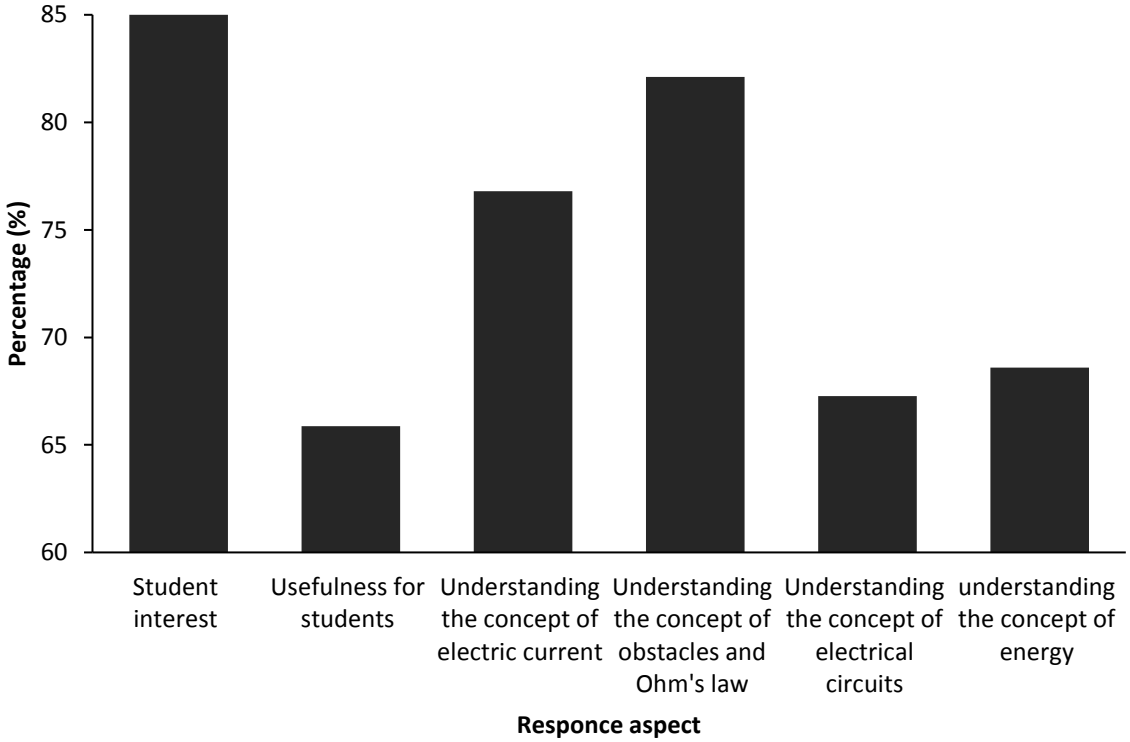


Figure 5. Recapitulation of Student Response Percentage Data on Every Aspect

Figure 5 shows that learning using PhET simulation media with the discovery learning model gets a positive response. Both from aspects of student interest, usefulness for students, understanding the concept of electric current, understanding the concept of obstacles and Ohm's law, understanding the concept of electrical circuits, and understanding the concept of energy sources with a percentage of consecutive response values of 85%, 65.87%, 76.8%, 82.11%, 67.27%, and 68.59%. It can be said that the learning process using PhET simulation media with the help of discovery learning models runs well. Based on student responses and student learning outcomes using discovery learning models with PhET media [15], students can discover the concepts and principles of dynamic electrical matter independently by observing, making hypotheses, conducting experiments, solving problems, and drawing conclusions [16].

In the aspect of interest, learning activities with PhET simulation media with a discovery learning model are new for students. Learning using PhET simulation media is interesting, fun, not boring, liked by students, following the learning that students want, making students more excited and interested in the following learning [17]. The percentage of student response values to the aspect of attraction is 85%, with a very strong (positive) category. Students are interested in participating in learning because the learning is very fun and does not make students bored.

In terms of usefulness, learning activities with PhET simulation media can make it easier to understand the concept of dynamic electricity, help in solving problems, and answer questions about dynamic electricity. In the aspect of understanding the concept of electric current, learning activities using PhET simulation media with discovery learning models can help students in understanding

the concept of electric current direction and the concept of the direction of electron movement on electrical circuits. In the aspect of understanding the concept of electrical circuits, learning activities using PhET simulation media with discovery learning models help students stringing electricity in series and parallels and help students distinguish between series and parallel series. In the aspect of understanding the concept of obstacles and Ohm's law, learning activities using PhET simulation media with discovery learning models can make it easier for students to understand the concept of obstacles on open and closed electrical circuits. In the aspect of understanding the concept of Energy Sources, learning activities using PhET simulation media with discovery learning models assist students in determining changes in electrical energy, and students can know the process of energy change [18-19].

The use of virtual media-lab simulation PhET causes students' learning interest because such media facilitates students when exploring abstract concepts [20-21]. The results of research stated that the use of the discovery learning model using PhET media has a significant influence on understanding the concept of physics. Students are required to be active in the process of collecting data in practicum and discussing to solve problems [22-23].

CONCLUSION

Based on data that have been analyzed in conclusions in learning implementation research using PhET simulation media with a discovery learning model at the overall meeting is categorized as good. The application of PhET simulation media with the discovery learning model affects the level of understanding of students' concepts in dynamic electrical materials. It is evident that the average N-gain of the entire sub-concept gets a moderate to high category. Implementing learning using PhET simulation media with the discovery learning model gets a positive response in a very strong category. Some suggestions are 1) the allocation of learning time must be considered because researchers feel that the time needed to carry out learning activities using PhET simulation media with discovery learning models takes a considerable amount of time. 2) in the learning process, teachers must still accompany students, especially when formulating problems, conducting experiments, and analyzing data so that students perform their responsibilities in groups.

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