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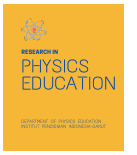

ARTICLE

The Effectiveness of discovery learning model integrating PhET simulation media to enhance understanding of optical concepts

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Abstract

This study aims to examine the increase in students' understanding of the optical geometry concept after being given treatment using the discovery learning model assisted by PhET simulation media and to test the effectiveness of this learning model to improve understanding of the optical geometry concepts. The method used in this research is quasi-experimental and uses the research design The Static Group Pretest-Post-test Design. The sampling technique in this study was taken using purposive sampling, namely where the control and experimental classes were selected based on the suitability of the student's character with the researcher's goals. Each experimental and control group consisted of 35 participants. The experimental class used the discovery learning model assisted by PhET simulation media and the control class uses the conventional learning model. The instrument in this study was using a multiple-choice test of 20 questions. Based on the test results of the Independent Sample Test, it obtained a significance value (*alpha* = 0.0001 < 0.05), which means that there is a difference in increasing understanding of the optical geometry concept between classes using the discovery Learning model assisted by PhET simulation media using the learning model conventional.

Keywords: Discovery Learning model, learning media simulation PhET, conceptual understanding

1. Introduction

A learning activity is an activity carried out by teachers and students in order to achieve a goal of learning (Hariyanto 2016). Where this activity or learning activity is also a process of changing behavior that is owned by students both seen from changes in cognitive, affective and psychomotor aspects resulting from the learning process which is carried out by guiding students to comply with predetermined learning objectives (Pane and Dasopang 2017). Physics is a branch of science that is closely related to knowledge, ideas, natural concepts obtained from scientific processes. In physics there are different levels of difficulty so that the level of student understanding of a concept will of

course be different. Therefore, to support the learning process, it requires an efficient learning media to use when studying. One of them is PhET simulation media. Based on the results of research from previous researchers, PhET simulations can stimulate students' attention so that students have a high curiosity. Therefore, PhET simulations can increase students' understanding and enthusiasm for learning (Kurniawan, Rifa'i, and Fajar 2020).

One of the effective learning models for implementing this PhET simulation is the Discovery Learning model. Which, this learning model is a student-centered model so that students can build understanding in their own opinion (Qurniati, Andayani, et al. 2015). According to one of the results of previous research, it stated that the Discovery Learning model was considered effective for increasing student learning outcomes and creative thinking abilities (Cintia, Kristin, and Anugraheni 2018). As for the results of an interview with a physics subject teacher at a school, when learning activities take place, he often uses the Discovery Learning model because according to his own experience this model has proven its effectiveness which makes students become more active while learning, students become ask more questions, and make students understand more about the material being studied.

One of the concepts of physics that is no less important than other physics concepts is the concept of optical devices, especially in geometrical optical materials. Geometry optics is the study of the approximation of light phenomena such as reflection and refraction for the formation of images by mirrors and lenses (Serway and Jewett 2018). According to the results of previous research, it was stated that students had difficulty understanding determining the position of an image, and determining the nature of the image (Sheftyawan, Prihandono, and Lesmono 2018). The existence of these difficulties is because students' understanding of the material is still lacking, giving rise to misconceptions about the material (Sutrisno, Koes-H, Supriana, et al. 2018). In addition, based on the results of interviews with physics subject teachers at a high school, according to his teaching experience there are still students who have difficulty understanding physics material, one of which is optical geometry. Because this material is considered difficult for students to understand, the teacher must also provide learning models and learning support media that are effectively used when studying. To understand more about this material, of course students must first understand the basics of this geometric optical material such as light and mirrors so that if students have understood this material in depth, then students will not experience difficulties when continuing to the next sub-material.

2. Literature Framework

2.1 Learning model in physics instruction

The learning model is an illustration of how teaching and learning activities will be carried out later in class (Avargil, Lavi, and Dori 2018). Which, in these activities there are stages of interaction activities between teachers and students and students with students. This is a characteristic or character of the syntax of a lesson. The following are the characteristics or characters that exist in the learning model, namely, there is syntax, the role of the teacher during learning, the teacher's efforts when providing guidance to students in learning, the teacher's potential for the model used as well as the teacher also needs to pay attention to whether or not there is a result of models used.

There are several things that need to be considered before choosing a learning model, namely the teacher needs to consider the learning objectives that will be implemented, the teacher needs to consider those related to teaching materials, the teacher must consider when viewed from the student's point of view, the teacher must consider anything else. In the physics learning, learning model should be directed to enhance students' activities in presenting creative and critical activities (Aksela 2019).

2.2 Discovery learning in the physics instruction

The discovery learning model was developed by Jerome Bruner. This model is a learning model that focuses on students and students can be directly involved in learning. Also in this model, students can cultivate their talents, abilities and skills in solving learning problems and everyday life (Simamora, Saragih, et al. 2019).

The Discovery Learning model helps students find findings that students have never encountered before through the role of a teacher with the help of teaching materials, namely student worksheets. The results of the findings that students succeed in encountering can be remembered more than the teacher explained because in this model students are directly involved in learning so that students can better understand what they are learning. The following are the stages in the discovery learning model (Sitorus and Hia 2022):

1. Stimulation, namely providing a stimulus to students so that an interaction occurs between the teacher and students;
2. Problem Statement, which provides opportunities for students to identify a problem as much as possible, then students choose one problem by making temporary presumptions;
3. Data Collection, namely providing opportunities for students to prove the temporary presumptions that students have made by assembling relevant information;
4. Data Processing, namely from the information that has been obtained then the data is processed and described;
5. Verification, namely checking the temporary presumptions that have been made earlier carefully. Then, connecting temporary presumptions with the results of data processing;
6. Generalization, namely making conclusions from the verification results.

2.3 Physics learning media and Physics Education Technology (PhET)

Media according to the root of the word media is from the Latin mediums which means "introduction", "middle" or "intermediary" (Jainal and Yosephine Louise 2019). Where the word Intermediary here has the meaning of an intermediary between the sender and the recipient of the message. So, the media is an intermediary or introduction that functions to convey a message in order to arouse enthusiasm, attention, interest, and students' minds in order to achieve the learning objectives that have been set.

Learning media essentially acts as a tool when learning takes place. These aids are in the form of visual aids, for example, photos, models, graphics, or real objects. Which, these tools function so that students gain experience factually and to generate student motivation when learning (Mukhadis et al. 2021). Meanwhile, learning media has an important role in education because it can change student behavior to be creative and (Hafizhah, Istyadji, et al. 2022). Along with the development of the times, learning media does not only act as a tool but has become an important part of the educational process.

Physics Education Technology (PhET) Simulation is an interactive simulation software in which there are several learning simulations of physics, chemistry, biology that are used to support the group learning process in class and for the benefit of individual learning (Haryadi and Pujiastuti 2020). This simulation was made by a university in the United States, namely the University of Colorado in 2002. Carl Wieman, Kathy Perkins and Wendy Adams is the character who developed the PhET Colorado simulation media. This Simulation can be used directly online through a standard web browser from the website http://phet.colorado.edu/en/get-phet/full-install. From this website PhET can be used free of charge for all people.

In this simulation there is an interactive animation, the learning atmosphere is like playing, where students learn through exploration like scientists. PhET simulation focuses on the relationship between real events and the science that underlies them. PhET also makes invisible things visible, such as electrons, photons, vectors, and so on. When students explore the simulation, a question "What,

if" will arise. PhET simulation tests their ideas to find and understand cause-effect relationships and also to develop students' science processes (Hensberry et al. 2013).

2.4 Conceptual understanding

According to Bloom, understanding the concept is a competency to master the meaning of an information obtained and then the information is converted into a different form (8). The following is a classification or level of cognitive development arranged from the lowest level to the highest level based on Bloom's classification which has been revised by Kraetwol and Anderson, namely remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creates (C6). Then, because in this study analyzes the understanding of the concept. So, the researcher took the cognitive level (C2), namely understanding which is further divided into 7 (seven) types, namely interpreting, exemplifying, classifying, summarizing, concluding, comparing, and explaining. So, from the 7 indicators of understanding the concept students must be able to master a material or information conveyed by the teacher in the form of pictures, writing, or orally from one form of information to another based on predetermined indicators.

3. Research Method

3.1 Research design

This research uses quantitative research methods. Then the type of research used in this study is a quasi-experimental. Meanwhile, the research design used in this study was the static group pretest-posttest design. This design is used to see how the comparison of student improvement before and after being treated in the experimental class and the control class. In this design, the initial test (pretest) and final test (posttest) are given to the experimental class and the control class. Then, giving treatment using the discovery Learning model assisted by PhET simulation media in the experimental class and applying the discovery learning model only to the control class.

Meanwhile, to find out the comparison of improvement between student learning outcomes in the experimental class and the control class, a research hypothesis is used which is stated in Ha and Ho:

> Ha: There is a difference in increasing understanding of optical concepts between classes using the Discovery Learning model assisted by PhET simulation media and classes using conventional learning models
>
> Ho: There is no difference in increasing understanding of optical concepts between classes using the discovery learning model assisted by PhET simulation media and classes using conventional learning models

3.2 Participants

The population of this study were all students of a high school in Garut, while the target population in this study were eleventh grade students concentrating on natural sciences. Then, the sample is part of the target population. Meanwhile, the sampling technique in this study was taken by purposive sampling, namely the experimental class (IPA 5) and the control class (IPA 6), each class numbering 35 students; the average age of these participants is 17-18 years. The experimental class was given treatment using the discovery learning model assisted by PhET simulation media and the control class using the conventional learning model.

3.3 Instruments

The instrument used in this test is a test of understanding the concept of optical geometry regarding mirrors. Which totals 30 multiple choice questions with 5 (five) answer choices. Students who answer

correctly get a score of 1 (one), while answering wrong gets a score of 0 (zero). In addition, other research instruments are questionnaires and interviews. Before carrying out a study, the researcher validated the instrument with 3 experts including 2 physicists and 1 linguist. Then the validation results from the three experts show that the instrument is feasible to use without revision. After that, the researcher carried out a test of the items first in a class that was not a sample, where the test results showed that the reliability of the instrument was 0.85. This value is obtained using test-retest reliability.

3.4 Data analysis

In this study using a quantitative data analysis approach because all data obtained through tests and questionnaires are quantitative. The data related to students' concept understanding scores were analyzed through the following steps. First, the raw score of student learning outcomes is calculated on a scale of 100, where the maximum score is 100 and the minimum score is zero for both pre-test and post-test. Second, determine normality and homogeneity tests for both pre-test and post-test results for the experimental class and the control class. Third, test the difference in mean using t-test and N-gain values to see the effectiveness of PhET simulation-assisted discovery learning. After that, the analysis of the questionnaire data was carried out using the obtained Likert scale. After getting the Likert scale value, category determination is carried out to determine whether it is included in the good category or not.

4. Result of the research

From the results of the initial test (pretest) and post-test of the data collection, the following are the results of research conducted on the experimental class by giving treatment using the discovery learning model assisted by PhET simulation media and the control class using the conventional model. From the table above, the results of the study show that learning in the experimental class is higher than that in the control class. After all the data has been collected, the researcher then conducts the data analysis stage. Which is none other than to find out the final results of the research that has been carried out by researchers by answering the research hypothesis. Hypothesis testing can be done when the research data shows data that is normally distributed and has a homogeneous variance. The following are the results of the pretest and post-test normality tests for understanding the concept of optical geometry in the experimental class and the control class.

Table 1. The descriptive statistical result

Measurements	Experiment group		Control group	
	Pretest	Posttest	Pretest	Posttest
Number	35	35	35	35
Ideal score	100	100	100	100
Minimum score	25	60	25	40
Maximum score	65	100	60	75
Averages	43,43	81,29	43,29	58,00

Based on table 2 above, the results of the pretest and posttest normality tests in the experimental class and the control class are both derived from populations that are normally distributed. This is because the significant value is greater than 0.05.

After the data is normally distributed, then the homogeneity test is carried out. The following are the results of the pretest and post-test homogeneity tests for understanding the concept of optical geometry in the experimental class and the control class:

Table 2. The result of normality test

Group	Shapiro – Wilk			Group	Shapiro – Wilk		
	Statistic	Df	Sig.		Statistic	Df	Sig.
Pretest (experiment group)	0.97	35	0.439	Posttest (experiment group)	0.969	35	0.423
Pretest (control group)	0.961	35	0.245	Posttest (control group)	0.959	35	0.206

Table 3. The result of the homogenity test

Score	Levene Statistic	df1	df2	Sig.
Pretest (based on mean)	0.016	1	68	0.9
Posttest (based on mean)	0.016	1	68	0.9

Based on table 3 above, the results of the pretest and post-test homogeneity tests in the experimental class and control class both have homogeneous variances. This is because the average significant value of the Based on Mean column is greater than 0.05. Then, after the data is normally distributed and has a homogeneous variant. Hypothesis testing can also be done. The following is the data from the results of hypothesis testing.

Table 4. The result of t-test

Measurement	Group	Average score	N-gain	Sig.
Posttest	Experiment	81,29	81,29	0,0001
	Control	58,00	58,00	

Based on table 4 above, the results of hypothesis testing in the experimental and control classes can be concluded that there are differences in increasing understanding of the optical geometry concept between classes using the discovery learning model assisted by PhET simulation media using conventional learning models. This is because, the significance value is less than 0.05. In addition, the following are the results of the N-Gain test in the experimental and control classes. With reference to the following hypothesis:

> Ha: There is the effectiveness of the discovery learning model assisted by PhET simulation media to improve understanding of the concept of geometric optics
>
> Ho: There is no effectiveness of the discovery learning model assisted by PhET simulation media to increase understanding of the concept of geometric optics

So, based on table 4. It can be concluded that the effectiveness level of using the discovery learning model assisted by PhET Colorado is moderate and quite effective in increasing students' understanding of the concept of geometric optics. Meanwhile, the level of effectiveness of using conventional learning models is low and less effective for increasing students' understanding of optical geometry concepts. Thus, according to the N-Gain results, Ho is rejected so that the final conclusion is that there is the effectiveness of the Discovery Learning model assisted by PhET Colorado simulation media to improve understanding of the concept of geometric optics. Meanwhile, the results of the questionnaire data analysis are as in the table below:

Based on Table 5. above, it can be concluded that the interpretation of the student response scale is in the very good category, meaning that the student's response to a given treatment produces a very good response. This is because, the sum or total score of $Smin + 4PST < Smaxor 29403047 < 3500$. In addition, the results of interviews conducted with 5 students showed that students liked things

Table 5. The result of the Likert Scale

Aspect	Number	Whole number	Information
Usefulness of PhET simulation	786	3047	Very good
Ease of use of the PhET simulation	1029		
Ease of learning of the PhET to be learned	442		
Satisfaction of the use of PhET simulation	790		

related to optics, students also really liked PhET simulation media because when students used the media students did not find it difficult, students also recommended PhET simulation media to friends. -other friends because thanks to this media students find it easy to understand the material, then students also really like learning using the Discovery Learning model because students can discuss with their friends, plus the existence of PhET simulation media so that learning becomes more exciting not monotonous like ordinary learning who only use blackboard media.

Then based on the results of observations of researchers in the experimental and control classes, namely during the course of learning in the experimental class by giving a treatment, students become more active, become a vehicle for interaction between students and students and students with teachers, then students are more courageous in expressing their opinions because they managed to find out for themselves regarding the concept of the material so that it creates a sense of satisfaction, this inner satisfaction encourages students' desire to make more discoveries so that student learning interest also increases. Whereas in the control class, students were less active when learning took place, lack of interaction between students and teachers, learning was less conducive because there were some students who did not pay attention to the material being explained.

5. Discussion

In this study, the discovery learning model can involve students directly in the learning process which makes students more courageous in expressing their opinions because they can find the results of their findings with their friends themselves. When they succeed in finding their findings regarding a material concept, a sense of satisfaction arises in them. It is this sense of satisfaction that encourages students' desire to make more discoveries so that student learning interest increases. This is in accordance with the statement from another research that the discovery learning model can help students to find findings that students have never encountered before through the role of a teacher with the help of teaching materials, namely student worksheets (Mawaddah and Maryanti 2016). The results of the findings that students successfully encounter can be remembered more than the teacher explained because in this model it directly involves students in learning so that students can better understand what they are learning.

Meanwhile, at the time the research was taking place there were several factors that hindered the learning process, namely time was limited by the school hours set by the school, so students had to be able to arrange discussion time with their friends, because they were too enthusiastic and happy so they forgot about learning time. Therefore, the teacher always reminds about the learning time that continues to roll. In addition, the availability of supporting media (laptops), in the experimental class there were only 6 (six) students who had laptops while the number of laptops required was 7 (seven) according to the number of groups, namely 7 (seven) groups. But these obstacles can be overcome by the way the teacher lends his laptop to a group of students who don't have a laptop yet.

Based on the results of data processing that has been done, the average pretest and post-test values in the experimental class are 43.43 and 81.29. Meanwhile, the average pretest and post-test scores in the control class were 43.29 and 58.00. This shows that learning using the Discovery Learning model assisted by PhET simulation media is higher than using conventional models.

In addition, the results of the hypothesis test showed that the posttest scores between the experimental class and the control class had a significant difference in improvement. The posttest value of the experimental class is higher than that of the control class. This is because students who study using the discovery learning model assisted by PhET simulation media are more active and enthusiastic compared to students who learn using conventional models. Considering the results of research from previous researchers, the results of this study are in line with the results of research from (Avargil, Lavi, and Dori 2018), namely the use of the Discovery Learning model assisted by using PhET simulation media is proven to have an effect on students' understanding of physics concepts. This happened because students who were given treatment in the experimental group were required to be active while studying while students in the control group just sat listening to the material delivered by the teacher.

Finally, based on the results of the N-Gain test that was carried out by the researchers, it was shown that the results of the pretest and posttest values in the experimental class and control class resulted in a decision that there was the effectiveness of the discovery learning model assisted by PhET Colorado simulation media to improve understanding of the concept of geometric optics. The results of this study are in accordance with the statement from another research that the Discovery Learning Model is a model that is considered effective because students can develop their abilities and become more active while learning so that students can gain their own understanding (Sheftyawan, Prihandono, and Lesmono 2018).

6. Conclusion and implication

The conclusion from this study is that the use of the discovery learning model assisted by PhET simulation media is proven to be able to increase students' understanding of the optical geometry concept compared to the use of conventional learning models, and the use of the discovery learning model assisted by PhET simulation media is proven to be effective in increasing students' understanding of the optical geometry concept. Meanwhile, the implication of this study is that the use of the discovery learning model assisted by PhET simulation media can be an option for teachers to teach, both in the field of physics and in other fields and from the many learning media, PhET simulation media can be a fairly effective teaching tool or material. to help the teacher when teaching.

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