Science Education and Application Journal (SEAJ) *Bulan Tahun. Vol. , No,*
Program Studi Pendidikan IPA *p-ISSN: 2656-6672*
Universitas Islam Lamongan *e-ISSN: 2656-8365*
http://jurnalpendidikan.unisla.ac.id/index.php/SEAJ *pp. 1- 9*

EFFECTIVENESS OF THE GUIDED DISCOVERY MODEL BASED VIRTUAL LAB PhET TOWARD MASTERY STUDENTS' CONCEPT ON TOPIC PHOTOELECTRIC EFFECT

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Article History
Received: 25 January
Revised: 19 February
Published: March

Abstract
Research has been conducted to determine the effectiveness of the guided discovery model based on the virtual lab PhET (Physics Education technology) on mastering students' concepts in the photoelectric effect material. The purpose of this study is describing the feasibility of learning, student activity, and the effectiveness of the model applied to the mastery of student concepts. This type of research is quantitative descriptive with the design of one group pretest-posttest. The data obtained were in the form of learning accuracy questionnaires, student activities, and the results of the pretest and posttest mastery of students' concepts. Analysis of data on implementation and activities of students used percentage of agreement, while mastery of students' concepts was analyzed descriptively quantitatively through homogeneity, normality, and N-gain test. Based on data and analysis, it was concluded that the implementation of categorical learning was very good, student activities were in good category, and guided discovery models based on virtual labs PhET were effectively used to improve mastery of students' concepts in the photoelectric effect material.

***Keywords**: guided discovery model based virtual lab, mastery of students' concepts, photoelectric effect*

How to cite: Habibbulloh, Muhammad. (2019). EFFECTIVENESS OF THE GUIDED DISCOVERY MODEL BASED VIRTUAL LAB PhET TOWARD MASTERY STUDENTS' CONCEPT ON TOPIC PHOTOELECTRIC EFFECT. Vol. 1 No.1: 1-9.

I. INTRODUCTION (12pt)

Physics learning on the topic of photoelectric effects is one of the discussion material in physics subjects in the XII class of senior high school. Various concepts that are abstract, often and many are found in physics subjects, so this becomes one of the causes of students having difficulty understanding the material [1]. The subject of the photoelectric effect is a type of material that is very abstract to be taught. This is due to several factors including the very small size of the subject discussed to the atomic level and the unavailability of supporting laboratory equipment in schools to the strategies chosen by the teacher to explain the material, so that supporting media is needed to teach the abstract concept. One solution used by researchers is the use of the Guided Discovery model combined with the PhET virtual laboratory (Physics Education Technology). Some studies that support the virtual lab is effective in increasing student understanding include the results of Salam, Setiawan, and Hamidah's research on the use of virtual labs on the topic of dynamic electricity [2], Sugiyono's research on the use of PhETs on optical instruments [3], research results Pfefferova about learning activities using computer simulations [4], and Research Marlinda et al., About Phet virtual lab learning on the concept of solubility and solubility results [5].

The guided discovery learning model is a mixture of teacher-centered and student-centered [6]. The use of this model is intended so that students can understand the concepts taught to the maximum. Holmes and Hoffman mention three characteristics of guided discovery learning, namely: (1) exploiting and solving problems in order to create, combine, and generalize knowledge, (2) student-centered, teachers only act as facilitators, (3) activities in the model guided discovery to combine new knowledge and existing old knowledge [7]. Through discovery learning, the teacher creates a learning atmosphere that reflects the discovery process for students. Students are given the opportunity to search for and find information from the teaching material being studied. With student involvement and also teacher guidance, students will be more focused on understanding abstract concepts such as the photoelectric effect. The use of this model combined with the virtual lab is expected to be able to answer abstract material problems and lack of school laboratories specifically for the concept of the photoelectric effect. Purnomo et al., Stated that cognitive learning outcomes among students using the guided discovery learning model with conventional learning models had significant differences [8]. The results of research by Maulidar et al., show that the increase in the average conceptual understanding and critical thinking skills of students occurs differences. Experimental classes that use guided discovery learning models experience increased understanding of concepts and higher critical thinking skills compared to control classes that use conventional learning [9]. Relia et al., In their study stated that when compared to the control class, students in the class using guided discovery learning assisted by a virtual laboratory or experimental class, were more active and easy to understand the concept [10]. The effectiveness of the guided discovery model is also reinforced by Harianti's research which concludes that there is influence of the use of guided discovery learning models on the learning outcomes of class VII students in algebraic operating material, Guided Discovery Learning models are more effective than conventional learning models [11].

II. RESEARCH METHOD

The type of this study is descriptive quantitative with one group pretest posttest design. This research was conducted in class XII in one of the high schools in Lamongan. The way to determine the sample is to use opportunity sampling techniques or random sampling, namely simple random sampling. The experimental design used is as follows:

Table 1. The Experimental Design

R_1	O_1	X	O_2
R_2	O_1	Y	O_2

Informations:
R1 = Experimental class, random samples taken
R2 = Control class, samples taken randomly,
X = The Guided Discovery Model based on the PhET virtual lab,
Y = conventional method,
O1 = Class before being treated. This class is tested with the matter of the pretest,
O2 = Class after being treated. This class is tested with the posttest question

The procedure for the research conducted in this design was chosen by two random classes. One class as the experimental class (R_1) and the other class as the control class (R_2). In both classes a pretest was conducted to determine the initial knowledge possessed as well as to test the sample with normal distribution through the normality test of both classes. Furthermore, class R_1 is given treatment X, namely the Model Guided Discovery based on the PhET virtual lab with steps and devices that have been developed [12]. Class R_2 is treated with

conventional methods, the method commonly used by teachers in class. Then posttest was given in each class. The t-test was performed on the pretest and posttest values. The purpose of the t-test was to find out whether there was a significant difference in the mastery of students' concepts before and after being guided by a guided discovery model based on virtual labs. The t-test was carried out with the help of SPSS 16.0. Paired t-test conducted using a significance level $\alpha = 0.05$ (2-tailed). Test criteria with the t-test have a hypothesis:
H0: $\mu1 = \mu2$, meaning there is no significant difference between the pretest and posttest values.
Ha: $\mu1 \neq \mu2$, there is a significant difference between the pretest and posttest values.
The hypothesis testing criteria are to reject or not reject H0 based on P-value (in the SPSS 16 program the terms Significance or "Sig" are used) according to Sugiyono [13] are as follows:
If P-value is $<\alpha$, then H0 is rejected and Ha is accepted.
If P-value$> \alpha$, then H0 is accepted and Ha is rejected.
Before the paired t test is carried out, there are requirements for assumptions that must be met, that the sample data comes from the population with normal distribution.

The normality test aims to find out the sample data obtained comes from a population with normal distribution or not. After getting the pretest value, the data was tested for normality. The statistical test used was the Saphiro-Wilk test reinforced with Kolmogorov-Smirnov through the help of SPSS 16.0 with a significance level of $\alpha = 0.05$ (2-tailed). The form of the hypothesis for the normality test is as follows:
H0: $\mu1 = \mu2$, meaning that the data sample comes from a population with normal distribution
Ha: $\mu1 \neq \mu2$, meaning the sample comes from the population not normally distributed
Criteria for testing hypotheses to reject or not reject H0 based on P-value.

Furthermore, the pretest and posttest values were analyzed by the N-gain technique. The N-gain technique is used to determine the increase in mastery of students' concepts while strengthening the results of the t-test. The following is the gain technique equation according to Hake [14]:

$$\text{N-gain} = \frac{Spost - Spre}{Smax - Spre} \quad (1)$$

With:
N-gain = gain value Spost = posttest value
Spre = value of pretest Smax = maximum value
Calculations with the N-gain technique can be converted based on the criteria in table 2 [14].

Table 2. Criteria of Normalized *Gain*

N-gain Score	Criteria of Normalized *Gain*
N-Gain > 0,70	High
0,30 ≤ *N-Gain* ≤ 0,70	Middle
N-Gain < 0,30	Low

During the learning process an assessment of 2 observers is given through the implementation of the learning and activity student rubric. The level of reliability of the data instruments from the two observers is matched using the formula Percentage of agreement (PA) equation (2) according to Borich [15] as follows:

$$\boldsymbol{PA} = \left(1 - \frac{A-B}{A+B}\right) \mathbf{x\ 100\%} \quad (2)$$

Percentage of agreement (PA) = the level of compatibility of two observers
A = the frequency of aspects that give a high value
B = frequency of aspects that give a low value
the instrument is said to be suitable if it has a match level of ≥ 75%.

III. RESULTS AND DISCUSSION (12pt)

The results of research data obtained from the rubric of student activity and the implementation of learning are presented in table 3 and table 4:

Table 3. Student activity data through observation rubrics during the learning process

#	Aspects observed	Percentage of Activity of Students Each RPP (Lesson Plan) / Meeting		Average %
		1	2	
1.	Listen to the teacher's explanation	90,63	96,88	93,76
2.	Make a guess / hypothesis about the misconception of the photoelectric effect through cognitive conflict	75,00	78,13	76,57
3.	Reading handout	21,88	18,75	20,32
4.	Working on Photoelectric Effect LKS (worksheets)	100,00	100,00	100,00
5.	Identify variables	90,63	93,75	92,19
6.	Perform experiments with virtual labs	84,38	90,63	87,51
7.	Collect the data	90,63	98,88	94,76
8.	Analyze data	90,63	93,75	92,19
9.	Have group discussions	81,25	87,50	84,38
10.	Present the results of the experiment	62,50	65,63	64,07
11.	Answer and respond to the presentation of other groups	90,63	93,75	92,19
12.	Conclude the results of the class discussion	68,75	75,00	71,88
13.	Communicate information to classes and teachers	87,50	90,63	89,07
	Total average			**81,21**

Based on the Table 3, some student activities observed by the observer as a whole showed that activity in the guided discovery model was well implemented. Among them are listening to the teacher's explanation, making guesses/hypotheses about the misconceptions of the Photoelectric Effect through cognitive conflict, reading the Handout, working on the Photoelectric Effect LKS (worksheets), identifying variables, conducting experiments with virtual labs, collecting data, analyzing data, conducting group discussions, presenting experimental results, answering experimental results, answering and respond to the presentation of other groups, conclude the results of class discussions, and communicate information to the class and the teacher.

Table 4. Learning Outcomes Data in R_1 class

Learning Activities	Meeting 1	Meeting 2	Average	Category	*Percentage of Agreement*
Introduction					
1. Conditioning a pleasant learning atmosphere	3,00	3,50	3,25	Good	92,3%
2. Motivating Students	4,00	4,00	4,00	Very Good	100%
3. Delivering the learning objectives	3,50	3,75	3,63	Very Good	96,6%
4. Conveying a problem	3,50	3,50	3,50	Good	100%
Main Activities					
5. Explaining the steps of guided discovery model learning and providing a simple demonstration	3,50	3,50	3,50	Good	100%
6. Organizing students in groups					
a. Dividing students into groups	3,50	4,00	3,75	Very Good	93,3%
b. Guiding students to understand LKS (Worksheets)	4,00	4,00	4,00	Very Good	100%
7. Doing experiment					
a. The teacher motivates student activities	3,50	3,50	3,50	Good	100%
b. Facilitating students based on the needs of student groups in the experiment	3,00	3,50	3,25	Good	92,3%
c. Monitor all student activities during the experiment	3,50	3,75	3,63	Very Good	96,6%
8. Present the results of the experiment					
a. Give students the opportunity to present the results of the experiment	4,00	4,00	4,00	Very Good	100%
b. Guiding students in making conclusions	3,50	4,00	3,75	Very Good	93,3%
9. Analyze the process of inquiry and feedback					
a. Provide analysis of the investigation process	3,50	3,50	3,50	Good	100%
b. Give feedback on the results of observations and check students' understanding	3,50	3,50	3,50	Good	100%
Closing					
10. Guiding students to communicate learning conclusions	3,50	3,50	3,50	Good	100%
11. Give evaluation	4,00	3,50	3,75	Very Good	93,3%
Time management	4,00	4,00	4,00	Very Good	100%
Observing the classroom atmosphere					
1. Enthusiastic students	4,00	3,50	3,75	Very Good	93,3%
2. Enthusiastic teacher	4,00	4,00	4,00	Very Good	100%
Average (∑K)			**3,67**		
Total Average					**97,42%**
Percentage (∑K/∑N)					**91,75%**

Based on the data in Table 4, it can be seen that the implementation of learning activities using the guided discovery model based on virtual labs has been fully implemented well in class R_1. This can be seen from the value of the Percentage of Agreement in the initial activity, the core and closing has a very high percentage and the average total PA is 97.42%. Next step to prove the effectiveness of the guided discovery model based on virtual labs, pretest samples were tested whether the samples were normally distributed. The results of the normality test for the pretest class R_1 and R_2 are outlined in Table 5 and Table 6:

Tabel 5. Tests of Normality R_1

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest R_1	.144	20	.200*	.910	20	.063

Tabel 6. Tests of Normality R_2

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest R_2	.199	20	.037	.914	20	.077

Based on the results of the pretest sample normality test that has been done with SPSS 16.0 and outlined in Table 5 and Table 6, it is seen that the significance value with the Shapiro-Wilk model is more than 0.05. This shows that H0 is accepted and Ha is rejected. The conclusions that can be drawn from Table 5 and Table 6 are data samples originating from populations with normal distribution.

After the sample is stated to be from a normal distribution population, the pretest and posttest sample data will be carried out t-test to test and prove whether there are significant differences between the results of the two pretest and posttest samples. The results of the t-test pretest and posttest samples are outlined in Table 7 and Table 8

Tabel 7. Paired Samples Test R_1

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-23.000	11.169	2.497	-28.227	-17.773	-9.210	19	.000

Tabel 8. Paired Samples Test R_2

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-59.250	4.375	.978	-61.298	-57.202	-60.559	19	.000

Based on Table 7 and Table 8, the results show that each class R_1 and R_2 have a significance of less than 0.05. This shows that the P-value <α, then H0 is rejected and Ha is accepted. So it can be concluded that there are significant differences between the values of the pretest and posttest classes R_1 and R_2. Class R1 is an experimental class given a guided discovery model based on the PhET virtual lab, while class R_2 is a control class with a conventional model. To strengthen the argumentation of the effectiveness of the guided discovery model based on the PhET virtual lab, an analysis using Gain techniques was carried out. The following table 9 is the result of N-Gain classes R_1 and R_2:

Table 9. N-Gain Class R_1 and R_2

Student	Class R_1 N-Gain	Category	Student	Class R_2 N-Gain	Category
A	0,81	High	A	1,00	High
B	0,75	High	B	0,60	Middle
C	0,73	High	C	0,55	Middle
D	0,87	High	D	0,56	Middle
E	0,92	High	E	0,55	Middle
F	0,87	High	F	0,60	Middle
G	0,81	High	G	0,50	Middle
H	0,92	High	H	0,33	Middle
I	0,85	High	I	0,33	Middle
J	0,92	High	J	0,45	Middle
K	0,86	High	K	0,60	Middle
L	0,93	High	L	0,11	Low
M	0,80	High	M	0,63	Middle
N	0,85	High	N	0,44	Middle
O	1,00	High	O	0,11	Low
P	0,73	High	P	0,25	Low
Q	0,79	High	Q	0,17	Low
R	0,77	High	R	0,18	Low
S	0,86	High	S	0,58	Middle
T	0,80	High	T	0,60	Middle
Class Average	**0,84**	**High**	**Class Average**	**0,46**	**Middle**

Based on Table 9, it can be seen that the N-Gain both classes R_1 and R_2 have significant differences in terms of individuals and class averages. At the individual level, class R_1 has a relatively high and high N-Gain value, while class R_2 has a varied N-Gain with moderate and low dominance. At the average level the class also experiences something similar to the individual level. Class R_1 with a mean value of N-Gain 0.84 with a high category, while class R_2 N-Gain mean value is 0.46 with a medium category. This shows that it has been statistically proven through normality test, t-test, and strengthened by N-Gain analysis that guided discovery learning model based on virtual PhET lab is effectively used to improve students' understanding of the photoelectric effect material

IV. CONCLUSION

Referring to the results and analyzes that have been carried out where based on the analysis of the implementation of learning that is carried out fully has a very good category with an average value of the total percentage of agreement reaching 97.42%. Analysis of student activities is categorized as good with a percentage of 81.21%. The guided discovery learning model based on the virtual PhET lab also proved effective to be used to improve students' understanding of the photoelectric effect material. This can be traced from the normality data of the sample, the pretest and posttest t-test for each class and supported by individual and class N-Gain data. This fact is in accordance with previous research that supports, among others, Sugiyono [3], Pfefferova [4], Maulidar, et al. [9], and Relia et al. [10]

V. SUGGESTIONS

Suggestions for the contribution of science education in the future, guided discovery models based on the PhET virtual lab can be developed for science material with abstract characteristics and difficult to understand with conventional learning such as photoelectric effects. Device development is very much needed considering the limited use of virtual labs on a national scale, especially in Lamongan, East Java..

VI. ACKNOWLEDGMENT

Special acknowledgments for The Head of Lamongan Islamic University (UNISLA), The Dean Faculty of Teacher Training and Education (FKIP), opportunities given in conducting research

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