

The Influence of PhET (Physics Education Technology) using the Guided Inquiry Model on the Cognitive Ability for Elementary School Students

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ABSTRACT

This study aims to analyze significant differences in the PhET (Physics Education Technology) with the use the Guided Inquiry model of in terms of students' cognitive abilities through science learning outcomes before and after being treated with PhET media using the Guided Inquiry model. The research method used quantitative methods of Quasi-Experimental type with Non-equivalent Control Group Design research design. The data collection tool used Pretest-Posttest questions totaling 25 items. The study population was all fifth grade students of SDN Tanggul Wetan 02, totaling 48 students. The results showed that there was a significant difference in the cognitive abilities of students who used PhET media assisted the Guided Inquiry model with the cognitive abilities of students who used conventional learning. There is a significant increase in cognitive abilities after being treated with the application of PhET media assisted by Guided Inquiry model with before being treated with the application of PhET media assisted by Guided Inquiry model. In general, there is a positive and significant effect (2 tailed) $p = 0.513 > 0.05$ from the application of PhET media using Guided Inquiry model in science practicum activities on the cognitive abilities of elementary school students.

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1. INTRODUCTION

In the 21st century, attempts to improve the quality of education in Indonesia to be able to adapt in the era of the industrial revolution 4.0 and society 5.0 is to emphasize students on mastering 4C (Creativity, Critical thinking, communication, collaboration) as a basic competency (Saptaningrum et al., 2023). One of the efforts in improving the quality of education and equipping children with 4C skills is through learning activities at school. Teachers should implement training, development and education based on knowledge of the individual characteristics of students, ensure their ascent to a higher level of development, conduct scientific-pedagogical searches and scientifically solve problems of forming the child's personality (Tsybulsky & Oz, 2019).

Learning is a process of effort made to obtain comprehensive changes in behavior, as a result of experience in interacting with the environment (Herliana, 2021). Learning outcomes can also be interpreted as attitudes, abilities, and skills that students get after getting treatment given by the teacher, so that the knowledge gained can be applied in everyday life (Andryannisa, 2023). Bloom's taxonomy divides learning outcomes into three domains, namely the affective domain, cognitive domain, and psychomotor domain. The cognitive domains used in the questions can prepare students to learn and apply knowledge in real-life situations (Fitriani et al., 2021). The acquisition of learning outcomes is closely related to the ability to process information on learning materials that students learn in the cognitive domain. All efforts related to brain activity are included in the cognitive domain (Bloom, 1956).

The cognitive domain is the domain that discusses learning objectives related to mental processes that start from the level of remembering to creating (Marta et al., 2024). The cognitive domain in Bloom's Taxonomy is divided into six levels ranging from low-level cognitive to high-level cognitive. Krathwohl (2002), the cognitive domain in Bloom's Taxonomy consists of remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). The first two aspects in the cognitive domain are called low-level cognitive and the next four aspects include high-level cognitive. Measurement of the cognitive domain is useful for improving quality and improving student learning outcomes (Ibtidaiyah, 2023). The process of improving the learning outcomes of the cognitive domain of students in science learning is more effectively done through practicum (Natalia et al., 2022).

Science subjects are materials that study natural phenomena in the form of facts (Wardani et al., 2022). Science can build a new generation that has scientific thinking and a strong scientific attitude to communicate integrated science to others, society and the environment. (Nuriman et al., 2022). The science learning process must involve observation, practicum, and experimentation activities because they greatly affect the level of understanding of students both affective, cognitive, and psychomotor (Anjarsari et al., 2023). Science learning content that is taught only through books or in theory, makes the content taught abstract so that it is difficult for students to understand. Therefore, every content in science learning needs to be taught in theory and practice.

Science learning essentially requires a laboratory to practice, laboratories are very important in carrying out science learning because through laboratories students can practice directly about the science content that is being studied (Sayildan, 2022). Science does not only learn something in theory, but science learning must be done through practicum to make it easier for students to understand every content presented by the teacher (M. Agustina, 2018). Therefore, there is a need for learning innovations that involve the achievement of student competencies to be able to compete in a global society through the development of science technology. Current technological advances can be utilized in educational development (Tamarin & Prastowo, 2024). The utilization of technology in education must be seen as one way to encourage the improvement of the quality of education in this era, as well as in science learning (Fredlina et al., 2021).

Physics Education Technology (PhET) is a web-based simulation learning media developed by the University of Colorado (Perkins et al., 2012). PhET learning media is a virtual laboratory that allows users to conduct science experiments through computer devices (Susilawati et al., 2022). One of the science learning materials in elementary schools in PhET media is electrical circuits. Ariyanto et al (2022), PhET media in science learning can improve student learning outcomes about electrical circuits. The nature of science learning is emphasized to provide direct experience so that students gain a deep understanding and can last longer in memory. Learning using simulations can increase the level of student achievement in physics compared to students who learn physics conventionally (Najib et al, 2022). The use of discovery learning learning models assisted by PhET media improves student learning outcomes in the C1, C2 and C5 cognitive domains on elasticity and hooke's law material (Hikmawati et al., 2021). Inayah (2021), state that the use of PhET media in learning can improve students' understanding and thinking skills with a percentage of 90%. The implementation of PhET as a virtual lab can reduce errors and accidents during practical work. In addition, virtual labs can also be a solution for schools that have problems with laboratory facilities (Fauziyah, 2025).

In Indonesia, the use of virtual laboratory media such as PhET is still rare, especially at the elementary school level. This is due to the time required for the learning process, which is relatively longer than conventional methods. Teachers need to prepare computers and internet connections in advance before teaching, and students do not fully understand how to operate computers. Therefore, teachers prefer to use the lecture method when teaching science concepts. The use of lecture methods makes it difficult for students to understand abstract concepts because, according to Jean Piaget's cognitive development theory, elementary school-aged students are in the concrete operational stage and require a learning process that presents real objects or media that can visualize those objects. The 2022 PISA (Programme for International Student Assessment) survey results ranked Indonesian students' science skills 70th out of 81 countries with a score of 383 points (OECD, 2023).

This is consistent with observational findings that show science learning in class V (fifth) SDN Tanggul Wetan 02 is carried out with conventional learning using books as teaching materials. Science practicum activities are not carried out because the school does not have a laboratory or learning media that supports. This makes it difficult for students to understand electrical circuit material and causes low learning outcomes. Based on the results of daily tests, students have an average science score of 70. This value is below the minimum completeness criteria (KKM) for science subjects which is 75. If this is left unchecked, it will cause low cognitive abilities of students and hamper their other competencies.

The use of learning media and learning models is very important in implementing the learning process. The selection of appropriate media and learning models will affect the level of understanding of students and their learning outcomes (Mecias-Valencia et al., 2024). Science learning using PhET as a practicum media

requires a learning design that is in accordance with the characteristics and mechanisms of PhET media. Perkins et al (2006) as a PhET media developer suggested that learning using PhET media is applied with a guided inquiry approach. The Guided Inquiry model is an approach that encourages learners to learn through their own active engagement with concepts and principles. In this model, educators act as facilitators and organizers who guide students to discuss and experiment in groups, so that students can learn to think logically, analytically, and critically in the process of finding answers (Sarifah & Nurita, 2023).

The guided inquiry model is divided into two types, namely deductive guided inquiry and inductive inquiry. Deductive guided inquiry is a learning model that emphasizes giving problems to students by the teacher to find a concept or theory independently which is used for the problem-solving process (Simamora et al., 2022). The characteristics of PhET media in the form of virtual laboratories are more in line with the characteristics of guided deductive inquiry models that emphasize a basic understanding of a subject, followed by in-depth investigation through experimental activities to discover the concepts of the subject in depth (Banda, 2023). This is useful for training students' higher-order cognitive skills according to Bloom's Taxonomy because it involves logical and analytical reasoning activities related to phenomena occurring in the virtual laboratory (Torregoza et al., 2024). Therefore, the deductive guided inquiry model is very suitable for use in science learning, especially in the use of PhET media for experiments.

Research conducted so far has used learning models that are not in line with the characteristics of PhET media, resulting in suboptimal research. The use of PhET media assisted by problem-based learning models did not show significant differences in students' cognitive abilities (Zulviani et al., 2024). The syntactic incompatibility of the learning model used in implementing PhET media resulted in no difference in students' abilities before and after treatment. In addition, previous studies only used PhET as a supporting medium in testing the effects of certain learning models. Therefore, the difference between this study and previous studies is that the PhET media was tested directly for its influence or lack thereof as an auxiliary medium and the use of guided inquiry learning models that have syntax in accordance with the characteristics of PhET media. The purpose of this study is to determine whether there is an effect of the PhET (Physics Education Technology) media assisted by guided inquiry learning models on the cognitive abilities of elementary school students.

2. METHOD

2.1. Research Design

This research method used a quantitative approach with an experimental research type. Experimental research aims to determine the presence or absence of the effect of a particular treatment on changes in a particular condition (Masyhud, 2021: 138). The type of experimental research used is a quasi-experimental with a Non-Equivalent Control Group Design.

Table 1. Research Design *Non-Equivalent Control Group*

t	O ₁	X	O ₂
C	O ₁		O ₂

The population in this study was fifth-grade A students, totaling 24 children, and fifth-grade B students, totaling 24 children, in the 2024/2025 school year. Determination of the sample class was carried out using sample random sampling with the results of fifth grade A as the control class and fifth grade B as the experimental class. Data collection techniques include interview techniques, observation, documentation, and multiple choice tests. The test conducted in this study was a pre-test conducted before treatment, with the aim of measuring students' initial cognitive abilities, and a post-test conducted after the class was given treatment, with the aim of knowing whether there were changes in students' cognitive abilities or not. The validity and reliability of the test were tested using SPSS version 25 software as a prerequisite for research instruments.

2.2. Hypothesis

H_a = there is an effect of PhET (Physics Education Technology) using the guided inquiry model on the cognitive abilities of elementary school students.

H_0 = there is no an effect of PhET (Physics Education Technology) using the guided inquiry model on the cognitive abilities of elementary school students.

2.3. Hypothesis Testing

If $t_{\text{count}} \geq t_{\text{table}}$, then the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted.

If $t_{\text{count}} \leq t_{\text{table}}$, then the null hypothesis (H_0) is accepted and the alternative hypothesis (H_a) is rejected.

2.4 Decision on the results of hypothesis testing

H_0 rejected and H_a accepted, if the t-test result shows a value greater than the t-table with a significance level of 0.05.

H_0 rejected and H_a accepted, if the t-test result shows a value low than the t-table with a significance level of 0.05.

3. RESULTS AND DISCUSSION

3.1. Description of Research Result

3.1.1 Validity Test

Validity is a measure that indicates the degree of validity of an instrument (Arikunto, 2015:211). The instrument used in this study was a test consisting of a pretest and posttest with a total of 30 multiple-choice questions. The test instrument validators in this study were Elementary School Teacher Education Lecturers and fifth-grade teachers at SDN Rowokangkung 04. The purpose of validating the instrument with validators was to determine the suitability of the instrument before it was tested in the field. The instrument validation score was then calculated using the following formula.

$$Valpro = \frac{SRT}{SMT} \times 100$$

$$Valpro = \frac{87}{100} \times 100$$

$$Valpro = 87\%$$

The results of the score calculation using this formula are then classified according to the instrument validity criteria. According to Masyhud (2021:317), a valpro score of 87% is considered very feasible. Then, the test instrument was tested on 22 fifth-grade students at SDN Rowokangkung 04. The results of the test instrument trial were calculated using product moment correlation in SPSS 25 and produced 20 valid questions. The results of the product moment correlation test of the test instrument are presented below.

No. Item	Correlation Coefficient		Results
	r-count	r-table	
1	0.663	0.423	Valid
2	0.694	0.423	Valid
3	0.680	0.423	Valid
4	0.726	0.423	Valid
5	0.730	0.423	Valid
6	0.769	0.423	Valid
7	0.806	0.423	Valid
8	0.701	0.423	Valid
9	0.590	0.423	Valid
10	0.796	0.423	Valid
11	0.618	0.423	Valid
12	0.690	0.423	Valid
13	0.719	0.423	Valid
14	0.702	0.423	Valid
15	0.747	0.423	Valid
16	0.653	0.423	Valid
17	0.60	0.423	Valid
18	0.639	0.423	Valid
19	0.716	0.423	Valid
20	0.727	0.423	Valid

3.1.2 Reability Test

One indicator of a reliable instrument is that when the instrument is used repeatedly with the same object, the results will be relatively the same (Masyhud, 2021:300). The type of reliability test used in this study was the Split-Half reliability test. The reliability test results are presented below.

Table 3. Reability Test

Reability Statistics	
Cronbach's Alpha	N of Items
.868	10

The basis for decision making refers to the results of the instrument correlation analysis. If the correlation analysis result is > 0.80 , then the research instrument is declared reliable (Sarwono, 2015:249). It is known that the Guttman Split-Half Coefficient is 0.868, which is greater than 0.80 ($0.868 > 0.80$). According to Masyhud (2021:327), a reliability value of 0.868 is classified as high.

3.1.3 Analysis of homogeneity test

The homogeneity test aims to determine the initial ability of students and to determine the difference in significant ability between the two classes before the pre-test. The data used in the homogeneity test is the daily test results of students in science subjects.

Table 4. Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.
Daily test scores	Based on Mean	.051	1	46	.823
	Based on median	.034	1	46	.854
	Based on Median and with adjusted df	.034	1	46	.854
	Based on trimmed mean	.055	1	46	.815

The test results show a significance value is $p = 0.82$. The basis for making homogeneity test decisions is if the significance value $p > 0.05$ then the data is homogeneous, while if the significance value $p < 0.05$ then the data is not homogeneous. Based on the homogeneity test results presented, it is known that the significance value is $p = 0.82 > 0.05$. The test results show that the data is homogeneous.

3.1.4 Analysis of Pre-test and Post-test Results

The results of the pre-test and post-test analysis of science subjects on the material of magnetism, electricity, and technology for life are used to measure students' cognitive abilities.

Table 5. Descriptive Research Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-test Control	24	27	72	51.00	12.040
Post-test Control	24	42	82	66.42	10.934
Pre-test Experiment	24	35	70	49.00	8.097
Post-test Experiment	24	55	92	75.25	9.162

The study showed that the control class had a pre-test average score of 51, a minimum score of 27, a maximum score of 72, and a standard deviation of 12.04. While the average post-test value of the control class is 66.42, the minimum value is 42, the maximum value is 82, and the standard deviation is 10.93. The experimental class had a mean pre-test score of 49, a minimum score of 35, a maximum score of 70, and a standard deviation of 8.097. While the average value of the experimental class post-test was 75.25, the minimum value was 55, the maximum value was 92, and the standard deviation was 9.162.

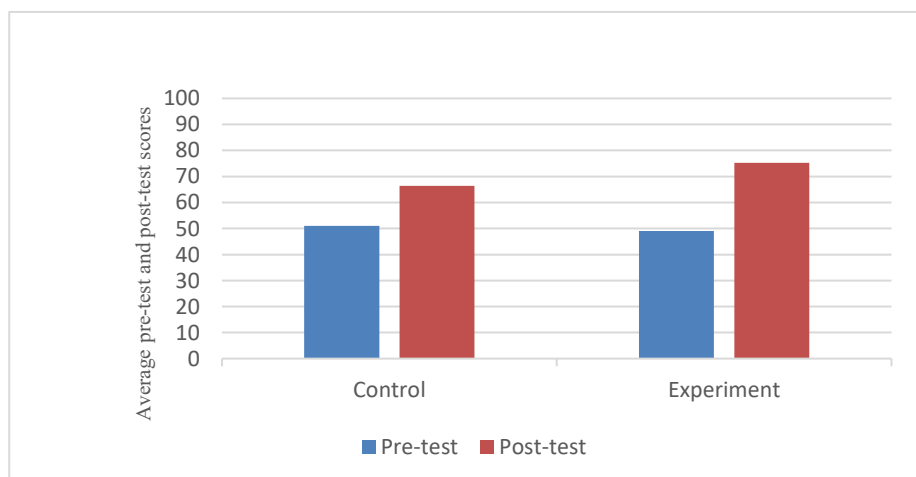


Figure 1. Improvement in student test scores

Students in the control and experimental classes showed an increase in scores from the pre-test to the post-test. However, a significantly higher increase occurred in the experimental class. This proves that PhET media has an impact on students' cognitive abilities compared to the control class. To measure the impact, the data was calculated using Cohen's d formula as follows.

3.1.5 Analysis of normality test

The research data obtained through the pre-test and post-test are then carried out a normality test which aims to determine whether the data of the two variances are normally distributed or not as a prerequisite for parametric statistical tests.

Table 6. Normality Test Results

	Shapiro-Wilk			
	Class	Statistic	df	Sig.
Pre-test	Control	.963	24	.497
	Experiment	.941	24	.169
Post-test	Control	.941	24	.173
	Experiment	.948	24	.243

The normality test produces a significance value $p = 0.497; 0.169; 0.173; 0.243 > 0.05$, which means that both variances have normally distributed data and meet the requirements for parametric statistical tests. The type of parametric statistical test used is the independent sample t-test.

3.1.6 Analysis of Independent Sample t-test

Independent sample t-test aims to determine whether there is a significant difference in cognitive ability based on learning outcomes after being given treatment in two different classes. The data used to conduct an independent sample t-test are the pre-test and post-test scores of the control class and experimental class.

Table 7. Analysis of Independent Sample t-test results

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Value	Equal variances assumed	.435	.513	-5.545	46	.000	-9.167	1.653

The Independent Sample t-test produces a $t_{\text{count}} = 5.545$ and the degree of freedom (db) is 46. The t-table value with a population of 46 is 1.679. So, it can be seen that $t_{\text{count}} > t_{\text{table}}$ ($5.545 > 1.679$). Therefore, it can be concluded that there is a significant difference between the learning outcomes of experimental class students and the learning outcomes of control class students.

3.1.7 Test of relative effectiveness

The relative effectiveness test is used to calculate the success rate of a treatment compared to other treatments. The relative effectiveness test is calculated using data from the average value of the difference between the post-test and pre-test of the experimental class and the control class.

$$ER = \frac{MX_1 - MX_2}{\left(\frac{MX_1 + MX_2}{2}\right)} \times 100$$

$$ER = \frac{26,35 - 15,52}{\left(\frac{26,35 + 15,52}{2}\right)} \times 100$$

$$ER = \frac{10,83}{\left(\frac{41,87}{2}\right)} \times 100$$

$$ER = \frac{10,83}{20,93} \times 100$$

$$ER = 0,51 \times 100$$

$$ER = 51\%$$

The results of the relative effectiveness test concluded that PhET media in learning is 51% more effective than conventional learning through books. Masyhud (2021: 441), the level of relative effectiveness with a percentage of 41.00% - 60.99% is in the medium category.

3.1.6 Research Hypothesis Test

The calculated $t_{\text{count}} = 5.545$ and the table $t_{\text{table}} = 1.679$ obtained in the independent sample t-test is concluded $t_{\text{count}} > t_{\text{table}}$ with a significance level of 0.05. Then these results are compared with the hypothesis testing criteria, namely if $t_{\text{count}} > t_{\text{table}}$ then the null hypothesis (H_0) is rejected and the alternative hypothesis

(H_a) is accepted. The decision on the results of hypothesis testing can be concluded that there is an effect of PhET (Physics Education Technology) using the guided inquiry model on the cognitive abilities of elementary school students.

The level of influence of PhET media on students' cognitive abilities was measured using Cohen's d effect size using the following calculation.

$$(1) SD_{pooled} = \sqrt{\frac{(SD_1^2 + SD_2^2)}{2}}$$

$$SD_{pooled} = \sqrt{\frac{(9^2 + 11^2)}{2}} \\ = 10.05$$

$$(2) d = \frac{M_1 - M_2}{SD_{pooled}} \\ d = \frac{75.25 - 66.42}{10.05} \\ = 0.87$$

The calculation uses the average post-test scores of the experimental and control classes along with the standard deviation. According to Cohen (1988), a value of $d = 0.87$ is classified as a large and practically significant difference. Therefore, it can be concluded that PhET media has a large and practically significant effect on students' cognitive abilities compared to conventional learning methods.

3.2 Discussion

This experimental research was conducted at SDN Tanggul Wetan 02 Jember with the aim to determine whether or not the influence of PhET (Physics Education Technology) using guided inquiry model on cognitive abilities of elementary school students. The research subjects used were fifth grade A and fifth grade B students with a total of 24 students each. The division of classes in this study is fifth grade A as the control class and fifth grade B as the experimental class. Fifth grade A as a control class uses conventional learning through books, while fifth grade B as an experimental class uses PhET media with the help of a guided inquiry model. The science learning material used in this study is the electrical circuit in chapter 3 "magnetism, electricity, and technology for life".

The homogeneity test produced a significance value of $p = 0.82$, it is known that $p = 0.82 > 0.05$. So, it can be concluded that the two variances are homogeneous. The next stage is to determine the control class and the experimental class using the sample random sampling technique which results in the decision of fifth grade A as the control class and fifth grade B as the experimental class. The control class conducted conventional learning using books, while the experimental class was given treatment using PhET media assisted by the guided inquiry model.

Determination of the research schedule was carried out by discussion between the researcher and the principal on July 22-25, 2024. The initial step of the research was carried out by giving a pre-test to students in the experimental class and control class to measure the initial ability of students. The pretest questions were in the form of multiple choice totaling 20 items consisting of cognitive domains C3, C4, and C5. After conducting the pre-test, treatment was then carried out to experimental and control class students for 2 meetings. The last step is giving a post-test to both classes to measure the final ability of students after being given treatment.

The first meeting in the experimental class was held on July 22 and the control class was held on July 24. The first meeting in the experimental and control classes was carried out by dividing students into 8 groups and providing LKPD as an observation sheet to each group. Furthermore, the teacher provides problems related to the series circuit to students. Then, students did a practicum by assembling a series electrical circuit using PhET media in the experimental class and electrical kit media in the control class to solve the problem presented by the teacher. Learners are directed to find how the series electrical circuit works along with its advantages and disadvantages. Then the results of the practicum were compiled through LKPD and presented in front of the class along with the electrical circuit that was compiled.

The second meeting of the experimental class was held on July 23 and the control class was held on July 25. The initial step of the second meeting was carried out by giving problems to students related to parallel circuits. Then, the teacher distributes LKPD to each group to do a practicum by assembling a parallel electrical circuit. The teacher guided learners to solve problems by understanding how parallel circuits work, analyzing the advantages and disadvantages of parallel circuits, and determining the differences between series and parallel circuits. Then students compile the results of the practicum through LKPD and are presented in front of the class along with the resulting electrical circuit.

The practicum steps carried out are adjusted to the guided inquiry learning design which consists of 7 stages, namely 1) Exploring phenomena and facts, 2) Focusing on the problems to be observed, 3) Planning practical activities, 4) Performing practical activities, 5) Analyzing the data obtained, 6) Constructing new knowledge, and 7) Presenting the results of practice (Llewellyn, 2013: 7). The learning outcomes to be achieved are in the cognitive domains of C3 (apply), C4 (analyze), and C5 (evaluate). In the C3 domain, students apply their initial understanding obtained from the teacher's explanation to the problems presented through the activity of assembling the electrical circuit in accordance with the LKPD guidelines. In the C4 domain, students analyze the data obtained from experimental activities by writing it down through the LKPD sheet to solve the problems presented. In the C5 domain, students evaluate their understanding by presenting the electrical circuit work and experimental results contained in the LKPD in front of the class.

After conducting 2 meetings in the experimental class and control class, a post-test was conducted to compare the results of the pre-test with the post-test in the control class and experimental class. The results of the pre-test and post-test of the two classes that have been obtained are then carried out a normality test to determine whether the data is normally distributed or not and as a requirement to determine the type of statistical test to be used. Based on the normality test that has been carried out, the significance value of $p = 0.497; 0.169; 0.173; 0.243 > 0.05$ so that the data can be said to be normally distributed and meets the requirements for conducting parametric statistical tests, namely the independent sample t-test. The average value of control class students before being given treatment (pre-test) was 51.14 and after being given treatment (Post-test) was 66.66. In the experimental class, the average value of students before being given treatment was 49.16 and after treatment was 75.52. The comparison of the pre-test and post-test scores of the control class is 15.52, while the comparison of the pre-test and post-test scores of the experimental class is 26.36. Based on the comparison of the pretest and posttest values of the control and experimental classes, it can be concluded that the pre-test and post-test values of the experimental class are greater than the control class.

The independent sample t-test using SPSS version 25 showed a $t_{\text{count}} = 5.545$. Then the value is compared with the t-table value at the 0.05 significance level with $df = 46$ which is worth 1.679. Based on the known value, $t_{\text{count}} > t_{\text{table}}$ is obtained ($5.545 > 1.679$). So, that H_0 is rejected and H_a is accepted, which states that there is a significant effect of PhET (Physics Education Technology) media using the guided inquiry model on the cognitive abilities of elementary school students. The next step was to see the level of effectiveness of PhET media in achieving the learning outcomes of fifth grade students at SDN Tanggul Wetan 02. Based on the relative effectiveness test conducted, a relative effectiveness value of 51% (medium) was obtained. The factors that cause PhET media to be 51% more effective than practicum using books in conventional learning are 1) PhET media is able to visualize electrical phenomena, 2) Students can arrange the form of electrical circuits with unlimited components, 3) Students can analyze the advantages and disadvantages of types of electrical circuits.

Circuit Construction Kit: DC - Virtual Lab in PhET media has an unlimited number of practicum tools, so that students can freely create the form of electrical circuits with the desired number of electrical components (Haetami et al., 2023). Practical PhET media can reduce learning time limitations and improve the quality of experiments because students can repeat experiments easily if there are results that are not in accordance with the steps of problem solving (Kurniawan et al., 2020). The use of books in conducting practicum makes it difficult for students because they cannot observe electrical phenomena and cannot analyze the advantages and disadvantages of electrical circuits (Jayanagara & Lukita, 2023). The use of interesting teaching aids for practicum activities can help students in practicing skills so that practicum results can be improved. The existence of teaching aids makes the number of students who are actively involved in practicum activities reach 96.96% (Umayah et al., 2020)

The results of this study are in accordance with previous research conducted by Inayah & Masrurroh (2021), namely the use of PhET simulation media has an effectiveness of 63% (medium) in influencing student learning outcomes. Another study conducted by Saputra et al (2020) showed that the average value of the control class pre-test was 33.20 and the average value of the control class post-test was 75.60 compared to the acquisition of the average value of the experimental class pre-test of 30.10 and the average value of the experimental class post-test of 80.57. The results showed that the quality of students' experiences changed during the practicum, ranging from boredom and difficulty to a sense of accomplishment and improved cognitive thinking skills.

4. CONCLUSION

Based on the results of the study, the cognitive abilities of students in the experimental class using PhET media assisted by guided inquiry models were better than students in the control class using conventional learning through books. This is evidenced by the learning outcomes that include cognitive domains C3, C4, C5 of experimental class students are higher than the learning outcomes of control class students. The results of the t-test calculation also showed a significant difference in the cognitive abilities of the two classes. This is

supported by the relative effectiveness level (ER) of using PhET media of 51% (medium). The results of this study are expected to broaden the understanding of Jean Piaget's cognitive development theory based on the findings, serve as a reference in the development of science-based learning media, which is still lacking in elementary schools, become a source of reference related to the cognitive abilities of elementary school students, and provide consideration for teachers to use interactive learning media based on virtual laboratories so that students are trained to think analytically and logically. The limitations in conducting this research were time constraints, the need to condition students, and the fact that not all students were able to operate computers. Therefore, the suggestion for further research is to prepare and condition students before the treatment is given in order to streamline the implementation time.

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