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# THE EFFECT OF PHET SIMULATION ON THE DISCOVERY LEARNING MODEL ON CRITICAL THINKING SKILLS OF SMA STUDENTS ON STRAIGHT MOTION MATERIALS

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**ABSTRACT**

*Critical thinking* is a competency that must be trained in students because this ability is needed in today's life. Discovery learning models can help students eliminate their doubts about a concept because it leads to a final and definite truth. This study aims to determine the effect of PhET simulation on the Discovery learning model on students' critical thinking skills. The research was conducted at SMA Negeri 1 Sape, Jalan Pelabuhan Sape, Bima, West Nusa Tenggara. The data collection technique in this study used a test instrument to measure students' thinking skills. Utilizing tests at the beginning of learning (pre-test) and tests at the end of learning (post-test), the results of the pre-test and post-test are the data to determine students' critical thinking skills. The data analysis used is parametric analysis. The results of this study show a significant effect between the PhET simulation and the Discovery learning model on students' critical thinking skills in the form of an increase in post-test scores that occur in the experimental class using PhET-based learning.



**Keywords:** PHET Simulation, Discovery Learning, Critical Thinking Skills.

## INTRODUCTION

Critical thinking is a competency that must be trained in students because this ability is indispensable in today's life (Schafersman, 1999; and Arnyana, 2004). Teachers need to help students to develop critical thinking skills through learning models that support students to learn actively. When there is a problem, problem-solving skills indicate thinking maturity. Through the Discovery learning method, which involves maximally thinking skills in finding their physics concepts, students can understand more and not easily believe what has not been proven true. Discovery learning models can help students eliminate their doubts about a concept because it leads to a final and definite truth. The results show that applying the Discovery learning model can improve students' critical thinking skills, Purwanto (2012). This also follows the results of Pratiwi's research (2014) which shows that improving students' critical thinking skills are more significant using the Discovery learning method than other learning methods. Overcoming students' difficulties in understanding the concept of Straight Motion can be overcome with multimedia. A multimedia tool can create dynamic and interactive presentations that combine text, graphics, animation, audio and video (Asthana, 2010), as well as be constructivist, provide good feedback, and provide a workplace (Finkelstein, 2006).

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Interactive multimedia is suitable for overcoming students' difficulties in exploring the ability to express ideas about the concepts being studied (Podolefsky, Perkins, & Adams, 2010). Efforts to increase students' activeness and critical thinking skills in finding their concepts learned and learning achievement require innovative learning methods. One alternative learning is discovery learning. Several studies on the application of discovery learning in learning state that it can improve students' ability to construct and build their knowledge compared to conventional learning (Klahr & Nigam, 2004; Putrayasa et al., 2014; Indarti et al., 2014). In addition, students can actively seek, process, construct, and search for the meaning of something they are learning (Nisa' & Suliyanah, 2014).

The PhET simulation program is a fun interactive simulation media based on the discovery in the form of software and can be used to clarify physical concepts or phenomena that have been put into practice (Mubarrok & Mulyaningsih, 2014). Learning using PhET simulations makes students interested and enthusiastic about doing practicums to complete student learning outcomes (Prihatiningtyas et al., 2013). In addition, learning physics using interactive multimedia PhET provides better learning outcomes than classes that only use practicum without PhET media (Mubarrok & Mulyaningsih, 2014). Learning that collaborates discovery learning and PhET simulation program packages is expected to create an enjoyable learning atmosphere, make students more active, and improve critical thinking skills to understand physics to help students improve critical thinking skills.

Students work in groups using worksheets with the PhET simulation program package through this learning. The existence of this worksheet can provide a role for students in helping to express their ideas and can provide appropriate feedback (Alfieri, 2011). Students interact with other students to achieve the goals to be achieved in groups. Cooperation in solving problems provides opportunities for students to achieve new knowledge they do not achieve when working alone. Through discovery learning, students are required to actively participate in finding information in groups (Balim, 2009). Information guides students in achieving the desired concept (Cohen, 2008).

SMA Negeri 1 Sape is a public high school in Bima Regency, West Nusa Tenggara and has used the 2013 curriculum. In the physics learning process, it turns out that it is still not optimal to maximize student participation in teaching and learning activities. According to the research results, learning physics that can maximize activities in the laboratory can produce a greater growth rate of thinking skills, Huda (2012). The use of the PhET simulation program package can complete physics learning outcomes (Prihartiningsih et al., 2013), understanding physics concepts (McKagan et al., 2008) and can provide opportunities for students to gain a good understanding of the concepts to be studied (Swaak & de Jong, 2004). Thus, students who learn through discovery learning assisted by the PhET simulation program package will have higher critical thinking skills than students who learn using discovery learning alone. Mastery of students' concepts is formed due to modification or strengthening of concepts that students already have (Azis, 2013).

## LITERATURE RIVIEW

The Discovery learning model using PhET simulation as learning that optimizes student participation can affect students' critical thinking skills. According to Scott's research (2008), students can improve critical thinking skills through expressing opinions, engaging in experiments, gathering information, conducting analysis, conveying tentative assumptions, asking questions about a thought, and demonstrating self-skills.

Learning science, especially physics, is learning that pays attention to understanding skills before trying. If students are given information in a new context, they will experience problems, so they forget to encourage students in the present. In physics learning, what is given only provides facts that are accepted as absolute truths and studied as they are. The material is given for memorization, which leaves little reason to think about the fact.

A process should be more focused than just a result. They are trying to grow the thinking skills of students who will become the nation's successors as thinkers in solving a problem. The PhET-assisted Discovery learning model is based on PhET simulation-assisted discovery, which is expected to stimulate students' thinking skills because students find their knowledge to deeply understand facts, concepts, principles and laws of physics. In the Discovery learning model, the teacher gives a problem so that students think until they can conclude PhET-assisted discovery activities.

Finding their knowledge of physics concepts allows students to see in-depth, analyze and evaluate more than just the information they receive. It is not easy to believe in accepted ideas before proving themselves true is one characteristic of critical thinking skills. It is hoped that the PhET-assisted Discovery learning model can improve students' critical thinking skills.

## METHODS

The research was conducted at SMA Negeri 1 Sape, Jalan Pelabuhan Sape, Bima, West Nusa Tenggara. This study uses a quasi-experimental design (Quasi-Experimental Design) in the form of a nonequivalent control group design. The total population of each class contains about 36 students. The samples in this study were two classes, namely the first class, X IPA 7, which will receive discovery learning models using PhET simulation. From now on referred to as the experimental class. At the same time, the second class, X IPA 5, which received discovery learning without using PhET simulation, was called the control class. With about 36 students in one class, the total number of both classes is 72. The data collection technique in this study used a test instrument to measure students' thinking skills. Employing tests at the beginning of learning (pre-test) and tests at the end of learning (post-test), the results of the pre-test and post-test are the data to determine students' critical thinking skills.

### Data Analysis

#### 1. Analysis Prerequisite Test

Priyatno (2009: 187) suggests that the normality test is carried out to determine whether the distribution of the sample data to be analyzed is usually distributed. Normality test using chi-squared. Calculate the chi-square value with the formula:

$$X^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

Information:
$X_2$ = Price chi-squared
$O_i$ = Frequency of observations
$E_i$ = Expected frequency
k = Number of class intervals

Comparing the chi-square value with the chi-square table to determine the test criteria used degrees of freedom (dk) = k – 3 and a significance level of 5%. Draw conclusions with the following criteria:
$H_0$ = rejected if $X_2$count≥ $X_2$table
$H_1$ = accepted if $X_2$count < X2table

The next is homogeneity test. Homogensity test was carried out by investigating whether the two samples had the same variance or not, then to determine the statistics to be used in hypothesis testing. To test the similarity of the two variants, the Fisher (F) test was used. The steps are as follows:

a) Determine the level of significance (α) to test the hypothesis.

$H_a = \sigma_1^2 = \sigma_2^2$ (variance 1 equals variance 2 or homogeneous), $H_a = \sigma_1^2 \neq \sigma_2^2$ (variance 1 is not equal to variance 2 or is not homogeneous) by test criteria: accept $H_1$ if and $F_{count} < F_{table}$; and reject $H_0$ if $F_{count} > F_{table}$

b) Calculate the variance of each group of data.
c) Determine the value of Fcount, that is $F_{count} = \frac{\max varian}{\min varian}$
d) Determine Ftable for the significance level , dk1 = dk the numerator = na - 1 And dk2 = dk the denominator = nb-1
e) Perform a test by comparing the values of Fcount and Ftable.

If $F_{count} < F_{table}$, then the data is homogeneously distributed. This means that the two groups have the same variance or are said to be homogeneous (Sugiyono, 2010: 276-277).

#### 2. Research Data Analysis

Analysis of the data used is parametric analysis, namely the analysis used if the data taken is data that is normally distributed. The

data analyzed were the pre-test and post-test scores. To analyze the data of this study, the t-test formula was used with the following hypothesis:

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

Information:
1 = Average score of experimental group learning outcomes
2 = Average score of control group learning outcomes

To test the hypothesis, the t-test formula is used as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}} \quad (2)$$

$$with\ s^2 = \frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2} \quad (3)$$

$$so\ t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}(\frac{1}{n_1}+\frac{1}{n_2})}} \quad (4)$$

Information:
$X_1$ = Average test data in the experimental class
$X_2$ = Average test data in the control class
$n_1$ = Number of students in the experimental class
$n_2$ = Number of students in control class
$s_2^1$= Experimental group variation
$s_2^2$= Control group variation

The applicable test criteria are to accept Ho if tcount ttable, which means there is no difference between critical thinking skills in the experimental class and critical thinking skills in the control class, and reject Ho if tcount > ttable, which means there is a difference between critical thinking skills in the experimental class and critical thinking skills in the class control with dk = (n1 + n2 – 2), significant level = 5% and probability (1 – 1/2a). Suppose the critical thinking skills of the experimental class are more excellent than those of the control class. In that case, it can be concluded that there is an effect of PhET simulation on the Discovery learning model on students' critical thinking skills.

## RESULTS AND DISCUSSION

### Description of Concept Mastery Ability Data

#### 1. Pre-test Data of Students' Concept Mastery Ability

The study was conducted three times in the experimental class and three times in the control class, each consisting of 36 students. The experimental group used PhET simulation-assisted Discovery learning, while the control class used a conventional learning model. The initial implementation of the research was carried out by giving a pre-test and, in the end, by giving a post-test to both classes. The pre-test is an initial measure of students' abilities regarding the concept of straight-motion material. The vulnerable value of the pre-test is 0-100. The data from the pre-test results of class X IPA 5 and X IPA 7 with class X IPA 5 learning discovery learning models using PhET simulation and X IPA 7 learning discovery learning without using PhET simulation can be seen in Table 1.

**Table 1 Data from the Pre-test Results of Concept Mastery Ability in Students**

| Sample | Total Students | Max Score | Min Score | Score | SD |
|---|---|---|---|---|---|
| Eksperiment Class | 32 | 93 | 30 | 56,15 | 16,80 |
| Control Class | 32 | 78 | 25 | 48,53 | 13,89 |

Based on Table 1, it is found that the average value obtained from the two classes is not much different. The experimental class got an average score of 56.15, while the control class got an average score of 48.53. This can also have a good impact at the beginning of the study because it can be said that both classes have the same initial ability in straight-motion material. If viewed as a whole, there are problems with the same results from both classes, namely in questions numbers 2, 10 and 28. The distribution of the pre-test scores for students' conceptual mastery abilities can be seen in Figure 1.

Figure 1 is the distribution of the pre-test scores for the experimental class and the control class. In the experimental class, it was found that eight students scored 0-40, 13 students scored 40-60, 9 students scored 61-80, and only two students scored above 80. While in the control class, 11 students scored 0- 40, 14 children scored 41-60, 7 children scored 61-80, and none scored above 80. The pre-test results for the two majority classes were 41-60. Of the 64 students who got scores above 60, 46 were students. More than 50% of students cannot achieve a score of 60. Based on these data, it can be indicated that students'

understanding of motion material is still minimum.

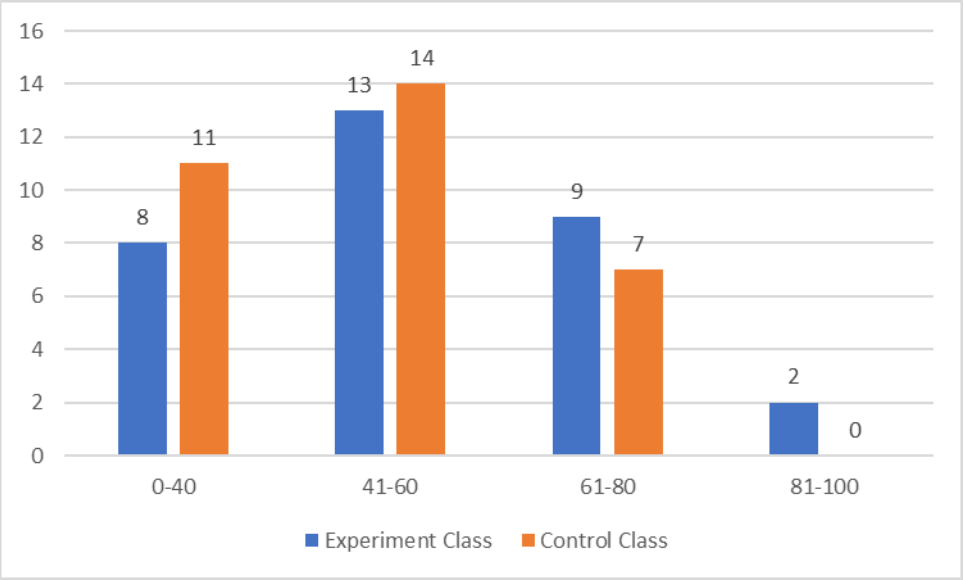


**Figure 1 Distribution of Pre-Test Values of Students' Concept Mastery Ability**

**2. Student Post-test Result Data**

After doing the pre-test, a post-test was carried out at the end of the lesson to measure the overall mastery of students' concepts of straight-motion material. The post-test also aims to obtain final data about the differences in students' knowledge before and after receiving the material. The range of values used in the post-test is the same as the pre-test, which is 0-100. The data from the post-test results of the discovery learning model using PhET simulation (experimental class) and discovery learning class without PhET simulation (control class) can be seen in Table 4.2.

**Table 2 Post-test Result Data of Concept Mastery Ability in Students**

| Sample | Total Students | Max Score | Min Score | Score | SD |
|---|---|---|---|---|---|
| Experiment Class | 32 | 100 | 40 | 66,75 | 18,53 |
| Control Class | 32 | 93 | 27 | 57,72 | 14,89 |

Based on Table 2, it was found that the average post-test value of the experimental class was higher than the control class. Likewise, with the highest value obtained. Some students have perfect scores in the experimental class, while the control class only gets a 93. From these results, it can be stated that discovery learning using PhET simulation can improve students' critical thinking in general. This also needs to be looked at further; therefore, data on the distribution of values obtained from the two classes are presented to increase the confidence of the provisional conclusions. The results of the distribution of the experimental class and control class values can be seen in Figure 2.

Figure 2 is the distribution of post-test scores obtained from the two classes. In the control class, five students scored 0-40, 15 students scored 41-60, 11 students scored 61-80, and only one scored 81-100. While in the experimental class, five students scored 0-40, 8 students scored 41-60, 11 students scored 61-80, and eight scored above 80. This data supports the general data in Table 4.1 that discovery learning using PhET simulation can improve students' critical thinking. In comparing the percentage scores obtained from the two classes, 60% of the experimental class students scored above 61, and only 37.5% of the control class students scored above 61.

**Data Analysis Results**

Before testing the research data hypotheses, meet the requirements for normality and homogeneity of the observed data. Normality requirements can be known through the normality test. At the same time, the homogeneity requirements can be known through the homogeneity test. The results of normality and homogeneity tests can be seen below.

**1. Analysis Prerequisite Test**

A normality test is used to determine whether the two samples are normally -

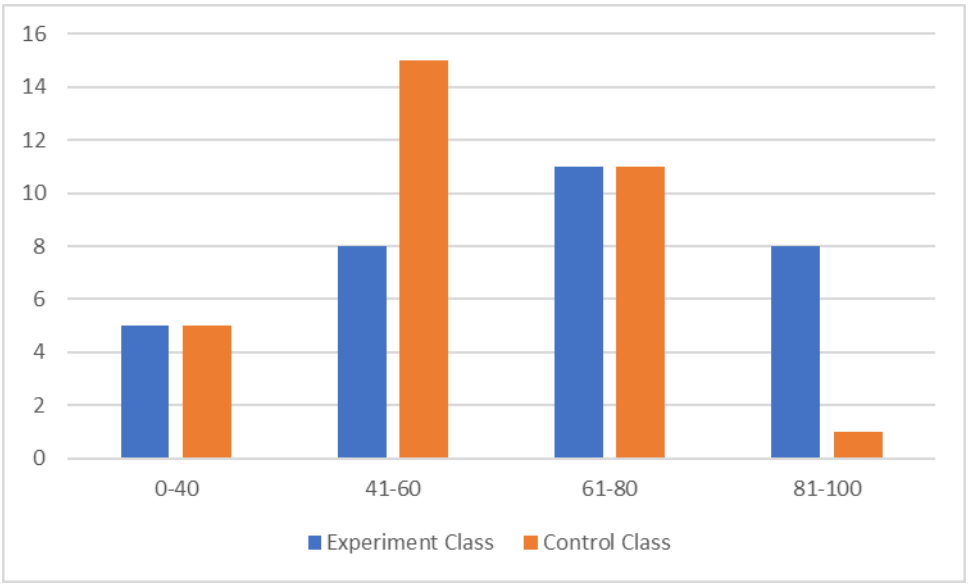


**Figure 2 Distribution of Post-test Scores of Students' Concept Mastery Ability**

- distributed or not. A normality test was carried out on the control and experimental classes. The normality test used is the Liliefors test.

To test normality in this study using the Chi-square test with significant or customarily distributed data, if the significance value is more significant than 0.05, if the significance value is less than 0.05, then the data is not normally distributed. The normality test results are presented in Table 4.3; the complete calculation results can be seen in the appendix.

**Table 3 Normality Test Results**

| Sample | Average | $X^2_{count}$ | $X^2_{table}$ | Information |
|---|---|---|---|---|
| Experiment Class | 66,75 | 0,14 | 0,15 | Normal |
| Control Class | 57,72 | 0,09 | 0,15 | Normal |

Information:

- If score Xcount < Xtable, then the data distribution is normal
- If score Xcount > Xtable, then the data distribution is not normal

Based on Table 3, it is found that the average value obtained by the experimental class is 66.75 and is usually distributed. Likewise, the control class found an average value of 57.72 and was normally distributed. These results are significant with the value of X2count <X2table of the experimental class of 0.14 <0.15. While in the control class also got the same result, which was 0.09 <0.15. Thus, it can be concluded that the post-test data of students in both classes, namely the experimental and control classes, are average.

The second prerequisite test is the homogeneity test. Data: The homogeneity test results can be seen in Table 4.

**Table 4 Results of Homogeneity Test**

| Class | Experiment | Control |
|---|---|---|
| Mean | 66,750 | 57,719 |
| Varians | 343,613 | 221,951 |
| N | 32 | 32 |
| Df | 31 | 31 |
| $F_{count}$ | 1,548 | |
| $F_{table}$ | 1,810 | |
| **Conclusion** | **Homogen** | |

Information:

- If the value of $F_{count} < F_{Table}$, then it is concluded that the data is homogeneous

- If the value of $F_{count} > F_{Table}$, then it is concluded that the data is not homogeneous

Based on Table 4, it can be seen that $F_{count} < F_{table}$ of 1.548 < 1.810. So, it can be said that the data above shows that the two classes are homogeneous. In addition, the data was obtained in the form of variants of the two classes, namely 343.61 for the experimental class and 221.95 for the control class. Following the results of research conducted (Mustakim et al., 2020), when the value of $F_{count} < F_{table}$, it can be said that the data is homogeneous. It is also strengthened by (Hakiki & Fadli, 2020), with the same results, it is known that both classes have the same variance.

**2. Hypothesis Test**

After the homogeneity test was carried out, the hypothesis was tested using the t-test. A T-test was conducted to determine the hypothesis to be determined. The t-test was conducted on two classes: the experimental and control classes. The applicable test criteria are if tcount ttable, then H0 is accepted. When H0 is accepted, there is no difference between the experimental class's critical thinking skills and the control class's critical thinking skills, whereas if tcount > ttable, H1 is accepted or H0 is rejected. When H0 is rejected, - there is a difference between the experimental class's critical thinking skills and the control class's critical thinking skills. The results of the t-test can be seen in Table 5.

Table 5 t-test Results

| Class | Experiment | Control |
|---|---|---|
| Mean | 66,750 | 57,719 |
| Varians | 343,613 | 221,951 |
| N | 32 | 32 |
| Df | 31 | 31 |
| $F_{count}$ | 2,14 | |
| $F_{table}$ | 1,810 | |
| **Conclusion** | **Significantly influential** | |

Based on Table 5, the value of tcount is 2.14, and ttable is 1.81. The t-test results show that tcount > ttable, so it can be said that H1 is accepted or H0 is rejected. When H1 is accepted, there is a difference between the experimental class's critical thinking skills and the control class's critical thinking skills. These results indicated differences in students' conceptual mastery abilities after treatment. These results also found a significant effect on student learning outcomes from the experimental class using the PhET model of learning compared to the control class using conventional learning.

This study uses 2 class samples with a quasi-experimental research format. This study aims to inform about the two classes' concept mastery differences. This study also aims to determine the effect of the simulation of using learning models based on Discovery learning on students' critical thinking skills. The two samples were divided into experimental class and control class. The experimental class was represented by class X IPA 5, and the control class was represented by class X IPA 7. The treatment for both classes was in the form of giving a pre-test at the beginning and a post-test at the end of the meeting. Giving the pre-test serves as a measure of a student's ability to the material of straight motion. At the same time, the post-test is intended as information on the absorption of the material that has been given to students. The hypothesis obtained in this study follows the existing hypothesis, namely that there is a significant influence between the thinking skills of students who use PhET-based learning in the Discovery learning model and Discovery learning without PhET simulation on heat material for class X at SMA Negeri 1 Sape.

As for the validation results, it was found that the correlation coefficient was 0.24-0.59 with rcount > rtable. These results state that the instrument used is valid. According to Albarado & Eminita (2021), it is also stated that when rcount > rtable with a = 0.05, then the instrument is declared valid. It is also reinforced by Abdi & Kamaruddin (2017) that when the sample validation value reaches > 0.4, it can be stated that the instrument is valid. Next, is the test results of the reliability level of the instrument used? The reliability test results showed that the reliability coefficient for critical thinking skills was 0.41. This result is sufficient because when 0.41 < rii < 0.60,

the instrument's reliability level is moderate. The reliability results are similar to research conducted by (K. P. Sari & Firman, 2019) in that the instrument can be reliable when the reliability coefficient is at least 0.41. Abdi & Kamaruddin (2017) also said that in their research, the instrument could be reliable when rcount > rtable and the absolute value obtained is > 0.41. Then the discriminatory power test was carried out on the questions used. The results of the difference in grain power obtained are 0.125 - 0.375. This result is quite good because the item power can be considered sufficient when the value is 0.20-0.39.

Based on the data obtained in the form of pre-test and post-test results. The data from the pre-test results for the two classes showed that the highest average score was obtained from the experimental class, which was 56.15. While the control class only got a score of 48.53. The difference between the two values is not far apart, only 7.62. Meanwhile, based on the post-test that has been carried out to determine the students' conceptual mastery ability, the average value data from both classes is 66.75 for the experimental class and 57.72 for the control class. Applying the concept of critical thinking to experimental class students, it were able to stimulate their understanding of the material of straight motion. This is supported by the data that the experimental class's post-test results obtained a higher score than the control class. This is also following research conducted by Lidiana et al. (2018) that PhET-based learning in the Discovery learning model can improve students' understanding of the material provided and can increase students' critical thinking levels. Furthermore, the data was tested using the normality test, and it was found that the sample was usually distributed.

In order to strengthen the above results, the details of the analysis of the normality test data from the two classes in the form of a value of X2count <X2table of 0.14 <0.15 for the experimental class and 0.09 <0.15 for the control class. These results state that the post-test data of the two classes are typically distributed. It is also said by Hidayat et al. (2019) that when the value of X2count <X2table with a significance level of> 0.05, it can be stated that the data is typically distributed. Likewise, according to P. I. Sari et al. (2017), in their research, the data requirements are customarily distributed; namely, the calculated Chi-Square value must be smaller than the Chi-Square table. Then the sample was also tested for the level of homogeneity using the homogeneity test, and it was found that the sample was homogeneous. This result is also supported by the value of Fcount < Ftable of 1.548 < 1.810 with a significance level of 0.05. According to the results of Harum et al. (2020) in their research, when the value of Fcount < Ftable, it can be said that the sample is homogeneous.

After conducting the normality and homogeneity tests, the hypothesis was tested using the t-test on the students' post-test results. From the t-test analysis data, the results obtained tcount = 2.14 > ttable = 1.810 with a significance level of 0.05. When tcount > ttable, H0 is rejected, and H1 is accepted, which means that there is a difference in critical thinking skills of students who learn physics using PhET simulation in the Discovery learning model and discovery learning without PhET simulation on straight-motion material for class X at SMA Negeri 1 Sape. Hidayat et al. (2019) also say that when tcount > ttable, H0 is rejected, and H1 is accepted. The difference in the results of the post-test mastery of concepts and critical thinking of the students in the two samples was caused by differences in treatment in the experimental class, which was waiting for the PhET simulation while the control class did not use it. PhET simulation is a fun interactive simulation media based on the discovery in the form of software and can be used to clarify physical concepts or phenomena that have been put into practice (Jauhari et al., 2017). Another reason Harum et al. (2020) stated that the PhET simulation makes students more interested and enthusiastic in practicums is to improve their critical thinking patterns and mastery of concepts. The PhET simulation conducted in the experimental class is used to clarify the concepts possessed by the students because the results of the pre-test can say that the students' conceptual ability is very lacking.

Giving different treatments to the two sample classes is intended to see the difference in the students' concept mastery ability and critical thinking skills after being given the treatment. Research conducted by Shidik (2020) states that the PhET simulation can explore students' weaknesses and learning difficulties in the form of misconceptions so that when students give feedback, educators can easily find out where

students have misconceptions and their critical thinking skills. Lidiana et al. (2018) also stated that the PhET simulation in Discovery Learning learning given to students could really influence their critical thinking skills; besides that, it can also affect their learning outcomes. Several indicators influence critical thinking, namely, (1) giving arguments, (2) deduction, (3) induction, (4) evaluating, and (5) making decisions and determining actions (Hayudiyani et al., 2017).

Suppose it is related to the post-test results of the experimental class using PhET simulation-based learning with indicators that affect critical thinking. In that case, it can be seen that there is a match contained. The first is to provide arguments. When students are given the freedom to give arguments, educators can quickly determine the extent to which the concept of the material obtained during learning takes place. This was also conveyed by alskdjalksdj that giving arguments or expressing opinions in the PhET simulation can stimulate children's critical thinking skills. Second, do deductions or general conclusions. In PhET simulation-based learning in the experimental class, students must deduce the case that has been done or when the material explanation process takes place. In this case, the deduction can also stimulate their critical thinking skills. Perdana et al. (2017) stated in their research that the more skilled students are in deducing daily physics cases they encounter, the higher their critical thinking level. The third is conducting induction and evaluation. This activity is carried out after deduction, and the goal is that students can elaborate on a case that they have known critically. In the PhET simulation conducted in the experimental class, induction and evaluation occur when students try to explain the material presented to educators. Students who are experts in making inductions usually have broader knowledge and are accustomed to critical thinking. This was conveyed by Handayani (2020) that students who can elaborate on physics cases in everyday life and can generalize cases tend to have critical thinking.

The fifth or last is to make decisions and determine actions. In this study, the PhET simulation conducted on experimental class students showed progress in students' thinking, especially in making decisions and determining actions, especially after evaluating the case of straight-motion material. This is also evidenced by the post-test results of the experimental class students being higher than the control class. Students who can decide and determine appropriate actions have good critical thinking skills. The research conducted by Hayudiyani et al. (2017) showed that students with critical thinking skills could determine the decisions taken after going through various induction thoughts and conducting post-deduction evaluations. Fithriani et al. (2016) also conveyed in their research on PhET simulation-based learning that most students in classes using PhET simulations have good decision-making skills, which can improve their critical thinking skills. So, based on this research, discovery learning based on PhET simulation can improve students' critical thinking skills in experimental class or X IPA 5 compared to discovery learning without using PhET simulation. It is proven by the results of the post-test scores of the two students and the results of observations during the research.

## CONCLUSION

The effect of PhET simulation on the Discovery learning model on students' critical thinking skills in the form of an increase in post-test scores that occurred in the experimental class using PhET-based learning. The critical thinking indicators that are influenced by the PhET simulation on the Discovery learning model are (1) giving arguments, (2) deduction, (3) induction, (4) evaluating, and (5) making decisions and determining actions.

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