

# The Effect of PhET Simulation-Assisted Guided Inquiry Learning Model on Students' Critical Thinking Ability in Elasticity Material

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**Abstract** - This study aims to determine the effect of PhET simulation-assisted guided inquiry learning model on students' critical thinking skills in Elasticity material. The type of research used is quasi-experimental with Nonequivalent Control Group Design. The population in this study were all students of class XI IPA at SMAN 1 Pringgabaya. The sample of this study was class XI H and class XI I, totaling 63 students, while the sampling technique was cluster random sampling method. The sample used in this study was class XI I (experimental class, totaling 32 people) and class XI H (control class, totaling 31 people). Before given the treatment, both classes were given an initial test to determine their initial ability. Based on the results of the initial test homogeneity test, the two samples had the same initial ability. The final test results for students' critical thinking skills obtained an average score of 79.45 with the highest score of 95 for the experimental class and an average of 74.27 with the highest score of 90 for the control class. The research hypothesis was tested with parametric statistical tests in the form of independent t-test variance. Such decision was taken on the basis of the testing. That is, the Sig (2-tailed) value of 0.028 is smaller than the significance level ( $\alpha$ ) of 0.05, and hence ( $H_0$ ) is rejected and ( $H_1$ ) is accepted. Thus, it can be interpreted that PhET simulation-assisted guided inquiry learning model has an effect on students' critical thinking abilities.

**Keywords:** Guided Inquiry; PhET Simulation; Critical Thinking

## INTRODUCTION

In the 21st century, science and technology has become a part of education—a guideline that must be prepared in order to produce quality human beings. Competencies that must be mastered to face competition in the 21st century world of work are creativity, critical thinking, independence, team collaborativeness, as well as information, communication and learning independence (Agnafia, 2019). Critical thinking is one of the higher order thinking skills, where students are not merely looking for answers but are also questioning answers, facts or existing information (Jamaluddin et al., 2019). Students need to have the ability to think critically so that it can be used in making decisions in their everyday life; someone who has the ability to think critically will be

able to analyze the problems they face, find and choose solutions that are appropriate, logical, and useful (Kurniasih, 2012).

Critical thinking aims to make rational decision processes that are continuous, active, and thorough (Haryani, 2011). Facione (2016) suggests six critical thinking skills: (1) Interpretation, namely the ability to understand, explain and give meaning to data or information., (2) Analysis, namely the ability to identify the relationship between all of the information used to express thoughts or opinions., (3) Evaluation, namely the ability to test the truth of the information used in expressing thoughts or opinions., (4) Inference, namely the ability to identify and obtain the elements needed to make a reasonable conclusion., (5) Explanation, namely the ability to explain or state the results of the thinking process based

on evidence, methodology, and context., (6) Self-regulation, namely a person's ability to regulate his thinking.

Based on the results of observations and interviews with students and teachers, it was discovered that physics teachers had been teaching using various methods of student-centered model in one month so that students did not feel bored. This model is indeed suitable for use so that students can play a more active role in examining the problems they face, as well as in finding and choosing the right and logical solutions. However, such method made the students believe that physics lessons tend to be boring—due to the experiments displayed or the practicum tools used being limited. The students' ability also varies; there are some students who cannot understand the physics material delivered by the teacher. According to Khastuti, one of the Physics teachers at SMAN (State Senior High School) 1 Pringngabaya, the limitation faced encompassed the lack of lesson hours for physics learning, students' lack of interest in learning physics, students' lack of basis in solving the mathematical problems of the physics problems, which led to the students' other critical thinking skills such as interpretation, analysis, evaluation, and explanation can hardly observable in physics learning.

One attempt that can be made to overcome these problems is selecting appropriate learning models that can support the improvement of students' physics critical thinking skills. Here, one of the learning models that allows for the attainment of such goal is inquiry learning. The inquiry learning model is a learning model that aims at exploring the students' activeness in finding knowledge and inviting them to be able to construct their own understanding by being involved in active activities for their learning. The inquiry learning model is also

a series of teaching and learning activities that involve all of the abilities possessed by the students in searching and investigating for something so that they can formulate their own findings (Ulandari et al., 2019). Teachers can conduct guided inquiry learning by guiding students, asking questions, and constructing experimental designs so that the students can develop their own concepts through observing experiments using scientific steps, namely formulating problems, conducting experiments, evaluating hypotheses, and making conclusions. Here, such steps of the learning model can support students' critical thinking skills (Nurhidayati et al., 2015).

The inquiry learning model cannot be separated from in-laboratory experiments and such activities will go well if supported by adequate laboratory facilities and infrastructure (Sumarni et al., 2020). Practicum activities are not only carried out in an actual laboratory, but can also be conducted in a virtual laboratory, so as to make it easier for the students to improve their critical thinking skills (Agustina et al., 2020).

Learning media serves as an alternative for the teachers in making the learning process easier. This is because a media is basically used to help teachers explain material in a simple way according to the students' own level of thinking. PhET (Physics Education and Technology) is a medium of projection in the form of an interactive simulation of physical phenomena with a research-based approach carried out by physicists (Aminah et al., 2020). According to Gunawan (2015), virtual simulation aims to give students the opportunity to learn and apply real-world skills. The scientific inquiry model is then combined with the media that is very interesting for the students, namely PhET simulation learning media. Using this

simulation, the students can be involved in the activities of obtaining data and facts, from which the students can draw conclusions on physics concepts (Debi et al., 2018).

Many researchers have previously conducted studies related to the guided inquiry learning model. The PhET simulation-assisted inquiry learning model had an effect on the physics learning outcomes of students in class X IPA SMAN 1 Jereweh in the 2019/2020 academic year (Agustina et al., 2020). The guided inquiry learning model improves critical thinking skills significantly better than conventional learning (Jayadinata & Gusrayani, 2016). Solihin et al., (2018) stated that the critical thinking ability of the students that learn in a class that used PhET-assisted guided inquiry learning model is better than those learning in a class that used conventional learning. Such finding applies to inference, interpretation, evaluation and self-regulation indicators of critical thinking.

**RESEARCH METHODS**

The type of research used is quasy experiment with Nonequivalent Control Group Research Design. In this research design, two classes were selected as samples: the experimental and the control class. The research on the effect of the PhET simulation-assisted guided inquiry learning model was conducted from March 2022 to September 2022. This research was conducted at SMAN 1 Pringgabaya, which is located in East Lombok Regency, West Nusa Tenggara.

The population of this study were all students of class XI IPA (Science major) at SMAN 1 Pringgabaya, whereby the sample of this study was class XI H and XI I, with a total of 63 students. The sampling was conducted using cluster random sampling. Research instrument testing was conducted

to test the questions' validity, reliability, discriminating power and level of difficulty. As for the data analysis, the tests used are normality and homogeneity test, hypothesis testing (t-test) and the N-Gain test. The normality test is conducted using Kolmogorov-Smirnov test in SPSS 25 software, while homogeneity test uses variance test or F-test. In addition, hypothesis testing is conducted using parametric statistical tests in the form of an independent t-test of variance, while the N-gain test is done by calculating the difference between the pre-test and post-test to determine the effectiveness of the method that has been implemented.

**RESULTS AND DISCUSSION**

**Results**

1. Pre-test results

The data obtained in this study were the results of the students' pre-test given prior to the treatment. Data on the results of the pre-test of the two classes can be seen in Table 1 below.

**Table 1.** Data on the results of the pre-test of the Experimental and Control Class

Dissemin ation and Centraliza tion of Data	Class			
	Experi mental	Categor y	Con trol	Category
Mean	54.61	Critical	54. 75	Critical
Total data	32	-	31	-
Highest	70	Critical	70	High
Lowest	32.5	Less Critical	37. 5	Low
Mode	57.5	Critical	55	Critical
Median	56.25	Critical	55	Critical
Standard Deviation	9.13	-	9.2	- 7

2. Post-test results

This study uses post-test data taken after the treatment is given as data on the students' final critical thinking abilities. Data on the results of the post-test of the two

classes can be seen in Table 2. It shows experimental class obtained score more high than the control class.

**Table 2.** Data on the results of the post-test of the Experimental and Control Class

Dissemination and Centralization of Data	Group/Class			
	Experimental	Category	Control	Category
Mean	79.45	Very Critical	74.27	Critical
Total data	32	-	31	-
Highest	95	Very Critical	90	Very Critical
Lowest	60	Critical	57.5	Critical
Mode	80	Very Critical	77.5	Very Critical
Median	80	Very Critical	75	Critical
Standard Deviation	10.31	-	7.72	-

### 3. Normality test

The normality test in this study was conducted on the pre-test and post-test data for both the experimental class and the control class. The normality test was conducted to discover whether or not the test data for the two classes were normally distributed. The normality test for the two sets of data used Kolmogorov-Smirnov test on SPSS 25 software.

**Table 3.** The Results of the Normality Test for Critical Thinking Ability Pre-test

Statistics	Pre-test	
	Experimental class	Control class
Significance	0.200	0.092
Significance level ( $\alpha$ )	0.05	0.05
Decision	Normally distributed	Normally distributed

**Table 4.** The Results of the Normality Test for Critical Thinking Ability Post-test

Statistics	Post-test	
	Experimental class	Control class
Significance	0.200	0.200
Significance level ( $\alpha$ )	0.05	0.05
Decision	Normally distributed	Normally distributed

### 4. Homogeneity test

The homogeneity test was conducted on the data from the experimental and control class, aiming to determine whether

or not the initial and final abilities of the two samples were homogeneous before they were given the treatment. The homogeneity test was conducted using the variance test (F-test) with a significant level of 5% (Table 5).

**Table 5.** Critical Thinking Ability Pre-test Result Homogeneity Test Data

Class	Total students	S <sup>2</sup> (variance)	F <sub>count</sub>	F <sub>table</sub>	Criteria
Experimental	32	83.35	0.9	3.1	Homogeneous
Control	31	85.93	0.9	3.1	Homogeneous

**Table 6.** Critical Thinking Ability Post-test Result Homogeneity Test Data

Class	Total students	S <sup>2</sup> (variance)	F <sub>count</sub>	F <sub>table</sub>	Criteria
Experimental	32	126.5	2.11	3.15	Homogeneous
Control	31	59.75	2.11	3.15	Homogeneous

### 5. Hypothesis testing

Hypothesis testing was conducted to determine the effect of PhET simulation-assisted guided inquiry learning model on students' critical thinking skills in the experimental class. The decision on the hypothesis testing used for the study was based on the homogeneity test and the normality test of the data from the pre-test and post-test results of the two samples, that is, the experimental class and the control

class, as well as the number of students who took the post-test in each class. After the homogeneity and normality test of the two classes have been conducted, it can be concluded that the two classes are homogeneous and normally distributed. Meanwhile, the number of students who take the post-test is different in each class: 32 students in the experimental class and 31 students in the control class. Therefore, the hypothesis testing uses a parametric statistical test in the form of an independent t-test of variance, the results of which can be seen in Table 7.

**Table 7.** The Results of the Critical Thinking Ability Hypothesis Testing

Statistics	Pre-test		Post-test	
	Control class	Experimental class	Control class	Experimental class
Sig. (2-tailed)	0.949		0.028	
Significance level ( $\alpha$ )	0.05		0.05	
Decision	$H_0$ rejected		$H_1$ accepted	

**Discussions**

This study aims to determine the effect of PhET simulation-assisted inquiry learning model on students' critical thinking skills for the material of elasticity and Hooke's law. The research method used was quasi-experimental (quasi-experimental) with a nonequivalent control group design. This design involves two classes, namely class XI I as the experimental class and XI H as the control class. The experimental class with 32 students was given treatment in the form of learning using PhET simulation-assisted guided inquiry model while the control class with 31 students used the discovery learning model. Both classes were given treatment for six meetings with a total meeting time allocation of 15 lesson hours (45 minutes / 1 lesson hour). Prior to the treatment, both classes were given a pre-test in the form of

long answer questions to determine students' initial critical thinking abilities.

The instrument used in this research is a critical thinking ability test, which had previously gone through some instrument testing. The purpose of the testing is to ensure that the instrument prepared is good at measuring the problem being studied. The test is tested for its validity, reliability, discriminating power, and difficulty level.

The instrument for the critical thinking abilities consists of 10 long answer questions. The results of the analysis of the validity test discovered that the 10 questions that will be used to test the critical thinking ability were included under the valid category since they had a value of  $r_{XY} \geq r_{table}$ . The results of the reliability test showed that all questions were included within the reliable category because they had a value of  $r_{11} \geq r_{table}$ . For the discriminating power, the questions will be categorized into five different categories, namely very bad, bad, fair, good and very good. Based on the results of the analysis of the discriminating power of the questions, 4 questions were included under the *good* category, while the remaining 6 were included under the *fair* category. In regards to the difficulty level, the questions will also be divided into five categories, namely too easy, easy, moderate or sufficient, difficult and too difficult. Here, it was discovered that 4 questions are included under the *moderate* category, while the remaining 6 are under the *difficult* category.

Before testing the hypothesis, normality and homogeneity tests were conducted on the results of the critical thinking skill pre-test and post-test. The results of the pre-test normality test obtained a Kolmogorov-Smirnov value of 0.200 for the experimental class data, and 0.092 for the control class data. The results of the post-test normality test obtained a Kolmogorov-

Smirnov value of 0.200 for the experimental class data, and 0.200 for the control class data. Based on the basis of normality test decision making (significance), both data are  $> 0.05$ . Thus, it can be concluded that both data is normally distributed.

The homogeneity test results in Table 4.9 show that the  $F_{\text{count}}$  for the pre-test is  $F_{\text{count}} < F_{\text{table}}$ , that is,  $0.96 < 3.15$ . Meanwhile, the  $F_{\text{count}}$  value for the post-test is  $F_{\text{count}} < F_{\text{table}}$ , that is,  $2.11 < 3.15$ . Thus, it can be concluded that the experimental and control class variance is homogeneous. These results are then taken into consideration in selecting the hypothesis testing to be used. The results that had meet the requirements will be followed with a parametric hypothesis testing, whereas those which had not meet the requirements will be followed with a nonparametric test. Based on the results of the normality and homogeneity tests for critical thinking skills, the hypothesis will be tested using the parametric test, namely, the independent sample t-test.

There are 5 indicators of critical thinking skills measured in this study, which are based on Facione's 5 indicators, namely: 1) interpretation, (2) analysis, (3) evaluation, (4) inference, (5) explanation. As seen from the students' pre-test results, the students' critical thinking abilities are moderate prior to the provision of the treatment. The pre-test mean scores for the experimental and the control class were 54.61 and 54.75 respectively. The students' low critical thinking pre-test scores can be caused by several factors. First, it can be the result of the knowledge possessed by students' being limited to only the basic knowledge they acquire, or the experiences they experience in the surrounding environment. Second, it can also be caused by the students' easily forgetting the knowledge explained by the teacher.

The independent sample t-test was used to test the differences in the physics critical thinking abilities as the effects of the provision of treatment to the experimental class. Based on the results of the independent sample t-test, it can be concluded that the physics critical thinking abilities of the experimental class are different from those of the control class. The existence of these differences can be seen from the t test scores of the students' critical thinking abilities. The post-test mean score for the experimental class was 79.45, far greater than the class' pre-test mean score (54.61). This means that there was a difference in the students' critical thinking abilities before and after they are given the treatment. As seen on Table 4.10, the value of Sig. (2-tailed) for the pre-test is  $0.028 < 0.05$  and thus ( $H_0$ ) is accepted, while the alternative hypothesis ( $H_1$ ) is rejected. Therefore, it can be concluded that there is no influence between the pre-test results of the control class and the experimental class. The Sig. Value (2-tailed) for the post-test is  $0.028 < 0.05$ , and thus  $H_0$  is rejected and  $H_1$  is accepted. Furthermore, in order to see the critical thinking abilities of both classes, the N-Gain test was conducted. Based on the data from N-Gain test results, it was discovered that there was an increase in the critical thinking skills of the experimental and the control class, with an average of 56.24% and 39.87% (moderate category) respectively. These results prove that the average score of the students' critical thinking skills is better in the experimental class than in the control class. This finding is in line with the research conducted by Agustina et al. (2020) which stated that PhET simulation-assisted inquiry learning model had an effect on the physics learning outcomes of class X IPA (Science major) students at SMAN 1 Jereweh in the 2019/2020 academic year.

Qahfi's research results (2022) also state that there was a significant increase in the critical thinking skills of MTs (Islamic Junior High School) Al-Ikhlas Donggo students after the students are taught using the PhET simulation-assisted guided inquiry model, which can be seen from the average pretest and posttest scores of 22.48 and 64.72 respectively. The paired test results obtained a sig. 2-tailed value of  $0.000 < 0.05$  with a t-count of -15.621.

The results of the research by Eka & Mardiyanti (2022) discovered that PhET simulation-assisted guided inquiry model significantly increased students' CBC by 5%. The guided inquiry model is an analytical, critical, systematic learning activity, that are conducted through investigative activities.

The research results from Correia et al., (2019) discovered that PhET simulation-assisted guided inquiry model is one learning model that can significantly spark further development of students' critical reasoning abilities. Here, the model has been proven to be effective in assisting the students in learning.

Based on this discussion, the results of the study indicate that the use of PhET simulation-assisted inquiry model can be used as an alternative in learning physics. In addition, based on data analysis calculations as well as other relevant research that has been presented, the use of PhET simulation-assisted inquiry model has been proven to have a significant effect on students' critical thinking skills for the material of elasticity and Hooke's law.

## CONCLUSIONS

Based on the results of the research conducted at SMAN 1 Pringgabaya, as well as data analysis, hypothesis testing at a significant level of 5% and discussion, it can be concluded that there indeed is an effect of

the PhET simulation-assisted guided inquiry learning model on students' critical thinking skills on elasticity and Hooke's law.

As for the schools, it is suggested that that teachers choose this guided inquiry learning model as an alternative method to be applied in the learning process. This is so that the schools can improve the students' critical thinking skills better.

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