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The Effect of The PhET Simulation-Assisted Think, Talk, Write Learning Model on The Ability of Students' Critical Thinking Skills on Parabolic Motion Material

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ABSTRACT

This research was motivated by the low ability of students to think critically in physics learning and the need for more innovation in the learning process. The researchers' efforts to overcome this problem are by applying the Think, Talk, Write learning model assisted by PhET Simulation. This research method is quasi-experimental with a non-equivalent control group design. The population in this study was class XI Physics students at a high school in Tasikmalaya, totaling 72 students. The data collection technique in this study describes the ability of critical thinking skills in as many as nine items. The data analysis techniques are prerequisite tests (normality and homogeneity tests), hypothesis tests, N-Gain, and model implementation analysis. The results of the analysis of hypothesis test data using the t-test at the significance level (α = 0.05) showed that after applying the Think, Talk, Write learning model assisted by PhET Simulation, we obtained 4.05 > 1.67, and the calculation results using SPSS showed sig results. (2-tailed) < 0.05 i.e. 0.000 < 0.05. Thus, Ha is accepted, and H0 is rejected. It means that it can be concluded that the Think, Talk, Write learning model assisted by PhET Simulation influences the ability of students' critical thinking skills on parabolic motion material in class XI Physics students at a high school in Tasikmalaya. These findings imply that integrating interactive technology into active learning models can yield better outcomes, suggesting the need for innovative teaching strategies to enhance education quality..

Keywords : Learning model Think, Talk, Write, Ability critical thinking skills, PhET Simulation, and Parabolic.

I. INTRODUCTION

Education is a formal or informal process that transfers knowledge, skills, values, and cultural norms from generation to generation. This educational process can occur at different levels and environments, such as schools, colleges, universities, training institutions, or even independently. In a simple and general sense, the meaning of education is a human effort to cultivate and develop innate potentials, both physical and spiritual, by the values and norms that exist in society [1]. Education has a very important role in forming individuals, cultures, and the progress of a nation. One of them is physics education.

Physics education is a branch of education that focuses on teaching and learning physics. Physical science is a natural science that studies basic principles about the universe, the nature of matter, energy, motion, and their interactions. In line with the opinion of Pratama dan Istiyono [2], physics learning is a process to develop the ability to understand concepts, principles, and laws of physics, so the learning process must consider effective and efficient learning strategies or methods. Physics learning emphasizes the activities and activeness of students more than teacher activities [3]. Physics lessons are one part of Natural Sciences (Science) that is important for students to learn. That is stated in one of the objectives of physics subjects for the high school level: developing experience

to formulate problems, propose and test hypotheses through experiments, design and assemble experimental instruments, collect, process, and interpret data, and communicate experimental [4]. Based on this, it is clear that knowledge of physics is a means for students to develop a scientific attitude, master physics concepts and principles, formulate problems, and solve them scientifically. Various information, concepts, theories, and principles related to physics are classified as physical knowledge.

Physics knowledge can be acquired in various ways, such as by reading or observing phenomena emphasizing students' direct experiences. Interaction between students and their natural environment is essential to meet students' needs. This interaction provides learning to students so that they find experiences that add insight, knowledge, and ability characterized by behavior changes. In physics, these collections of knowledge can be facts, concepts, principles, laws, formulas, theories, or models [5]. With direct experience, students can feel and be curious about what has been experienced. So that later, students will know the meaning and can practice skills from the learning that has been done. One of the skills developed on direct experience is the ability of critical thinking skills.

According to Ennis, critical thinking is reasonable and reflective thinking that focuses on deciding what to believe or do [6]. Critical thinking includes thinking and using logical reasoning, including the skills of comparing, classifying, sequencing, connecting cause and effect, describing patterns, making analogies, compiling series, giving reasons deductively and inductively, forecasting, planning, formulating hypotheses, and delivering critically. With the rapid development of globalization and technology, science and education are also growing rapidly. Therefore, students are required to follow these developments [7]. Critical thinking is one of the skills individuals must have in facing 21st-century competition. In various countries, critical thinking has become one of the goals and competencies of educational goals [8]. The ability of critical thinking skills is very important to be trained in students because the ability of critical thinking skills is one way that will be able to assist in solving various problems experienced in everyday life. In this 21st century, students must have creative thinking skills, critical thinking and problem-solving, communication, and collaboration, commonly called the 4Cs [9]. So, critical thinking skills are important for students to develop according to the times, and they need the 4C skills needed in 21st-century learning.

Based on the results of a preliminary study conducted at SMA Negeri 10 Tasikmalaya in classes XII MIPA 1 and XII MIPA 2, which involved a measurement test of indicators of students' critical thinking skills on parabolic motion material, it can be concluded that students' critical thinking skills are still weak, with a score of 41.67, categorized as very low. This is because the learning process has yet to involve practical activities or documentation, and using teacher-centered learning models has yet to develop students' critical thinking skills. Dominance by the teacher will cause various problems, including (1) most students not preparing themselves before the lesson begins, (2) students still closed and seeming reluctant to work with friends, and (3) students not being able to solve problems [10]. One of the physics materials that students consider difficult is parabolic motion, where it can be seen that the student's scores in the physics subject of parabolic motion material are still below KKM (Minimum Completeness Criteria). Namely, only 32 out of 72 students get higher scores than KKM.

Based on the background above, researchers will apply the Think, Talk, Write (TTW) learning model assisted by PhET Simulation to parabolic motion material in class XI of Physics interest by conducting a research entitled "The Effect of the Think, Talk, Write (TTW) Learning Model Assisted by PhET Simulation the Ability of Students' Critical Thinking Skills on Parabolic Motion Material"

II. METHOD

The research used by researchers is using quantitative design. Quantitative research is widely demanded using numbers, starting from data collection, interpretation of the data, and the appearance of the results [11]. The type of research used in this study is an experiment using a Non-equivalent Control Group Design. The application of this type of quasi-experimental research is because this research is in the form of educational research that uses humans as research subjects; humans are not the same. In this study, saturated sampling is used as a sampling method carried out by researchers, and all populations in this study are sampled. Saturated sampling is a sampling technique for all population members [12]. The data collection technique in this study was carried out with a description test that represents indicators of critical thinking skills ability with a total of 9 questions. The data collection techniques used in this study are the initial test (pretest) and final test (posttest) to obtain quantitative data so that data processing can be carried out and see students' abilities before and after learning with the treatment given.

The data analysis technique is instrument testing, which includes validity tests. This study divides the validity tests into two: the expert and the validity tests. It used the expert validity test to analyze the critical thinking skills description test, using two experts from Physics Education lecturers at Siliwangi University. The validity test uses Aiken's V test, where Aiken's test equation is as follows.

$$V = \frac{\sum s}{n\,(c-1)} \quad (1)$$

Source: Ref [13])

The validity test is carried out by conducting trials on the question item instrument; the validity test of the questions is tested in class XII MIPA at SMA Negeri 10 Tasikmalaya. Validity is a measure that indicates the level of validity or absence of an instrument to be studied [10]. The validation of the question items is calculated using the following formula.

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}} \quad (2)$$

(Source: Ref [12])

To determine the consistency of the instrument, an instrument reliability test is carried out using the following formula.

$$r_{11} = (\frac{k}{k-1})\,(1 - \frac{\sum \sigma_i^2}{\sum \sigma_t^2} \quad (3)$$

(Source: Ref [14])

The classification of reliability coefficients can be seen in Table 1.

Table 1. Classification of reliability coefficients

Reliability Index	Reliability Criteria
$0{,}80 \leq r_{11} < 1{,}00$	Very high
$0{,}60 \leq r_{11} < 0{,}80$	high
$0{,}40 \leq r_{11} < 0{,}60$	Enough
$0{,}20 \leq r_{11} < 0{,}40$	Low
$0{,}00 \leq r_{11} < 0{,}20$	Very low

The prerequisite test in this study is the normality test and homogeneity test. Microsoft Excel is used for calculations, and SPSS version 26 is used for comparison. The t-test is used as a hypothesis test.

The normalized gain (N-gain) test is carried out to determine the increase in critical thinking skills that occur in each student. This N-gain test analyzes students' scores before treatment (pretest) and after treatment (posttest) using the following formula.

$$gain\ score = \frac{skor\ posttest - pretest}{100 - skor\ pretest} \quad (4)$$

(Source: Ref [15])

The analyzed data are interpreted according to the obtained value criteria listed in Table 2.

Table 2. Criteria N-Gain

Gain index	Interpretation
$g > 0{,}70$	High
$0{,}70 \geq g \geq 0{,}30$	Medium
$g < 0{,}30$	Low

III. RESULTS AND DISCUSSION

Based on the results of research that has been carried out on class XI students interested in Physics at SMA Negeri 10 Tasikmalaya for the 2023/2024 academic year, pretest (before) and posttest (after) were carried out, XI-2 as an experimental class using the *Think, Talk, Write* (TTW) learning model assisted by *PhET Simulation* while XI-3 as a control class using the *Direct Instruction* learning model (DI) assisted by *PhET Simulation*. The *pretest*

results of learners' critical thinking skills can be shown in Table 3.

Table 3. Pretest *Results* of Experimental Class and Control Class

Value	Ability of critical thinking skills	
	Experiment	**Control**
Lowest	9	7
Highest	26	24
Average	17,83	16,33
Standard Deviation	4,01	3,37
Varians	16,09	11,37

Based on the data above, the experimental and control classes still scored low on the pretest of critical thinking skills. It can be seen in the middle value in each class both in the experimental class and the control class, the value obtained is still below KKM. It can be seen in the middle value in each class both in the experimental class and the control class, the value obtained is still below KKM. To see the variation in values, variance calculations were carried out, and the results obtained by the pretest variance of critical thinking skills in the experimental class were greater than in the control class, in the experimental class the variance value obtained was 16.09 and in the control class was 11.37. This showed that the pretest data on critical thinking skills ability in the control class were more varied than in the experimental class. Then to see the distribution of data for the two groups, a standard deviation calculation was carried out, it was obtained that the standard deviation value in the experimental class was 4.01 and in the control class was 3.37. The standard deviation value showed that the pretest data on critical thinking skills in the control class were more evenly distributed than the experimental class. Students are still unable to practice critical thinking skills in description problems because they have never formally studied parabolic motion in school. This makes it clear that students' critical thinking skills still need to be improved, this is in line with the analysis on [16] the acquisition of Indonesian students' rankings in the results of TIMSS and PISA which states that Indonesian students still lack mastery of high-level questions that require students to be able to think critically. Arini and Juliadi [17] also revealed in their research that the critical thinking skills of students in the low category, besides that also based on interviews and preliminary study tests conducted with students are still in the very low category.

Post-tests are carried out after students have finished learning and received treatment in experimental and control classes. The instruments used in the posttest are the same as those provided in the pretest. Below are the posttest scores of critical thinking skills.

Table 4. Posttest Results of Experimental Class and Control Class

Value	Ability of critical thinking skills	
	Experiment	**Control**
Lowest	16	13
Highest	33	30
Average	27,31	23,67
Standard Deviation	3,84	3,79
Varians	14,73	14,34

Based on the data above, there was an increase in critical thinking skills in experimental and control classes. The data showed that students' ability to think critically in the experimental class had a higher grade point average than the control class. To see the variation in values, variance calculations were carried out, and the results obtained by posttest variance in critical thinking skills in the experimental class were almost the same as in the control class, in the experimental class the variance value obtained was 14.73 and in the control class was 14.34. This shows that posttest data on critical thinking skills in experimental classes and in control classes are equally variable. Then to see the distribution of data from both groups, standard deviation calculations were carried out, it was obtained that the standard deviation value in the experimental class was 3.84 and in the control class was 3.79. The standard deviation value shows that the posttest data on critical thinking skills in the experimental class and in the control class are equally distributed. This shows that the experimental class outperformed the control class. In line with the research of Mita, Maryani and Bambang [18] where in the learning process of students after the application of the *Think, Talk, Write* (TTW) learning model students experience an increase in activeness in student learning activities, where students become more aware of physics concepts which can later affect the critical thinking skills of students. Mukarramah and Ririn [19] also revealed in their research that the *Think, Talk, Write* (TTW) learning model helps students be actively involved in the learning process with learning situations that are like competitions, thus spurring students to be more enthusiastic and critical in the learning process.

The normality test is used to check whether the data is normal, and the results of manual calculations using Microsoft Excel and comparison using SPSS software version 26 are as follows.

Table 5. Normality Test Result Using Microsoft Excel

Data	Level of Trust	X^2_{count}	X^2_{table}
Experimental class *posttest* score	99,5%	3,89	12,8
Control class *posttest* score	99,5%	3,83	12,8

The table above shows the test results, which show that the data is distributed normally. Such results can be explained as well as seen at x^2_{count} smaller than x^2_{table}. Thus, it can be concluded that the *posttest score* of the ability of critical thinking skills in the experimental class and the control class is normally distributed with a confidence level of 99.5%. This was confirmed by testing its significance using SPSS software version 26. The results of this analysis are shown in the figure below.

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		36
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	3.78717615
Most Extreme Differences	Absolute	.119
	Positive	.074
	Negative	-.119
Test Statistic		.119
Asymp. Sig. (2-tailed)		.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Fig 1. Normality Test Results Using SPSS 26

Posttest results in experimental and control classes obtained a significance level of 0.200, and the value was greater than 0.005, which indicates that the data is normally distributed in both experimental and control classes. The homogeneity test was conducted to determine the ability of students' critical thinking skills between the experimental class and the control class, whether it was the same or there was an imbalance in ability. The results of the homogeneity test of processing using Microsoft Excel are as follows.

Table 6. Homogeneity Test Results Using Microsoft Excel

Data	Homogenitas		F_{table}
	F_{count} *pretest*	F_{count} *posttest*	
Analysis of homogenety of KBK posttest scores (experimental – control)	1,41	1,027	1,75

Based on the data above, it can be seen that the results of processing F_{count} using Microsoft Excel obtained a value of 1.41 on the *pretest* and 1.027 on the *posttest*, where the results are lace than . This indicates that it is F_{count}, H_0 accepted and rejected. Therefore, it can be concluded that the Hα *pretest* and *posttest* scores in the experimental class and the control class have almost the same or homogeneous results. This is reinforced by obtaining similar results using SPSS software version 26, and SPSS version 26 results can be seen in the following figure.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Nilai	Based on Mean	.002	1	70	.961
	Based on Median	.002	1	70	.961
	Based on Median and with adjusted df	.002	1	69.520	.961
	Based on trimmed mean	.001	1	70	.969

Fig 2. Homogeneity Test Results Using SPSS 26

Based on the figure, it can be seen that the sig value is 0.969, where the value is greater > than 0.05. From these results, H_0 is accepted, and the data is homogeneous because the sig value > the significance level (0.05).

The next step is to test the hypothesis once it is confirmed that the data obtained follow a normal and homogeneous distribution. The hypothesis test used is the t-test. The results of the hypothesis test analysis using Microsoft Excel are as follows.

Table 7. Results of Hypothesis Test (t Test) Using Microsoft Excel

Data	Level of Trust	t_{count}	t_{table}
Posttest Score	95%	4.05	1,67

Based on the results of the hypothesis test, the posttest results of students in the experimental class and the control class showed that $t_{count} > t_{table}$ was 4.05 > 1.67, so H_α was accepted and H_0 was rejected. This means that there is a significant influence on the *Think, Talk, Write* (TTW) learning model assisted by *PhET Simulation* on the ability of critical thinking skills in parabolic motion material in class XI minar Physics SMAN Negeri 10 Tasikmalaya. This is proven by the results obtained with SPSS version 26, as follows.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai	Equal variances assumed	.002	.961	4.049	70	.000	3.63889	.89869	1.84650	5.43128
	Equal variances not assumed			4.049	69.987	.000	3.63889	.89869	1.84650	5.43128

Fig 3. Results of Hypothesis Test (t Test) Using SPSS 26

Based on the figure, it is obtained that the sig value is 0.000. Therefore, the sig value is smaller than < 0.05; it can be concluded that there is an influence of the Think, Talk, Write (TTW) learning model assisted by PhET Simulation on the ability of students' critical thinking skills.

Furthermore, the Ngain Test was carried out to see the improvement in students' critical thinking skills between pre-test and post-test scores. The results of N-Gain can be seen in the following Table 8.

Table 8. Normalized Gain Test *Results* (N-Gain Test)

Data	Experiment Class	Control Class
Pretest Average	17,83	16,33
Posttest Average	27,31	23,67
Gain (g) Average	0,53	0,38
Upgrade Categories	Medium	Medium

Based on the data above, the average N-gain value in the experimental class and the control class is different. The experimental class obtained an N-gain value of 0.53. In contrast, the control class obtained an N-Gain value of 0.38, which interpreted this value as an increase in the ability of critical thinking skills of students who received

the treatment of the Think, Talk, Write (TTW) learning model assisted by PhET Simulation and did not get the treatment of the Think, Talk, Write (TTW) learning model assisted by PhET Simulation in the category of moderate N-Gain increase.

Based on data processing in research activities, in accordance with Sudany's opinion, the Think, Talk, Write (TTW) Learning Model is a step to create meaningful learning; basically, learning is built through the process of thinking, speaking, and writing [20]. This model can train students' thinking and speaking skills. That is, the Think, Talk, Write (TTW) learning model builds thinking, reflects, and organizes ideas, then tests those ideas before learners are expected to write [21]. In this learning model, learners are encouraged to think, speak, and then write with respect to a topic [22]. So it can be concluded that the Think, Talk, Write (TTW) Learning Model assisted by PhET Simulation can help train and improve the ability of critical thinking skills in students; this is evidenced by the data of pretest and post-test results on students for experimental classes experiencing a better increase in class average scores.

IV. CONCLUSION

Based on the results of the study, the author can conclude that the Think, Talk, Write (TTW) learning model using PhET Simulation affects the ability of students' critical thinking skills in parabolic motion learning. Judging from the N-Gain score and the average percentage of posttest essential skills of thinking, it shows that the experimental class is better than the control class. With an N-gain value of 0.53 for the experimental class and 0.38 for the control class with the same N-gain category, which is medium. The average percentage of posttest critical thinking indicators in the experimental class was 74.93 with the high category, while in the control class, it was 64.86 with the sufficient category. These findings imply that integrating interactive technology into active learning models can yield better outcomes, suggesting the need for innovative teaching strategies to enhance education quality. The results can guide curriculum developers to incorporate interactive simulations like PhET in physics curriculum design, particularly for parabolic motion topics, to improve critical thinking skills. Teachers should receive training on applying the TTW model and using PhET simulations to implement this strategy in classrooms effectively. Future research should test this model on other subjects, involve diverse populations, conduct longitudinal studies, develop structured learning modules, and explore combining TTW with different instructional strategies to enhance learning outcomes further.

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