



The Influence of Problem-Based Learning Model Assisted by PhET Media on Critical Thinking Skills and Physics Learning Outcomes of High School Students

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Abstract: This study aims to test the effect of problem-based learning model assisted by PhET media on critical thinking skills and physics learning outcomes of high school students. The type of research used is a Quasi experiment with a pretest posttest control group design. The population in this study were all students of class XI of SMA Negeri 5 Mataram. The research sample used class XI 3 as many as 32 people as the experimental class and class XI 2 as many as 32 people as the control class. The experimental class was given treatment using a problem-based learning model assisted by PhET media and the control class used a conventional model. The test instrument used 5 descriptive questions to measure critical thinking skills and 6 questions to measure students' physics learning outcomes. The hypothesis test used in this study was the manova test. The results of the hypothesis test showed a significance value of 0.007 less than 0.05, so H_0 was rejected and H_a was accepted. Based on these results, it was concluded that there was an effect of the problem-based learning model assisted by PhET media on critical thinking skills and physics learning outcomes of high school students.

Keywords: Critical thinking skills; Learning outcomes; Problem-based learning model; PhET media

Introduction

Physics is a branch of natural science and is a science that studies natural phenomena through various scientific processes. Some physics concepts are abstract concepts. Some abstract concepts in physics cause difficulties in visualizing and communicating to students. The role of teachers in guiding students during physics learning activities is important. Teachers are expected to be able to create and build student-centered learning. Student-centered learning will make students more active during the learning process (Agustina et al., 2020; Keiler, 2018). Based on the results of observations that have been carried out at SMAN 5 Mataram, researchers found that students had difficulty understanding the physics concepts they were studying.

In addition, the use of less varied learning models also affects the lack of enthusiasm for students to learn. This can have an impact on critical thinking skills and less than optimal learning outcomes. The selection of an appropriate learning model is important for teachers to consider. One learning model that can be used as an alternative is the problem-based learning model (Palinussa et al., 2023).

This model is a model that focuses on students to be actively involved in solving problems by finding answers to the problems given. While the role of the teacher is only as a mediator and facilitator to help students (Schaller et al., 2023; Muhammadiyah et al., 2022). Research conducted by Malik et al. (2019), Uwambajimana et al. (2023) and Dap-og et al. (2022), stated that the learning outcomes of students taught

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using the demonstration method assisted by PhET simulation media were better than the learning outcomes of students using conventional methods. The difference in student learning outcomes is because the demonstration method assisted by PhET simulation media can attract students' attention to participate in learning in class and students do not only imagine abstractly about the physics concepts taught by the teacher (Amini et al., 2019; Anggraini et al., 2018). The application of PhET media in problem-based learning allows students to combine their theoretical knowledge with direct experiences created through virtual media (Doyan et al., 2023; Widiarta et al., 2023).

One of the abilities that students must have is critical thinking skills. Critical thinking is the ability to manage information related to problem identification so that you can find the cause of an event, think logically, evaluate the impact of events, find solutions, and draw conclusions (Aprilianingrum & Wardani, 2021; Mubarok et al., 2023; Safitri, 2023). Critical thinking is the ability to analyze, connect, and create all aspects of a particular situation or problem (Hasanah et al., 2023; Li, 2023). The importance of students' critical thinking skills in learning can also affect the learning outcomes obtained (Syamsinar et al., 2023; Yona et al., 2023).

Based on the description above, this study aims to test the influence of the problem-based learning model assisted by PhET media on students' critical thinking skills and physics learning outcomes. This study differs from previous studies in terms of innovation in the learning materials used, namely elasticity and variables in the form of critical thinking skills and learning outcomes, as well as different research locations.

Method

The type of research used in this study is a quasi-experimental study characterized by the presence of treatments that are designed and given intentionally to change conditions (Darling-Hammond et al., 2020). The design of this study is a pretest posttest control group design.

Table 1. Pretest-Posttest Control Group Design Research Design (Siedner et al., 2020)

Class	Pretest	Treatment	Posttest
Experiment	O ₁₁	X ₁	O ₁₂
Control	O ₂₁	X ₂	O ₂₂

This research was conducted at SMAN 5 Mataram. The population in this study were all students in grade XI. Sampling used a purposive sampling technique, namely a sampling determination technique with certain considerations (Campbell et al., 2020) so that class XI 3 consisting of 32 students was obtained as the

experimental class and class XI 2 consisting of 32 students as the control class. The experimental class was given treatment using a problem-based learning model assisted by PhET media while the control class used a conventional model. The variables in this study consisted of independent variables, namely the problem-based learning model assisted by PhET media, dependent variables, namely critical thinking skills and learning outcomes. The data collection technique used a descriptive test consisting of 5 critical thinking ability questions and 6 learning outcome questions.

The critical thinking ability indicator has 5 indicators namely: basic explanation, Basic decisions, conclusions; further explanation, and reasoning and integration. Meanwhile, the learning outcomes measured in the cognitive domain C1-C6 are as follows: remembering, understanding, applying, analyzing, evaluating, and creating. The research instrument used to measure critical thinking skills and learning outcomes before being used in both sample classes, has been tested using validity, reliability, difficulty level and question discrimination tests. The prerequisite test uses a normality test and a homogeneity test. Hypothesis testing is carried out using a manova test with a significance level of 5%. Data analysis uses the assistance of the IBM SPSS 22 program.

Result and Discussion

Based on the results of the pretest that has been conducted, it was found that the critical thinking and problem solving skills of students in the experimental class and control class were still low. The low average pretest score was because students had not received elasticity material (Syaripudin et al., 2023), so students only relied on the basic knowledge they had obtained during the learning process at school and the experiences they had with the surrounding environment (Montenegro-Rueda et al., 2023; Farhi et al., 2023; Almulla, 2020). After being given treatment during the learning process, students were then given a posttest with the same weight of questions as the pretest. Data on the results of critical thinking skills and learning outcomes for the experimental class and the control class can be seen in Table 2 and Table 3.

Table 2. Data on Critical Thinking Skills Pretest-Posttest Experimental Class and Control Class

Test	Class	N	The highest score	Lowest Value	Average
Pretest	Experiment	32	65	20	42.03
	Control	32	60	30	42.50
Posttest	Experiment	32	90	60	74
	Control	32	85	50	70

Table 3. Pretest-Posttest Learning Outcome Data for Experimental Class and Control Class

Test	Class	N	The highest score	Lowest Value	Average
Pretest	Experiment	32	66.70	25	42.40
	Control	32	58.30	25	40.60
Posttest	Experiment	32	95.80	62.50	81.60
	Control	32	91.70	54.20	75.50

Based on the results of the study in the table above, it shows that the average pretest value of critical thinking skills and student learning outcomes in the experimental class and control class are still unsatisfactory. This is because the two classes have not received material on elasticity and student knowledge is only limited to basic knowledge (Khaeruddin et al., 2023; Indri et al., 2020; Rosiqoh et al., 2020). An increase in student posttest scores can be seen after the two classes were given different treatments and the experimental class score was higher than the control class. The data obtained from the pretest and posttest of the experimental class and control class were used to test the hypothesis. Before that, the data was analyzed for normality and homogeneity. The results of the normality test of the pretest and posttest data for critical thinking skills in the experimental class obtained Shapiro-Wilk sig values of 0.63 and 0.11. While in the control class, Shapiro-Wilk sig values were obtained of 0.05 and 0.09.

The normality test of the pretest and posttest data for student learning outcomes in the experimental class obtained Shapiro-Wilk sig values of 0.147 and 0.135. Meanwhile, in the control class, the Shapiro-Wilk sig value was 0.23 and 0.05. Based on the results obtained, the significance value is > 0.05 , so the data is normally distributed. The results of the homogeneity test of the pretest and posttest data on critical thinking skills in the experimental class obtained a significance value of 0.37. While in the control class, a significance value of 0.47 was obtained. The homogeneity test of the pretest and posttest data on student learning outcomes in the experimental class obtained a significance value of 0.16. While in the control class, a significance value of 0.30 was obtained. The data obtained are included in the homogeneous category because the significance value is > 0.05 .

Hypothesis testing was carried out using the manova test using the IBM SPSS 22 program. The data tested were the final test of critical thinking skills and student learning outcomes in the experimental and control classes. The Manova test was used to determine whether or not there was an effect of the problem-based learning model assisted by PhET media on critical thinking skills and student physics learning outcomes. Before conducting the MANOVA test, it is necessary to conduct the Levene's test and the Box's M test, which are

requirements for conducting the MANOVA test, as in Table 4.

Table 4. Levene's Test Results

Dependent Variable	Mean Square	F	Sig.
Critical Thinking	306.25	4.80	0.03
Learning Outcomes	631.26	6.96	0.01

The results of Levene's test obtained an F value for critical thinking ability of 4.801 with a significance value of 0.032 and an F value for learning outcomes of 6.960 with a significance value of 0.011. If the significance level is set at 0.05, then the critical thinking ability and physics learning outcomes of students have homogeneous variants, so that the Manova test can be continued. The fulfillment of the Box's M test is one of the prerequisites for the analysis of the Manova test. The following results of the Box's M test can be seen in Table 5.

Table 5. Box's M Test Results

Box's M	F	df1	df2	Sig.
1.85	0.59	3	691920	0.61

The Box's M test results obtained a value of 1,853 with a significance of 0.617. Based on these results, it can be seen that the Box's M test results are met. The significance value obtained in the Box's M test is greater than 0.05 so that the requirements are met and the data can be tested with the manova test. The results of the Manova test can be seen in Table 6.

Table 6. Multivariate Test Results

Effect	Value	Sig.
Pillai's Trace	0.15	0.007
Wilks' Lambda	0.84	0.007
Hotelling's Trace	0.17	0.007
Roy's Largest Root	0.17	0.007

The results of the Manova test show that the values for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root obtained a significance value of 0.007 in each test. If a significance of 0.05 is used, then $0.007 < 0.05$, so it can be concluded that there is an influence of the problem-based learning model assisted by PhET media on critical thinking skills and physics learning outcomes of students (Liana et al., 2023; Rianti et al., 2024; Rahmat et al., 2024). The problem-based learning model is a learning model that uses real-world problems encountered in the environment as a basis for gaining knowledge and concepts through critical thinking and problem-solving skills (Nashar et al., 2021). The application of the problem-based learning model can make learning more meaningful, help students have high self-confidence and independent learning abilities. The problems raised in problem-based learning are real

problems that exist around (Susilawati et al., 2023; Oktadela et al., 2022).

In the 21st century learning process, the use of technology cannot be separated from everyday life. Integrating information and communication technology (ICT) as a learning tool can facilitate the explanation of abstract concepts that are easy to understand. Teachers and students can use technology as a means of learning (Rahayu et al., 2022; Haleem et al., 2022). One of the learning media that can be used is PhET (Physics Education and Technology). PhET is a series of interactive simulations developed by the University of Colorado Boulder that are specifically designed to support physics learning. This simulation allows students to run virtual experiments, observe physical phenomena, and apply the concepts learned interactively (Arifin et al., 2022; Stein et al., 2023; Safitri et al., 2019).

Conclusion

Based on the formulation of the problem, research results, and discussion, it can be concluded that: There is an influence of the problem-based learning model assisted by PhET media on the critical thinking skills of high school students; There is an influence of the problem-based learning model assisted by PhET media on the critical thinking skills of high school students; There is an influence of the problem-based learning model assisted by PhET media on the critical thinking skills of high school students.

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Author Contributions

Conceptualization, N.M. and A.D.; methodology, N.M. and A.D.; formal analysis, N.M. and A.D.; investigation, N.M.; resources, N.M. and M.T.; data curation, N.M. and A.D.; writing—original draft preparation, N.M. and M.T.; writing—review and editing, N.M. and A.D.; visualization, A.D. and M.T. All authors have read and approved the published version of the manuscript.

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Conflict of Interest

There is no conflict of interest.

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