EDUMATSAINS
JURNAL PENDIDIKAN MATEMATIKA DAN SAINS
E-ISSN:2527-7235
Volume 10 Issue. 1, July 2025, pp 393-402
http://ejournal.uki.ac.id/index.php/edumatsains

The Effect of Contextual Teaching and Learning Model Assisted by Physics Education Technology Simulation on Motivation and Physics Learning Outcomes

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Article Info

Article history:
Received : April 3rd 2025
Revised : July 29th 2025
Accepted : July 30th 2025
Available online : July 31st 2025

https://doi.org/10.33541/edumatsains.v10i1.6698

Abstract

Motivation and physics learning outcomes among students remain low. One approach to improving both aspects is the use of contextual teaching assisted by PhET. This study aims to examine whether, and to what extent, the implementation of the contextual teaching and learning (CTL) model facilitated by PhET simulations is effective. influences students' motivation and physics learning outcomes. This research employs a quantitative quasi-experimental method and was conducted at SMA Negeri 71 Jakarta, with samples selected through purposive sampling. The instruments used include a questionnaire to measure learning motivation and a test to assess learning outcomes on Ohm's law, resistor circuits, and Kirchhoff's first law. Hypothesis testing using an independent sample t-test resulted in a significance value of 0.000 < 0.05, indicating a significant effect of PhET-assisted contextual learning on motivation and learning outcomes. The effect size analysis showed values of 0.289 for motivation and 0.655 for learning outcomes, categorized as moderate and high, respectively. Thus, it can be concluded that PhET-assisted contextual learning has a moderate impact on motivation and a strong influence on learning outcomes.

Keywords: : Contextual Learning, PhET simulation, Learning motivation, learning outcomes, dynamic electricity

1. Introduction

Physics is a fundamental branch of natural science that plays a crucial role in human life, particularly in education. It involves the study of matter, its physical properties, composition, transformations, and the energy it produces (Satriawan & Rosmiati, 2017). Many students perceive physics as a difficult subject due to the need to understand concepts and analyze real-world

phenomena (Pasaribu, 2017). Therefore, teachers should create effective learning experiences by selecting appropriate teaching models. Commonly used models include conventional learning, contextual learning, and discovery learning. Learning motivation is an internal driving force that stimulates students to engage in learning activities (Sardiman A. M, 2018). It can be observed through persistence, enthusiasm, and active participation in learning (Made Wena, 2010). Learning outcomes refer to the changes in behavior and abilities acquired through learning, reflected in mastery, knowledge, and basic skills (Fauziddin & Mayasari, 2018).

Initial observations and interviews at SMA Negeri 71 Jakarta indicated that physics instruction typically involves teacher-led explanations followed by varied-difficulty worksheets (LKPD). However, student motivation remains low, as evidenced by many students not completing all exercises, lacking engagement in lessons, and showing little enthusiasm during learning sessions. Additionally, practical experiments are rarely conducted due to limited facilities and time constraints. Survey results indicate that 59.85% of students experience challenges in learning physics, whereas 79.55% perceive that incorporating hands-on learning methods may effectively mitigate these difficulties (Masta & Yonas Ferdinal Silaban, 2024). To address these issues, a more engaging learning model is needed. One suitable approach is the Contextual Teaching and Learning (CTL) model, which integrates real-world contexts into classroom learning, allowing students to connect their knowledge with practical applications. Through this model, students gradually construct their own understanding, equipping them with problem-solving skills for real-life situations (Chityadewi, 2019).

The implementation of the Contextual Teaching and Learning (CTL) model can be operationalized through multiple approaches, with online simulations—such as those offered by Physics Education Technology (PhET)—serving as an effective medium to enhance conceptual understanding. PhET simulations emphasize the connection between real-world phenomena and the underlying scientific principles, enabling students to contextualize abstract concepts. These simulations support an interactive and constructivist learning approach by actively engaging students in the learning process. Additionally, PhET provides immediate feedback, allowing students to evaluate and refine their understanding in real-time. Furthermore, PhET simulations offer a creative and exploratory virtual workspace that enhances students' problem-solving skills and fosters a deeper comprehension of physics concepts.

2. Methods

This study utilizes a quantitative quasi-experimental design involving both an experimental group and a control group to assess the impact of the intervention. The study seeks to investigate the impact of the Contextual Teaching and Learning (CTL) model, facilitated by PhET simulations, on students' motivation and their learning outcomes in physics. Motivation is measured using questionnaires, while learning outcomes are assessed through test questions administered to both groups before and after the intervention. The experimental group receives instruction using the CTL model with PhET, whereas the control group follows a conventional lecture-based approach. The study population comprises all 12th-grade students at SMA Negeri 71 Jakarta in the 2023/2024 academic year, with eight classes of 36 students each. The sample is selected purposively, with the

CTL model assisted by PhET as the independent variable and students' motivation and learning outcomes as the dependent variables. Data is collected through pre- and post-treatment questionnaires for motivation and pre- and post-tests for learning outcomes..

The normality of the data is tested using the Kolmogorov-Smirnov test, given the sample size exceeds 50 participants. If the p-value (2-tailed) is less than 0.05, H0 is rejected, suggesting non-normal distribution. If sig. (2-tailed) > 0.05, H0 is accepted, indicating that the data is normally distributed. If the p-value (2-tailed) exceeds 0.05, H0 is not rejected, indicating that the data follows a normal distribution.(Sianturi, 2022). If the data variance is homogeneous, data analysis can be conducted with a significance level of 0.05 or an error rate of 5%. If the significance value < 0.05, the data variance is not homogeneous. If the data variance is homogeneous, analysis can be performed at a 0.05 significance level (5% error rate). A significance value less than 0.05 indicates heterogeneity in the data variance..

This study employs hypothesis testing to assess the impact of the Contextual Teaching and Learning (CTL) model, supported by PhET (X), on students' physics learning motivation (Y1) and learning outcomes (Y2), using a 5% error rate. The hypothesis test employs the Independent Sample t-test to determine whether there is a significant difference in the average motivation and learning outcomes of students before and after the treatment in both the experimental and control classes. The hypothesis test uses the Independent Sample t-test to assess whether there is a significant difference in the average motivation and learning outcomes of students before and after the treatment in both experimental and control groups. Cohen's d is used to quantify the treatment effect size, which can be calculated using the following formula.(Surya putra & Rahayu, 2021)

$$\mathrm{d} = \frac{m_E - m_K}{\sqrt{\frac{sd_E^2 + sd_K^2}{2}}}$$

By explanation: d = Cohen's d, effect size measure to determine the impact of treatment, m_E = mean of the intervention group, m_K= mean of control group, sd_E = The square of the standard deviation of the Intervention group, sd_K = The effect size is calculated as the square of the standard deviation of the control group. The interpretation of the effect size is as follows: $d < 0.2$ indicates a very small effect, $0.2 \leq d < 0.5$ represents a small effect, $0.5 \leq d < 0.8$ signifies a medium effect, and $d \geq 0.8$ denotes a large effect (Arafatu Saniah, 2022).

3. Result and Discussion

The research method employed at SMA Negeri 71 Jakarta is a quantitative quasi-experimental study, involving two classes: an experiment group and a control group, each consisting of 36 students. However, only 32 students were present during data collection. The research instruments include a questionnaire to assess students' motivation in learning physics and a test to measure learning outcomes. Both instruments were validation before and after the treatment in both classes, with 25 questionnaire items and 10 test questions. The judgment validity test was used to evaluate the feasibility of the instruments before conducting the study.

a. Analysis Results of Learning Motivation in the Control and Experimental Classes

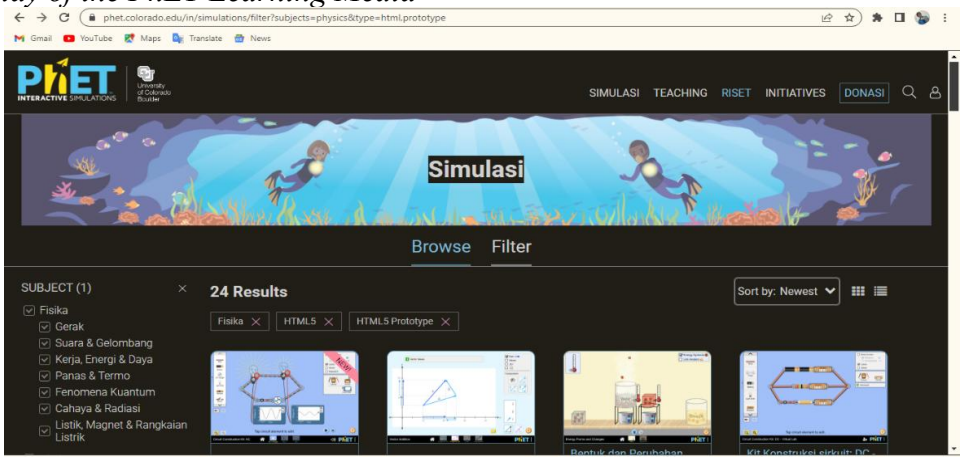
To assess students' learning motivation, four aspects were considered: the drive to achieve, commitment, initiative, and optimism.

Table 1.
Learning Motivation Description

Dimension	Percentage (%)			
	Control Group		Experimental group	
	Pre Experimental	Post Experimental	Pre Experimental	Post Experimental
The drive to achieve	44.05	62.95	35.05	81.50
Commitment	41.33	79.50	35.90	95.16
Initiative	43.62	63.12	35.45	77.70
Optimism	42.13	61.27	34.86	81.00

Among these aspects, the highest score was in the commitment aspect in the experimental class, reaching 83%. This value corresponds to the indicator that individuals have an awareness of learning. In the experimental class, nearly every student felt that their abilities were still lacking, which led them to develop a stronger awareness and motivation to study harder. Below is the PhET simulation interface used in the study.

Figure 1
Initial Display of the PhET Learning Media



Based on the results of the analysis, the increase in motivation in the experimental class was superior compared to the control class. This occurred because the experimental class used a CTL (Contextual Teaching and Learning) approach during the learning process. The use of PhET simulations made the learning more engaging, allowing students to perform simulations

themselves, even if not in a real setting. Students did not need to imagine or fantasize about the flow of electric current in a circuit, how light bulbs are arranged in series or parallel, or how much current enters or exits. In addition, students were more active and enthusiastic when PhET simulations were implemented during learning. It can be concluded that applying the CTL model assisted by PhET can enhance students' learning motivation.

b. Results of the Analysis on Student Learning Outcomes in the Control and Experimental Groups

Test instrument was used to assessed learning outcome in this study,

Table 2.
Learning Outcomes Description

	Control Group		Eksperimental group	
	Pretest	**Postest**	**Pretest**	**Postest**
N	32.00	32.00	32.00	32.00
Mean (Avarage)	30.00	50.00	30.31	80.00
Median	30.00	50.00	30.00	80.00
Modus	30.00	50.00	30.00	80.00
Std. Deviation	13.19	13.19	13.07	13.19
Minimum	10.00	30.00	10.00	60.00
Maximum	50.00	70.00	50.00	100.00

The average pre-treatment learning outcomes for the control group were 29.38, while for the intervention group, they were 30.31, resulting in a difference of 0.93. Despite this difference in average scores, the maximum, minimum, and median values were identical, indicating that the initial cognitive abilities of both classes were comparable, thereby supporting the research process. After the treatment, the average learning outcome for the control class was 50.00, whereas for the experimental class, it was 80.00, with a difference of 30.00. The standard deviation in the control group was 13.198, with scores ranging from a minimum of 30 to a maximum of 70. In the experimental group, the standard deviation was also 13.198, with scores ranging from 60 to 100. The median scores were 50.00 for the control group and 80.00 for the intervention group, while the mode values were also 50 and 80, respectively. These findings indicate a significant improvement in students' learning outcomes after the treatment in both the control and experimental classes.

The improvement in learning outcomes in the experimental class was high because the learning process was consistently accompanied by virtual experiments using PhET. In addition, the use of the CTL learning model can enhance students' problem-solving skills, as this model emphasizes the discovery process. Students are trained to explore information, ask questions, conduct experiments, and draw their own conclusions. Moreover, students are also required to be active in class by posing challenging questions. All these activities lead to a deeper understanding of the material, which in turn improves their learning outcomes.

c. Normality and Homogeneity Test Results

The normality test results for the learning motivation questionnaire revealed a significance value of 0.081 in the intervention group before treatment and 0.200 after treatment. In the control group, the significance value was 0.200 both before and after treatment. In accordance with the normality test criteria, It can be inferred that all four questionnaire Data from both groups, before and after treatment, had significance values > 0.05, Implying that the residual variables exhibit normal distribution.

For student learning outcomes, the significance value in the experimental class before and after treatment was 0.063, while in the control class, it was 0.078 before treatment and 0.063 after treatment. Inline on normality test criteria, it can be inferred that all four data in both groups, before and after treatment, had significance values > 0.05, meaning that the residual variables follow a normal distribution. The homogeneity test results for student learning motivation showed that the significance value for the pre-questionnaire in the intervention control resulted 0.226 > 0.05, while for the post-questionnaire, it was 0.767 > 0.05 (homogenous variance). For student learning outcomes, the significance value for the pretest in both the intervention and control groups was 0.903 > 0.05, while for the posttest, it was 1.000 > 0.05 (homogenous data variance).

D. Hypothesis Testing Results by using Independent Sample t-test

Description of Students' Learning Motivation Data in the CTL instructional model assisted by PhET among the intervention and Control Group Using Independent Sample t-Test for Post-Questionnaire as shown in Table 3

Table 3.
Description of Students' Learning Motivation Data Using Independent Sample t-Test

		Equal variances assumed	***Equal variances not assumed***
Levene's Test for Equality of Variances	f	0.089	
	Sig	0.767	
t-test for Equality of Means	T	21.07	21.07
	df	62.00	61.50
	Sig. (2-tailed	.000	.000
	Mean Difference	22.31	22.31
	Std. Error Difference	1.059	1.059
95% Confidence Interval of the Difference	*Lower*	20.19	20.19
	Upper	24.42	24.43

According to the data presented in Table 3, the significance value of 0.000, which is below the threshold of 0.05, leads to the rejection of the null hypothesis (H0) and acceptance of the alternative hypothesis (Ha). Furthermore, the computed t-value of 21.070 exceeds the critical t-value of 1.671,

further supporting the rejection of H0 and the acceptance of Ha. This result suggests that the Contextual Teaching and Learning (CTL) model assisted by PhET significantly influences students' learning motivation in the experimental class.

Table 4.
Description of Students' Learning Outcomes Data Using Independent Sample t-Test

		Equal variances assumed	***Equal variances not assumed***
Levene's Test for Equality of Variances	f	.000	
	Sig	1.000	
t-test for Equality of Means	T	9.092	9.092
	df	62	62.000
	Sig. (2-tailed	.000	.000
	Mean Difference	30.000	30.000
	Std. Error Difference	3.300	3.300
95% Confidence Interval of the Difference	*Lower*	23.404	23.404
	Upper	36.596	36.596

The results presented in Table 3 indicate a significance value of 0.000, which is significantly lower than the 0.05 threshold, leading to the rejection of the null hypothesis (H0) and the acceptance of the alternative hypothesis (Ha). Additionally, the calculated t-value of 9.092 exceeds the critical t-value of 1.671, further reinforcing the rejection of H0. These findings provide strong statistical evidence in support of Ha, confirming a significant difference between the groups under study. This result suggests that the CTL model assisted by PhET significantly influences students' learning outcomes in the experimental class.

E. Effect Size

To measure the extent of the impact of the CTL model assisted by PhET due to students' learning motivation, an effect size test was conducted. The analyzed data consisted of questionnaire (pre-questionnaire and post-questionnaire) results from each class. Following the calculation of the mean and standard deviation using SPSS, The data set contained further processed to determine the effect size.

Table 5.
Effect Size

	Learning Motivation	Learning Outcomes
Effect Size	0,289	0,655

Based on the effect size calculation, a value of 0.289 was obtained, which falls into the moderate category. This indicates that the Contextual Teaching and Learning (CTL) model assisted by PhET has a moderate impact on students' learning outcomes in the experimental class. This result is influenced by the limited availability of laptops, as only six laptops were available during the study. Consequently, each group of six students had to share one laptop. The lack of learning tools reduced students' motivation to study physics, as not all students were able to actively participate in the PhET simulations.

The effect size calculation yielded a value of 0.655, which falls into the high category. These results indicate that the Contextual Teaching and Learning (CTL) model, supported by PhET simulations, has a statistically significant effect on the learning outcomes of students in the experimental group. The substantial effect size further underscores the effectiveness of this instructional approach in enhancing students' comprehension and retention of the subject matter. This suggests that the integration of PhET-assisted CTL fosters a more profound understanding of physics concepts among students.The integration of PhET simulations provides an interactive learning experience, allowing students to visualize and comprehend abstract physics concepts more effectively. Therefore, the use of CTL assisted by PhET can be considered an effective instructional approach to improve student learning outcomes in physics.

4. Conclusion

Based on the results and data analysis conducted in this study, the hypothesis testing reveals that the significance value for both motivation and learning outcomes is $0.000 < 0.05$. This finding confirms that the Contextual Teaching and Learning (CTL) model assisted by PhET significantly influences students' motivation and learning outcomes in physics. To measure the extent of this impact, the effect size analysis was applied, revealing a moderate effect on motivation (0.289) and a high effect on learning outcomes (0.655). The results suggest that the implementation of the Contextual Teaching and Learning (CTL) model, enhanced by PhET simulations, exerts a significant effect on students' motivation and demonstrates a strong influence on their learning outcomes. For future research, it is recommended that researchers using the CTL model assisted by PhET carefully consider aspects such as time management, facilities, and infrastructure to ensure an engaging and effective learning process. Additionally, future studies could explore the integration of game-based learning models to further enhance students' engagement and motivation in physics education.

5. Aknowledgments

The author expresses gratitude to Universitas Kristen Indonesia and SMA Negeri 71 Jakarta for granting permission to conduct this research. Special thanks are also extended to Asrama Yap Thiam Universitas Kristen Indonesia for providing dormitory throughout the author's academic journey.

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