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THE INFLUENCE OF PROBLEM BASED LEARNING ASSISTED BY PhET COLORADO MEDIA ON STUDENTS' LEARNING OUTCOMES AND SCIENCE PROCESS SKILLS ON THE MATERIAL OF FORCE AT PUBLIC JUNIOR HIGH SCHOOL 37 MEDAN

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Abstract

This research explores the effects of applying the Problem-Based Learning (PBL) model, supported by PhET Colorado media, on students' learning achievement and science process skills in the topic of force among seventh-grade students at SMP Negeri 37 Medan during the 2024/2025 academic year. The study employs a quasi-experimental approach using a Pretest-Posttest Control Group Design, with two classes selected as the research sample, VII-E (Experimental Class) using PBL with PhET Colorado and VII-F (Control Class) without PBL and PhET Colorado. The sampling technique applied was Purposive Sampling. Data collection was conducted through tests and observations, followed by analysis using the Independent Sample t-test. In the experimental class, the average pretest score was 40, while the posttest score showed a significant improvement, reaching 84, while in the control class, they were 39 and 67. The hypothesis test confirmed a significant effect of PBL with PhET Colorado on students' learning outcomes. Additionally, the final assessment of science process skills revealed that the experimental class achieved a proficiency rate of 79.41%, whereas the control class attained a lower percentage of 39.16%, demonstrating a significant impact of the implemented learning model.

Keywords: PBL, PhET, colorado, science, skills

Introduction

Entering an era of increasinggly tight competition, Indonesia faces various challenges in various aspects of life. It is important for us to realize that education is the main foundation in living life and facing dynamics and challenges that continue to develop (Wulandari, 2022). Humans must be able to understand knowledge and integrate it into their real lives and can be called quality human resources (Maharani et al., 2024). The Indonesian service of instruction and culture has again overhauled the curriculum into the Independent Curriculum. Current learning provides freedom and flexibility for teachers in teaching, this is adjusted aligned with students' needs and focuses on strengthening the character of students (Masgumelar & Mustafa, 2021).

Natural Sciences is a field of study that requires active participation from students. Science is not just information in the form of a collection of facts, concepts, and principles, there is also a series of activities to acquire new knowledge (Pasaribu et al., 2020). One part of science is physics which is commonly found in the real world and is divided into several parts that discuss various aspects of the material that require cognitive understanding and mastery of science process skills (Novita & Fatmi, 2023). One of them is the material on force which is the material for grade 7 science phase D. Cognitive capacity can be behavior that occurs in the cognitive range as a result of learning. The levels of cognitive domains according to Anderson et al. (2001) consist of Knowledge (C1), comprehension (C2), application (C3), analysis and synthesis (C4), evaluation (C5), and creativity (C6) (Djulia et al., 2023). Science process skills refer to the capability to investigate students' logical capacity to solve a problem so that an innovative, critical, and creative student identity is formed (Rustan et al., 2020). The Independent Curriculum has six minimum science process skills that must be developed in students, namely observing, questioning and predicting, planning and conducting investigations, processing/analyzing data and information, evaluating and reflecting, communicating results.

According to previous studies analyzing students' cognitive abilities in science learning, it has been found that their cognitive skills remain at a lower-order thinking level (Berlian et al., 2022). Additionally, students' science process skills in Indonesia are still considered relatively low (Saleh et al., 2020). The weak science learning process, learning preparation that is still focused on how to exchange learning materials sourced from educators for students are factors that cause this to happen. (Stevani et al., 2023).

Interviews and pre-research observations conducted with science teachers at SMP Negeri 37 Medan, produced information that conventional learning is still often applied. Facilities and infrastructure are also limited such as laboratories that cannot be used because they are damaged. Students' cognitive abilities are also relatively low based on the results of students' cognitive domain learning, as many as 78% are still below the Learning Objective Achievement Criteria set by the school of 75 in science subjects. Students' science process skills have also not developed. Conventional learning makes students irresponsible in learning because they feel that everything will be conveyed by the teacher.

Learning models and media that are able to support students' learning outcomes and science process skills are urgently needed as a solution to the problems that have been explained, namely the problem-based learning (PBL) instructional model supported by PhET Colorado. PBL is a model carried out with a limited number of learners where educators have a role in guiding and facilitating encouraging students to take a more active role in the investigative process (Bilodi, 2019).

The application of PBL in learning enables students to communicate their thoughts to face a problem and can support students' science process skills by utilizing skill aspects (Kurt & Sezek, 2021). Problem-Based Learning has the potential to enhance students' cognitive development, problem-solving, and mental abilities and learn aspects of adults by facing them through real situations or simulations, and becoming learners (Arends, 2012). Effective and

efficient media are needed to create interesting learning (Setyabudi et al., 2021). PhET Colorado simulations can be used as a substitute for laboratory practicums (Verawati et al., 2022). PhET can offer assistance to students to better understand concepts and improve science process skills in understanding a problem (Verawati & Sukaisih, 2021).

The comes about of a think about conducted by Dachi et al. (2023) expressed that the application of PBL with the assistance of PhET media had a positive effect on understudy learning results, where the post-test scores of the test course were higher than those of the control lesson. The comes about of a consider by Lestari et al. (2022) expressed that the application of PBL made understudies facilitated towards genuine examinations. The comes about of a ponder by Marianus et al. (2020) too expressed that the utilize of PBL backed by PhET media can progress understudy learning results and get science process aptitudes scores within the great and exceptionally great categories. PBL assisted by PhET media can be displayed again in the form of illustrations and intuitive controls, the use of this virtual practicum is not complicated and can be connected in the classroom.

Research Method

This study follows a quantitative research approach, which is considered most appropriate when the essential objective of this think about is to examine the cause-effect relationship of a treatment (Yusuf, 2019). This study employs a quasi-experimental research design consisting of two classes, one serves as the experimental class, while the other functions as the control class. Both groups received learning with a scientific approach, but the experimental group was provided with an additional intervention in the form of the application of PBL syntax supported by PhET Colorado, in contrast the control group was not given PBL syntax treatment assisted by PhET Colorado media. This study uses Pretest and Posttest Control Group Design. The pretest is given before the learning is carried out, while the posttest is given after the learning is carried out.

The inspecting strategy utilized in this ponder is purposive testing. The most characteristic of this inspecting is that test individuals are chosen particularly based on inquire about goals (Hardani et al., 2020). Researchers and teachers work together to determine the sample by considering the similarities in abilities of the 8 existing classes. The results of the decision that became the research sample consisted of 60 students, where class VII-E served as the experimental group, while class VII-F functioned as the control group. Both classes were given the same material, namely style.

The test instrument employed in this research; the instrument is designed to assess learning outcomes in the cognitive domain through multiple-choice questions arranged based on predetermined competency achievement indicators. This study uses a test instrument taken from a question bank book so that no instrument trial is carried out. The test instrument is tested for construct validity by involving expert judgment (Sugiyono, 2019). The non-test instrument used in this research; the focus is on science process skills observation sheet. This non-test instrument will be tested for validity with expert judgment involving expert opinion (Sugiyono, 2019). After being validated, the non-test instrument is suitable for use in research.

The data analysis techniques employed in this study include descriptive statistical analysis, prerequisite test analysis, hypothesis testing, and gain normality testing. The prerequisite test analysis consists of a normality test and a homogeneity test. The normality test is conducted to decide whether the information takes after a typical conveyance. To perform this test, the Shapiro-Wilk method is utilized with the assistance of the Statistical Program for Social Science (SPSS) version 21 application. To ensure whether the two sample groups in the same population are homogeneous or not, the Lavene homogeneity test is used with the help of SPSS version 21 software. If the sig price is more than α (0.05), then the data is deemed to follow a normal distribution. Giving a

significance value of α = 0.05 for the homogeneity test using SPSS software. Data variance can be declared the data is considered homogeneous if the Levene's statistical value exceeds 0.05

Result and Discussion

When This research was conducted at SMP Negeri 37 Medan on the subject of style for class VII in the 2024/2025 academic year. The research sample comprised two classes, class VII-E, designated as the experimental group, and class VII-F, assigned as the control group. The research began by giving a pretest administered to both classes to evaluate students' prior knowledge and skills. After the outcomes of the pretest were obtained, each class was given different treatments according to the research design. Furthermore, a posttest was given to measure improvements in learning outcomes. In addition, research data were also collected through observations of student science process skills during learning activities.

1. Cognitive Domain Learning Outcomes

The research data were derived from the pretest and posttest results administered to both the experimental and control classes. The pretest produced data on the level of students' initial understanding before receiving learning, while the posttest was used to produce data on their increased abilities after the application of the PBL instructional model integrated with PhET Colorado media. The average pretest and posttest scores of both classes are summarized in Figure 1.

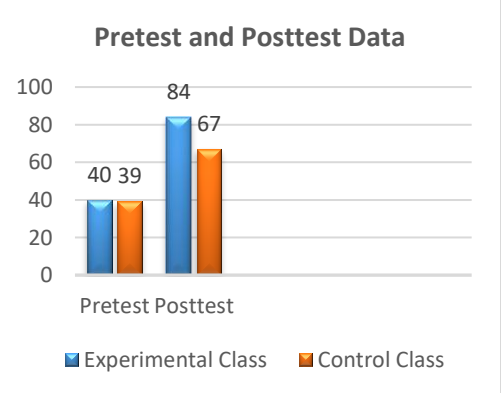

Figure 1. Comparison diagram of Pretest and Posttest data

The experimental class had a pretest score that was not much different from the control class, both classes did not achieve a score that met the learning objective achievement criteria set by the school of 75 in the science subject. Based on this, it is known that the preliminary skills of students in both classes are equivalent.

The low pretest score was caused by the lack of implementation of instruction pertaining to the topic of force, so that students still do not have sufficient understanding of the concept. The posttest scores of both classes indicate that the experimental class utilizing the PBL instructional model supported by PhET Colorado is superior for the control group. Within the experimental group with PBL supported by PhET, participants are taught to start a problem at the beginning of learning and then conduct an investigation to find a solution.

2. Science Process Skills

Science process skills were measured through observations by five observers during learning activities. The assessment data the science process skills of both classes are presented in Table 1.

Table 1. Science Process Skills Percentage Data

Class	Category	Value Range	F	$\bar{X}$
Exsperi-mental	Very High	81-100%	9	79,41 %
	High	61-80%	21	
Control	Medium	41-60%	11	39,16 %
	Low	21-40%	19	

The comes about of the think about appeared that understudies who learned with PBL demonstrate helped by PhET Colorado media had way better science process skills than students who did not receive such learning.

3. The Influence of the PBL Instructional Model Supported by PhET Colorado Media on Learning Outcomes

a. Results of Normality Test of Learning Outcome Values

Table 2. Normality Test on SPSS

Class	Shapiro-Wilk		
	Statistic	df	Sig.
Experimental Pretest	.964	30	.392
Experimental Posttest	.969	30	.510
Pretest Control	.957	30	.253
Posttest Control	.985	30	.930

The results of the normality test of learning outcome data produced pretest and posttest data from both classes were normally distributed. In the experimental class, the significance value the pretest results indicated 0.39 while the posttest results showed 0.51, both of which were greater than 0.05. This indicates that the pretest and posttest data from the experimental class followed a normal distribution. Similarly, for the control class, the obtained significance value was the pretest was 0.25 and the posttest was 0.93, which were also greater than 0.05, indicating a normal distribution.

b. Results of Homogeneity Test of Learning Outcome Values

Table 3. Homogeneity test of pretest data

Test of Homogeneity of Variances

Pretest

Levene Statistic	df1	df2	Sig.
2.056	1	58	.157

Table 4. Homogeneity test of posttest data

Test of Homogeneity of Variances

Posttest

Levene Statistic	df1	df2	Sig.
.762	1	58	.386

The homogeneity test results for learning outcome data revealed a pretest significance value of 0.157 and a posttest significance value of 0.386. Since both values exceed 0.05, the pretest and posttest data meet the homogeneity criteria. The learning outcome data of both classes comes from a populace that has the same change or is homogeneous.

c. Results of Hypothesis Testing of Cognitive Domain Learning Outcomes

Table 5. Hypothesis test of posttest data

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
									Lower / Upper
Cognitive Domain Learning Outcomes	Equal variances assumed	.762	.386	7.820	58	.000	16.767	2.144	12.475 / 21.058
	Equal variances not assumed			7.820	50.346	.000	16.767	2.144	12.461 / 21.072

The results of the hypothesis testing on learning outcomes, obtained a posttest significance value for both classes of 0.000. The hypothesis test results for the posttest data show a significance value of 0.000, which is less than 0.05. Therefore, it can be concluded that Ho is rejected, and Ha is accepted. Based on the hypothesis test that has been tested using SPSS 21, there's an impact of the application of the PBL model enhanced by PhET Colorado simulations on students' learning achievement in the material of force.

d. Normality-Gain

Based on N-Gain analysis results, the experimental group showed a significant increase in learning outcomes with an N-Gain score of 0.714, categorized as high, the experimental class demonstrated significant improvement. Meanwhile, the control class appeared an increment in learning results with an N-Gain esteem of 0.434, which is categorized as moderate. In percentage terms, the experimental class demonstrated an improvement in learning outcomes of 71.43%, while the control class showed an enhancement in learning outcomes of 43.40%. The application of PBL supported by PhET Colorado in the experimental class exhibited a greater improvement in learning outcomes compared to the control class that did not implement such learning.

4. The Influence of the PBL Learning Model Assisted by PhET Colorado Media on Science Process Skills

a. Results of the Normality Test of Science Process Skills Scores

Table 6. Normality test on SPSS

Class	Shapiro-Wilk		
	Statistic	df	Sig.
Science Process Skills Experimental	.940	30	.092
Science Process Skills Control	.961	30	.325

The normality test results for science process skills data yielded a significance value in the experimental class of 0.092 and in the control class of 0.325. The significance value of science process skills in the experimental class (0.092 > 0.05) and the control class (0.325 > 0.05), it can beconcluded that the science process skills data from both classes follow a normal distribution.

b. Results of Homogeneity Test of Science Process Skills Scores

Table 7. Homogeneity test of data

Test of Homogeneity of Variances

Science Process Skills

Levene Statistic	df1	df2	Sig.
3.966	1	58	.051

The results of the homogeneity test of science process skills data, yielded a significance value of 0.051 in both classes. This value is greater than 0.05 (0.051 > 0.05), thus it can be concluded that the science process skills data from both classes are come from homogeneous samples.

c. Science Process Skills Score Hypothesis Test Results

Table 8. Hypothesis test of science process skills

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Science Process Skills	Equal variances assumed	3.966	.051	28.394	58	.000	40.267	1.418	37.428	43.105
	Equal variances not assumed			28.394	53.473	.000	40.267	1.418	37.423	43.111

The findings of the hypothesis testing of science process skills show that the significance value of both classes is 0.000, which is less than 0.05, indicating that the null hypothesis (Ho) is rejected, while the alternative hypothesis (Ha) is accepted. Based on the hypothesis analysis conducted using SPSS 21, these findings suggest that the implementation of the PBL instructional model with the support of PhET Colorado has a positively influences science process skills in a significant way in the material of force.

5. Discussion of the Influence of PBL Assisted by PhET Colorado Media on Cognitive Domain Learning Outcomes

Research shows that the implementation of PBL assisted by PhET Colorado simulation significantly improves student learning outcomes compared to conventional learning. Students in the experimental class showed better conceptual understanding, stronger memory, and superior analytical and evaluative skills.

PhET interactivity helps students experience concepts directly, increases learning interest, and allows exploration of various solutions to the problems given. Several studies support these findings, such as those conducted by Oktavia et al. (2023) and Rohmawati et al. (2023), which state that interactive simulations increase student reflection and creativity.

In addition, other studies confirm that the PBL model makes learning more contextual and meaningful, in contrast to conventional methods which are more structured and teacher-centered. Students who use PBL are more independent in understanding concepts, while control classes tend to be passive because learning still focuses on teacher lectures.

Hardiansyah et al. (2021) found that PBL can be a challenge that encourages students to deepen their understanding and discover new concepts independently. Sutrisna & Sasmita (2022) emphasized that the Problem Based Learning model proves to be designed to increase students' interest in the learning process by offering a more contextual and meaningful educational experience.

According to Afafa (2021), PhET simulations help connect science concepts with everyday events through interesting animations, thus supporting and facilitating learning. The application of PBL allows teachers to deliver material more concisely, while students are encouraged to explore concepts independently. In contrast to classes without PBL, where the delivery of material is more structured by the teacher, the use of PhET in PBL makes students more independent in understanding concepts, while in control classes, learning tends to be monotonous and passive because it is centered on teacher lectures.

6. Discussion of the Effect of PBL Assisted by PhET Colorado Media on Science Process Skills

The study showed that the implementation of PBL assisted by PhET Colorado significantly improved students' science process skills compared to conventional learning. The experimental class showed a higher percentage of SPS in various aspects in contrast to the control class.

Observing – The experimental class achieved 83.5% ("Very High" category), whereas the control class only achieved 46.5% ("Moderate" category). PhET simulations help students observe scientific phenomena in more depth (Lestari et al., 2022).

Questioning and Predicting – The experimental class achieved 73.5% ("High" category), while the control class only achieved 38.5% ("Low" category). PhET-assisted PBL encourages students to ask questions and make predictions based on their observations (Lestari et al., 2022).

Planning and Conducting Investigations – The experimental class achieved 77% ("High" category) compared to 40% ("Low" category) in the control class. PBL encourages students to conduct independent investigations, while PhET supports more interactive virtual experiments (Lestari et al., 2022).

Processing and Analyzing Data and Information – The experimental class achieved 76.5% ("High" category), while the control class only achieved 40% ("Low" category). PhET simulation helped students process and analyze data more effectively.

Evaluating and Reflecting – The experimental class achieved 75% ("High" category), while the control class only achieved 36.5% ("Low" category). PBL encourages continuous evaluation and reflection on the learning process (Lestari et al., 2022).

Communicating Results – The experimental class achieved 90% ("Very High" category), much higher than the control class which only achieved 35% ("Low" category). PhET-assisted PBL encourages students to communicate their findings effectively through oral and written presentations.

The implementation of PBL assisted by PhET Colorado has been shown to significantly improve students' science process skills. This finding is in line with research by Lestari et al. (2022) and Suryanti (2023), which shows that the combination of PBL and PhET models supports students' active involvement in inquiry-based learning, thereby improving their understanding and skills in science.

Conclusion

Students who received problem-based learning (PBL) supported by PhET Colorado showed a significant increase in learning outcomes in comparison to students who underwent conventional learning. The implementation of PBL supported by PhET Colorado had a substantial impact on the learning outcomes of seventh-grade students of public junior high school 37 Medan in the 2024/2025 academic year on the material "Force". The Problem Based Learning model enhanced with the support of PhET Colorado had a notable impact on students' science process skills. Learners in the experimental class had a greater average science process skill score than learners in the control class.

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