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EXPLORATION OF THE USE OF PHET SIMULATION ON NEWTON'S LAW MATERIALS TO IMPROVE STUDENT PHYSICS LEARNING OUTCOMES

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Abstract

The background to this research is that physics lessons are often considered difficult and less interesting by students, especially because of their abstract nature, the complexity of mathematical calculations, and the difficulty in connecting theory with practice. One of the challenging topics is Newton's Law of motion, which includes the connection between force, mass and acceleration. This study was conducted at MA Muallimin UNIVA Medan, utilizing the Problem Based Learning (PBL) learning model, an innovative approach learning media that is relevant to development. technology. This research utilizes PHET (Physics Education Technology), an interactive simulation platform developed by the University of Colorado Boulder, to support learning Newton's Laws. PHET allows students to carry out virtual experiments independently with various variables, such as mass, force and surface type, so that student learning outcomes increase. The research method used is quantitative in class X-G. The instrument used is a written test (essay) with a total of 10 questions. It is established that the pretest and posttest data follow a normal distribution with a significance value of Pretest (0), Posttest (0,), and are declared homogeneous with a significance value Based on Mean (0.245) where the normality and homogeneity test values exceed (>) the real level used in the measurement namely α = 0.05 or 5%. With the help of SPSS, it is known that the average posttest student learning outcomes (85.93) are higher than the pretest (58.80).Therefore it can be concluded that the hypothesis is accepted.

Keywords: *PHET; PBL; Newton Law*

Abstrak

Penelitian ini dilatarbelakangi Pelajaran fisika sering dianggap sulit dan kurang menarik oleh siswa, terutama karena sifatnya yang abstrak, kompleksitas perhitungan matematis, dan kesulitan dalam menghubungkan teori dengan praktik. Salah satu topik yang menantang adalah Hukum Newton tentang gerak, yang mencakup hubungan antara gaya, massa, dan percepatan.. Penelitian ini dilaksanakan di MA Muallimin UNIVA Medan, dengan menerapkan model pembelajaran Problem Based Learning (PBL) media pembelajaran yang inovatif dan relevan dengan perkembangan teknologi. Penelitian ini memanfaatkan PHET (Physics Education Technology), sebuah platform simulasi interaktif yang dikembangkan oleh University of Colorado Boulder, untuk mendukung pembelajaran Hukum Newton. PHET memungkinkan siswa melakukan eksperimen virtual secara mandiri dengan berbagai variabel, seperti massa, gaya, dan jenis permukaan, sehingga hasil belajar siswa meningkat. Penelitian ini menggunakan metode kuantitatif pada kelas X-G. Instrumen yang digunakan adalah tes tertulis (esai) dengan jumlah soal sebanyak 10 soal. Diketahui data pretest dan posttest berdistribusi normal dengan nilai signifikansi Pretest (0,), Posttest (0,), dan dinyatakan homogen dengan nilai signifikansi Based on Mean (0,245) dimana nilai uji normalitas dan homogenitas melebihi (>) taraf nyata yang digunakan dalam pengukuran yaitu α = 0,05 atau 5%. Dengan bantuan SPSS diketahui rata-rata hasil belajar siswa posttest (85.93) lebih tinggi dibandingkan pretest (58.80)

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INTRODUCTION

Physics lessons are often lessons that students don't like (Meiliyadi et al., 2023). Students find physics lessons boring, complicated in understanding physics concepts involving mathematical calculations and understanding abstract natural phenomena, and have difficulty connecting theory with practice (Saharsa et al., 2018). Another factor that also influences is the lack of students' skills in carrying out experimental experiments. However, in the era of modern technology, knowledge of physics is the key to the development of various technological innovations (Husain & Kaharu, 2020). Physics teaches the basic concepts that underlie many technological devices, from computers, telecommunications, to renewable energy technology (Anggeraeni et al., 2022). Apart from that, understanding physics is also important for developing critical thinking skills, problem solving, and analytical abilities.

One topic that students often find difficult is Newton's Laws of motion . Newton's laws, which include the three basic laws of motion, are the basis of many advanced physics concepts (Amri et al., 2024). These three laws explain the relationship between the forces acting on an object and the movement of that object, which is a fundamental concept in mechanics (Silaban et al., 2024). Some of the main difficulties that students often face are the abstraction of the concepts of force, acceleration, mass, and the mathematical relationships used in these laws (Widyastuti et al., 2024).

Results of observations and interviews conducted at MA. Muallimin UNIVA students often find it difficult to understand and study physics due to limitations in the use of less relevant media and difficulty interpreting the material directly. To face the problems above without ignoring the technology needed according to current developments, learning media is needed as a tool to help the learning process in the classroom (Anggeraeni et al., 2022). It is hoped that this media will be able to help students understand physics concepts, solve problems mathematically, and there will be elements of direct experimentation related to the concepts being studied, even though experiments are carried out virtually or through applications and the like (Rahma, 2022). And the media used is supported by the PBL learning model (Saharsa et al., 2018), so that students are able to easily understand learning concepts and objectives and student learning outcomes will increase (Fatma & Budhi, 2018)(Widyastuti et al., 2024).

The media used in this research is PhET. PhET (Physics Education Technology) is a platform that provides various interactive simulations for physics subjects (Dy et al., 2024). This simulation was developed by the University of Colorado Boulder and has been used widely at various schools and universities. PHET simulations on Newton's Law material can provide a deeper and more enjoyable learning experience, which is difficult to achieve through conventional learning (Verdian et al., 2021). By utilizing PHET, students can conduct experiments with various variables such as the mass of the object, the force applied, and the type of surface used to minimize friction (Batuyong & Antonio, 2018). This allows students to more easily understand how Newton's laws are applied in real situations. For example, students can observe how changes in force or mass affect the acceleration of an object, which directly reflects Newton's second law (F = ma). for example, students are able to complete the PhET simulation on Newton's law material about forces and motion basics. In this simulation, students can carry out simple experiments to explore the relationship between force, mass, acceleration, and action-reaction.

In addition, the PHET application allows students to carry out experiments independently and repeat experiments as needed, without being constrained by the limitations of physics equipment in the laboratory (Mallari, 2020). The use of this simulation can help students overcome difficulties in understanding abstract

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physical theories (Najib et al., 2022), as well as give them a better understanding of the application of Newton's laws in everyday life. Thus, the use of the PHET application in Newton's Law material is an effective alternative in increasing students' understanding of difficult physics concepts, as well as giving them the opportunity to learn in a more interactive and visual way (Saputri, 2021). This approach can be the right solution to overcome students' learning difficulties and provide a more enjoyable and meaningful learning experien (Amri et al., 2024).

RESEARCH METHODS

The method used in this research is a quantitative method, where this method is a type of research that is very strong in measuring cause and effect (Dr. Juriko Abdussamad et al., 2024). The research design employed in this study is the Pretest-Posttest Control Group Design. This research is intended to determine the effect of using Phet simulations on Newton's law material to improve student learning outcomes. The design of this research is as follows:

Tabel 1. Research Design

Group	Pretest	Treatment	Posttest
Eksperimen Class	O1	X1	O2

Information :

O1 = Pretest Expeimental Group

X1 = Treatment using Problem Based Learning by Phet Simulation

O2 = Posttest Experimental Group

The subjects in this research were students of class X-G MA. Muallimin UNIVA Medan. The object of this research is the PBL (Problem Based Learning) Learning Model assisted by Phet Simulation on Newton Law to improve student learning outcomes. When the research was carried out in the odd semester of the 2024/2025 academic year, it was carried out at MA. Muallimin UNIVA Medan whose address is at Jl. Sisingamagaraja, km 5.5 Medan Amplas District, North Sumatra.

The instruments used in this research were tests and documentation. The test technique is this study was conducted by administering a test instrument consisting of a set of questions designed to measure student learning outcomes. Researchers used tests in the form of descriptions. Written tests in the form of descriptions or essays require students to recall, comprehend, organize, apply, analyze, synthesize, evaluate, and engage with the material in various ways. Documentation is carried out to obtain data sourced from available records or documents. Such as the presence of students in taking part in class learning which can be seen in the student attendance list, as well as the MA profile. Muallimin UNIVA Medan.

The research procedure carried out went through three stages, namely the planning stage, implementation stage and completion stage. The data analysis technique used in this research is the t-test and f-test with the help of IBM SPSS Statistics 20.0.

In this research, the media used to help students understand the learning material is the use of the following physical simulation:

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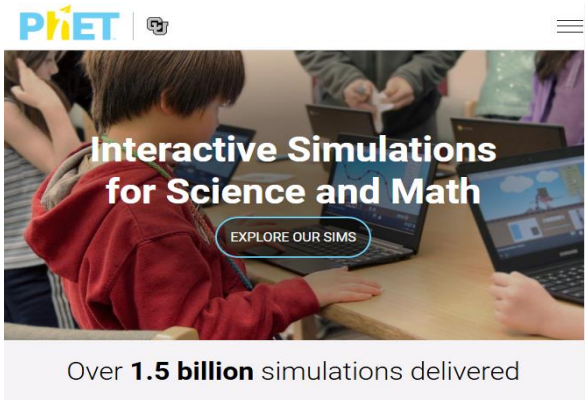

Figure 1. PHET View

Figure 2. Simulated Lessons

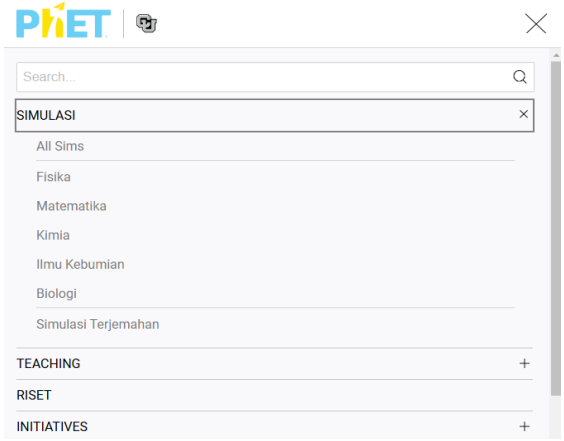

Figure 3. Menu Display

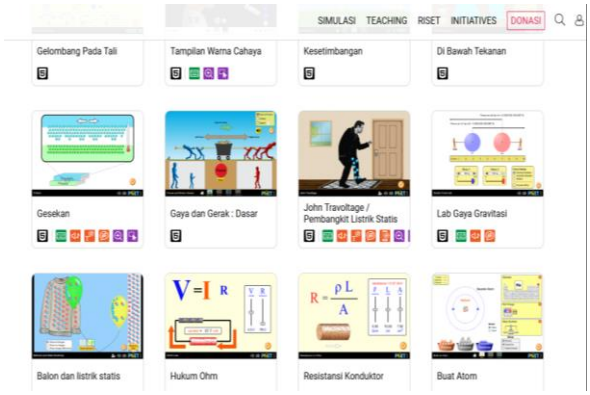

Figure 4. Simulation series on PHET media

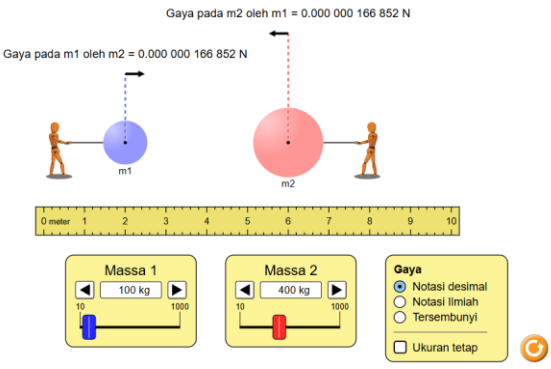

Figure 5. Gravity LAB

Figure 5. Force and Motion LAB

The images above are several examples of the use of PHET simulations in physics subjects, where the virtual lab can be used anywhere and at any time using a device, making it easier for students to repeat the lessons the teacher has delivered in class. In this research, the PHET simulation is used as a medium for understanding Newton's law material.

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RESULTS AND DISCUSSION

This research uses Phet simulation media with the help of the PBL learning model in Newton's law material so that it is hoped that it will be able to improve student learning outcomes, make it easier for students to practice learning material virtually but related to real life and this media can be reached anywhere so that students can repeat learning material in class or in class. outside the classroom, with easy access to the media.

This research was also carried out to strengthen previous research. Previous research only discussed how to develop computer-based learning media based on Newton's laws but did not specify what media were used and were able to make students understand the material according to direct examples in the media (Amri et al., 2024). In other research, the PhET simulation media was used in conjunction with the discovery learning model (Widyastuti et al., 2024). In other research, PhET simulations were used which were accompanied by a PBL learning model but not Newton's law material (Satipa et al., 2024). Different from previous research, this research uses PhET simulation media with the learning model used is Problem Based Learning on Newton's Law material, where the media used really supports students to further develop the use of technology with a more contextual, collaborative and interdisciplinary PBL approach, so that it is more effective in developing critical thinking skills, problem solving, and team work on Newton's law material which is basic material and students have a good understanding of this material so that it will have a very good impact in the future on students' development in understanding physics.

Results of prerequisite testing for research data analysis conducted at MA. Muallimin UNIVA Medan, Medan City, North Sumatra where class Before being given treatment, students are first given a pretest with a total of 10 essay questions, then after being given treatment they are tested with posttest essay questions. To determine the suitability of the questions and media used as research instruments, the validity of the questions and media was tested by a validator. The following is data obtained from research that has been carried out.

Table 2. Descriptive Statistics

	Class			Statistic	Std. Error
Test Scores	Pretest	Mean		58.80	1.374
		95% Confidence Interval for Mean	Lower Bound	55.85	
			Upper Bound	61.75	
		5% Trimmed Mean		59.00	
		Median		60.00	
		Variance		28.314	
		Std. Deviation		5.321	
		Minimum		48	
		Maximum		66	
		Range		18	
		Interquartile Range		5	

JURNAL EDUSCIENCE (JES)
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		Skewness		-.905	.580
		Kurtosis		.073	1.121
	Posttest	Mean		85.93	2.224
		95% Confidence Interval for Mean	Lower Bound	81.16	
			Upper Bound	90.70	
		5% Trimmed Mean		86.37	
		Median		87.00	
		Variance		74.210	
		Std. Deviation		8.614	
		Minimum		68	
		Maximum		96	
		Range		28	
		Interquartile Range		15	
		Skewness		-.673	.580
		Kurtosis		-.352	1.121

Test Normality

Test normality done for know whether the data is normally distributed or not. For test normality researcher using IBM SPSS 20.0 with level significance 0.05 or 5%. Test This used for insufficient sample of 50 in order to produce accurate decisions (Oktaviani & Notobroto, 2019). As for results test normality on class experiment nor control can seen on Table 3.

Table 3. Test Normality Student Learning Outcomes

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Nilai Ujian	Pretest	.189	15	.154	.899	15	.092
	Posttest	.149	15	.200*	.933	15	.306

Based on Table 3, values on significance on Pretest (.154) and Posttest (.200). In study This level actually used for measure its normality is α = 0.05 or 5%. If results obtained exceeds α = 0.05 or 5% then the data stated good normal distribution on class experiment nor class control .

Test Homogeneity

Test homogeneity This done for know variant between second group after given different treatment or done in frame test similarity variance every data group . Base taking decision in test homogeneity If mark significance (sig) on Based on Mean > 0.05 means the data is homogeneous, however If mark significance (sig) on Based on Mean < 0.05 then the research data No homogeneous.

Table 4. Test Homogeneity Student Learning Outcomes

		Levene Statistic	df1	df2	Sig.
Test	Based on Mean	4.168	1	28	.051
	Based on Median	3.457	1	28	.074

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Scores	Based on Median and with adjusted df	3.457	1	26.116	.074
	Based on trimmed mean	3.860	1	28	.059

Based on Table 4, values on significance on Based on Mean (.051). In test homogeneity This level actually used for measure its homogeneity is α = 5 % or 0.05. Based on results using IBM SPSS 20.0 results exceed of α = 5 % or 0.05 so that can concluded the variant data second population stated homogeneous.

Test Hypothesis

Test hypothesis can done after obtained results test precondition data analysis viz test normality and test homogeneity that shows the data normally distributed and homogeneous. Test hypothesis done to know exists difference pretest and posttest results from research data. One of technique analysis statistics for testing the average is statistical t- test in matter. This on class experiment and control use independent sample t test served on Table 5.

Table 5. Test Paired Sample T Test Student Learning Outcomes

Class	N	Mean	Std. Deviation	Std. Error Mean
Pretest	15	58.80	5.321	1.374
Posttest	15	85.93	8.614	2.224

Based on Table 5 can seen that the average results Study students who are on posttest (85.93) more tall from on pretest (58.80) so can concluded that hypothesis accepted and posttest stated more good than the pretest.

CONCLUSION

Based on the research results obtained from data analysis, normality tests, homogeneity tests, and data processing hypothesis tests, the following conclusions can be drawn: The application of Phet Simulation learning media with the Problem Based Learning learning model on Newton's Law material has an influence. on student learning outcomes providing a rapid influence in stimulating students' ability to understand learning material so that student learning outcomes increase; After being given treatment after the pretest, the comparison of learning outcomes looked different, namely at the posttest (85.93) higher than at the pretest (58.80); The impact of this research will make it easier for students and teachers in the teaching and learning process where teachers can provide direct practice related to the material being taught and students are able to understand easily through PhET simulations which can be used anywhere and anytime;

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