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The Effect of the PhET Assisted Problem Based Learning Model on Student Learning Outcomes in Wave Material

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Abstract: This study aims to examine whether or not there is an influence of the PhET-assisted problem-based learning model on student learning outcomes in Wave material. The type of research used is a quasi-experimental research design with Nonquivalent Control Group Design. The population in this study were all students in class XI MAN 1 Mataram with the sample being students in class XI MIPA 3 with a total of 31 students as the control class and students in class XI MIPA 4 with a total of 29 students as the experimental class. The test instrument used is in the form of multiple choice questions. Before the test instrument is given, the instrument is tested first, namely testing validity, reliability, difficulty level, and discriminating power. The results of the analysis showed that the average score of the physics learning outcomes of students who were taught with the PhET-assisted problem-based learning model was 79.65 and students who were taught without using PhET had an average value of 69.77. The results of testing the hypothesis using the t-test obtained a t-count of 6.45 and a t-table of 2.0017. Thus the value of t-count is greater than t-table then Ha is accepted and H0 is rejected. This means that there is an influence of the PhET-assisted problem-based learning model on student learning outcomes in class XI MAN 1 Mataram class wave material.

Keywords: Learning outcomes; PhET; Problem based learning

Introduction

Education in the 21st century is required to prepare students to have learning and innovation skills, skills to use, utilize information technology and media (Dewantara, 2021). This is because quality education is education that can equip students with the demands of the skills needed today.

The skills students need for the 21st century are very important. Traditional or conventional learning approaches emphasize students' ability to remember or simply practice various types of subject matter (facts, concepts, principles, and procedures). Such an approach is not able to train students to improve their critical and creative thinking skills as well as their ability to learn independently. Because students are only asked to memorize and practice in a simple way and are not yet at the level of understanding and applying it to learning and real-life contexts. To develop high-level skills, individuals must carry out a meaningful learning process through inquiry learning (learning through direct observation) which has value and relevance for personal and societal life (Mashudi, 2021).

The technology used is part of the supporting effort in the learning process, but in fact the use of technology in learning is used to introduce that the 21st century learning experience is more than just the use of technology in learning (Prianto et al., 2019).

Various kinds of technological advances have begun to be applied and are growing rapidly in the world of education, as well as to support efficient learning and the use of technology in learning activities. In the learning aspect, this technological progress makes it easier for students to access the latest learning information (Mardhiyah et al., 2021). The development of 21st century skills requires appropriate learning, it requires teachers who are able to design effective learning strategies. Because at this time educators do not only transfer knowledge, but can condition students to have learning experiences that suit the needs of students.

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Life in the 21st century demands student mastery of various skills so that in the future they will become successful generations. To grow skills in the 21st century, an appropriate learning model is needed. One learning model that can be applied is the Problem Based Learning model (Kartini et al., 2022).

The Problem Based Learning Model is an educational technique that uses real world problems, scenarios and cases to improve students' problem solving and critical thinking skills (Anderson et al., 2020). The Problem Based Learning model is a learning concept that helps educators build a learning environment that begins with important and relevant issues for students, and students get a more real learning experience. In PBL students are put into active learning situations by giving them clinical problems and coaching them to identify what they need to learn to solve those problems. Usually PBL tutorials involve groups of 5 to 8 students discussing and analyzing problems (Kibret et al., 2022).

Problem-based learning is a learner-centered learning model that contextualizes learning in authentic problem-solving situations and has been extensively applied as an experimental teaching method (Yin et al., 2021). According to Kartini et al. (2022) this Problem Based Learning Model can stimulate the character of cooperation in students at school. Elements of cooperation that can be formed include interaction with each other, positive interdependence, and respect for each other. With this problem-based learning model, collaboration skills can be fostered, which is one of the skills in the 21st century.

In addition to using the right learning model, the use of learning media can also affect the success of learning. More specifically, the notion of media in the teaching and learning process tends to be interpreted as graphic, photographic or electronic tools for capturing, processing and rearranging visual and verbal information (Anwarinngsih et al., 2022). Learning media are intermediaries or liaisons from information providers, namely educators to recipients of information or students who aim to encourage students to be motivated and able to participate in the learning process in a complete and meaningful way (Hasan et al., 2021).

One of the learning media that can be used to assist teachers in explaining abstract physics concepts and can attract students' interest in participating in the learning process is PhET (Physics Education Technology) media. The team from the University of Colorado in the United States developed this virtual laboratory. Additionally, this simulated PhET can download and install entire websites for offline use. This PhET Simulation runs best on a PC (Personal Computer). PhET simulation media can be obtained free of charge either by educators or students through the site http://phet.colorado.edu/en/get-phet/full-instal (Rizaldi et al., 2020). PhET simulation is a very effective learning medium for improving the quality of students' mastery of concepts ((Yunita et al., 2020).

The advantages of using this PhET simulation are effective learning media and can improve students' ICT literacy. Due to the ease of use of PhET, this simulation medium can be used independently. Apart from that, there are other advantages to using PhET, namely being able to provide an overview of abstract phenomena in physics that are difficult to observe directly with the human senses, which is possible and easier with PhET simulations (Verdian et al., 2021). According to Susilawati et al. (2022) this PhET simulation can make it easier for students to understand the physics concepts being studied by displaying visual and conceptual model animations. In addition, in PhET there are theoretical and experimental simulations that involve users actively. Users can manipulate activities related to experiments, so that PhET media can be used for physics learning (Ginting et al., 2020).

Based on the results of research by Rizaldi et al. (2020) it shows that the use of PhET simulation media is effective to use and helps educators and students learn physics concepts with an attractive appearance.

Learning outcomes are abilities that are obtained after students gain experience when participating in a lesson. Learning outcomes are students' abilities in the cognitive, psychomotor, and affective domains, as well as the norms taught, therefore learning outcomes are achievements after students go through the learning process (Nurhaedah. et al., 2022). According to Hidayati et al. (2021) that apart from the interaction between students and their environment, learning activities can also be considered to take place because of the communication interactions that are carried out between educators and students. So that from the aspects obtained by these students, their achievement can be measured based on the subject matter in school and can be called learning outcomes.

Based on initial observations made at MAN 1 Mataram class XI MIPA 3. The results of the answers to the questions given to all students obtained information that most "students think that physics is a difficult and boring subject, and they think that Physics lessons are always filled with complicated formulas. The negative assumptions of these students are due to the learning that is given is still passive and monotonous. Learning patterns like that result in students tending to get bored quickly in learning, so to overcome this it is necessary to make changes in terms of learning physics.

Based on these problems, the researchers argue that a learning model is needed that can help students to be actively involved in the process of learning activities. One of them is problem based learning to optimize

learning, researchers are interested in using PhET media as an experimental medium. Therefore, researchers are interested in conducting research with the title "The Effect of the PhET-Assisted Problem Based Learning Model on Student Learning Outcomes".

Method

This type of research uses a quasi-experimental research type that has a control group, but cannot fully function to regulate external variables that have an impact on the implementation of experiments (Sugiyono, 2019). In this study, 3 types of experiments were used, namely PhET on traveling waves, bound end stationary waves and free end stationary waves. This research was conducted by connecting a laptop to an internet network to open the PhET virtual laboratory program. Then choose "Wafe On a String" in the Physics simulation. For the first experiment using a traveling wave, the second experiment is a bound end stationary wave and the last experiment is a free end stationary wave. Then set the amplitude and frequency to 1.00 cm and 1.50 Hz and the voltage in medium mode and the attenuation is zero. For traveling waves, after the simulation is run, a wave will be formed, and the wavelength can be obtained with a frequency that can be changed, namely from 1.00 Hz, 2.00 Hz, 3.00 Hz. Meanwhile, for stationary waves the bound and free ends can determine the distance of the knot and belly with the rope tension from low, medium to high.

The research design in this study is the Nonquivalent Control Group Design. The population in this study were all students of class XI MAN 1 Mataram with a total of 4 MIPA classes. The sampling used is purposive sampling. This technique is a sample determination with certain considerations (Hermawan, 2019), so that two research classes are obtained, namely class XI MIPA 4 as an experimental class totaling 29 students and class XI MIPA 3 as a control class totaling 31 learners. Class XI MIPA 4 was given a treatment using a problem based learning model assisted by PhET while class XI MIPA 3 used a conventional model without PhET assistance. The independent variable in this study is the PhET-assisted problem-based learning model, while the dependent variable is student learning outcomes (Sugiyono, 2019).

Before being given treatment for both classes, students are given a pretest first which aims to determine the initial abilities of students. Then given a posttest to find out the increase in student learning outcomes after being given treatment. The test given is a cognitive test in the form of multiple choices. The research instrument was tested for validity which aims to find out whether the data obtained is valid or invalid (Umar et al., 2020), reliability aims to determine the extent of the confidence level of an instrument (Puspasari et al., 2022), difficulty level aims to find out the views of ability or ability of students to answer questions (Fatimah et al., 2019), and discriminating power aims to be able to distinguish between proficient students and students who are not proficient (Amanda et al., 2019).

The data analysis technique used to determine the effect of the PhET-assisted problem-based learning model on student learning outcomes uses the t-test polled hypothesis test with a significance level of 0.05. Before the hypothesis test is carried out, first carry out a prerequisite analysis test, namely the homogeneity test and the normality test using the Chi Square test (x^2).

Result and Discussion

The quality of the measuring instruments used for research data collection greatly influences the reliability of the data obtained. Thus, the reliability of research results is largely determined by the quality of the instruments used to collect data (Sukendra et al., 2020). Based on the instrument trials that have been carried out and analyzed with validity tests, reliability tests, difficulty level tests, and differential power tests, the results can be seen in Table 1 and Table 2.

Table 1. Results of the Validity Test and Reliability Test

Number of Students	Valid	Invalid	r_{11}	r_{table}
31	18	2	15.24	0.355
Category				Reliable

Based on Table 1, the results of the instrument try-out show that out of the 20 questions tested, 18 questions were valid and 2 questions were invalid. While the reliability test results obtained were r11 of 15.24 while the rtable was 0.355. Based on the calculation results, it can be seen that $r_{11} > r_{table}$ so that the 20 questions are said to be reliable.

Table 2. Results of Difficulty Level Test and Different Power Test

Difficulty Level Test			
Number of question	Easy	Medium	Difficult
20	4	14	4
Different Power Test			
Enough Question		Bad Question	Very bad Question
-		8	12

Based on the results of the calculation of the test difficulty level of the 20 items, 2 questions were found in the easy category, 14 questions in the medium category,

and 4 questions in the difficult category. The different power test results obtained 8 questions in the bad category and 12 questions in the very bad category.

PhET (Physic Education Technology) is one of the simulation media released by the University of Colorado which contains simulations of learning science, namely physics, chemistry, and biology. PhET simulation focuses on the relationship between real-life phenomena and science in favor of an interactive and constructivist approach, providing a creative workplace (Saputra et al., 2020). Phet has theoretical and experimental simulations that actively engage users. PhET simulations can display animations in abstract physics such as atoms, electrons, photons, and magnetic fields that cannot be seen with the naked eye. Apart from being able to build concepts, PhET can also be used to bring up science process skills (Susilawati et al., 2022).

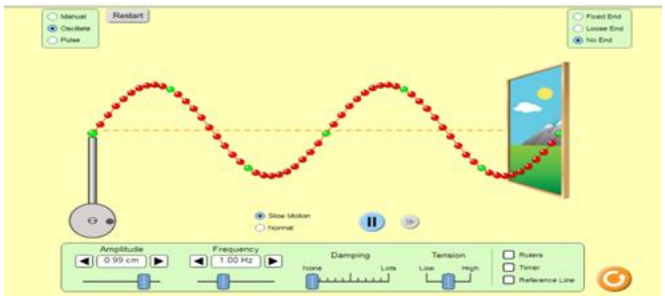

Figure 1. Running waves

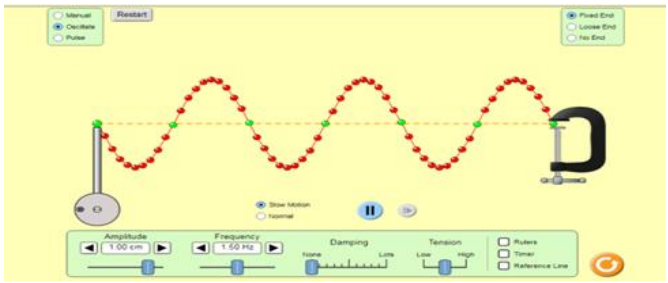

Figure 2. Tied end stationary waves

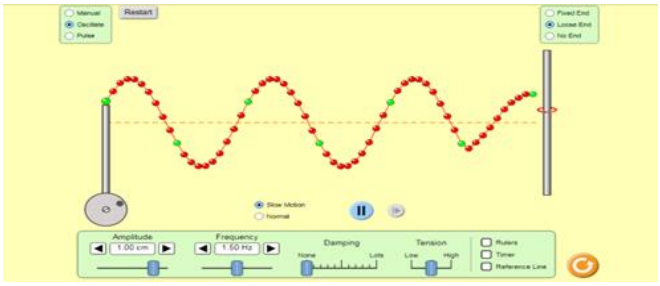

Figure 3. Free end stationary waves

In this study using a PhET wafe on a string which includes traveling waves, bound end stationary waves and free end stationary waves, where initially the wave is still in a normal state it will move up and down when given isolation so that the wavelength can be measured. The description of the waves when given oscillations can be seen in Figure 1, Figure 2, and Figure 3.

Research data analysis in the cognitive domain consists of pretest and posttest scores. The pretest results of students in the experimental class with an average value of 60.03, in the control class obtained an average value of 53.74. Meanwhile, the average posttest score for experimental class students was 79.65. In the control class, an average value of 69.77 was obtained. This is supported by the research of Ramadhan et al. (2019) they argue that learning with PhET media and simple demonstrations will be more effective than conventional learning with blackboard media. In addition to the use of PhET media, another factor that causes an increase in grades in the experimental class is the application of the problem based learning model. This is in accordance with the results of research by Helyandari et al. (2020) stating that the experimental class applied to the problem based learning model has the advantage of being able to get used to dealing with and solving problems skillfully and can stimulate and develop creative thinking skills. Comparison of the average pretest and posttest scores for the experimental class and the control class can be seen in Figure 4.

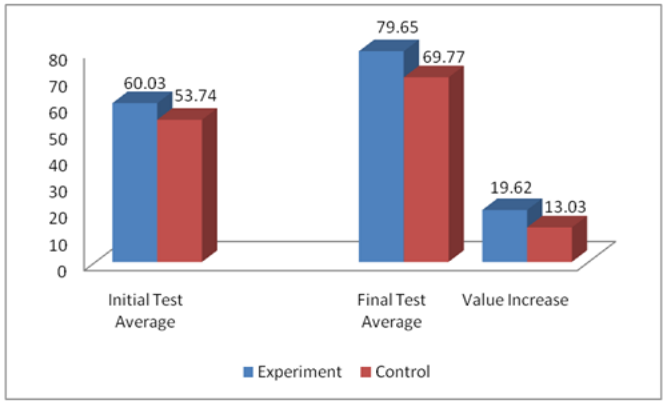

Figure 4. Comparison of the average increase in learning outcomes

The prerequisite test will be carried out first before the hypothesis test is carried out, while the results of the prerequisite test carried out include a homogeneity test which aims to determine the variance of the initial abilities of students in the experimental class and control class before being given treatment and the normality test aims to find out whether the final test data is the second learning result normally distributed class or not normally distributed.

In Table 3 it is found that the F_{count} value is smaller than the F_{table}, namely 1.406344 ≤ 1.8687 at the 5% significance level. Meanwhile, for the normality test, it was found that $X^2_{count} < X^2_{table}$. From this information it can be concluded that both samples are homogeneous and normally distributed.

Table 3. Results of the Pretest Homogeneity and Normality Test

Component	Result of Pretest	
	Experiment class	Control class
Total students	29	31
Average	60.03	53.74
Standard Deviation	9.86	8.32
Varians	97.39	69.25
F_{count}	1.406	
F_{table}	1.868	
X^2_{count}	8.74	8.15
X^2_{table}	11.07	
Category	Homogeny Normal	

Table 4. Results of the Posttest Homogeneity and Normality Tests

Component	Result of Posttest	
	Experiment class	Control class
Total students	29	31
Average	79.65	69.77
Standard Deviation	5.98	5.97
Varians	35.73	35.64
F_{count}	1.0024	
F_{table}	1.868	
X^2_{count}	8.88	9.62
X^2_{table}	11.07	
Category	Homogeny Normal	

In Table 4 it is found that the F_{count} value is smaller than the F_{table}, namely $1.0024 \leq 1.8687$ at a significance level of 5%. Meanwhile, for the normality test, it was found that $X^2_{count} < X^2_{table}$. From this information it can be concluded that both samples are homogeneous and normally distributed.

Based on the calculation results, it is known that the data of both classes are normally distributed and homogeneous, so that the hypothesis test used based on the prerequisites is parametric statistics, namely t-test polled variance. The results of hypothesis testing can be seen in Table 5.

Table 5. Hypothesis Test Results

Component	Experiment class	Control class
Total students	29	31
Average	79.65	69.77
Varians	35.73	35.64
T_{count}		6.45
t_{table}		2.0017

Based on Table 5 above, it can be seen that the value of $t_{count} > t_{table}$ is $6.45 > 2.0017$. This is in accordance with the criteria for testing the hypothesis, namely $t_{count} > t_{table}$, then H0 is rejected and Ha is accepted. Thus, from the results of the study it can be concluded that the PhET Assisted Problem Based Learning model has an effect on student learning outcomes in the wave material of class XI MAN 1 Mataram students in the 2022/2023 academic year. In line with that, based on the results of research by Umayrah et al. (2023) that there is a positive and significant influence from the application of the problem based learning model on student learning outcomes.

Conclusion

Based on the data and results of the research analysis that has been conducted on the effect of the PhET-assisted problem-based learning model on student learning outcomes in wave material, it can be concluded that the PhET-assisted problem-based learning model has an effect on student learning outcomes in wave material.

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All authors listed in this article contributed to the research and development of the article. Conceptualization: Esa Imaniah, data curation: Susilawati, funding acquisition: Esa Imaniah, methodology: Esa Imaniah, visualization: Susilawati, original drafts: Esa Imaniah, Susilawati, writing-review & editing: Esa Imaniah, Susilawati.

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Conflicts of Interest
For the publication of this article, we certify that there is no conflict of interest.

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