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The Effectiveness of Using PhET Simulation Media to Improve Science Literacy Among High School Students on Pulau Banyak

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Abstract. *This study aims to measure students' science literacy abilities as well as assess their responses to learning using PhET simulation media. The research method used was quantitative descriptive with data collection through science literacy tests and student response questionnaires. The research sample consisted of 24 students in grade XI of SMA Negeri 1 Pulau Banyak, who were selected as a whole in one class. The science literacy competencies analyzed refer to the 2017 PISA framework which includes three main aspects: (1) explaining phenomena scientifically, (2) designing and evaluating scientific investigations, and (3) interpreting data and evidence scientifically. This is shown from the overall comparison of 25 pretest questions, with the average score of the student's correct answer percentage is 8.13, while the average score on the posttest is 18.92, This increase can also be seen from the average value of the gain normalized N-Gain which shows a percentage increase of 0.72 and is at the high improvement criterion. Meanwhile, according to the three aspects of scientific competence, there was also an increase. In addition, the questionnaire results showed that students' responses to the use of PhET simulation media were very positive. The average overall percentage of student responses reached 84.32%, in the good category.*

Keywords: *: Learning Media, PhET, Science Literacy*

1. Introduction

At the beginning of the 21st century, there was rapid technological development that could affect various aspects of life, including education (Muhammad Arsyad et al., 2024). In this era of civilization, the field of education can equip students with abilities. Science learning aims to develop scientific attitudes such as curiosity, active participation, honesty, fairness, perseverance, and the ability to make decisions (Kemendikbudristek, 2022). The way to solve this problem is by creating a classroom learning environment that helps students learn to solve problems thru critical thinking (Nainggolan et al., 2021).

Indonesia falls into the category of developing countries with low educational quality, ranking 65th out of 130 countries according to the Global Human Capital Report data. In reality, scientific literacy in Indonesia is still far from the expected standard. Results of the 2022 Program for International Student Assessment (PISA) study by (OECD, 2023). This shows that Indonesia has an average science literacy score of 383 points, compared to the average of other OECD countries at 485 points, and this value is still below the international average. According to research conducted by PISA in 2022, Indonesian students have low science literacy levels, especially in remote areas like Pulau Banyak, which has limited access to quality learning resources (Pratiwi et al., 2024). Science literacy should be a particular focus in the Indonesian education system.

Science learning is not just about theory; it must begin to be meaningful in everyday life so that students not only acquire standard concepts without knowing that there is knowledge and concepts familiar to their environment and daily lives that can foster students' conservative

values (Fauziah et al., 2019). Curriculum improvement from the 2013 curriculum to the independent curriculum is a wise step in addressing this. The independent learning curriculum is specifically designed to provide the right to learn independently (Inayati, 2022). Currently, the government is implementing a new curriculum with a new policy focusing on numeracy and science literacy. This learning focuses on everyday problem-solving activities related to science and mathematics (Nyamik & Wahyuningtyas, 2022).

Learrning media is very necessary for teachers to help deliver learning material. Students tend to be more interested and understand more easily when the learning process uses an animation, and they will find it easier to remember and maximize their learning outcomes. Science education is expected to shape individuals who have a deep understanding of natural phenomena and the ability to utilize them in daily life. One important aspect of science learning is science literacy, which is an individual's ability to understand, interpret, and use scientific information in various contexts (Vavilaya et al., 2024).

Digital media like PhET simulations (Physics Education Technology) serve as a cognitive bridge, connecting theoretical content with concrete and engaging learning experiences. Learning becomes more effective when information is presented visually and verbally, as this reduces cognitive load and helps form stronger mental representations (Augustine et al., 2025).

In this study, to measure the improvement in science literacy that will be conducted in the Banyak Islands region, which is an archipelago with limited educational infrastructure, including access to adequate science laboratories. One solution to overcome this obstacle is to utilize technology-based learning media, such as interactive PhET (Physics Education Technology) simulations.

2. Method

This research uses a quantitative approach with a Pre-Experimental design, specifically employing a one-group pretest-posttest. In this design, the first observation was made before treatment was given to one class that served as the sample: X (Fatimah et al., 2024). The research design is illustrated as follows:

Figure 1. one group prettest-posttest Design

Description:
O_1 = Pretest Before Treatment
X = Treatment (given the treatment)
O_2 = Final Test (Posttest) after Treatment

This research was conducted at SMAN 1 Pulau Banyak. Using total sampling or saturated sampling techniques. The sample consists of 24 students in one class. The test format used in this study was to provide questions based on science literacy indicators (e.g., understanding concepts, analyzing data, and applying science concepts). The type of questions chosen for this study was in the form of valid and reliable multiple-choice questions (validated thru expert review).

The instruments in this study consisted of pretest and posttest question sheets for science literacy skills, and a student response questionnaire that had been validated by three expert lecturers from the Physics Education Study Program at Universitas Serambi Mekkah. The learning instrument was then tested using a validation test, which yielded an average of valid and reliable criteria before the research was conducted.

The N-Gain analysis technique is used to examine the improvement in students' scientific literacy by comparing the increase in pretest and posttest scores (Nuzula & Sudibyo, 2022). The average N-gain score obtained is then interpreted based on Table 1 below:

Table 1. Interpreting the average N-Gain score

Value <g>	Criteria
<g> ≥ 0,7	High
0,3 ≤ <g> < 0,7	Currently
<g> < 0,3	Low

Analysis of student assessment questionnaire data to determine student responses to the use of PhET simulations in Physics Learning using a Likert scale. Percentage values (%) are adjusted to Table 2 below to determine the suitability of the device based on the following score achievement criteria:

Table 2. Criteria for Student Questionnaire Achievement

Percentage	Category
85 – 100%	Very good
70 – 85%	Good
50 – 70%	Less
<50%	Very Less

3. Result and Discussions

Result

This research was conducted at SMAN 1 Pulau Banyak, with students from class XI MIA. The sample consisted of 24 students in one class. In the description of this study, the Pretest was conducted before the treatment to determine the students' initial level of science literacy. The Posttest was conducted after the treatment to measure the improvement in students' science literacy. The findings regarding the analysis of N-Gain in science literacy competency are presented further in Table 3.

Table 3. N-Gain pretest and posttest of students' science literacy skills

N	*Pretes*	*Posttest*	*N-Gain*	Criteria for improvement
24	8.13	18.92	0.72	High

Table 3 shows that there was an improvement in science literacy skills before and after learning. The improvement in students' science literacy skills was determined by N-Gain

analysis using Excel. The average N-Gain score for science literacy skills was 0.72, which falls into the high category. The results of the N-Gain analysis related to each science literacy variable are presented in Figure 2.

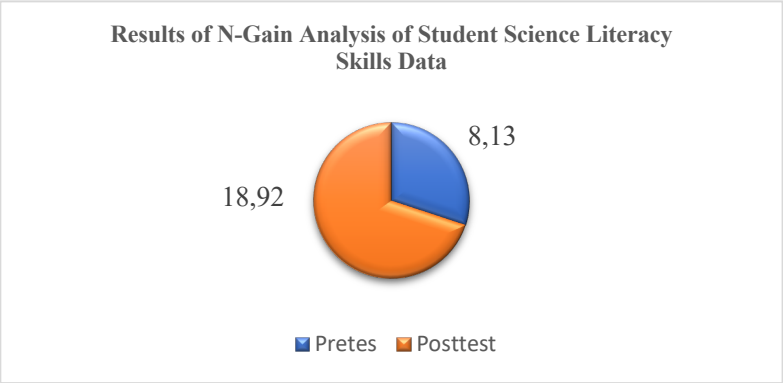

Figure 2. Results of N-Gain Analysis of Pretest and Posttest in Students

As shown in Figure 2, it can be concluded that the use of PhET simulation media results in an improvement in students' science literacy skills, as evidenced by the N-Gain value obtained from the average pretest and posttest scores. Meanwhile, science literacy skills based on competency indicators are shown in Table 4 below:

Table 4. Results of N-Gain Analysis for Each Indicator of Students Science Literacy Skills

Competency Indicators	Pretest	Posttest	N-Gain	Category
Explaining phenomena scientifically	7.38	19.77	0.75	High
Designing and evaluating scientific investigations	7.25	8.00	0.43	Currently
Interpreting data and evidence scientifically	8.88	17.25	0.55	Currently

Table 4 illustrates the improvement in science literacy across all indicators, with noticeable progress in the indicators related to explaining phenomena scientifically, achieving an N-Gain of 0.75, which is categorically classified as high. Improvements in the indicator of designing and evaluating scientific investigations reached an N-Gain of 0.43, categorically classified as moderate, while interpreting data and evidence scientifically achieved an N-Gain of 0.55, which falls into the moderate category.

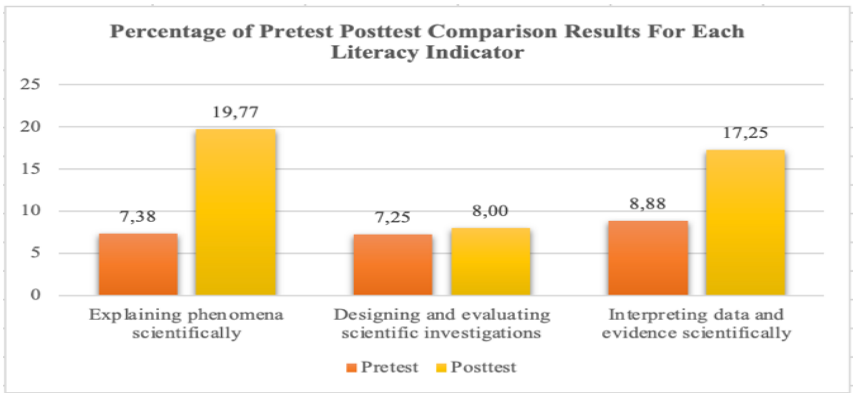

Figure 3. Pretest and Posttest for Each Science Literacy Indicator

As shown in Figure 3, it can be concluded that each indicator has experienced an improvement in students' science literacy skills, and each indicator also has differences in the improvement of science literacy skills. As for the students responses to the learning media, they are shown in the following table 5:

Table 5. Student responses after learning using media

Number of Students	Knowledge %	Category
24	84.32	Good

Based on Table 5, it can be seen that students' responses to Physics learning regarding light material using PhET simulations show a positive or good response to each statement listed in the questionnaire instrument. The average overall response percentage from students was 84.32%. This indicates that student responses were in a good category in this context. The results of this study are consistent with (Muna et al., 2023), which showed a positive student response to PhET simulations across various Physics topics. Finding a positive response rate of 84.50%. This is in line with (Aurora & Sholeh, 2023) reporting a student engagement rate of 82.187%.

Discussions

The results of this study began by administering a pretest before teaching and a posttest after The results of this study show that utilizing PhET simulation tools significantly enhances students' science literacy skills. With an average N-Gain score of 0.72, categorized as high, it is evident that incorporating interactive simulation-based learning effectively improves students' grasp of scientific concepts, especially regarding the topic of light. This advancement is consistent with earlier studies indicating that PhET simulations create an engaging and exploratory learning atmosphere that fosters conceptual understanding (Sakona et al., 2024; Warneri et al., 2024).

Moreover, the evaluation centered on competency indicators shows that the most notable enhancement was seen in the indicator for “explaining phenomena scientifically,” achieving an N-Gain of 0.75 (high category). This indicates that PhET simulations support students in visualizing and reasoning through abstract scientific concepts, thus enhancing their capacity to articulate natural phenomena. The visual and interactive features provided by PhET enable students to adjust variables and observe results, which enriches their understanding of explanations.

In comparison, the metrics for “designing and evaluating scientific investigations” (N-Gain = 0.43) and “interpreting data and evidence scientifically” (N-Gain = 0.55) indicated a moderate level of improvement. These findings suggest that while students can comprehend and articulate phenomena, they might need additional structured support and practice in crafting experiments and effectively analyzing data. This observation aligns with research that shows inquiry-based skills develop at a slower pace and require continuous application and support (Arnold et al., 2014).

The favorable feedback from students, with an average score of 84.32%, reinforces the efficacy of PhET simulations in learning physics. Students described the media as engaging and beneficial for grasping concepts related to light, which probably played a role in enhancing their literacy skills. This aligns with the findings of (Koilmo et al., 2025), who indicated that greater student engagement is linked to improved learning outcomes.

In summary, the use of PhET simulation tools has been shown to significantly improve students' understanding of science, especially in the explanation of scientific phenomena. Nevertheless, to attain a more even growth across all literacy measures, upcoming instructional frameworks should include additional tasks that promote skills in experimental design and data analysis. These initiatives will guarantee that students can not only grasp scientific principles but also utilize them in practical situations.

4. Conclusions

This research was conducted at SMA Negeri 1 Pulau Banyak using PhET simulation media, with the aim of improving students' science literacy skills in the aspect of science competence. The research results show that the science literacy skills of 9th-grade MIA students improved after participating in the learning process. This result is indicated by the score value obtained, which is 0.72 for the average Ngain score, categorized as high. Based on these results, it can be concluded that the PhET simulation media is effective in improving students' science literacy skills in the aspect of scientific competence. This is followed by three aspects of scientific competence, which show an increase in students' science literacy abilities. Moreover, the survey results indicate that students' responses to the use of PhET simulation media were very positive. The overall average response rate from students reached 84.32%, which is considered good.

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