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Increasing Scientific Literacy using a Guided Inquiry Approach assisted by PhET Simulations in Wave Material

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Abstract. This research was conducted to assess the growth of students' scientific literacy skills using the Guided Inquiry learning model assisted by PhET Simulation on Wave material. The method used in this research is Penelitian Tindakan Kelas (PTK) or Action Research with the research subjects was 39 students of SMA Negeri 6 Kabupaten Tangerang class XI MIPA 3. This research design consists of three cycles with each cycle consisting of four stages: planning (plan), implementation (action), observation (observe), and reflection (reflect). The results of the research show that the application of the Guided Inquiry learning model assisted by PhET Simulation can improve students' scientific literacy abilities with the average percentage value of scientific literacy abilities in the "good" category, this can be seen in the greatest increase that occurred in cycle III, which was found The average percentage increase in the science content indicator was 68.7%, the science context indicator was 63.7%, and the science process indicator was 65.5%. From the results of observations from this research, it can be seen that through the Guided Inquiry learning model assisted by PhET Simulation, students are more active in the learning process.

Keywords: Guided inquiry, PhET simulation, science literacy, Physics Learning

1. Introduction

Increasing students' scientific literacy skills is one of the important things in 21st-century education. According to the National Research Council, scientific literacy is crucial to cultivate as it (1) offers personal fulfillment and joy that comes from comprehending and exploring science; (2) is essential for making informed decisions and employing scientific reasoning in everyday life; (3) is necessary for actively participating in discussions and deliberations on significant scientific and technological matters; (4) holds significance in professional environments, thereby necessitating individuals learn science, make decisions, solve problems, reason, and think creatively [1].

Scientific literacy is involves employing scientific knowledge to identify the problems and reach conclusions based in evidence in order to comprehend and make decisions about the natural world and alterations resulting from human activities [2]. Science literacy skills is the ability to engage with science-related issues, scientific ideas, and the capability of becoming a reflective thinking person [3]. This can be obtained in the context of everyday life. In other words, someone who is literate in science will be able to creatively utilize scientific knowledge in everyday life to solve problems and make decisions [4].

The use of innovative and effective learning methods is essential to help students enhance their scientific literacy skills. Guided inquiry-based physics learning models can provide problem-based learning models and train students in problem-solving [5]. This literacy skill involves more than just reading and writing but involves thinking skills which make them a literate generation in learning, including in science learning. Students' literacy abilities are closely related to reading skills in understanding information analytically, critically, and reflectively [6]. One method that has been proven

effective is the guided inquiry approach, this has been proven in previous research where guided inquiry can improve students' scientific literacy skills [7].

The guided inquiry approach is a variation of the inquiry model, where the teacher's role is as a facilitator, the teacher facilitates students in developing critical and analytical thinking skills through structured scientific investigations. This allows students to develop understanding independently but still be focused. The guided inquiry model can help students learn, think critically, and be creative among students. Then the guided inquiry model involves all students' ability to find answers to critical, analytical, and logistical problems with full confidence [8].

21st-century learning also needs to be integrated with ICT, one form of learning that is integrated with ICT is by utilizing PhET (Physics Education Technology) software. The University of Colorado has developed PhET, a simulation contains biology, chemistry, and physics learning simulations designed for use in classrooms or for individual learning purpose. PhET simulations emphasize the relationship between real-life phenomena and the underlying science, support interactive learning using a constructivist approach, provide feedback, and make someone more creative [9].

The use of PhET (Physics Education Technology) in science learning has been recognized as an effective innovation for increasing student involvement in the learning process [10]. Based on previous research conclude that students should be trained to solve problems by using various types of approaches in active learning, such as inquiry-based learning with PhET simulations [11]. Through this simulation, abstract concepts such as the properties of deep waves are visualized more clearly, thereby helping students to more easily understand deeper theories and principles.

Despite the recognition of the importance of scientific literacy in the 21st century in education, the organized benefits of guided inquiry, and the integration of ICT in education, there is still a gap in effectively interpreting these methods into broad classroom practices, especially in the context of teaching complex science concepts such as wave phenomena. Previous studies have demonstrated the potential of guided inquiry to improve scientific literacy, but many have not fully explored the synergistic effects of combining guided inquiry with ICT tools, such as PhET simulations. Furthermore, although PhET has been praised for its ability to make abstract concepts more tangible, there is a lack of comprehensive research that specifically focuses on its effectiveness in improving scientific literacy when used in conjunction with structured pedagogical approaches such as guided inquiry.

The novelty lies in the integration of a guided inquiry approach with PhET simulations to not only improve students' understanding of wave concepts but also to enhance their overall scientific literacy. This research will provide new insights into how combining guided inquiry with interactive simulations (PhET) can lead to better educational outcomes, particularly in fostering critical thinking, problem-solving, and decision-making skills based on scientific evidence.

This research aims to discover more about the effectiveness of the guided inquiry approach assisted by PhET simulations in increasing students' scientific literacy in wave material. It is hoped that through this approach students will not only be able to understand basic concepts about waves but also to develop scientific skills to make decisions based on data and solve the problems.

2. Method

The research methodology employed in this study is Penelitian Tindakan Kelas (PTK) or Action Research. Action Research This class has a role in solving problems that occur in class. This research was carried out at SMAN 6 Kabupaten Tangerang, with the research subjects being class XI MIPA 3 students for the 2023/2024 academic year, totaling 39 students, consisting of 22 women and 17 men. Data collection was carried out from the fifth week of May 2024 to the first week of June 2024.

Action research defined as the processes related to methods professionals use to strengthen their practice and knowledge of their practice contexts, as well as to create information that can guide other practitioners in the same field. In the context of educational action research, the concept of the teacher researcher, first introduced by Lawrence Stenhouse in 1975, has played a pivotal role in the growth and development of action research within the field of school-based pedagogy [12].

Referring to several existing Action Research models, the model that is often used in education is the model brought by John Elliot. This is because in its implementation, Elliot's Action Research model is easier to understand, and has a spiral shape. Action Research with an investigative process has a

reflective and cyclical nature. The Action Research cycle aims to be a revision effort. The cycle or repetitive process in Action Research activities can be described as follows [13].

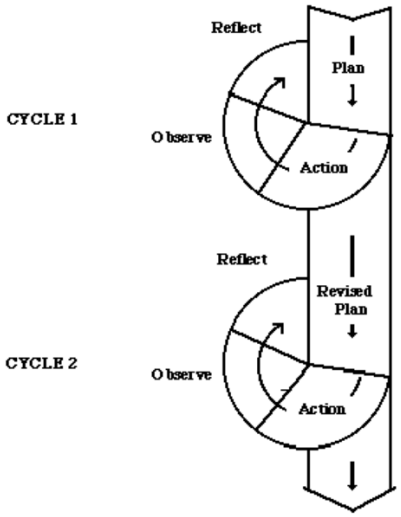

Figure 1. Action research cycle.

This research carried out an Action Research cycle with four stages, namely plan or create a learning plan, action or implementation, observe, and reflect or evaluate. This research was carried out over three Action Research cycles, where each cycle consisted of one meeting.

The research instruments used in this research include observation sheets to observe and record student participation throughout the classroom activities, scientific literacy test questions to measure students' scientific literacy abilities before and after each cycle action, as well as interview (reflection) sheets to obtain a deeper understanding. about the condition of the students and the student's experiences regarding the learning carried out.

The data analysis method used in this research is qualitative and comparative. Qualitative analysis was carried out by classifying and interpreting data from observations and interviews, while comparative analysis was carried out by comparing the results of scientific literacy tests before and after each cycle to see improvements in students' scientific literacy skills.

The independent variable in this research is the application of a guided inquiry approach assisted by PhET simulations. Meanwhile, the dependent variable in this research is the value of the results of scientific literacy abilities for each indicator. The total number of scores resulting from each indicator of scientific literacy ability with a maximum score of 100 and a minimum score of 0. The data results for the percentage of students' scientific literacy skills can be calculated using the formula below [14]:

$$P_n = \frac{n}{N}\, x\, 100\% \quad (1)$$

where P_n as percentage of students' scientific literacy skills scores, n as total student scores and N as maximum total score.

The students' overall scores are then categorized based on the criteria for the level of students' scientific literacy abilities following Table 1. [14]

Table 1. Scientific literacy categories.

Percentage (%)	Criteria
81-100	Very Good
61-80	Good
41-60	Average
21-40	Poor
0-20	Very Poor

3. Results and Discussion

This research produces data on students' scientific literacy abilities when learning physics on waves using a guided inquiry model approach assisted by PhET simulations. The results of the scientific literacy ability data were analyzed according to each indicator, there are three indicators, explain a scientific phenomenon, Evaluate and design scientific inquiry, and Interpret data and evidence scientifically. The results of this scientific literacy data were produced from students' literacy ability test work. The data obtained from the scientific literacy test results for each cycle are shown in Table 2.

Table 2. Results of Increasing Scientific Literacy Ability

No.	Scientific Literacy Indicators	Results of Cycle I	Results of Cycle II	Results of Cycle III
1.	Explain a scientific phenomenon	47,1%	51,3%	68,7%
2.	Evaluate and design scientific inquiry	56,3%	58,1%	63,7%
3.	Interpret data and evidence scientifically	50,5%	57,7%	65,5%

Based on the results in Table 2. The results of the research data confirm that students' scientific literacy skills increase in each learning cycle, this shows the effectiveness of the guided inquiry model using PhET simulations in increasing students' scientific literacy in wave material. In the results of cycle I and cycle II, it can be seen that the increase in scientific literacy was not very significant. This could be because students need to adapt to the learning model being carried out, where previously students only used conventional learning models or lectures and students also had to adapt to the use of technology, namely PhET simulations which students had never done before. The difficulty encountered is that students are not used to identifying existing problems. As in previous research, the solution given at the stimulation stage requires being confronted with something that raises questions, and then continuing not to provide generalizations, so that the desire arises in students to investigate for themselves. Teachers may begin instructional activities with questions, book reading, or various tasks that encourage problem-solving [15].

However, in cycle III (final results) there was a significant increase in scientific literacy skills with good categories in each indicator. The first indicator, explaining scientific phenomenon was found to be 68.7% in the good category, where explaining scientific phenomena involves referring to essential scientific concepts required to comprehend natural events and the alterations in nature caused by human activities [16]. The second indicator, evaluate and design scientific inquiry was found to be 63.7% in the good category, where this dimension includes understanding situations that involve the application of science in everyday life, which is used as material for implementing processes and understanding scientific concepts [17]. The last indicator, interpret data and evidence scientifically was 65.5% in the good category, where the Interpret data and evidence scientifically measured was divided into three indicators, namely identifying scientific questions, explaining phenomena scientifically, and using scientific evidence [18].

Supported by the previous research provide evidence that the designed simulation and inquiry support had a long-term effect on the students' scientific literacy. Replacing conventional teaching with inquiry activities did not harm the students' school science achievement performances[19] and from previous research the integrated guided inquiry model of the PhET application can be applied to the learning of physics and can facilitate students to train their critical thinking abilities [20].

The final results can be good because there is a guided inquiry learning model assisted by PhET simulations which is more interactive and interesting than previous (conventional) learning models. The increased active involvement of students is also strong evidence of the success of this guided inquiry approach. Observation results show an increase in student involvement in the learning process, which can be seen from the quantity and quality of students' questions and answers during the learning process. Previous research states that the teaching and learning process using a learning model that allows

students to actively search, explore, and discover concepts and understand the application of these concepts in everyday life can improve students' literacy skills [18].

Based on the explanation above, increasing scientific literacy including science content, science context, and science processes can be done using a guided inquiry learning model assisted by PhET simulations on wave material.

4. Conclusion

In accordance with the results of the three cycles that have been conducted and test in each cycle to see the increase in scientific literacy using a guided inquiry model assisted by PhET simulations, cycle III (last cycle) was obtained with the highest average percentage increase in each scientific literacy indicator with a science content indicator of 68.7%, the science context indicator is 63.7%, and the science process indicator is 65.5%. Therefore, it was determined that increasing scientific literacy using the guided inquiry learning model assisted by PhET simulations on wave material resulted in improvements in the good category. Observations during the research also showed increased student involvement during the learning process. Suggestions for further research are to carry out a pre-test in the first cycle before collecting data to better understand students' scientific literacy abilities before implementing the guided inquiry learning model assisted by PhET simulations.

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