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The Effectiveness of STEM-Based Guided Inquiry Learning to Train Science Literacy of Physics

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ABSTRACT

This study aims to determine the effectiveness of STEM-based guided inquiry learning on physics science literacy. This study uses a research and development (R & D) development model with a one group pretest-posttest design. The sample used was class XI students with three replications. The data collection technique is in the form of a science literacy test sheet. Then analyzed with a quantitative and qualitative descriptive approach. The research data shows that the learning model developed is theoretically valid by three expert validators. The effectiveness of learning tools is shown by the science literacy scores of students who have increased after applying the STEM-based guided inquiry learning model. Based on the discussion of the research results, it can be concluded that the learning tools developed are effectively applied in schools to train students' science literacy in sound wave material.

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INTRODUCTION

The shift in the educational paradigm in the 21st century education era demands human resources to be able to compete globally. 21st century education is the main focus in developing students' thinking skills today, especially in science learning (Nisrina et al., 2020). The need for 21st century skills is the main foundation in science learning which is currently still classified as inappropriate (Astuti et al., 2012). Science can be applied in the form of science literacy-based learning (Suryani et al., 2017). Science literacy is an important skill for students in 21st century learning, Deming (2007) stated that science literacy skills are the main needs of students in the application of learning in the 21st century. Science literacy focuses on four aspects, namely knowledge, context, competence, and attitudes where these aspects are interrelated. Science literacy is a competency in education in an effort to prepare a nation that is capable of being responsible and sensitive in dealing with problems in society (Ridwan, 2013). Literacy is the ability of students to read, understand, and solve problems in social life with their innovations (Rusilowati et al. 2016). Education is the right place to measure the literacy of students as the nation's young generation. Student literacy can be measured through assessments developed by educators.

The Organization for Economic Co-operation and Development (OECD) is an international institution that evaluates learning outcomes which show the quality of education in a given country. OECD has conducted tests through the Program for International Student Assessment (PISA) survey to determine the abilities of 15 year old students in aspects of reading, mathematics and science in a number of member countries. The test results can show a country's position internationally. The results of the 2018 PISA assessment put Indonesia in 70th place out of 78

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participating countries with an average of 393 (OECD, 2019). The PISA results above show that science education in Indonesia is classified as low, while science is needed in challenging global progress and technology.

Science literacy is defined in the 2018 PISA Science Framework (OECD, 2019) science literacy is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. PISA defines science literacy which consists of three aspects, namely context, knowledge, and attitudes that lead to one aspect, namely the competency of students' science literacy achievement. The context aspect focuses on personal, local, and global issues. The knowledge aspect focuses on understanding facts, concepts, and theories that build knowledge through content, procedural, and epistemic. The attitude aspect is observed from the students' interest in science and technology to solve environmental issues. The three aspects lead to aspects of competence, which are a benchmark for students' science literacy achievement. Students' science literacy competencies include explaining phenomena scientifically, interpreting data and evidence scientifically, and evaluating and designing science experiments. This definition explains that science is indispensable in challenging global progress and technology, while science literacy in Indonesia is relatively low.

Students' science literacy skills are trained by solving problems with various new innovations, so that learning is able to accommodate students to express creative ideas in representing their abilities in everyday life (Tjjala, 2022). Rusilowati et.al., (2016) states that the literacy profile of students belongs to the low category, this is indicated by a percentage below 50% for each characteristic. So that the development of problem-based or discovery-based innovative learning is very much needed to train students' science literacy. STEM-based learning can train students to solve real problems in everyday life by involving science literacy (Jauhariyyah, et.al., 2017). The demands of the National Curriculum implicitly in the basic competencies of physics apply the concepts of physics in everyday life and technology. The connection between phenomena and the use of technology is very appropriate in efforts to support students' science literacy. So that education needs to develop student competencies in the realm of knowledge, skills, and social attitudes in order to prepare individuals who are able to compete globally (Kemendikbud, 2016). Learning methods that combine science with other disciplines are needed to boost learning innovation in the classroom. STEM is an integrated learning between science, technology, engineering, and mathematics which has real problem solving characteristics in everyday life. STEM integrated learning methods are the main focus in increasing students' knowledge and creativity (Knezek, 2015). According to the National Academy of Engineering (2008) students should start associating the possibilities of STEM aspects with the need for creativity and skills in solving problems in the environment.

The learning model that can be involved in using STEM is learning that provides experience to students in solving problems (Ismail, 2015). The inquiry learning model is a learning model that involves the ability of students to carry out systematic, critical, logical, and analytical investigations. Putra (2016) revealed that inquiry learning can increase students' science literacy. According to Sanjaya (2009) inquiry learning is a series of learning activities where students find their own answers to the problems they get, so the emphasis on inquiry learning is on the process of thinking critically and analytically. Inquiry learning model has a relationship with STEM-based learning with students' science literacy learning outcomes in physics subjects. The study of physics in classroom learning involves investigating phenomena that can be described factually. Inquiry learning based STEM process has the basic concept of making discoveries or science investigations.

The purpose of this study was to determine the effectiveness of guided inquiry learning based STEM on physics literacy. The guided inquiry model based STEM developed includes lesson plans, student worksheets, and science literacy assessment instruments. The reason for the researchers developing the guided inquiry model based STEM is to produce innovative learning tools that are able to train students' science literacy. The resulting guided inquiry model based STEM is expected to be a learning tool that can be applied in all schools.

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RESEARCH METHOD

Sample and Procedures

This study use the STEM-based guided inquiry learning to train science literacy of Senior High School students. The trials were carried out on students through empirical tests using the type research is pre experimental One Group pre-test and post-test design with three replications for the experimental class with a sample of 73 students. The research design is show in Figure 1.

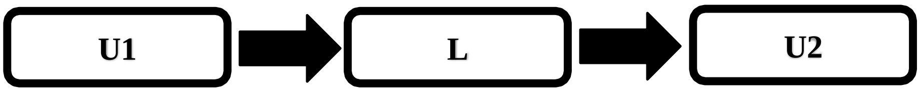

Figure 1. Research design

(Prabowo, 2011)

Explanation:
U1 = Pre-test, to determine the ability of students before being given the treatment
L = Treatment, learning process using the guided inquiry learning based STEM
U2 = Post-test, to determine the ability of students after being given the treatmen

In this study, three classes were used, namely the experimental class with three replications. The design of this study was carried out so that the research was more accurate in comparing before being given treatment with after being given treatment (Sugiyono, 2013).

Data Analysis

The improvement of students' thinking skills can be seen from the results of the pre-test and post-test and can be measured using n-gain. The normality test is used to test whether a variable has normal data or not. The data normality test in this study used the Kolmogorov-Smirnov test with the condition Asymp > 0.05, the data is normally distributed. Homogeneity test was carried out to find out which class used for research was a homogeneous class. To determine the effectiveness of STEM-based guided inquiry on students' science literacy using a paired t test. If $t_{count} > t_{table}$ means there is a significant difference between the variants, there is an effect of STEM-based guided inquiry learning on students' science literacy abilities.

Analysis of Students' Science Literacy Test

The level of students' physics science literacy ability measured is sound wave material determined based on the science literacy assessment rubric Table 1.

Table 1. Science literacy assessment rubric

Level	Description	Max Score
6	Given a phenomenon, students are able to design or provide solutions in the case of sound waves in everyday life.	63 - 73
5	• Given a phenomenon, students are able to evaluate the impact that sound waves can have in everyday life. • Given a phenomenon, students are able to evaluate the benefits of sound waves in everyday life.	53 - 62
4	Given a phenomenon, students are able to analyze related sound waves in everyday life.	42 - 52
3	• Given a phenomenon, students are able to interpret sound waves in everyday life. • Given a phenomenon, students are able to determine the value of the wave magnitude related to sound waves in everyday life.	32 - 41

Level	Description	Max Score
2	• Given a phenomenon, students are able to provide opinions regarding sound waves in everyday life. • Given a phenomenon, students are able to determine the magnitude of sound waves in everyday life.	21 - 31
1a	Given a phenomenon, students are able to explain the characteristics of sound waves in everyday life	11 - 20
1b	Given a phenomenon, students are able to show the characteristics of sound waves in everyday life	0 - 10

To find out the achievement of students' science literacy competence, a mapping was carried out on the science literacy questions given. The mapped questions are used to measure which science literacy competencies students have achieved well. Achievement of students' science literacy competence is obtained from the total score achieved by students in each competency. Interpretation of the percentage of students' science literacy competency achievement can be seen in Table 2.

Table 2. Criteria for student science literacy

Percentage	Predicate	Criteria
86 – 100%	Very good	High
76 – 85%	Good	
60 – 75%	Well	Medium
55 – 59%	Enough	Low
< 55%	Not enough	

(Purwanto, 2006)

RESULTS AND DISCUSSION

Student's Science Literacy

The ability of students' physics science literacy is determined from the results of tests before and after being given learning using the STEM-based guided inquiry model to determine the effectiveness of learning. The questions used in the test are about 20 items describing sound waves. The description questions are used in order to be able to assess students' abilities in terms of creativity, analyze, and synthesize a problem so as to give students freedom in providing responses related to these problems (Arifin, 2012). The results of students' scientific literacy are shown in Figure 2.

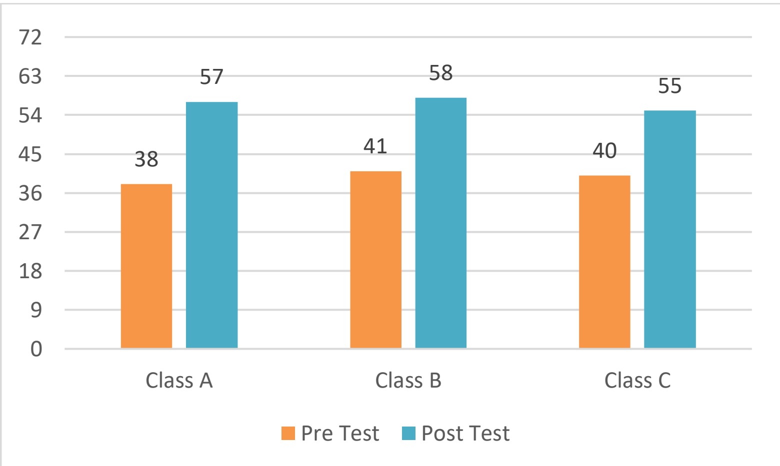

Figure 1. Graph of student physics literacy results

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Based on the results in Figure 5, it shows the differences in students' literacy results before treatment (pre-test) and after being given STEM-based guided inquiry learning (post-test). The results of the students' pre-test and post-test were analyzed to determine the n-gain value which indicates an increase in student learning outcomes. From the three classes there was an increase in students' scientific literacy respectively of 5.52; 0.52; and 0.47 where the increase is in the moderate category. The increase in value from the pre-test to the post-test indicates that learning has occurred in students by processing the information received so that the information enters the students' understanding (Nur, 2008).

To determine the effect of the STEM-based guided inquiry learning, a paired T-test was carried out. The T test is carried out if the sample used is a sample that is homogeneous and normally distributed. Therefore a normality test was carried out using the Kolmogorv Smirnov test to find out whether the scores in the sample come from a population that has a theoretical distribution. The samples from the three classes show statistics above 0.05, which means there is no significant difference. There is a good agreement between the sample distribution (observation score) and the theoretical distribution. After the sample is declared normally distributed. After the sample is declared to be normally distributed, then the sample is tested for homogeneity using the Levene test, where the p value > α, then H_0 is accepted. In this study, 73 samples were used which were selected based on many classes. Based on the number of samples used, it can be determined that the value of α or p table is 2.73. While the p value statistically shows 0.391. This shows that if H0 is rejected, the probability of a type 1 error is 39%. These results indicate that the sample used comes from the same population, in other words that the students studied have the same characteristics. After the sample is declared to be normally distributed and homogeneous, a paired t-test can be performed.

The results of the paired T test are assumed if the Sig. (2 tailed) < 0.05, then H_0 is rejected and H_a is accepted. This means that there is influence between the independent variables on the dependent variable. Based on the statistical tests performed, it was found that the Sig. (2 tailed) for the three classes of 0.000 <0.05, then H_0 is rejected. This shows that significantly STEM-based guided inquiry learning has an influence on students' scientific literacy abilities.

Achievement of scientific literacy competence

The results of students' scientific literacy competency achievements after being given STEM-based guided inquiry learning show good criteria. Scientific literacy competencies that are measured are explaining phenomena scientifically, interpreting data and evidence scientifically, and designing and evaluating scientific investigations. The results of scientific literacy competence are known from the tests done by students. The test is mapped into three aspects of scientific literacy competency and then presented. The results of achieving scientific literacy competence of students are shown in Table 3.

Table 3. Achievement of students' science literacy competence

Science Literacy Competence	Number test	Percentage	Average
Explain phenomena scientifically	1	100	89%
	2	98	
	4	79	
	6	81	
	8	85	
	9	82	
	10	79	
	18	100	

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Science Literacy Competence	Number test	Percentage	Average
	19	100	
Interpret data and evidence scientifically	3	89	85%
	7	93	
	11	100	
	15	61	
	16	70	
	20	96	
Evaluate and design inventions scientifically	5	72	66%
	12	75	
	13	76	
	14	61	
	17	46	
Average Achievement of Scientific Literacy Competence			80%

Based on Table 3 the criteria for achieving scientific literacy of students as a whole of 80% can be categorized in good criteria. Of the 20 items tested, all represent scientific literacy competence, namely 9 items explaining phenomena scientifically, 6 items interpreting data and evidence scientifically, and 5 items evaluating and designing scientific investigations. Based on these findings, scientific literacy competency outcomes have different percentages. In the competence to explain phenomena scientifically, the percentage of students' scientific literacy is 89%. This shows that students are able to explain various phenomena scientifically and evaluate various explanations for various natural and technological phenomena is good. This ability is shown by students in remembering, identifying, making predictions, providing hypotheses, and explaining the potential implications of scientific knowledge. The abilities possessed by students are in line with the STEM-based guided inquiry learning process being carried out. Guided inquiry is a scientific discovery learning that represents everything related to natural phenomena and the laws involved. So to identify students' problems requires a broad understanding of science (Torlakson, 2014). In addition, guided inquiry learning also teaches students to determine hypotheses. Guided inquiry teaches students to identify problems to determine temporary answers from various thoughts.

In the competence to interpret scientific data and evidence, the percentage of students' scientific literacy achievement is 85%. This shows that students are able to analyze scientific data and provide arguments in various forms of representation. This ability is demonstrated by students in transforming data, analyzing data, identifying assumptions and evaluating arguments based on scientific evidence. Scientific literacy skills in this competency are supported by STEM-based inquiry learning. Inquiry learning teaches students to get the data or information they need from an experiment. The collected data is then analyzed by testing the specified hypothesis (Sanjaya, 2013).

In the competency of designing and evaluating scientific investigations, the percentage of students' scientific literacy is only 66%. These results interpret students' scientific literacy skills in these competencies to be in the medium category. This shows that students' ability to explain and assess scientific investigations and propose ways to solve problems is still medium. This ability is measured by students in exploring, evaluating, and describing the methods used to ensure the objectivity of data and the generalization of an issue. In this competency, guided inquiry learning actually teaches students to interact with the problems they find to find the truth. However, the ability of students to carry out scientific investigations and propose ways to solve problems is still medium. In this study, the causal factor was the implementation of learning when the experiment was running less optimally because the teaching aids had to be used interchangeably. Rustaman (2011) states that, by doing practicum students will become more sure of one thing than just receiving from teachers and books, and can enrich students' experiences in interpreting data and scientific evidence, as well as developing a scientific attitude, and learning outcomes will last longer in student memory.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the following STEM-based guided inquiry learning tools to train students' scientific literacy are declared theoretically valid. The STEM-based guided inquiry learning model meets the effective criteria in terms of students' scientific literacy scores which have increased significantly. From the results of the research and discussion that has been carried out, the STEM-based guided inquiry learning tool developed is feasible to apply in schools to train students' scientific literacy skills.

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