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Effectiveness of PBL-Based E-LKPD to Improve High School Students' Science Literacy on Global Warming Material

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ABSTRACT

This study aims to test the effectiveness of PBL-based e-LKPD in improving high school students' scientific literacy on global warming. The effectiveness test used pre-experimental research with a design.One Group Pretest-Posttest Design. This test was conducted on one group that was given a pretest at the beginning of the learning and a posttest at the end of the learning. This research was conducted at SMAN 1 X Koto Diatas in the odd semester of the 2024/2025 academic year. This study used class X phase E.2 totaling 25 students as research subjects. The research instrument was in the form of five scientific literacy test questions compiled based on the PISA 2018 indicators. The data analysis of this study used normality test data analysis, N-gain score test, and effect size of students' scientific literacy test obtained from the pretest and posttest results. E-LKPD based on the PBL model to improve high school students' scientific literacy on global warming material. The N-gain score obtained was 0.56 so it was included in the sufficient category.

Keywords:E-LKPD, PBL, Science Literacy, Global Warming, Effectiveness.

I. INTRODUCTION

Scientific literacy is a fundamental ability that students must have in the modern era to face the challenges of scientific development.[1]The term scientific literacy comes from a combination of two Latin words, namely literatus, which means marked with letters, literate, or educated, and scientia, which means having knowledge.[2]Paul deHart Hurd first introduced the term "scientific literacy" through an article entitled "Science Literacy: Its Meaning for American Schools" in 1958, which describes the understanding of science and its application in society.[3]. Scientific literacy is very important for students so that they can contribute to technological progress and make the right decisions about scientific problems in everyday life.[4][5].

In physics learning, scientific literacy plays a crucial role in making learning more meaningful. Scientific literacy supports the development of skills in identifying problems, exploring resources to solve them, and enhancing understanding of the principles and

applications of physics in industry and other fields.[6].[7]Mastering scientific literacy skills enables students to develop strong competencies, think logically, critically, and creatively, reason effectively, communicate, collaborate, and understand and communicate science both orally and in writing. This empowers students to develop a strong sense of self and their environment, enabling them to make decisions based on scientific considerations.[8]Therefore, various efforts need to be made to improve students' scientific literacy.[9]One way is through the development of interactive teaching materials such as Electronic Student Worksheets (E-LKPD).[10].

E-LKPD is an electronic student worksheet that contains learning materials with images and videos that can attract students' attention and help students understand the material.[10]. Electronic student worksheets also contain a summary of the material, questions and instructions for completing the tasks that students have worked on, designed in interactive multimedia.[11].

The PBL model is a learning model that is based on solving real-world problems.[12]**.**This model facilitates students to solve problems through authentic investigations.[13]Problem-based learning with the PBL model helps students develop critical thinking skills and problem-solving skills that can be applied in everyday life.[14] [15].

Based on the results of the PISA (Programme for International Student Assessment) study, it shows that Indonesian students' scientific literacy is still in the low category. These results are also relevant to the results of the PISA test conducted by the Organization for Economic Cooperation and Development (OECD) every three years. The PISA International Assessment assesses the knowledge and skills of 15-year-olds in literacy, mathematics, and science in developing countries.[16].

In line with PISA, the scientific literacy of students at SMAN 1 X Koto Diatas is still relatively low, with details of the teaching materials used not being specifically designed to facilitate students' scientific literacy. Based on the results of interviews with physics teachers, information was obtained that the teaching materials used were varied, such as modules and textbooks, but not specifically to encourage students' scientific literacy skills. Teachers also stated that they had never used Student Worksheets (LKPD) to assist the learning process and still used printed textbooks.

The low scientific literacy skills of students require improvement through learning innovation. One solution that can be implemented is the use of e-LKPD based on the PBL model. The combination of e-LKPD and the PBL model is expected to create optimal synergy in learning global warming. PBL-based e-LKPD not only presents engaging digital content but also facilitates a constructivist learning process where students actively construct their own knowledge through problem-solving. [17].

Tanjung (2025) has developed an E-LKPD based on the PBL model to facilitate high school students' scientific literacy on global warming using the Liveworksheets platform [18]. The developed E-LKPD has gone through a validation process by experts and obtained an average score of 0.94 with a very valid category. The practicality test by teachers showed an average score of 95% with a very practical category, while the practicality test by students obtained an average score of 84.5% with a practical category. Although it has been valid and

practical, the effectiveness of the E-LKPD in improving students' scientific literacy still needs to be tested through implementation of learning in the field.

Based on the description above, it is necessary to conduct research to test the effectiveness of E-LKPD based on the PBL model that has been developed byCape (2025)in improving high school students' scientific literacy on global warming material, especially at SMAN 1 X Koto Diatas. This study aims to test the effectiveness of PBL-based E-LKPD to improve high school students' scientific literacy on global warming material.

II. METHOD

This research is a type of development research that aims to produce an E-LKPD product based on the PBL model that is effective in improving students' scientific literacy. The effectiveness test was carried out at SMAN 1 X Koto Diatas in the odd semester of the 2024/2025 academic year. The class used in this study was class X phase E.2, totaling 25 students. The effectiveness test of E-LKPD used pre-experimental research with a one-group pretest-posttest design. This test was carried out on one group that was given a pretest at the beginning of learning and a posttest at the end of learning activities. The test results were used to test the effectiveness of E-LKPD used in learning by comparing scientific literacy scores before and after being taught using E-LKPD. The one group pretest-posttest research design is presented in Table 1.

Table 1. One Group Pretest-Posttest Research Design

Pretest	Treatment	posttest
o_1	x	o_2

Information:

- O_1 = Student pretest score before being given the action
- X = Treatment (learning using E-LKPD based on the PBL model on global warming material)
- O_2 = Posttest score of students after being given the action

The effectiveness test was conducted in class X phase E.2 of SMAN 1 X Koto Diatas in the odd semester of 2024/2025. This study used a scientific literacy test instrument. The test instrument was in the form of an essay question compiled based on the scientific literacy indicators proposed by PISA 2018, namely 1) explaining phenomena scientifically, 2) interpreting data and evidence scientifically, 3) evaluating and designing scientific investigations.[1]This scientific literacy test is based on the first semester's 10th grade material on global warming. The previously developed test instrument was pilot-tested to determine item consistency and instrument reliability. This resulted in a valid and reliable scientific literacy instrument.

This research was analyzed using data analysis, namely N-Gain, normality, and effect size of students' scientific literacy tests processed from pretest and posttest results. Learning

outcomes between before and after the implementation of PBL-based E-LKPD. The N-Gain test formula is as follows:

$$N_{Gain} = (1)\frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Ideal - Skor\ Pretest}$$

To find out the category of student ability improvement using the Normalized Gain (N-Gain) test, we can refer to the normalized gain criteria table in Table 2.

Table 2. N Gain Criteria

N-Gain Value	Interpretation
0.70 ≥ g ≤ 100	Tall
0.30 ≥ g ≤ 0.70	Currently
0.00 ≥ g ≤ 0.30	Low
g = 0.00	There was no increase
-1.00 ≥ g ≤ 0.00	There was a decline

The effect size test was conducted to determine the extent of the influence of learning using PBL-based E-LKPD to improve scientific literacy on global warming at SMAN 1 X Koto Diatas. Based on the t value obtained from the paired sample t-test, the effect size calculation was then carried out, the effect size calculation was carried out using the following formula:

$$Effect\ size = (2)\frac{t^2}{t^2 + df}$$

Information:
t = t count from paired sample t-test
df = degrees of freedom

Table 3. Effect size criteria

Criteria	Influence
<0.15	Ineffective
0.15 – 0.40	Less effective
0.40 – 0.75	Quite effective
0.75 – 1.10	effective
>1.10	Very effective

The test criteria accept H1 if the significant value (2-tailed) < 0.05 (there is a large difference in the average pretest and posttest values) and accept H0 if the significant value (2-tailed) > 0.05 (there is no difference in the average pretest and posttest values).

III. RESULTS AND DISCUSSION

Results

The effectiveness test was conducted to determine how effective the E-LKPD was in improving students' scientific literacy through implementation activities in the field. The E-LKPD implementation activity was carried out by applying the E-LKPD that had been validated and practical in actual classroom learning with one sample. The material studied was global warming which was designed for face-to-face learning with four meetings and two meetings for pretest and posttest. The implementation of learning using E-LKPD was carried out on 25 students of class X phase E.2 of SMAN 1 X Koto Diatas. The design used in the implementation stage was a one group pretest-posttest design.

The science literacy test, used as a research instrument, consisted of five questions. The instrument was distributed to students in the form of printed sheets of science literacy questions. The time allocated to students was twice the class period, or 90 minutes. Students were asked to submit their answers when the time was up.

The data obtained in this study consisted of pretest and posttest scores for each scientific literacy indicator. The pretest and posttest scores for the experimental class are presented in Table 4 below:

Table 4. Average Results of the Science Literacy Test

No	Science Literacy Indicators	The results of the average pretest score	Posttest average score results
1	Explaining phenomena scientifically	43	83
2	Interpreting data and evidence scientifically	40	84
3	Evaluating and designing scientific investigations	39	82

Based on the data analysis in Table 4, it can be described that the average value of scientific literacy per science competency shows that there is a difference in students' scientific literacy values between the pretest and posttest, where students' scientific literacy during the posttest is superior to the pretest. To see the effectiveness of the PBL-based E-LKPD to improve high school students' scientific literacy on global warming material in the experimental class, it can be seen in the N-Gain test, Normality test, and Effect size test below:

Table 5. N-Gain Score Results

N-Gain Test Results	**Lowest Score**	**Highest Score**	**Average N-Gain**	**category**
N-Gain Score	0.36	0.71	0.56	Enough
N-Gain Percent	0.35	0.70	0.56	Enough

Based on table 5, it can be seen that the average N-Gain score of the experimental class is 0.56, with the highest score being 0.71 and the lowest score being 0.36. Meanwhile, the average percent score is 56, with the highest score being 70.49 and the lowest score being 35.71.

Table 6. Results of normality test

Science Literacy Test Results	Class	Shapiro-Wilk		
		statistics	df	Sig.
	Pretest	.920	25	.050
	Posttest	.934	25	.109

Based on the results of the normality test, it can be seen that the pretest value of the experimental class obtained a significant value of 0.050 and the posttest obtained a significant value of 0.109. Based on the testing criteria, the data is said to meet the normality assumption if the significant value is > 0.05. The significant value of the pretest data is sig 0.05 > 0.05 and the significant value of the posttest is 0.109 > 0.05. Therefore, it can be concluded that the pretest and posttest values in the experimental class are normally distributed.

DISCUSSION

This research was conducted in class X phase E.2 SMAN 1 X Koto Diatas by implementing E-LKPD based on the Problem Based Learning (PBL) model. Learning was carried out following the syntax of the PBL model which consists of five stages, namely: (1) orienting students to the problem, (2) organizing students to learn, (3) guiding individual and group investigations, (4) developing and presenting work results, and (5) analyzing and evaluating the problem-solving process.

Learning begins with introductory activities where the teacher conveys the learning objectives, forms study groups consisting of 4-5 students, connects the global warming material with previous material, and raises problems related to the students' daily lives.

The first stage is the initial phase of problem-based learning, which aims to introduce students to authentic problems related to global warming. According to Arends[22]At this stage, the teacher presents real-life problems to students and motivates them to actively engage in problem-solving activities. In this study, students are confronted with the phenomenon of climate change and the impacts of global warming that they can observe in their daily lives.

In the second stage, the teacher helps students define and organize learning tasks related to the identified problem. Hmelo-Silver[23]He added that at this stage, students activate their prior knowledge and identify what needs further study to solve the problem. Students in groups discuss formulating research questions and planning steps for investigating global warming.

The third stage is the core phase where students conduct investigations. Savery[25]states that in PBL, students must actively seek information, analyze various sources, and construct their own knowledge through an inquiry process. At this stage, E-LKPD plays a crucial role in

facilitating the inquiry process by providing activity guides, multimedia information sources, and guiding questions that guide students in developing their scientific literacy.

The fourth stage involves students in developing research products and presenting them.[24]He added that presenting work in PBL is not just about conveying information, but also a science communication process that trains students to communicate scientific ideas clearly and convincingly. Students present their findings on the causes, impacts, and solutions to global warming based on the results of group investigations.

The final stage is the reflection phase, where students analyze and evaluate the problem-solving process they have undertaken. Savery[25]states that reflection is an important component in PBL that allows students to consolidate their learning, identify strengths and weaknesses in the inquiry process, and connect new knowledge with their previous knowledge.

The results of the study indicate that learning using PBL-based E-LKPD is effective in improving students' scientific literacy. This is evident from the increase in the average scientific literacy score from 40.6 in the pretest (low category) to 83 in the posttest (high category). The N-gain score of 0.56 indicates a moderate increase, while the effect size test result of 0.96 indicates that PBL-based E-LKPD has an effective influence on improving students' scientific literacy.

This increase in scientific literacy occurred across all three scientific literacy competencies based on the 2018 PISA indicators. The competency of explaining phenomena scientifically showed an average posttest score of 83%, the competency of interpreting data and evidence scientifically reached 84%, and the competency of evaluating and designing scientific investigations reached 82%. The even increase across these three competencies indicates that the PBL-based E-LKPD is capable of facilitating the development of scientific literacy comprehensively.

The effectiveness of PBL-based e-LKPD in improving scientific literacy can be explained by several factors. First, e-LKPD provides interactive multimedia content that is engaging and makes it easier for students to understand the concept of global warming. Second, the systematic syntax of PBL guides students to develop higher-order thinking skills through authentic problem-solving. Third, problem-based learning encourages students to actively construct their own knowledge, making learning more meaningful.

The findings of this study are in line with Harahap's opinion that the use of PBL-based E-LKPD can improve students' scientific literacy by teaching students to use their scientific knowledge to solve questions, make decisions based on facts, and relate them to everyday life. Problem-based learning supported by E-LKPD facilitates students to develop the ability to explain scientific phenomena, interpret data and evidence, and design scientific investigations, which are core competencies of scientific literacy.

Thus, the PBL-based e-LKPD has proven effective as an alternative teaching material to improve high school students' scientific literacy on global warming. Learning with PBL-based e-LKPD not only improves conceptual understanding but also develops the scientific literacy skills students need to face the challenges of the 21st century.

IV. CONCLUSION

E-LKPD based on PBL model aims to determine the effectiveness of improving low scientific literacy skills of students. The effectiveness test uses scientific literacy questions totaling 5 valid and reliable questions. This E-LKPD obtained effective results in improving scientific literacy of students. The average pretest score was 40.6 with a low category, while the average posttest score was 83 with a high category. The N-gain score obtained was 0.56 so it is included in the moderate category. Based on the results of the study, it can be concluded that PBL-based LKPD to improve scientific literacy is effectively used in learning physics on global warming material at SMAN 1 X Koto Diatas (H0 is accepted). based on the results of the effect size test obtained was 0.96 with an effective category.

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