The Influence of an Integrated STEM Project-Based Learning toward Science Literacy Abilities Students in Elementary School'
[Pengaruh Model *Project Based Learning* Terintegrasi STEM Terhadap Kemampuan Literasi Sains Peserta Didik Sekolah Dasar]

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Abstract*. This study aims to demonstrate the effect of Project Based Learning integrated with STEM on the science literacy skills of students, given the low level of science literacy skills among elementary school students. Using a quantitative quasi-experimental approach, data was collected using a test sheet instrument, and data analysis was conducted using independent samples t-test and paired samples t-test. The results of the independent samples t-test showed a sig value of 0.003 < 0.05, indicating that the null hypothesis (H0) was rejected and the alternative hypothesis (Ha) was accepted. This means that the science literacy skills of students who used the Project Based Learning integrated with STEM model were more effective than those who learned using conventional models. Furthermore, the paired samples t-test showed a sig value of 0.00 < 0.05, indicating that Ha was accepted and H0 was rejected, meaning that the use of the Project Based Learning integrated with STEM model can improve students' science literacy skills. Based on these results, it can be concluded that the implementation of the Project Based Learning integrated with STEM model can have an impact on students' science literacy skills.*

Keywords - *Science Literacy Abilities, Integrated STEM Project-Based Learning, Elementary School.*

I. PENDAHULUAN

Science or STEM education is highly relevant to real-life situations. At the elementary school level, science education is highly beneficial to a student's overall education as it provides a foundation for them to face the challenges of the global era. One of the goals of science education at the elementary level is to develop skills and understanding of scientific theories that are useful and applicable in daily life [1]. The objective of science education is to support students in mastering and interpreting facts and scientific theories from natural phenomena, and to apply them in their daily lives in order to develop a scientific attitude [2]. Developing knowledge and abilities to make decisions regarding problem-solving requires skills such as scientific literacy [1].

The term "science literacy" consists of the words "literacy" and "science". Literacy refers to the ability to read and write, while science refers to the knowledge and understanding of the natural world. [3]. Science literacy is the ability of students to use scientific concepts and apply them in their daily lives, explain scientific phenomena, and describe them based on scientific evidence [4]. Science literacy involves interpreting scientific concepts and processes that enable individuals to draw conclusions from their understanding, and participate in matters of state, economic growth, and culture [5]. To compete in the modern era and to provide a foundation for students to face the changing times with the skills they have, science literacy is essential to be taught to elementary school students. Science literacy can be taught and developed during the learning process [6]. Science literacy is an important component to be mastered by every student because it is closely related to how a person can understand the environment and the problems faced by modern society, which are usually centered around technological and scientific advancements. Social issues are one of the problems that need to be addressed [7]. In conclusion, the importance of mastering science literacy lies in the rapid development of technology and science. Therefore, the ability to think systematically, creatively, critically, and communicate effectively in various fields is ademand for every individual [1].

More than 10 million students in OECD (Organization for Economic and Cultural Development) countries have low literacy skills. Compared to 2009, Science Literacy Skills have not shown significant progress (≤ 2%). Indonesia is one of the countries with a low level of Science Literacy Issues [8]. The results of the Trends in International Mathematics and Science Study (TIMMS) 2015 assessment, which was taken by fourth-grade elementary school students in Indonesia, scored 397 points and ranked 44 out of 49 countries [9]. The interest in reading among Indonesian society is very concerning, with only 0.001% of 1000 people having an interest in reading according to UNESCO [10]. The government has made efforts to improve students' literacy skills, including reading literacy, science literacy, and mathematics literacy. The implementation of a curriculum that requires integrated learning is part of the government's policy, with hopes that students can capture a subject holistically and integratively. However, this is not accompanied by the provision of learning materials such as science literacy textbooks or science literacy questions as evaluation tools [4]. The level of science literacy among students in Indonesia is still below average, which is influenced by various problems, including the education system, curriculum, methods, and models chosen by teachers, learning facilities, learningresources, and teaching materials. One of the main factors that is closely related to students' low literacy skills is the selection of teaching methods and models during learning activities [7]. The issue of literacy skills has long been the focus of discussion and debate in various media. Students' literacy skills play a crucial role in shaping their learning behavior [11]. Reasoning, logic, critical and creative analysis are components that form science literacy skills. To form these components, there needs to be science literacy indicators. PISA 2018 divides science literacy indicators into three aspects: (1) Being able to explain phenomena scientifically, (2) Evaluating and designing scientific investigations, (3) Interpreting data and evidence scientifically [12]. PISA 2018 also divides the assessment of students' science literacy into three parts: (1) Context refers to situations that can provide problems, from which information can be obtained to solve the problem, (2) Knowledge refers to understanding facts, concepts, and theories to form the basis of knowledge, (3) Competencies refer to the ability to explain phenomena scientifically, evaluate, design and interpret data and evidence scientifically [12].

In reality, many elementary school students still have low science literacy skills. This was proven by the results of a pre-research test conducted by researchers on January 9, 2023, at Boro Elementary School on the topic of temperature and heat. The test results conducted on fifth-grade students at Boro Elementary School indicated that their science literacy skills were still relatively low, as shown by the average test score obtained, which was 45.2. This means that the science literacy skills of students at SD Negeri Boro are very low. The lack of science literacy skills among students is also due to the learning process that has not yet focused on science literacy [13]. This is evidenced by the results of interviews conducted at SD Negeri Boro, where many students are still not competent when asked to explain natural phenomena scientifically. They are still unable to explain the knowledge they have gained in their own words, and they also struggle to solve science-related problems. The results of these interviews indicate that the learning activities used at the school have not yet focused on science literacy.

Efforts to solve the existing problems at Boro Elementary School include innovation and changes in the learning process to expand students' creativity, thinking patterns, and science literacy. The improvement of creativity, thinking patterns, and science literacy can be achieved through various learning strategies, such as Project-Based Learning. Project-Based Learning is a learning model that focuses on project activities [14]. This learning model is used to help students easily absorb the material during the learning process by allowing them to practice directly. When students encounter problems, they can analyze, respond, and solve them immediately [15]. One of the benefits of implementing the Project Based Learning model is that: 1) students are directly involved in a real-life problem that is interconnected and aims to describe the issues and problems in everyday life; 2) it requires inquiry techniques, research, planning skills, critical thinking, and problem-solving skills in project development; 3) students must be involved in project development to practice their knowledge and skills in various contexts; 4) students are given the opportunity to learn and hone interpersonal skills while working in a group with adults; 5) it provides time for students to use the skills and abilities needed for life and work; 6) it includes speculative actions that encourage students to think critically, relate their experiences to learning standards [16]. Project Based Learning can also be integrated with the STEM learning approach. The implementation of a STEM-based Project Based Learning model, as shown by research results, can improve science literacy skills, make learning more meaningful, and help students solve real-life problems. [14]. Moreover, the Project Based Learning model integrated with STEM provides challenges and motivates students because it can train them to think critically, analyze, and improve their skills.[17].

The Project-Based Learning model can develop students' science literacy in terms of competence and attitude, as well as integrating Project-Based Learning with STEM approaches in learning [18]. Project Based Learning integrated with STEM is one of the efforts to improve creativity for students, which must be done to improve the quality of learning activities. With the Project Based Learning integrated with STEM model, the learning process will be more meaningful and increase the creativity of students. Students can be more active and able to solve problems on their own. Project Based Learning integrated with STEM can improve students' science literacy skills, problem-solving skills, and communication skills, which can be trained through the use of digital media technology. [19]. The role of technology cannot be denied as a tool to facilitate human activities, including learning. Digital media can be used as a learning resource when the environment, tools, or materials are not feasible or even dangerous to use. The use of STEM approaches in learning will provide variation and innovation so that students can learn by linking problems that exist in everyday life.

The STEM learning approach is an approach that combines four disciplines that were originally separated in traditional learning activities and applies them to make learning relevant for students. The four disciplines integrated in the STEM approach are Science, Technology, Engineering, and Mathematics. Students are required to have knowledge and skills to solve science problems using technology [1]. The STEM approach can guide students to gain a comprehensive understanding, be more capable of solving problems in daily life, and develop critical thinking skills [20]. The use of the STEM approach in the learning process can provide many benefits for students because it does not focus on one science discipline only [6].

The steps or syntax of Project-Based Learning developed by The George Lucas Educational Foundation are as follows: (1) Starting with Essential Questions - selecting a topic that is relevant to the real world. This is aimed at eliciting knowledge, responses, criticisms, and ideas from students on the project theme to be undertaken, (2) Planning Project Work Rules - planning project work rules, selecting activities that support answering essential questions, integrating various subjects, and determining the tools and materials needed for project completion, (3) Scheduling Activities - collaboratively scheduling project completion activities between teachers and students. This is done to determine the time needed to complete the project, (4) Monitoring - teachers monitor project work carried out by students, facilitating students at every stage of the project, (5) Evaluation - assessment is done to measure the achievement of standards, evaluate student progress, and provide feedback on the level of understanding achieved by students. Students present the results of their project work and write a report on the work done, (6) Reflection - teachers and students reflect on the activities and results of the project undertaken. At this stage, students are asked to express their feelings and experiences during the project completion process.

Based on the background information presented in this study, it is necessary to use a learning model to determine the effect on students' science literacy skills. Therefore, this research was conducted to analyze the effect of Project Based Learning-STEM on the science literacy skills of elementary school students.

II. METODE

This research uses a quantitative approach, which is a research method that uses data in the form of numbers [21]. With a Quasi-Experimental or Pseudo-Experimental research design. The Quasi-Experimental design is a development of the True Experimental design, which is difficult to implement. Quasi-experiments have a control group, but cannot fully function to control external variables that affect the experiment [22]. Experimental research design aims to examine the causal relationship between the treatment given to one group and the absence of treatment given to another group [21]. Experimental research also has a special characteristic, which is the manipulation of variables or the relationship between variables [21].

This research uses the first group (experimental) which uses the Project-Based Learning model integrated with STEM, and the second group (control) which uses the Conventional learning model. By using a nonequivalent control group design, which is almost the same as the pretest-posttest control group design, but in the nonequivalent design, the experimental and control groups are not selected randomly. This design uses two groups, namely the experimental group (which is given the Project-Based Learning model integrated with STEM) and the control group (which is given the Conventional learning model). Pretest and Posttest are used to determine the level of success of using the learning model. Pretest provides an overview before the learning model is given to determinethe initial condition of students' science literacy ability. Posttest provides an overview after the learning model is given, to determine the extent of the influence of the Project-Based Learning model integrated with STEM. When a significant change occurs in the science literacy ability of students during the science learning process in the experimental group, then the results of this experiment can be said to have an effect.

Table 1 : Non-equivalent Control Grup Design

Kelompok	Pretest	Variabel Bebas	Posttest
Eksperimen	O_1	X_1	O_3
Kontrol	O_2	X_2	O_4

Explanation of Table 1
X_1: Giving the Project-Based Learning model integrated with STEM.
X_2: Giving conventional learning model.
O_1: Pretest results of the experimental group.
O_2: Pretest results of the control group.
O_1: Posttest results of the experimental group.
O_2: Posttest results of the control group.

During population research, population and sample are essential elements. Population refers to a large group within an institution or organization that will be studied [21]. The population in this study is the students of Boro

Elementary School in Tanggulangin District, Sidoarjo City. Meanwhile, the sample is a group of individuals or items. The sample used in this study consists of 16 students from class VA as the experimental group and 16 students from class VB as the control group, selected using probability random sampling technique by drawing from each class. Thus, a total of 32 students were selected as the sample. There are two variables used in this study, namely the independent variable with the Project Based Learning integrated STEM model and the dependent variable with the form of science literacy ability. The instrument used in this study is an assessment test sheet used to measure the science literacy ability of students. The assessment test sheet is divided into two parts, namely the pretest and posttest. The pretest is conducted at the beginning of the learning process to determine the level of science literacy ability before the implementation of the Project Based Learning integrated STEM model, while the posttest is given to determine the science literacy ability after the implementation of the Project Based Learning integrated STEM model. The pretest and posttest sheets have undergone validity and reliability testing, with the final result using 10 valid and reliable questions. The pretest and posttest sheets contain 10 multiple-choice questions, with a scoring technique of 10points for correct answers and 0 points for incorrect answers. The data collection technique used in this study is a method used by the researcher to produce data from the study in the form of the test sheets. The data obtained from this study is the science literacy ability data of the students. The data collection instrument used in this study is a pretest and posttest sheet.

Before conducting data analysis, prerequisite tests such as normality test and homogeneity test were performed using SPSS version 26.0 for Windows. The data analysis technique used was inferential data analysis, which includes the independent samples t-test and paired samples t-test. These tests were also performed using SPSS version 26.0 for Windows.

III. Hasil dan Pembahasan

Project Based Learning integrated with STEM is a learning model that requires students to create a project. Class VA, as the experimental group that received the Project Based Learning integrated with STEM model, created a simple project, which was a water purification tool. The activity was conducted in two learning sessions. In the first session, students were given a topic that is related to daily life, which is water issues. The teacher presented a problem to the students and they analyzed two pictures to determine how a dirty river can become clean. The following excerpt illustrates this process:

Teacher	: "Which picture is better to look at?"
Amel	: "Picture B."
Teacher	: "What is your reason for choosing picture B?"
Satrio	: "Because the river in picture B looks clean."
Aisyah	: "There is no trash."
Teacher	: "Correct. The river in picture A is not pleasant to look at because of the accumulation of garbage. Based on this picture, what should you do to make the water in the river clear?"
Students	: "Clean the river from the trash, and do not throw trash in the river."

During this learning session, the teacher guided the students to predict and explain which picture is better to look at and what should be done to make the river clean. The teacher then guided the students to design a project plan in the form of a water filter device. The students searched for information about water purifier designs on electronic media. After finding the designs, the students were asked to write down thematerials and steps on the provided worksheet. Then, the students designed the water purifier device and sketched the design.

Figure 1. Designing Product Planning

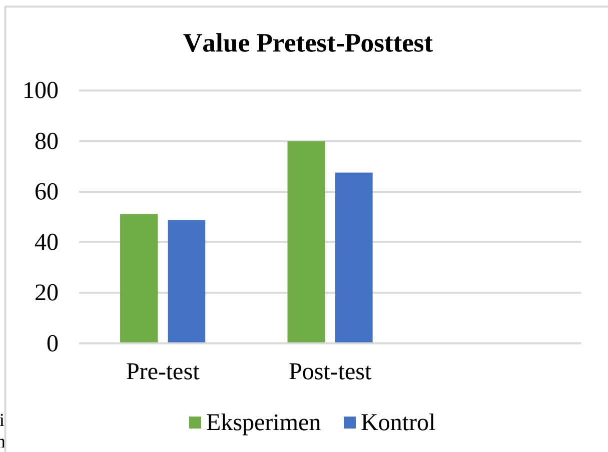
When designing the water filter tool, the students made design drafts with different arrangements of materials. Next, the students were asked to arrange a schedule for completing the product. They discussed the schedule with their groupmates to determine how long the product could be completed.

On the second day of learning, the teacher monitored the progress of the water filter tool project, asking about the progress of the project starting from the materials that had been brought. Then, the teacher guided the students to start conducting experiments. The students started by cutting and arranging the materials from the sketch made the day before. After the arrangement of the water filter tool materials was completed, the students then conducted an experiment by pouring murky water into the water filter tool.

Figure 2. Product Trials

In the first experiment using the arrangement of materials such as sponge, coconut fiber, charcoal, and coconut fiber head, the result of the first filtration was still slightly cloudy, and they tried to filter it again until the 8th filtration, and the filtered water became clear. In the second experiment using a different arrangement of materials such as cotton, tissue, gravel, coconut fiber, charcoal, and tissue, the first filtration produced clear water. The groups then concluded from the products they tested. The conclusion of the water purifier experiment was that the water quality produced by each group's water purifier with different material arrangements varied. In the first experiment, the water was slightly cloudy due to the sponge material not being able to absorb dirt from the cloudy water effectively and the material arrangement not being compact enough. Thus, multiple filtrations were required. In the second experiment, the water became clear after a single filtration because the cotton and tissue in the material arrangement could directly absorb the dirt in the cloudy water.

The activity was conducted in two classes, VA as the experimental group who received the Project Based Learning integrated STEM model, and VB as the control group who received conventional learning models. The material used was theme 8, sub-theme 3, environmental conservation efforts. The discussion of the research results will show the learning outcomes of the experimental and control groups. The experimental group was given the Project-Based Learning-STEM model, and the control group was given the conventional learning model. After the experimental group received theProject-Based Learning integrated STEM model and the control group received the conventional learning model, pretest and posttest scores were obtained for both groups. The results will be used to analyze the effectiveness of the Project-Based Learning integrated STEM model in improving students' learning outcomes compared to the conventional learning model.



Picture 3. The Pretest and Posttest Results for the Experimental and Control Groups

The results in Figure 3 show that the science literacy score for the experimental group before receiving the Project Based Learning integrated with STEM model was 51.25, and after receiving the model, the score increased to 80. This is because in the learning process using Project Based Learning integrated with STEM, students play a major role in formulating and solving problems on their own.

Furthermore, a prerequisite test was conducted, followed by a hypothesis test, to determine the effect of using the Project Based Learning integrated with STEM model for problem-solving. The summary of the prerequisite test is presented in Table 2.

Tabel 2 : Test of Homogeneity

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Learning Outcomes	Based on Mean	.808	1	30	.376
	Based on Median	.789	1	30	.381
	Based on Median and with adjusted df	.789	1	29.917	.381
	Based on trimmed mean	.808	1	30	.376

Based on the data in Table 2, The homogeneity test was performed using the Levene's test in SPSS for Windows version 26. The result showed a significance value based on mean of 0.376. According to the decision rule, if the significance value of the mean is found to be > 0.05, the data can be concluded as homogenous. After that, the sample was determined using simple random sampling method. Simple random sampling was carried out by randomly selecting 16 students from class VA as the experimental group and 16 students from class VB as the control group. Subsequently, the normality test was conducted, as presented in Table 3.

Table 3 : Tests of Normality

Tests of Normality				
	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Student Learning Outcomes	Pretest Eksperimen	.922	16	.184
	Posttest Eksperimen	.911	16	.122
	Pretest Kontrol	.922	16	.182
	Posttest Kontrol	.921	16	.176

Based on the results in Table 3, the normality test was performed using SPSS for Windows version 26. The Shapiro-Wilk formula was used, and the significance values for the pretest and posttest data in the experimental and control groups were found to be > 0.05. This means that the pretest and posttest data in both the experimental and control groups are normally distributed. Since the normality test results are normal, data analysis can proceed.

Pretest data analysis, or the analysis of science literacy skills before the implementation of the STEM-based Project Based Learning model, was conducted to determine whether there was a difference in the average science literacy skills of students in the experimental and control groups. If the significance value is < 0.05, then the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted, indicating a significant difference. The hypothesis test was performed using the independent samples t-test, which is presented in the table below.

Table 4 : Hypothesis Test Independent Sample t-test Pretest

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning Outcomes Pretest	Equal variances assumed	.808	.376	.587	30	.561	2.500	4.257	-6.195	11.195
	Equal variances not assumed			.587	29.019	.562	2.500	4.257	-6.207	11.207

Based on Table 4, the independent samples t-test for the pretest data yielded a significance value of 0.561, which means that the significance value is > 0.05. This indicates that there is no significant difference or that the initial science literacy skills in the experimental and control groups in Class V are the same or not different.

Next, the hypothesis test was conducted to determine the science literacy skills of students in the experimental and control groups using the Independent Samples t-test. The hypothesis test was performed using SPSS version 26.0 for Windows with a significance level of $\alpha = 0.05$ or 5%. If the significance value is < 0.05, then the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted, indicating that the science literacy skills of students in the experimental group are better than those in the control group. The hypothesis test using the t-test is presented in the table below.

Table 5 : Hypothesis Test Independent Sample t-test Posttest

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning Outcom	Equal variances assumed	1.596	.216	3.2	30	.003	12.500	3.819	4.701	20.299

es		7						
Posttest		3						
	Equal variances not assumed	3.273	28.846	.003	12.500	3.819	4.688	20.312

Based on Table 5, the t-test results for the science literacy skills posttest yielded a significance value of 0.03, which means that the significance value is < 0.05. This indicates that the science literacy skills of students who received the Project Based Learning integrated with STEM model are better than those who received the conventional model. Therefore, it can be concluded that the use of the Project Based Learning integrated with STEM model has an effect on the science literacy skills of Class VA students at Boro Elementary School.

The next hypothesis test was conducted to determine whether there was an increase in the pretest and posttest scores after the implementation of the Project Based Learning integrated with STEM model in the experimental group. This test used the paired samples t-test.

Table 6 : Hypothesis Test Paired Sample t-test

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-28.750	15.000	3.750	-36.743	-20.757	-7.667	15	.000

Based on Table 6, the significance value obtained is 0.00, which is less than 0.05. This means that there is a significant effect on the science literacy skills of students after the implementation of the Project Based Learning integrated with STEM model at Boro Elementary School. Therefore, it can be concluded that the use of the Project Based Learning integrated with STEM model has a significant effect on the science literacy skills of students.

The difference in models and methods used in the learning process between the experimental and control groups can differentiate the results of students' science literacy ability. The implementation of the Project-Based Learning integrated STEM model makes students more active. By using the Project-Based Learning integrated STEM model, learning becomes more interesting and engaging [20]. That being said, the implementation of the Project Based Learning integrated with STEM model in learning activities is expected to provide a new experience for students and motivate their interest in learning about environmental preservation. Through project-based learning, students can help develop their creativity, making learning more meaningful. This can help students remember the knowledge they have gained for a longer time, especially when using the Project Based Learning integrated with STEM model. The integration of STEM (Science, Technology, Engineering, and Mathematics) in this model allows students to apply their knowledge and skills simultaneously to solve problems they encounter.

The project results in the form of a water purifier tool and student worksheets. The application of the material concept through the Project-Based Learning integrated STEM approach can train students to understand the concept holistically based on contextualapplication, so that students can investigate the learning material and find solutions to solve problems. The project task is carried out in groups by conducting experiments with the water purifier tool. The water purifier tool is designed using various materials. Students will try to connect the concepts learned in the material and the problem to be solved in the project. The students' problem-solving abilities can be seen through the way they describe the problem and the solutions they provide.

Based on the research results obtained by the researcher, it is consistent with the findings of previous studies, such as [14], which showed that the science literacy achievement of students in the experimental group using Project-Based Learning based STEM has a higher average score compared to students in the control group using conventional learning. The same results were also obtained by [18], who showed that the influence of STEM learning through designing a boat model on STEM science literacy of students indicated a high achievement of science literacy ability in the experimental group. Additionally, according to the study conducted by [20], The results showed that there was no significant difference in the improvement between male and female students. Both male and female students experienced improvement in science literacy skills using the Project Based Learning integrated with STEM model. The findings of this study suggest that the Project Based Learning integrated with STEM model can improve the science literacy skills of students.

IV. Simpulan

Based on the results of the study, it can be concluded that the Project Based Learning integrated with STEM model has an effect on the science literacy skills of students in Class VA and VB at Boro Elementary School. This is confirmed by the hypothesis test using independent samples t-test, which yielded a significance value of 0.03, indicating that Ha is accepted and H0 is rejected. This means that the science literacy skills of students in the experimental group who used the Project Based Learning integrated with STEM model are better than those in the control group who used the conventional model.

Furthermore, the paired samples t-test also showed a significance value of 0.00, indicating that Ha is accepted and H0 is rejected. This means that there is an effect of the Project Based Learning integrated with STEM model on the science literacy skills of students after its implementation. In summary, it can be concluded that the implementation of the Project Based Learning integrated with STEM model has an effect on the science literacy skills of elementary school students at Boro Elementary School.

The author suggests that for future research on science literacy skills of students, the researchers should use test instruments that pay attention to the same number and level of questions in each aspect of science literacy and the tested content material. The researchers are also expected to use more diverse sources to improve the quality of the research.

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