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Research Artikel

THE INFLUENCE OF THE ILL-STRUCTURED PROBLEM BASED LEARNING MODEL ON STUDENTS' SCIENCE LITERACY ABILITY IN ENVIRONMENTAL CHANGE CONCEPT

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Abstract

Problem-based learning (PBL) is an effective pedagogy in increasing scientific literacy among students, and this strategy helps students acquire and apply knowledge and develop higher-order thinking skills that prioritize problems obtained from real life.This study aims to investigate the influence of ill-structured type problem-based learning (PBL) model on students' science literacy skills in environmental change concept. The research was conducted at MAN in Pandeglang in the 2023/2024 school year using a quasi-experimental method using a non-equivalent control group design. Two classes were selected as research samples (experimental class and control class) through simple random sampling technique. Data analysis using independent samples t-test with the help of IBM SPSS Statistics 26 showed that the value of sig. (2-tailed) of 0.004, which is below the significance level of α = 0.05. These results show that the use of ill-structured type problem-based learning models has a significant influence on improving students' science literacy skills. Thus, this learning model is effective in improving science literacy skills on the concept of environmental change.

Keywords*: Environmental change; ill-structured problem; problem based learning, science literacy, problem solving.*

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INTRODUCTION

Currently, education is crucial for the development of human resources, especially in science education in schools, which has a significant role in improving the standard of living of a country. One of the main goals of the science curriculum has been directly linked to scientific literacy as a global trend in science education (Guerrero and Torres-Olave, 2022). Science education has changed, focusing on helping students become scientifically literate (Bugtai et al., 2024)

A critical component of the Directorate of Education, formed collaboratively by countries in the Organisation for Economic Cooperation and Development (OECD), is the Programme for International Student Assessment (PISA) (OECD, 2019). PISA measures how students acquire the skills and information necessary to engage actively in society. The three fields evaluated in PISA are mathematics, literacy, and science. Indonesia has been participating in PISA since 2000. The 2018 PISA assessment ranked Indonesia 74th out of 79 countries, highlighting its low literacy rate (OECD, 2019).

As evaluated by PISA, scientific literacy involves engaging with scientific concepts and topics, evaluating and organizing scientific research, analyzing data and evidence, and using science to explain phenomena (OECD, 2017). According to PISA (2018), scientific literacy can be seen in three aspects: Competence, knowledge, and context.

However, education in Indonesia needs to address literacy needs better. Concerns about Indonesian students' poor scientific literacy have been raised, especially in biology classes (Adnan et al., 2021). True scientific literacy involves understanding scientific theories, knowing the nature of science, and appreciating the scientific endeavor, making it a significant and demanding achievement (Istyadji and Sauqina, 2023). Despite this, students' literacy skills are not developing because they need help to apply the concepts and theories they learn (Fauziyah et al., 2021)

This issue is further compounded by Indonesia's current learning process and assessment, which focus heavily on instructional aspects and cognitive mastery, often neglecting scientific literacy. Scientific literacy includes understanding and communicating science, using scientific knowledge to solve problems, showing sensitivity to oneself and the environment, and making judgments based on scientific information (Lestari et al., 2024)

In addition, science education in schools is expected to keep students up-to-date with technological advancements. This educational evolution is driven by technological progress, aiming to improve students' abilities and attitudes toward the scientific process for long-term concept retention.

In many cases, learning models still adhere to conventional methods, focusing solely on imparting knowledge to students without engaging their skills (Trisnayanti, 2017). Incorporating enjoyable techniques or approaches that prompt students to think critically while studying biology can make the subject more engaging and facilitate better comprehension of the material (Juriah and Zulfiani, 2019).

Interviews with biology teachers at MAN in Pandeglang show that some teachers have adopted a problem-based learning model. However, due to time constraints, biology learning is carried out through lectures and discussions; if teachers adopt a problem-based learning model, then the learning process will take longer. This lecture approach is often taught using textbooks provided by the school and supplemented by other resources such as presentations and group discussions.

Although various learning models have been available, problem-based learning models have become more attention-grabbing among academics. The learning model, "*Problem Based Learning* " utilizes scenarios or circumstances in situations similar to reality Camperos et al., 2022). PBL is a technique that can provide teachers extra time to oversee students' progress or facilitate group discussions to enhance the efficacy of learning (Lim, 2023). This is supported by research

(Supriwardi et al., 2021) on applying the PBL learning model, where students work on real-world problems to gain knowledge, hone their analytical skills to find the correct answers to problems and gain independence to feel more confident.

The following is a Figure 1 of a comparison of problem-based learning models and traditional learning models:

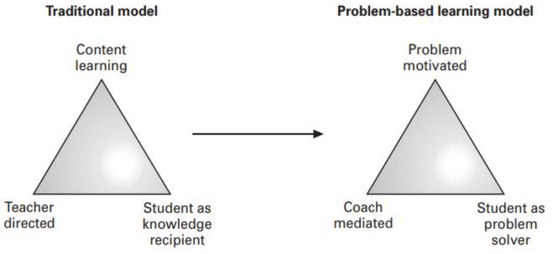

Figure 1. Comparison of problem based learning models and traditional learning models (Tan, 2021)

Problem-based learning has unique characteristics related to the various challenges during the learning process. In addition, there is a difference between learners' problem-solving skills for well-structured and ill-structured problems.

The problem-based learning (PBL) model is a model in which students are given real-world problems to solve. Learners' challenges before learning are intended to allow them to investigate, characterize, and resolve these issues. (Ardianti et al., 2022). *Problem-based learning* is a learning approach that encourages students to actively participate in their education by presenting contextual real-world challenges. Students are encouraged to "learn to learn" and collaborate in groups to find answers to problems often encountered in everyday life through problem-based learning. The challenge still connects students' interests with the subject matter studied. Before learning concepts or information related to the topic to be answered, students are first given a problem (Junaidi, 2020).

PBL is the best method to use higher-level critical thinking skills. The notion of critical thinking and the components of thought that go into it align with the PBL process. Students question, analyze, synthesize, interpret, infer, reason, apply, and employ creativity and intuition, for example, in PBL (Seibert, 2021).

The many types of problems are separated into two categories: problems that are not well structured or *ill-structured* and problems that are well structured or *well structured*. An ill-structured problem needs a clear statement, is open-ended, and has several possible solutions. Conversely, a well-structured type of problem is one that is closed, has a single solution, and is presented in an understandable way (Rahmasari and Susanah, 2022). The challenge was designed to capture the essence of ill-structured issues, including realism, transparency, and intrigue. Because of this, much information is offered in a problem scenario; Thus, it is essential to choose and arrange the information required for issue resolution (Cho and Kim, 2020). Research indicates that students find unstructured or ill-structured questions more challenging compared to well-structured ones (Supeno et al., 2020).

Problem-based learning uses ill-structured problems to help students integrate new cognitive thinking skills with prior information, experiences, and examples. This method also encourages diverse opinion for simplicity and adaptable problem-solving through thoughtful decision-making. This model aims to enhance students' technical, cognitive, creative, and problem-solving skills, making them valuable in today's global, competitive sectors (Miner-Romanoff et al., 2019).

The relationship between science literacy skills and the phases of *ill-structured* type problem-based learning shows that the PBL learning paradigm starts from a problem. Uncertain, unclear, or complex problems without a clear solution are called *ill-structured* problems. The problem-based learning model is caused by the problems given. To help learners develop their critical thinking skills, unstructured problems can be leveraged to engage and motivate learners. In addition, learners can find difficulties by compiling a list of questions that serve as clues to find and overcome the main problems raised in the reading (Septiana et al., 2017).

In biology subjects, the concept of environmental change is significantly related to the environment. Therefore, using the ill-structured *problem-based learning* model is undoubtedly the suitable learning innovation to improve the science literacy ability of students at MAN in Pandeglang. This allows learners' knowledge to develop by seeing and understanding the problems in their immediate environment and the factors contributing to environmental change. Gaining scientific literacy in biology might be challenging but worthwhile since it enables people to understand local and global social challenges (Bórquez-Sánchez, 2024).

Hafizah and Nurhaliza (2021) show that PBL-based learning is considered ideal for developing students' science process abilities from the problem-solving process. Apart from that, the ill-structured problem-based learning model is seen as more dialectical in building a problem space, generating solutions, and monitoring and implementing strategies. Therefore, problem-based learning of the ill-structured type involves not only the process of representing the problem and producing a solution, as found in the well-structured type of problem-based learning (although with different characteristics) but also, most critically, the process of building arguments as well as monitoring and evaluate, both explicitly and implicitly (Ge et al., 2016). This research focuses on improving students' scientific literacy skills by applying an ill-structured problem-based learning model to environmental change.

METHOD

This research is quasi-experimental research using the concept of environmental change. This research was conducted in the 2nd of the 2023/2024 academic year at MAN in Pandeglang. *Non-equivalent control group design* is the type of research design used in this study (Yasri et al., 2016).

Table 1. Research design non-equivalent control group design

	Pretest	**Treatment**	**Posttest**
Experiment	O_1	X	O_2
Control	O_3	-	O_4

(Abraham and Supriyati, 2022)

Information:

O_1 : Pretest on experiment class

X : PBL strategy was applied

O_2 : Posttest on experiment class

O_3 : Pretest on control class

O_4 : Posttest on contol class

The population of this study was all students of grade X at MAN in Pandeglang, while the research sample used in this study was class X-1 as an experimental class and X-8 as a control class of 30 students each. The research instrument used was a test of scientific literacy skills in the form of 6 essay questions.

The research was carried out in three stages. The first stage is pre-research observation with the aim of a preliminary study of the problems to be researched. The second stage is to analyze the test results, namely with essay test questions in the form of pre-test and post-test. The pre-test is carried out to determine students' initial abilities. The post-test was conducted to determine the student's final abilities after the treatment. The third stage is data analysis of scientific literacy ability scores using the independence samples t-test.

The science literacy test instruments used in this study have been tested for validity by qualified parties using construct and content validity. Science literacy problems are designed to include two aspects, namely, aspects of competence and knowledge of the concept of environmental change. In addition, an observation sheet is included to see student activities detailing the *Ill-Structured* type *Problem-Based Learning* learning model in the experimental class and the conventional learning model in the control class. At the same time, inferential analysis aims to test the hypothesis of the research being tested.

Students' scientific literacy ability scores refer to the percentage of achievement of a score for a parameter to be determined (Purwanto, 2006).

$$NP = \frac{R}{SM} \times 100\%$$

Information, NP = Value of scientific literacy abilities; R = The number of questions answered correctly, SM = Maximum value of the test.

The percentage of criteria for achieving students's scientific literacy abilities is categorized based on criteria according to the rules Arikunto Suharsimi (2013) as shown in Table 2.

Table 2. Criteria for achieving student's scientific literacy abilities

Achievement Interval	Criteria
86-100%	Very high
71-85%	High
56-70%	Moderate
41-55%	Low
≤ 40%	Very low

RESULTS AND DISCUSSIONS

Data analysis was performed using *IBM SPSS Statistics SPSS 26.* This study's assessment instruments comprised six items with 60 respondents. Data on the results of students' science literacy skills in grades X-8 (control class) and X-1 (experiment class) related to the concept of environmental change are shown in Table 3. Below.

Table 3. Data Centering and Dissemination Control Class and Experiment Class

Concentration and Data Deployment	Control Class		Experiment Class	
	Pre-test	*Post-test*	*Pre-test*	*Post-test*
Value max	57	92	50	92
Value min	14	35	14	42
Mean	37	59.2	32	68.6
Median	35	57	31.5	71
Modus	35	50	28	71
Varians	138	168	79.06	131
Std.Deviation	1.63	1.82	1.25	1.62

Table 3. shows that the average pretest and posttest in control and experiment class. In addition, the standard deviation of the control class was greater than that of the experimental class before treatment. In other words, if the numbers in standard deviation are smaller, the data is usually distributed. Conversely, the mean value is less accurate if the standard deviation value is more significant. Compared to the control class, which had a standard deviation of 1.63 for the pretest and 1.82 for the posttest, the experimental class had a standard deviation of 1.25 before receiving treatment and 1.62 after receiving treatment using the problem-based learning model.

Science Literacy Ability per Indicator

The Programme for International Student Assessments (PISA), part of the *Organisation for Economic Cooperation and Development (OECD)* since 2000, is used to assess the knowledge and skills of 15-year-olds worldwide every three years. The three areas evaluated were science literacy, reading comprehension, and mathematical literacy. In this study, science literacy skills are the key focus, while also incorporating both competency and knowledge components as aspects of the literacy assessment.

According to PISA 2018, the three competencies assessed in science literacy ability are explaining scientific phenomena, evaluating and designing research scientifically, and interpreting data and evidence scientifically. The aspects of knowledge assessed are content, procedural, and epistemic knowledge. The following figure shows the average percentage of *pre-test* and *post-test* scores of science literacy skills in control and experimental classes from before and after the test:

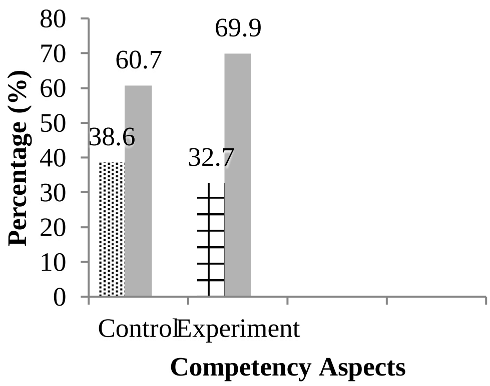

Figure 2. Average Percentage *of Pre-test* and *Post-test* Classes Control and Experimental Competency Aspects

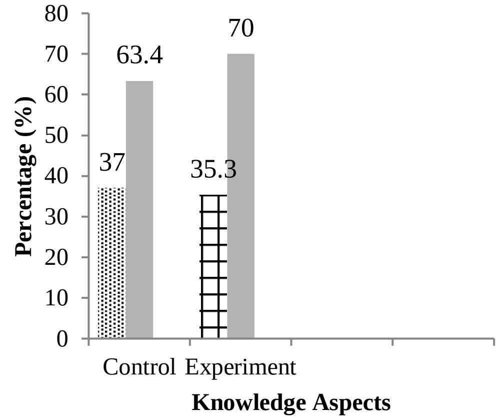

Figure 3. Average Percentage *of Pre-test* and *Post-test* Control Class and Experimental Class Knowledge Aspects

Figures 2 and 3 show that the average percentage of results of science literacy ability in 2 aspects (competence and knowledge) increased in the experimental class compared to the control class. The maximum percentage score obtained by the experimental class on two elements with three indicators each, namely 69 on the competency aspect and 70 on the knowledge aspect.

The ability to increase students' science literacy can be ensured using the *N-Gain*formula. Figure 4 below shows the average N-Gain values of both classes.

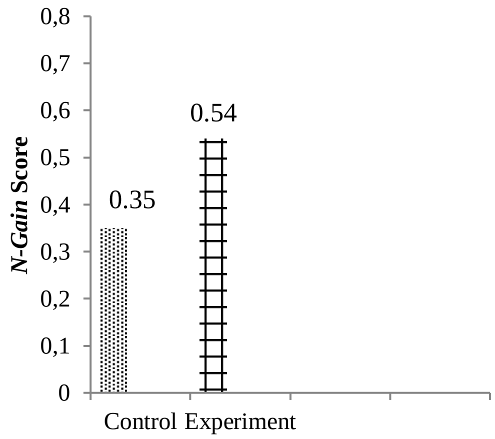

Figure 4. *N-Gain* Score Control Class and Experimental Class

Figure 4 shows the average *N-Gain scores of* the control and experimental classes indicating the changes of student's science literacy in the concept of environmental change. The control class had an *N-Gain score* of 0.35, placing their science literacy level in the moderate category. In contrast, the experimental class had an *N-Gain* score of 0.54 which falls into medium category and scored higher than the control class.

A normality test was conducted to determine whether the samples used in this study came from a normally distributed population. Normality was assessed using the *Shapiro-Wilk* test.

Table 4. Normality Test Results

Shapiro-Wilk	**Control Class**		**Experiment Class**	
	Pre-test	***Post-test***	***Pre-test***	***Post-test***
Sample (N)	30	30	30	30
Sig	0.119	0.105	0.220	0.338
α	0.05			
Results	Normal			

The data in Table 4 shows that the control and experimental classes get a sig value of > 0.05, so it can be concluded that the *pre-test* and *post-test results* in both classes are normally distributed. A homogeneity test was carried out after the normality test, and data was normally distributed in both classes. The homogeneity of variance was evaluated using Levene's test. The results of the homogeneity test can be seen in the following Table 5.

Table 5. Homogeneity Test Results

Levene Statistics	***Pre-test***	***Post-test***
Sig	0.217	0.497
α	0.05	0.05
Information	0.217 > 0.05	0.497 > 0.05
Results	Homogen	Homogen

The data in Table 5 shows that the control and experimental classes get a sig value of > 0.05, it can be concluded that the *pre-test* and *post-test results* in both classes are homogeneous. After normality and homogeneity tests, the data showed that both classes were normally distributed and homogeneous. A hypothesis test was then conducted, which measured differences in literacy skills in both classes. SPSS 26 is used to test hypotheses. Table 6. shows the results of hypothesis testing.

Table 6. Independent Samples T-Test

	Independent samples t-test t-test for equality of means		
	Sig.(2-tailed)	***Mean difference***	***Std.error difference***
Equal variances assumed	.004	-1.333	.446
Equal variances not assumed	.004	-1.333	.446

According to the criteria used to draw test conclusions, if the significance level exceeds 0.05, H0 is considered acceptable, and H1 is ignored. An independent samples t-test was conducted to compare the post-test scores of the experimental group and the control group. The results (Table 6) show a significant difference between the groups, with a sig. (2 tailed) of 0.004 this indicate that the ill-structured problem-based learning method had a statistically significant impact on student literacy skills compared to conventional methods.

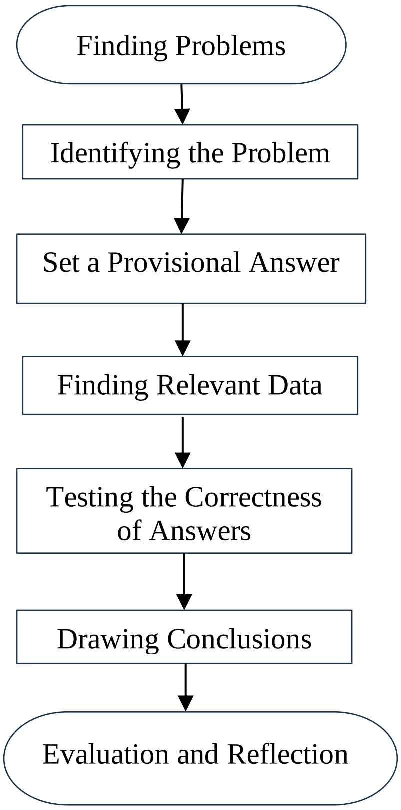

Figure 5. Stages Problem Based Learning Ill-Structured

Figure 5 Shows the stages of ill-structured problem-based learning. The stages of ill-structured problem-based learning begin with finding the problem. The problems found by students are then identified by determining the problem's core and formulating problems related to the problems presented. In the next stage, students are asked to establish temporary answers in the form of hypotheses to the problems presented. After students make hypotheses about the problems presented, they seek information using literature studies; at this stage, students begin to collect the information presented in the problem and create appropriate solutions. Students in the next stage test the correctness of the answers; in this stage, students discuss with each other and develop solutions in several aspects of the problem so that appropriate solutions to the hypotheses proposed are obtained. Concluding is the last stage of the *problem-based learning stage of ill-structured learning; after* students discuss each other in determining solutions and the most appropriate solution, students conclude that appropriate solutions to problems are obtained. After that, the completion stage is completed by evaluating and reflecting on students' performance in solving problems using *the ill-structured problem-based learning model.*

The learning model analyses how to improve students' science literacy skills. The average result of science literacy ability when *pretesting* in the control class was 37, while the experimental class got an average pretest value of 32. These results showed that science literacy skills between students in the experimental and control classes still needed to be improved. The results of pretest data testing are used as the basis for the first decision-making.

After being given treatment, there were visible differences in the science literacy ability of students between experimental classes using *ill-structured problem-based learning* models and control classes using conventional learning models. This can be seen from improved science literacy skills results, especially in experimental classes that apply *ill-structured* problem-based learning *models*. Based on post-test results, the average results of students' science literacy skills in the experimental class increased to 68.6.

Problem-based learning, ill-structured, allows students to work in a learning environment that mimics real-world difficulties, where they must discover related information, generate hypotheses, and generate solutions to complex and unclear problems that are supported by evidence. Students with a deeper understanding often approach PBL with extraordinary enthusiasm because it allows them to use their scientific knowledge and abilities in a relevant and in-depth context. In addition, because the PBL class genuinely led to critical thinking over time, the approach can help students develop their critical thinking skills more effectively (Noprianda et al., 2019). One of the students in the experimental class was a clear example of this; he succeeded in incorporating scientific ideas into a PBL model about how the environment changes. This can be seen from how these students participate in group discussions to discuss their findings and explore solutions to environmental problems. This discussion can be supported by the data collected during the literature study.

Students enhance their science comprehension through this problem-based learning experience and gain expertise in data analysis, scientific reasoning, and teamwork. As a result, top students understand better how science relates to environmental change. The ill-structured problems direct perfectly outstanding students to comprehensively learn their science literacy skills and engage them to face real-world problems with greater competence and confidence.

A final test or post-test was given after being treated in the experimental class using a PBL model and in the control class using conventional learning. Prerequisite testing is performed against *the post-test* data of both classes before proceeding to hypothesis testing.

Hypothesis testing is done after homogeneity and normality tests have been performed. With the help of the SPSS 26 program, hypothesis testing *of the independent samples t-test* obtained hypothesis H1 accepted and hypothesis H0 rejected, meaning that students who use problem-based learning models have a higher average score than students who use conventional learning models in science literacy skills.

The learning model affects the difference in science literacy scores between the two classes. This is consistent with research (Nurhayati et al., 2023) that PBL helps students gain analytical skills and a better understanding of science subjects, which are very important for improving science literacy.

The two aspects researchers use to improve science literacy skills in both classes are different. For each competency aspect indicator, the average percentage of the experimental class was more significant than the control class after using the problem-based learning model. This shows that applying *a problem-based learning* approach improves the science literacy ability of students in the excellent category. A study (Fani et al., 2023) show that *the problem-based learning* model can be applied when the learning process includes learning processes and stages that require students to find their starting point from problem formulation, data collection, problem-solving, and conclusions so that students in experimental classes have a high level of science literacy. This *problem-based learning model* also indirectly teaches problem-solving strategies to students by inviting them to read to find solutions.

In addition, the experimental class obtained a higher average percentage than the control class in knowledge. Knowledge aspects such as procedural, epistemic, and content improved in the experimental class after treatment. Experimental classes with the influence of problem-based learning models are very close to aspects of knowledge. Students are accustomed to using various approaches to solve problems throughout the learning process. In addition, students assess tasks related to daily events (content) and provide the best solutions, which are grouped into various given solutions. Students also use epistemic aspects of knowledge to form beneficial study habits in certain circumstances.

The results of this study are also corroborated by previous research conducted by Novianti (2016), which found that giving poorly organized tasks to learners will increase motivation to strive to overcome challenges. Students will be interested in following the learning process if they have adequate basic skills and can understand the material. Students will only be motivated to participate in the learning process if they have the necessary basic skills because they cannot understand what is being taught.

In addition, research conducted by Lendeon and Poluakan (2022) revealed a significant difference in the science literacy of students in control classes using conventional learning models with experimental classes using PBL models. The learning outcomes of students who have increased in the literacy component show this, especially in experimental classes that use the problem-based learning paradigm. Then according to research by Tawfik et al., (2020) revealed that learners who apply a PBL approach with unstructured or unorganized questions are better able to solve problems at a higher level, this also encourages learners to think critically and intellectually complex.

There is a difference between science literacy skills that use external approaches such as questionnaires to evaluate students' understanding of science concepts. This method allows researchers to obtain objective data without requiring direct interaction in the classroom, providing in-depth insight into how students understand the subject matter. Research by Fauziyah et al., (2021) titled analysis of scientific literacy skills in solving questions science on food security themes in Serang city reveals that 36% of junior high school students in Serang city have deficient scientific literacy skills when it comes to solving science problems on the theme of food security. Competence, context, and content are the three components of scientific literacy abilities. With a content aspect proportion of 35%, every component fell into the inferior category.

On the other hand, the research conducted by the researchers in 3 meetings provides a quick solution for the initial evaluation with a focus on efficient data collection and analysis in a short time, although limited in the scope and depth of the analysis. These two approaches can complement each other to provide a comprehensive picture of students' science literacy skills, depending on the specific goals of the research and the needs of decision-makers in the field of education.

This research has limitations such as a limited sample population, short duration, and limited assessment instruments. The Ill-Structured Problem-Based Learning model can be used in biology learning. However, it is necessary to pay attention to the concepts or materials that suit the characteristics of this learning model. For further research, it is hoped to improve the presentation of problems by utilizing increasingly complex techniques, problem contexts and concepts. Apart from that, it is hoped that the ill-structured problem-based learning model will be linked with other aspects of scientific literacy abilities, such as context aspects based on PISA.

CONCLUSION

Based on the study's results, it can be concluded that the Ill-Structured type *Problem-Based Learning* model affects the science literacy ability of students on the concept of environmental change. In addition, through this problem-based learning approach, learners can gain problem-solving skills that can be applied in everyday life when faced with several alternative solutions.

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