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Measuring Scientific Literacy of Students' Through Environmental Issues Based on PISA 2025 Science Framework

Pramita Nabilla Putri[1*], Fida Rachmadiarti[2], Tarzan Purnomo[2], Muhammad Satriawan[3]

[1] Master Program of Science Education, Universitas Surabaya, Indonesia.
[2] Department of Biology, Universitas Surabaya, Indonesia.
[3] Department of Physics Education, Universitas Surabaya, Indonesia.

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Corresponding Author:
Pramita Nabilla Putri
pramitanabilla@gmail.com

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Abstract: This study aims to measure students' scientific literacy of science concepts, especially environmental pollution. This study assesses the scientific literacy of eighth-grade students' using a quantitative descriptive method, with a sample selected through random sampling. Data were collected through a scientific literacy test focused on environmental issues and reinforced with interview and students' respons. The science literacy test contains 10 double-choice questions that have been validated and tested for reliability. The research results revealed that students' scientific literacy in three competencies falls within the profience category, specifically: explain phenomena scientifically (72%), construct and evaluate designs for scientific inquiry (53%), and research, evaluate and use scientific information (69%). The average scientific literacy score was 67%, indicating that junior high school students' scientific literacy needs improvement in competency 2. The findings of Indonesian students' performance in this assessment highlight the need to improve learning strategies to strengthen students' ability to engage in critical scientific investigations.

Keywords: Environmental issues; PISA 2025 science framework; Scientific literacy

Introduction

Providing students' with competencies is a significant challenge in 21st-century learning (Funa, 2021). Scientific literacy, deemed essential by the World Economic Forum (Toole et al., 2020). Scientific literacy is the ability to analyze situations, formulate questions, and draw conclusions based on scientific knowledge and evidence (Rukmananda, 2024). Scientific literacy is important because it emphasizes the importance of developing critical thinking and the ability to respond, which involves applying the scientific method to address and solve problems. This ability is critical to understanding various aspects of modern life and issues related to science, including environmental problems, economic challenges, and technological advances (Toole et al., 2020). Therefore, measuring scientific literacy is important to determine the level of students' scientific literacy (Siswanto et al., 2023). Thus, it is hoped that high scientific literacy will be achieved so that the quality of education in Indonesia can improve and be able to compete with other countries.

To assess scientific literacy of students', the Programme for International Student Assessment (PISA) conducted by the Organisation for Economic Co-operation and Development (OECD) provides valuable data on how students from different countries, including Indonesia, perform in science education (Effendi et al., 2021). The development of the PISA 2025 scientific literacy framework has undergone significant changes compared to the previous framework. These modifications aim to align the science framework with the math and reading frameworks and to represent the broader outcomes of science education. The PISA 2025

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scientific literacy framework includes explain phenomena scientifically; construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically; research, evaluate and use scientific information for decision making and action (OECD, 2023b). The scientific literacy framework is used as an indicator or guideline to assess students' scientific literacy.

Based on the results of the Program for International Student Assessment (PISA) conducted by the Organization for Economic Co-operation and Development (OECD) on 15-year-old students, Indonesia's average score decreased from 2018 to 2022. In 2018, Indonesia obtained an average score of 396, while the global average PISA score was 489. Indonesia is ranked 74th out of 78 participating countries. In 2022, Indonesia's average score decreased again to 383, so it is still in the low category because it is below the average PISA score of 485. In 2022, Indonesia's ranking will be 71 out of 81 participating countries. Specifically, the ability of Indonesian students refers to the three lowest levels of proficiency of levels 1b, 1a, and 2. Among these levels, most Indonesian students are at level 1a (OECD, 2023a). According to the PISA framework, level 1a indicates that students have limited scientific knowledge and basic skills. This shows that Indonesian students have difficulty understanding scientific concepts and processes and are unable to apply their scientific knowledge effectively in real-life situations (Sutrisna, 2021).

The low level of scientific literacy, according to several studies , indicates that the methods and learning models used in the implementation of learning processes and activities have not aligned with the nature of science (Nuha et al., 2023). The current science learning activities emphasize more on the transfer of science knowledge such as facts, laws, and theories that must be memorized by students. This learning ignores the development of science process skills and is still teacher-centered, so it does not encourage critical thinking and problem-solving skills among students which are characteristics of science literacy (Wola et al., 2023). In the learning process, science topics are often not aligned with real-life problems and experiences. As a result, students' lose the opportunity to understand the relevance of the science knowledge learned to everyday life (Fuadi et al., 2020).

One approach to bridging this gap is context-based science education, which teaches science based on the local environment and grounded in students' experiences (Gecolea et al., 2022). An example of a problem that can be used as a context for real problems for students' is the environmental issues, the topic is proven to be relevant to the life of students'. The demands of the environmental pollution topic require students' to develop creative ideas to overcome environmental changes around them (Kemendikbudristek, 2022). In principle, material about environmental issues is easy to understand because it is real and can be observed directly by students' in life. However, the fact shows that most students' still have difficulty in formulating practical solutions to deal with ongoing environmental problems around them (Leasti & Ibrahim, 2021).

Several studies have assessed students' science literacy on a variety of topics, and the results are generally low. For example, research on acid-base materials shows an average score of 49.65% (Djatmiko R, 2022; Zahara & Alvina, 2023). In atomic nucleus and science literacy radioactivity, students obtained a score of 44% (Zuhrotul et al., 2023). Research on ecosystems also shows low science literacy skills (Bungawati, 2024; Imanto, 2021). In the kinetics and straight motion materials in two different studies, science literacy received an average score of 31.58, and a score of 57.50% (Mukharomah et al., 2021; Sutrisna, 2021). In Newton's law material, science literacy scored low and needed to be improved (Afkar et al., 2024). In the science material, vertebrates got a score of 37.66 (Niate M, 2022). In the temperature and heat material, science literacy students get low scores and are improved (Milanto et al., 2021). Based on the research, all of them use PISA 2018 indicators.

Several studies indicate that research on scientific literacy using PISA 2025 Science Framework has not yet been conducted. Most previous studies focused on the 2018 framework and were limited to specific topics. Therefore, further research is needed using PISA 2025 Science Framework, especially regarding environmental issues, to enhance our understanding of scientific literacy, which are very relevant issues in the midst of the challenges of climate change and global environmental degradation. Given the low science literacy among Indonesian students, this study aims to assess the scientific literacy skills of junior high school students' on environmental issues topics based on the PISA 2025 framework. This provides an overview of Indonesia's science literacy capabilities that can be used as a reference to improve science learning. By using PISA 2025 as a reference, this research is expected to provide a more accurate overview of students' ability to apply science knowledge to solve real-world problems, especially those related to the environment.

Method

This study employs a quantitative descriptive method and was conducted at a junior high school in

Sidoarjo Regency in November 2024. The subjects were selected using probability sampling, specifically simple random sampling, where classes were chosen at random without considering the strata within the population and assuming that all classes have the same science literacy ability. Random sample is 31 students' from class VIII 1 was selected, including 17 males and 14 females. Data collection involved with semi interviews where the list of questions has been prepared but is still adjusted during the interview, student questionnaires with several questions related to activities and obstacles for students in learning science, and scientif literacy tests on environmental issues. The test consisted of 10 multiple-choice questions adapted from the PISA test, aligned with the PISA 2025 science competencies, The questions were distributed Table 1.

Before using the scientific literacy test instrument in this study, its validity and reliability were evaluated. The designed scientific literacy test instrument has proven to be highly valid and reliable, with an average reliability coefficient of 0.90 (very reliable). This percentage indicates that the test instrument consistently measures students' scientific literacy and can be effectively used across various student groups. (Sinaga et al., 2023).

Table 1. Classification of Scientific Literacy Test Questions Based on the PISA 2025 Science Framework

Scientific Competencies	Question
Explain phenomena scientifically	1, 4, 6 and 10
Construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically	2 and 5
Research, evaluate and use scientific information for decision making and action	3, 7, 8, and 9

The technique of data analysis was done by using quantitative descriptive analysis with certain calculations to measure scientific literacy.

$$\text{Scientific literacy} = \frac{Obtained\ Score}{Maximum\ Score} x100 \quad (1)$$

(Arikunto, 2017)

The correct answers of students in the test are calculated using formula (1). The data analysis results were interpreted to assess students' scientific literacy based on the criteria in Table 2 (Firdaus et al., 2021). The research flow can be seen in the following Figure 1 (Meliyanti et al., 2024).

Table 2. Scientific Literacy Level

Score	Category	Description
75-100	Advance	This student already has the ability to reflect on the content of the discourse to make decisions regarding the concept very well, so without guidance, students' are able to solve problems presented smoothly
51-75	Proficient	Students' already have the ability to understand texts literally and can solve the heat concept problem well without must be guided
26-50	Basic	Students' are able to search for information in the science texts presented. However, guidance is still needed in selecting information that is currently relevant to understanding the concept of heat when looking for the truth of the concept in question
0-25	Need Special Intervention	Students' at this level have great mastery of concepts minimum. Students' need to be accompanied starting from recording data and doing it. Discussion to validate the results of data recording. Discussions can be held with friends who are competent or proficient.

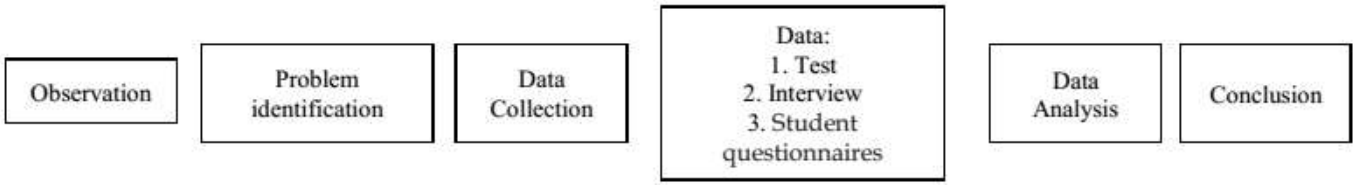

Figure 1. Research flow diagram

Result and Discussion

Results of the Scientific Literacy Test for Students'

Based on the results of the scientific literacy test conducted by students', the average distribution of scientific literacy test scores is presented in Table 3. Students' are grouped based on their ability levels by analyzing their average scores and standard deviations. This analysis classifies students' scientific literacy abilities into four competency levels: needing special intervention, basic, capable, and proficient. The distribution of students' scientific literacy achievements in each category is illustrated in Figure 2.

Table 3. Results of Student Test

Statistic	Score
Highest score	100
Lowest score	20
Average score	67
Standard deviation	16.1

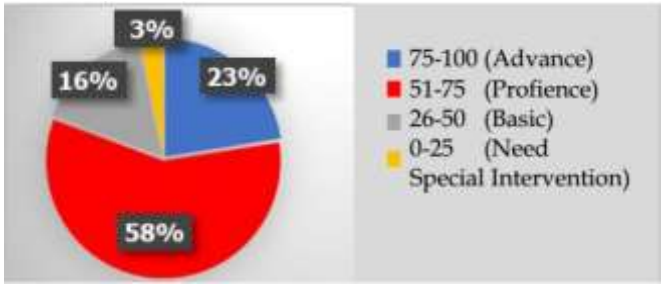

Figure 2. Interpretation of scientific literacy test

Figure 2 shows that most students' (58%) are in the proficient category (51-75), indicating they have sufficient scientific literacy but need further development. 23% are in the advanced category (75-100) and demonstrate strong understanding and application. 16 fall into the basic category (26-50), showing limited mastery and the need for guidance. Lastly, 3% are in the needs special intervention category (0-25) and require intensive, tailored support (Firdaus & Asmali, 2021). This distribution highlights the importance of differentiated learning strategies to address the diverse needs of students' (Tulaiya et al., 2020).

Based on Figure 3, student achievement in each science competencies shows varying percentages. Science competencies 1, which explains phenomena scientifically, reached a percentage of 72% in the proficient category, indicating that students' have a strong understanding of basic concepts (Firdaus et al., 2021). In contrast, science competencies 2, which focuses on Construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically recorded the lowest percentage at 53.2%. Science competencies 3, which includes researching, evaluating and using scientific information for decision-making and action, achieved a score of 69.3%.

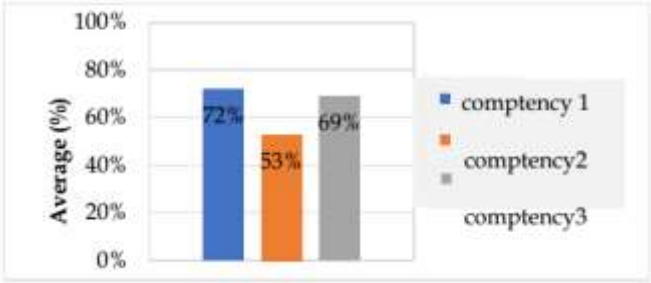

Figure 3. Percentage of average scientific literacy based on scientific competencies

Based on the science competencies, questions related to explain scientific phenomena receive the highest scores. This observation highlights students' ability to recall and apply relevant scientific knowledge to everyday situations (OECD, 2023b). One reason for this trend may be that school science education often emphasizes understanding and mastering basic scientific concepts. As a result, students' become more familiar with tasks that require remembering and applying relevant content knowledge (Mulyani et al., 2020). Additionally, the competence to explain scientific phenomena does not demand advanced data analysis skills or complex investigation designs, which allows students' to excel in reading, understanding, and interpreting the information presented in questions.

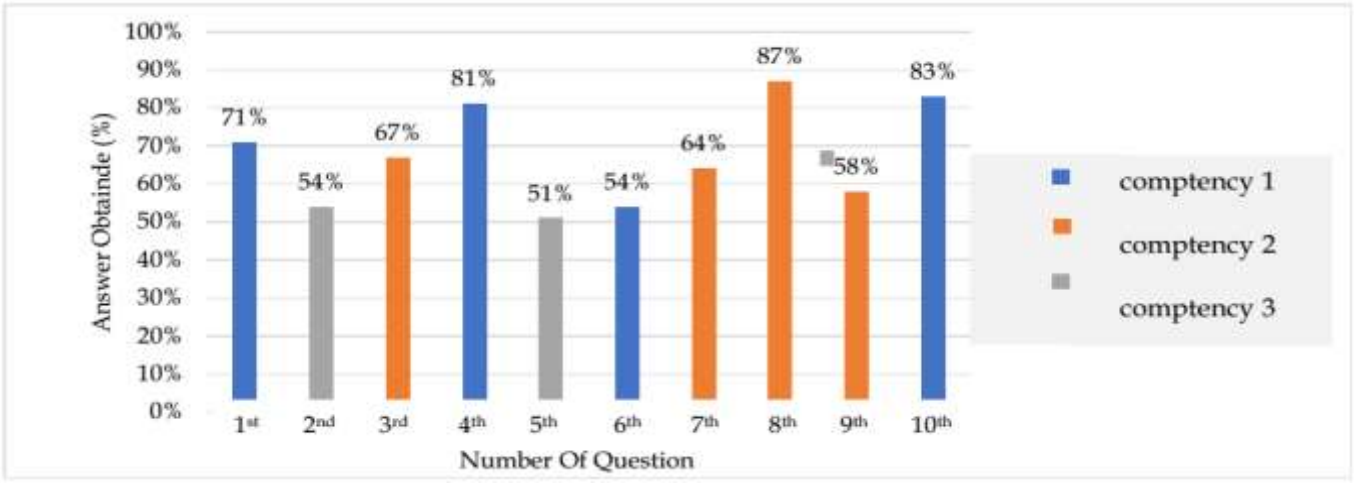

Figure 4. Percentage of correct answers for each question

Figure 4 shows the percentage of students' who answered correctly. The highest score in science competencies 1 was achieved on question number 10, 83% of students' answered correctly, while 17% answered incorrectly. This question required students' to evaluate a soil pollution control model utilizing efficient bioremediation techniques. The high percentage of correct answers shows that students not only understand the basic concepts of bioremediation but are also able to relate scientific principles to real applications in environmental management. This ability is likely supported by discussions about contaminated land rehabilitation strategies that they have undertaken during the learning (Rahmadani et al., 2022).

The lowest score in science competencies 1 was recorded for question number 6, only 54% of students' answered correctly, resulting in 46% answering incorrectly. Based on Table 2, students' science literacy in this question is included in the proficiency category, which requires them to apply knowledge, make predictions, and develop hypotheses related to strategies to reduce the impact of air pollution. In the process of making a hypothesis, students need to first gather relevant information and understand the relationship between causal factors and possible solutions. The difficulties faced can be seen from the low percentage of correct answers, which indicates that students experience obstacles in systematically identifying scientific problems, connecting concepts with real situations, and formulating science-based predictions. This shows the need for learning strategies that emphasize more on exploration and critical analysis of environmental issues so that students can develop more in-depth scientific thinking skills (Fitri & Fatisa, 2019; Rahmadani et al., 2022). This shows the need for learning strategies that emphasize more on exploration and critical analysis of environmental issues so that students can develop scientific thinking skills in more depth.

Based on the test results, science competencies 2 has the lowest score compared to the other competencies. The performance of students' in answering the test questions is illustrated in Figure 3. In question number 2, about 54% of students' answered correctly, while 46% answered incorrectly. According to Table 3, students' scientific literacy for this question are categorized as proficient. This question presents data from research on the quality of polluted river water, requiring students' to interpret the information provided in various formats and draw appropriate conclusions. One reason for the limited ability of students' to interpret data is that they are primarily accustomed to completing tables provided by educators. As a result, their skills in interpreting table results and graphs are not well-developed (Budiarti & Tanta, 2021). Additionally, students' abilities in this competency are classified as low, primarily due to their insufficient procedural knowledge (Tulaiya & Wasis, 2020). To effectively interpret scientific data and evidence, students' need both procedural knowledge and epistemic knowledge (Milanto et al., 2021). This skill can be enhanced by training students' and introducing them to evaluation questions that involve discussions, visual representations, graphs, and tables (Tillah & Subekti, 2025).

The lowest score in science competencies 2 was recorded for question number 5, only 51% of students' answered correctly, while 49% answered incorrectly. Based on Table 3, students' scientific literacy in this question fall within the proficiency category. This question addresses the phenomenon of air pollution in Jakarta and requires students' to formulate questions related to the provided scientific study. The low performance indicates that many students' struggle to comprehend the context of scientific issues and to connect them with relevant research questions (Fuadi et al., 2020). This competency is crucial, as it develops critical thinking skills necessary for analyzing information, distinguishing between facts, and formulating appropriate questions based on the presented phenomenon (Wahab et al., 2024).

The science competencies percentage for achievement level 3 secured second place. The results from the conducted tests reveal the percentage of correct answers provided by students', as illustrated in Figure 3. The question with the highest success rate was question 8, where 87% of students' answered correctly, while 13% responded incorrectly. This question examined the phenomenon of air pollution and required students' to formulate conclusions and arguments regarding solutions to mitigate its impacts. According to Table 3, students' demonstrated advanced scientific literacy in this question. In this category, students' exhibited the ability to apply their knowledge across various contexts and reason effectively to solve problems, particularly in constructing conclusions based on the provided arguments (Firdaus & Asmali, 2021).

In Competency 3, question number 9 has the lowest percentage of correct answers, which is 58%. This question requires students to evaluate and critique arguments related to soil pollution solutions appropriately. The low percentage of correct answers shows that many students still have difficulty in assessing the validity of a scientific argument, especially in identifying weaknesses or limitations of the proposed solution. This ability is a crucial aspect of science literacy, as it allows students to think reflectively, distinguish between strong scientific evidence and less basic assumptions, and make decisions based on a more

comprehensive understanding (Zulaiha & Kusuma, 2021). These results indicate the need to strengthen learning strategies that encourage students to be more active in analyzing and debating scientific arguments, for example through evidence-based discussions or case studies on environmental pollution.

Based on the gathered data, the average scientific literacy score of students' is 67%, indicating they possess a basic understanding of key concepts. However, they encounter difficulties in applying this knowledge to real-world situations. Students' need examples of how to present data effectively and convert their recorded information into clear and accurate presentations. Interviews conducted reveal that the lack of explicit and optimal learning aimed at improving scientific literacy contributes to these challenges. Currently, the learning activities are predominantly centered around teacher-led lectures, which do not adequately support students' in developing their scientific inquiry skills. As a result, students' find themselves in the low capability category, particularly because their procedural skills remain underdeveloped (Tulaiya & Wasis, 2020). Therefore, it is essential to provide students' with examples that demonstrate how to present data and transform their notes into a more effective representation (Firdaus & Asmali, 2021).

Indonesia has made significant progress in promoting gender equality. A study conducted by the OECD revealed that the gender gap in scientific literacy is narrowing. This study uses the OECD findings to evaluate the level of gender equality in scientific literacy achieved in Indonesia.

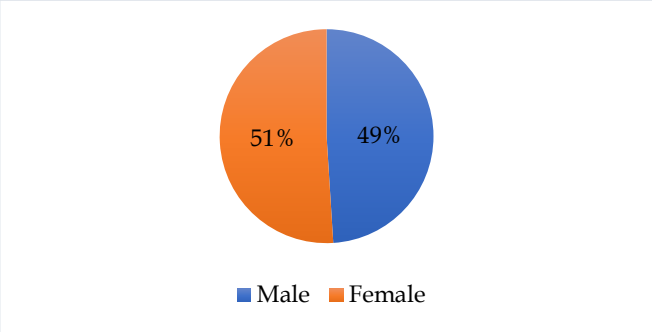

Figure 5. Comparison of scientific literacy scores by gender

Figure 5 shows a comparison of scientific literacy scores by gender, indicating a minimal difference between male and female students'. Female students' achieved an average score of 51%, while male students' scored an average of 49%. This data suggests that scientific literacy among male and female students' is relatively balanced. The study reveals that female students' possess better scientific literacy than their male counterparts, with a difference of 2%. This small discrepancy indicates that gender does not significantly affect overall scientific literacy abilities. It is likely that female students' tend to be more conscientious, diligent, and receptive to explanations (Mulyani et al., 2020).

The low scientific literacy among students' can be attributed to insufficient practice in solving problems similar to those found in PISA questions (Rohmah & Hidayati, 2021). Additionally, the challenging curriculum contributes to students' difficulties in developing their scientific literacy. When the required material is too extensive, teachers often focus on conveying only the core concepts due to time constraints, which leaves little room for adequate introduction (Fajaruddin et al., 2022). To enhance students' scientific literacy, effective learning strategies are essential. Such strategies enable students' to apply new concepts and knowledge in their everyday lives. Proper learning not only boosts students' interest but also motivates them to actively seek out new information that is relevant to the concepts they have learned (Putriyani, 2024).

Students Response to Science Learning

According to Table 4 in Statement 1, the assertion that "Science learning in the classroom is currently attracting interest" received a favorable response. Specifically, 80.65% of students agreed with the statement, while 16.13% strongly agreed. This highlights that students interest in learning significantly influences their understanding during the learning process, as interest plays a crucial role in teaching and learning activities (Mozana, 2023).

Statement 2 "Teachers often do learning is associated with real problems" scored 90.32% of students agree. This indicates that the majority of students feel that teachers often associate learning with the context of a real problem. This is very important in creating relevant and applicable learning, which will make it easier for students to understand science material (Pertiwi et al., 2018). By relating lessons to real situations, scientific concepts become easier for students to accept and understand (Picardal & Sanchez, 2022)

Statement 3 "I often use the concept of science to solve problems", as many as 61.29% of students agree and 9.68% strongly agree with this statement. This shows that most students are able to apply the science concepts learned to solve problems in life. Learning that focuses on the application of concepts in real life can strengthen students understanding of the theory taught in the classroom (Destini et al., 2021)

Statement 4 shows that 77.42% of students agree that teachers often use the lecture method to explain material, while 22.58% disagree. This indicates that the lecture method is still predominantly used in teaching,

although it is less effective in improving scientific literacy compared to student-oriented models (Tillah & Subekti, 2025). Meanwhile, Statement 5 reveals that only 51.61% of students agree that teachers frequently provide learning through practical activities or investigations. This suggests there is room to increase practice-based learning activities, which can deepen students' understanding of scientific concepts and encourage critical and analytical thinking (Mulia & Murni, 2022; Picardal & Sanchez, 2022).

Statement 6 "I am used to explaining natural phenomena using the concept of science", as many as 78.13% of students feel used to explaining natural phenomena using the concept of science. This shows that most students already have the ability to relate the knowledge they have learned to the phenomena around them (Kamila et al., 2025).

Statement 7 "I am used to designing and conducting experiments and analyzing data", as many as 48.39% of students feel used to doing experiments and analyzing data, while 38.71% do not feel used to it. This shows that although some students are used to experimental activities, there are still some who are less involved in practicum activities. Improving experimental and data analysis skills is very important because it is part of in-depth science learning and can strengthen students' ability to solve scientific problems (Aditomo & Klieme, 2020).

Table 4. Students Response to Science Learning

Question	Scoring			
	1	2	3	4
	Highly Disagree	Disagree	Agree	Highly Agree
Science learning in the classroom is currently attracting interest	0.00%	3.23%	80.65%	16.13%
Teachers often do learning associated with real problems	0.00%	0.00%	90.32%	9.68%
I often use the concept of science to solve problems	6.45%	22.58%	61.29%	9.68%
Teachers often provide learning by lecturing/explaining the material in front of the class	0.00%	0.00%	77.42%	22.58%
Teachers often provide learning with practicum/investigation activities.	9.68%	51.61%	32.26%	6.45%
I am used to explain phenomena scientifically using the concept of science.	0.00%	25.81%	61.29%	12.90%
I am used to designing and doing simple experiments and analyzing data.	0.00%	48.39%	38.71%	12.90%
I often make decisions and actions related to the concept of science.	0.00%	19.35%	41.94%	38.71%
I am used to looking for accurate and relevant scientific information.	0.00%	6.25%	78.13%	15.63%
I feel that learning science helps me in understanding environmental issues, especially environmental issues.	0.00%	4.88%	46.34%	24.39%

Statement 8 "I am used to making decisions and actions related to the concept of science", as many as 41.94% of students agreed that they are used to making decisions and actions related to the concept of science. This shows that students are starting to be able to make scientific decisions based on the concepts learned. Good decision-making in a scientific context can train students critical thinking skills and prepare students to face real-world challenges (Rumbewas, 2024; Valladares, 2021).

Statement 9 "I am used to looking for accurate and relevant scientific information", as many as 78.13% of students feel used to looking for accurate and relevant scientific information. This shows that most students have been trained in seeking and using scientific information to explore the topics studied. As they seek and organize relevant information, they close their own knowledge gaps that lead to understanding and learning new concepts (Funa, 2021).

Statement 10 "I feel that learning science helps me in understanding environmental issues, especially environmental issues", as many as 46.34% of students feel that learning science helps me understand environmental issues, especially environmental pollution. Science learning, which includes environmental issues, instills awareness and creates individuals who care about the environment to understand the challenges faced by the environment, and contribute solutions that can be implemented to overcome these problems (Permatasari et al., 2024).

Based on the results of data analysis, it can be concluded that although most students show high interest in science learning and can relate science concepts to life, students still experience difficulties in carrying out practical activities or investigations and analyzing data well. This shows that students' competence in the aspects of practicum and data analysis still needs to be improved, this is in line with the results of the students' scientific literacy ability test which is still low in science competencies 2. Based on this, it is necessary to develop learning strategies that emphasize more practical activities, investigations, and direct data analysis.

Case method brings a piece of the real world into the classroom to facilitate elevated thinking skills among students, develop a deeper understanding of problems, and arrive a better solution (Seprianto &

Hasby, 2023). using an enriched learning materials can effectively improve students scientific literacy, especially if the materials that developed involving the daily life phenomena as a source of learning (Utari et al., 2024). The Problem Based Learning model provides a space for students to exchange ideas and concepts in solving problems. The application of the PBL model in learning can improve the aspects of data interpretation and evidence scientifically. The solution from the result of the formulation of the problem can develop scientific evidence from relevant and scientific sources to create a solution. Students will communicate opinions with the support of analyzed scientific references (Alatas & Fauziah, 2020; Widiana, 2020).

Conclusion

Based on the measurement of science literacy ability of grade VIII students, the results show a percentage in the three science competencies explain scientific phenomena obtaining an average of 72%, the competence to compile and evaluate designs for scientific investigations and interpret scientific data and evidence critically 53%, and the competence to research, evaluate, and use scientific information for decision-making 69%. The average scientific literacy score was 67%, indicating that junior high school students' scientific literacy needs improvement in competency 2. These improvement efforts can be focused on activities to compile and evaluate designs for scientific investigations and interpret scientific data and evidence critically. To improve scienctific literacy, can uses a contextual learning-based model, namely problem-based learning (PBL).

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P.N.P: Preparation of research concepts and designs, module development, data collection, data analysis, manuscript writing and editing. F.R Guidance during research and manuscript writing. T.P: Guidance during research and manuscript writing. M.S: Guidance during research and manuscript writing.

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