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Research Article

# Science Literacy Profile of High School Students as A Basis for Ethnoscience Integration in Learning

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**ABSTRACT**

**Purpose of the study:** This study aims to analyze the scientific literacy profile of high school students in physics using the PISA 2025 framework, focusing on identifying strengths and weaknesses in each competency dimension as a basis for developing ethnoscience-integrated learning.

**Methodology:** This study employed a quantitative survey with a diagnostic approach using a science literacy test adapted from the PISA 2025 framework. The instrument consisted of 20 multiple-choice items. Data were collected online and analyzed using descriptive statistics and Benchmark Reference Assessment (PAP). Sampling used simple random sampling on grade XI students.

**Main Findings:** The results show that students' scientific literacy is in the moderate to low category with uneven competency distribution. Students performed better in explaining scientific phenomena but showed low achievement in designing investigations, evaluating evidence, and interpreting data. Scores ranged from 25 to 85, with an average of 55.07, indicating limited higher-order thinking skills.

**Novelty/Originality of this study:** This study provides an updated empirical mapping of students' scientific literacy using the PISA 2025 framework, which is still rarely applied. It offers a diagnostic basis for integrating ethnoscience in learning, emphasizing the development of higher-order thinking and contextual understanding aligned with students' cultural environments.



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## 1. INTRODUCTION

In the 21st century, marked by the rapid development of digital information and technology, scientific literacy has emerged as a crucial competency for addressing global complexity [1]. The complexity of global issues demands critical, creative, collaborative, and communicative thinking skills [2]. Recent data consistently shows that students' scientific literacy levels remain very low. The gap between student competency and performance underscores a critical educational challenge. Therefore, education is no longer solely oriented toward mastering concepts; it must equip students with the ability to use scientific knowledge to understand, make decisions, and solve real-life problems. In this context, scientific literacy is a key competency needed to improve the quality of education [3].

Science literacy skills are one of the main targets that must be achieved in the education process [4]. However, the condition of science literacy in Indonesia based on the 2022 PISA results is still relatively low. The data shows a decline in Indonesia's learning outcomes at the international level after the pandemic [5]. In addition to the impact of the pandemic, other factors that also affect students' reading interest include students' reading interest and metacognitive strategies in reading [6]. Several previous studies have shown that students' science literacy levels are still relatively low. Research conducted by [7] used the science literacy test (NOSLit) and obtained an average of 40.5% in the low category. Research [8] It also reported student literacy outcomes based on seven variables, including information access and digital skills. Meanwhile, research [9], [10], and [11] still refers to the 2018 PISA science literacy competency framework and concludes that students' science literacy skills are in the low category. Based on these findings, students' scientific literacy in Indonesia is still considered low. However, most previous studies still use the PISA 2018 framework and have not implemented the updated PISA 2025 framework. This indicates a clear gap, as the newer framework focuses more on real-life problem-solving skills. Therefore, this study analyzes students' scientific literacy using the PISA 2025 framework to provide a more relevant profile. To support learning development, an appropriate learning approach is required [12], including integrated ethnoscience learning.

The low achievement cannot be separated from learning practices that tend to emphasize problem solving and memorization of concepts, especially in physics learning in high school [2]. Physics is often perceived as a discipline that is abstract, mathematical, and far from the reality of everyday life [13]. As a result, there is a gap between mastery of concepts and the ability to apply them in a real context. Students may be able to solve numerical problems, but have difficulty when asked to explain natural phenomena in the surrounding environment using relevant physics principles. A number of national studies report that students are relatively more able to answer questions based on factual content than questions that test reasoning skills in real-life contexts [14]. This condition illustrates the difference between what is learned in class and the reality that students are facing. So the right approach is needed in learning.

One of the approaches that is considered potential to bridge this gap is the integration of ethnoscience in learning [15]. Studies on ethnoscience show that associating scientific concepts with local practices, wisdom, and phenomena can increase the relevance of learning, strengthening learning motivation [16], as well as helping students build more contextual and meaningful conceptual understanding [11]. By presenting phenomena that are close to the student's life experience, the concept of physics is no longer understood as an abstract formula, but as a tool to explain the reality around it [17]. However, most ethnoscience research still focuses on the development of tools or tests of the effectiveness of learning interventions, while studies that specifically map the science literacy profile of students as the basis for designing ethnoscience integration are still relatively limited, especially in the context of high school physics. In fact, a comprehensive mapping of the achievements of each dimension and science literacy indicators is essential to identify the aspects that need improvement the most. Thus, diagnostic studies are important because they can provide a comprehensive picture of students' science literacy profiles [18]. The results of the mapping can be used as a basis for designing contextual learning [19], according to the actual needs of students, as well as presenting novelty in the research developed [20].

Based on this urgency, this study aims to analyze the scientific literacy profile of high school students in physics using the PISA 2025 framework. The analysis focuses on identifying students' strengths and weaknesses in each dimension of scientific literacy as a basis for developing ethnoscience-integrated learning. The research questions asked in this study are: (1) What is the scientific literacy profile of high school students in physics based on the PISA 2025 framework?; (2) How are students' competencies distributed across the domains of scientific literacy in PISA 2025?; (3) How can the identified scientific literacy profile inform the integration of ethnoscience in physics learning?.

## 2. RESEARCH METHOD

This study is designed to map students' scientific literacy profiles using a quantitative survey with a diagnostic approach. The survey design was chosen to obtain an empirical picture of the science literacy profile of students systematically in the context of a specific population and to identify achievement trends in each competency indicator [21]. Diagnostic approaches are used to map students' conceptual strengths and weaknesses in a more structured manner so that the results of the research can be the basis for data-based pedagogical decision-making [22].

The research population included grade XI high school students in the odd semester of the 2026/2027 academic year, East Java. The sample was determined using a simple random sampling technique, which is the random selection of respondents without considering a specific grouping in the population [23]. This technique is used to minimize selection bias and improve data representativeness.

The instrument used is a multiple-choice science literacy test adapted from the framework of the Programme for International Student Assessment (PISA) based on the latest framework published by [4]. The framework includes three main competencies, namely: explain phenomena scientifically; compiling and evaluating designs for scientific inquiry and critically implementing scientific data and evidence; researching, evaluating and using scientific information for decision-making and action. The instrument, consisting of 20 multiple-choice questions with five answer options, was adopted from the research instrument by [22] and has undergone a validation process, with a Cronbach's Alpha score of 0.764 (reliable). The test was administered online under direct supervision by the researcher to maintain the integrity of the implementation. The time limit was set at 45 minutes to ensure consistency of the measurement conditions.

This study applies a quantitative descriptive approach with descriptive statistical analysis to describe the science literacy achievements of students. The analysis is carried out through the following stages [24]: Calculating scores and percentage of achievement on each science literacy indicator. Calculate the value of each indicator using the formula with the equation below:

$$x = \frac{score\ obtained\ by\ each\ indicator}{total\ score\ for\ each\ indicator} \times 100 \qquad \ldots (1)$$

Description:
$x$ = Value of Each Indicator

Identify the question items with the highest and lowest success rates to detect comprehension pattern tendencies; Calculate the overall average score as a representation of the student's science literacy profile. Calculate the value of each indicator using the formula with the equation below:

$$\bar{x} = \frac{total\ student\ grades}{total\ students} \qquad \ldots (2)$$

Description:
$\bar{x}$ = Overall average score of students

The interpretation of scores used the Benchmark Reference Assessment (PAP) approach based on the criteria of [25] with five categories: 81–100 (very high), 61–80 (high), 41–60 (adequate), 21–40 (low), and 0–20 (very low). The use of PAP was chosen because it allows the interpretation of achievement based on a specific criterion standard, rather than comparisons between individuals, making it more relevant for ability mapping purposes.

## 3. RESULTS AND DISCUSSION

The results of this study provide an overview of students' scientific literacy and reveal several important issues that require serious attention. Overall, the findings from the scientific literacy diagnostic test indicate conditions that require serious attention.. When students are given questions that demand the ability to explain scientific phenomena, design investigations, and utilize scientific information for decision-making, most of the score is still below the expected criteria, namely the lowest score is 22 and the highest is 43. The results of the analysis showed that students were relatively able to answer questions that were factual or relied on memorization, but experienced difficulties when faced with tasks that required higher reasoning, such as interpreting data, developing experimental designs, and applying concepts in contextual situations. This condition is becoming increasingly crucial in the midst of the development of the digital era that demands science literacy skills as a provision to sort information and respond critically to various global issues [26].

Furthermore, an analysis was carried out on three aspects of science literacy that have been trained based on the PISA 2025 framework to obtain a more specific picture of the profile of students' abilities. The results of data processing show that the achievements in each aspect are still in the fairly – low category. Overall, the science literacy profile scores of grade XI students at SMAN 1 Nganjuk are depicted as presented in Figure 1.

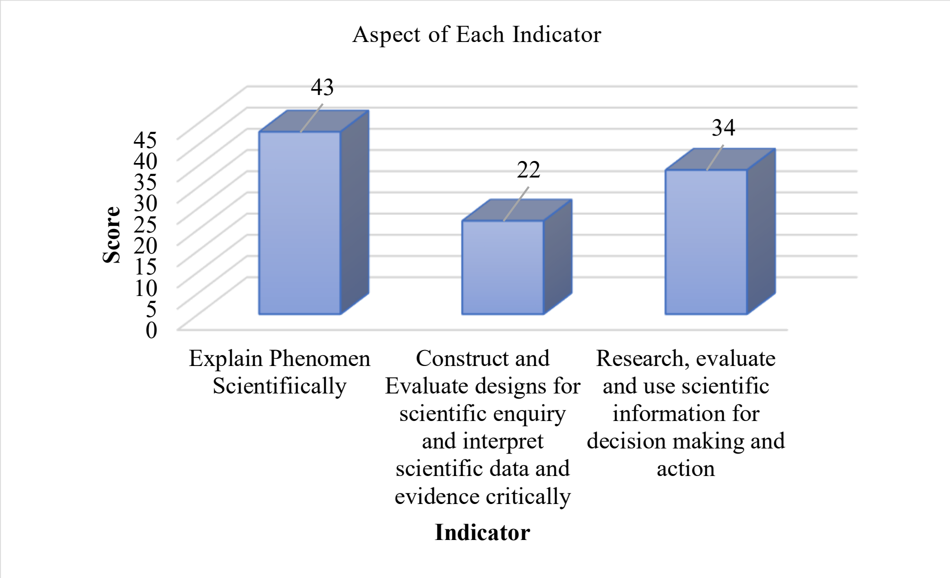


Figure 1. Students' Abilities in Each Aspect of Science Literacy Ability

Figure 1 shows that students' scientific literacy achievement is uneven across indicators. The highest score was found in the ability to explain scientific phenomena (43), indicating that students are relatively capable of understanding and applying basic scientific concepts. Conversely, the lowest score was found in designing and evaluating scientific investigations and interpreting data and evidence (22), indicating that students still face difficulties in higher-order thinking tasks, such as analyzing data, developing investigations, and drawing conclusions. Meanwhile, the ability to use scientific information for decision-making obtained a moderate score (34), indicating that students have begun to connect scientific knowledge with real-life situations. This is despite the fact that one of the main goals of scientific literacy is for students to be able to make evidence-based decisions in everyday life [27]. Overall, these findings indicate that although students have a basic understanding of scientific concepts, their process and evaluation skills still need to be strengthened.

This profile provides a strong foundation for integrating ethnoscience into learning [28]. The relatively high achievement in explaining scientific phenomena indicates that students already possess basic conceptual knowledge, which may be influenced by learning practices that still emphasize understanding and memorizing concepts. However, low performance in designing investigations and evaluating evidence suggests that students are not yet accustomed to engaging in inquiry-based activities that require higher-order thinking, such as analyzing data and drawing conclusions. This condition is likely caused by classroom learning that tends to focus more on final answers than on the scientific process [29]. Integrating ethnoscience can be a relevant alternative, as it connects scientific concepts with cultural practices and local wisdom that are familiar to students [30]. Through this approach, students are encouraged not only to understand concepts but also to observe, analyze, and reflect on real phenomena in their environment, so that learning becomes more meaningful [31]. Therefore, this profile not only describes students' scientific literacy but also highlights the need to strengthen their inquiry and critical thinking skills while maintaining their conceptual understanding. The integration of ethnoscience is expected to strengthen the inquiry aspect [32] and critical thinking skills that are still weak [33], while maintaining students' skills in the conceptual understanding aspect. Analysis of test results for each item is presented in Figure 2.

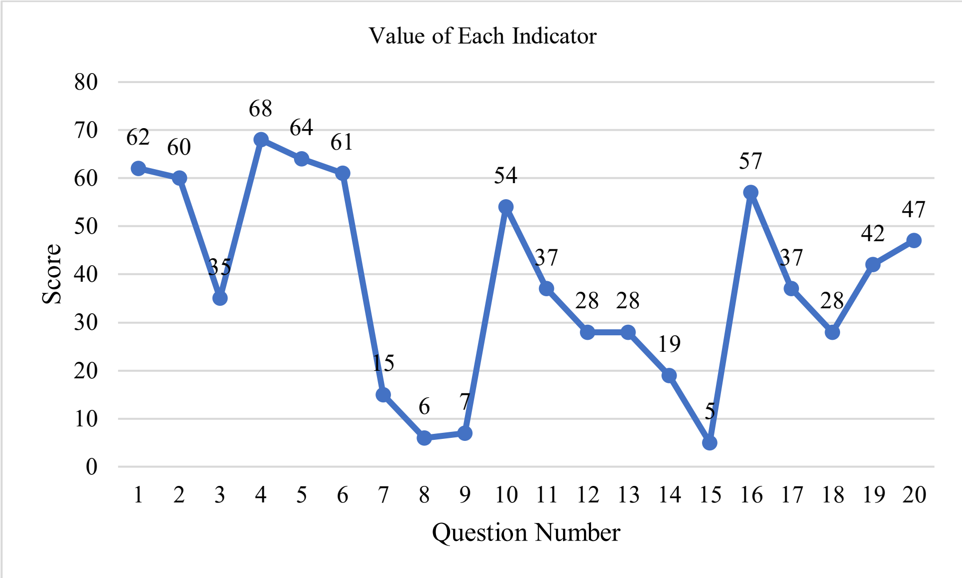


Figure 2. Score each indicator for each question.

Figure 2. shows the variation in scores on 20 items of science literacy questions. If viewed in general, there are quite striking differences between items. Some questions have high scores, such as questions number 4 (68), number 16 (57), and number 1 (62). This shows that in certain contexts or indicators, students are able to understand and answer questions well. These questions are on the indicator explaining the phenomenon scientifically, which in the previous graph did show the highest achievement. On the other hand, there are several items with very low scores, such as number 8 (6), number 9 (7), and number 15 (5). This score that is far below the average indicates difficulties in the indicator. When associated with science literacy indicators within the OECD framework through the Programme for International Student Assessment (PISA), these low-scoring questions require the ability to design investigations, evaluate procedures, or interpret data critically. This competence does require more in-depth analytical skills than just understanding concepts. Interestingly, there is a fluctuating pattern. For example, after a high score on the number 6 (61), there is a sharp drop in the number 7 (15), 8 (6), and 9 (7), then rises again at the number 10 (54). This pattern shows that students' abilities are inconsistent and are greatly influenced by the characteristics of the questions. This means that when the questions are still based on direct concepts, students are relatively capable. However, when the question demands more complex data interpretation or contextual reasoning, students have difficulty [34].

The variation in scores between items shows that students' science literacy is not stable in all aspects. This is an important basis for learning innovation. By raising local phenomena, cultural practices, or the wisdom of the surrounding community as material for scientific discussion, students are expected to more easily understand the context of the questions and be trained to think critically and be culturally literate more deeply [35]. Thus, this graph not only shows the achievement number per question, but also illustrates the patterns of students' strengths and weaknesses. Weaknesses in certain items become an entry point for designing learning that is more contextual, reflective, and based on real experiences [36], so that the integration of ethnoscience has a clear foundation and is relevant to the needs of students.

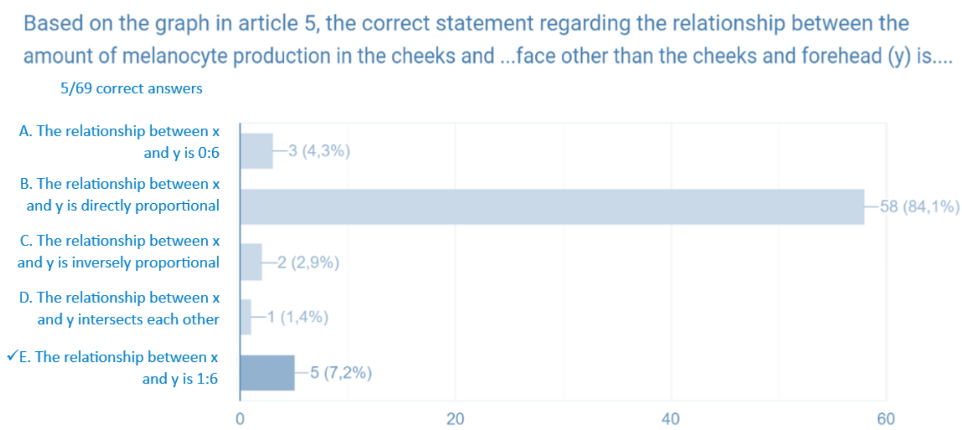


Figure 3. Analysis of the Answer with the Lowest Score (Question Number 15)

Figure 3. shows the analysis of students' answers to question number 15 which is the item with the lowest score. Of the 69 students, only 5 students (7.2%) answered correctly. Most of the students, namely 58 people (84.1%), chose the wrong option. This data shows that the majority of students have not been able to identify the correct relationship based on the graphical information presented. This question is included in the indicators of research, evaluate and use scientific information for decision making and action as formulated in the OECD science literacy framework in the Programme for International Student Assessment (PISA) study. In this indicator, students are required to read data-based information (graphs), evaluate the relationships between variables, and then determine the most appropriate statement. This means that the questions not only test the understanding of concepts, but also the ability to interpret data and make decisions based on evidence.

The low percentage of correct answers indicates that students still have difficulty in reading and interpreting the graph carefully. It is likely that students only see general trends without actually analyzing the relationships between the variables shown [37]. These findings reinforce the results of previous graphs that the aspect of using scientific information for decision-making has not been optimally developed. In fact, this ability is very important in daily life, especially when one has to make decisions based on available data or scientific information [27].

The low achievement in question number 15 shows the need for more contextual and real-experience learning. Ethnoscience integration teaches students to not only understand concepts, but also to be accustomed to using information to make logical, evidence-based decisions [38]. Overall, the analysis of this item confirms that students' weaknesses are not only in the mastery of the material, but in the evaluative ability and data-driven decision-making. Therefore, strengthening these indicators needs to be the main concern in the design of the next learning.

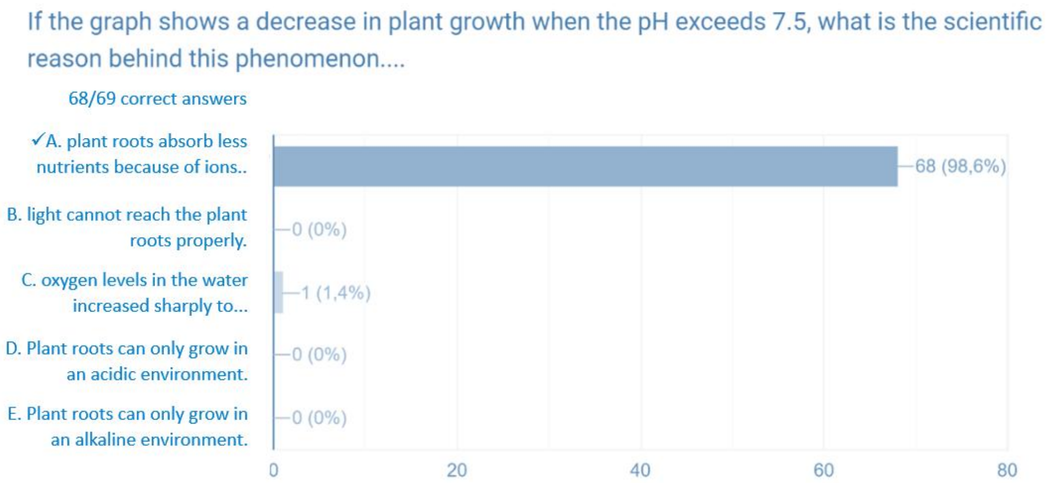


Figure 4. Analysis of the Answer with the Highest Score (Question Number 4)

Figure 4 shows that almost all students answered question number 4 correctly (98.6%), indicating that this item was relatively easy. This can be explained by the characteristics of the question, which required students to apply familiar and basic concepts about plant growth and environmental factors. In addition, the use of a clear and straightforward graph made the information easier to interpret, so students only needed to connect the visual data with prior knowledge they had already learned. The context of the question was also close to everyday scientific concepts, reducing the level of abstraction and making it more accessible. These characteristics suggest that the item mainly measured students' ability to recall and apply basic concepts rather than engage in complex reasoning or multi-step analysis. This explains why most students were able to answer correctly and is consistent with the overall finding that students perform better in tasks related to explaining scientific phenomena.

The results of the analysis indicate that the learning that has been going on has been enough to help students in mastering concepts. However, strength in this aspect has not been followed by evaluative and decision-making skills that are also an important part of science literacy. In this study, the high achievement in the Explain Phenomena Scientifically indicator is a good starting capital for ethnoscience integration. Through the context of the local culture, students can further deepen their understanding of concepts by relating them to real phenomena in the surrounding environment [39], [40], [41]. Thus, learning not only retains strength in conceptual aspects, but can also be developed towards broader analytical and reflective skills.

Table 1. Statistical Distribution of Overall Score Results for Science Literacy Questions

| Number | Aspects | Total Point Distribution |
|---|---|---|
| 1 | Average | 55,07 |
| 2 | Median | 55 |
| 3 | Range | 25-85 |

The distribution of scores in the science literacy aspect provides an overview of the level of participants' ability to answer the questions given. The average score was recorded at 55.07. This achievement shows that in general, the participants' abilities are still in the middle to lower category, especially when considering that the highest score only reaches 85 out of the ideal score of 100, while the lowest score is at 25 which is still far from the adequate category. A median score of 55 indicates that half of the participants scored below that number and the other half were above it. The comparison between the average and median values shows a tendency to be positively skewed, as the median is slightly below average. In addition, the wide range of scores shows that there is a striking variation in abilities between participants. This condition indicates that there are groups of students with a low level of science literacy, but on the other hand there are also students who have achieved relatively high achievement [3], [42]. Overall, these findings illustrate the gap in understanding science literacy among the participants. These differences may be influenced by various factors, such as academic background, learning strategies applied, and the availability and utilization of learning resources that support the student learning process [43].

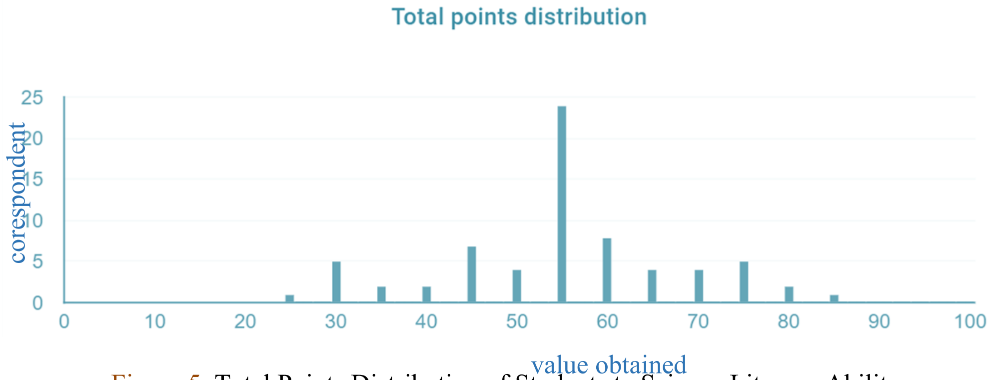


Figure 5. Total Points Distribution of Students to Science Literacy Ability

Figure 5. shows the distribution of the final score of science literacy from all respondents. Overall, student scores are spread over a range of about 25 to 85. However, most students are in the 50–60 grade range, with the highest frequency being around a score of 55. This distribution shows that students' science literacy skills are in the medium and uneven category. Although there are some students who score high (above 70), the number is relatively few. Likewise, students with very low scores are not dominant, but remain in the range below 40. This condition shows that there is a fairly clear variation in ability between students [44].

When associated with the science literacy framework according to the OECD in the Programme for International Student Assessment (PISA) study, the achievement in the medium range shows that students generally already have a basic understanding of science, but are not yet fully able to apply and evaluate scientific information consistently. This is in line with previous findings that indicators explaining phenomena tend to be stronger than evaluative and decision-making indicators [45]. The distribution of values that are grouped in the middle also shows that the learning that takes place is not fully able to encourage students to achieve higher science literacy skills. This means that learning innovations are still needed that can improve the quality of understanding while strengthening critical thinking skills [46]. This finding is consistent with previous studies that also reported low levels of students' scientific literacy [47], [48]. However, compared to those studies, this research reveals a more specific weakness in higher-order skills, particularly in designing investigations and evaluating evidence.

The value distribution profile is an important basis for the integration of ethnoscience in learning. Since most of students' science literacy skills are in the medium category, a more contextual approach to learning that is close to everyday life is expected to help students understand concepts more meaningfully [49]. The integration of ethnoscience reduces the gap between science concepts in the classroom and cultural realities in the student environment [50], thus not only improving understanding, but also strengthening the ability to use science in real life. Overall, this graph confirms that students' science literacy is not optimal and still needs strengthening, especially in the aspects of information analysis and evaluation [42]. Therefore, the results of this value distribution can be used as an empirical basis in designing ethnoscience-based learning that is more relevant and contextual. The findings of this study indicate that students' scientific literacy is still not evenly developed across all competencies. Students tend to perform better in understanding and explaining concepts, but face difficulties in higher-order skills such as analyzing information, evaluating evidence, and designing investigations. This imbalance reflects the need for learning approaches that not only strengthen conceptual understanding but also support the development of inquiry and critical thinking skills. Therefore, integrating contextual approaches such as ethnoscience becomes important to bridge this gap and to help students apply scientific knowledge more effectively in real-life situations.

## 4. CONCLUSION

This study shows that high school students' scientific literacy in physics, based on the PISA 2025 framework, is still at a moderate to low level, with notable weaknesses in inquiry and data interpretation skills. This study contributes theoretically by providing an updated profile of scientific literacy aligned with the PISA 2025 framework and highlighting ethnoscience as a relevant approach to address these gaps. Practically, the findings suggest the need to integrate ethnoscience into physics learning to enhance contextual understanding and higher-order thinking skills. At the policy level, the results support the development of curricula that emphasize scientific literacy and culturally responsive pedagogy. Further research should focus on testing ethnoscience-based learning models to improve students' scientific literacy competencies.

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## AUTHOR CONTRIBUTIONS

WR was responsible for the study design, data collection, data analysis, and manuscript preparation. W and HS contributed to the conceptual development and critical review of the manuscript.

## CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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