Analysis of Students' Science Literacy Skills at SMAN 4 Makassar

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Received: 8th June 2026; **Accepted**: 29th June 2026; **Published**: 30th June 2026
DOI: https://dx.doi.org/10.29303/jpft.v12i1.12345

Abstract - *This study aimed to assess the scientific literacy levels of Grade X students at SMAN 4 Makassar. The study population consisted of all 311 Grade X students enrolled at the school. Data were collected using a scientific literacy test developed based on the Programme for International Student Assessment (PISA) framework, comprising essay questions designed to measure three scientific literacy competencies within the topic of measurement. The results showed that the students' overall scientific literacy level was categorized as moderate, with a mean score of 61.59. Performance was evaluated across three scientific literacy competencies: identifying scientific issues, explaining scientific phenomena, and using scientific evidence. Among these, identifying scientific issues achieved the highest mean score (67.91, SD = 23.33), followed by explaining scientific phenomena (61.84, SD = 26.18). The lowest performance was observed in using scientific evidence, with a mean score of 42.31 (SD = 30.31). These findings indicate that while students demonstrated a moderate level of scientific literacy overall, their ability to use scientific evidence requires further improvement.*

Keywords*: Scientific Literacy Skills; Test Instruments; PISA.*

INTRODUCTION

Scientific literacy can be defined as an individual's ability to understand, communicate, and apply scientific knowledge to solve various problems, while fostering a caring and sensitive attitude toward the surrounding environment (Gultom & Alwi, 2024). Furthermore, scientific literacy encompasses a comprehensive understanding of the nature of science, awareness of the influence of science and technology on the physical, intellectual, and cultural environment, and encouragement for active engagement in science-related issues (Nudiati & Sudiapermana, 2020). According to Syofyan & Amir (2019), teachers need to enhance scientific literacy so that students are guided in meaningful, active, and responsible learning, utilizing technology, and becoming competent individuals capable of decision-making and adapting to a multicultural society.

However, students' scientific literacy scores remain low. Based on the 2022 PISA (Programme for International Student Assessment) results which regularly measure the scientific abilities of students across various countries, it is shown that the scientific literacy skills of Indonesian students are still low compared to other nations. Therefore, an improvement in the quality of science education is necessary to produce graduates who are competent and globally competitive (Limiansih, 2024). According to data released by PISA, the scientific literacy skills of students in Indonesia are at a relatively low level. In the 2022 PISA assessment, Indonesia ranked 65th out of 81 participating countries, with an average scientific literacy score of 395. This figure is significantly below the average score of OECD member countries, which reached 500 (OECD, 2023).

According to Yusmar & Fadilah (2023), based on the impacts described, it is crucial to analyze the low scientific literacy skills of students in Indonesia. This analysis should be conducted with reference to PISA results and the various underlying factors. By doing so, we can identify which aspects need to be updated and improved in the learning process to meet the demands of modern developments. Research conducted by Pertiwi et al. (2018) shows that students' learning success can be measured by their ability to apply acquired knowledge in daily life, specifically through scientific literacy. Therefore, it is vital for students to understand the benefits of studying science. This understanding will help shape their perception of the utility, meaning, and necessity of science in life.

These conditions reinforce the urgency of conducting research focused on analyzing students' scientific literacy skills at SMAN 4 Makassar. Based on preliminary observations and confirmed by a teacher, it was found that no scientific literacy skills test has ever been administered to the students. This study aims to determine the level of students' scientific literacy, the aspects that need reinforcement, and the factors influencing them. The results are expected to serve as a foundation for SMAN 4 Makassar in designing contextual science learning strategies that align with student characteristics in the global era.

Based on the background described above, this research is focused on "Analysis of Students' Scientific Literacy Skills at SMAN 4 Makassar." The results obtained from this study are expected not only to serve as a reference for internal evaluation and improvement within SMAN 4 Makassar but also to contribute to the development of effective, contextual science learning models oriented toward strengthening scientific literacy relevant to 21st-century skill requirements.

RESEARCH METHODS

This study employed a descriptive quantitative research design to describe and analyze students' scientific literacy levels using numerical data. The research was conducted at SMAN 4 Makassar during the second semester of the 2024/2025 academic year. The study population consisted of all 311 Grade X Mathematics and Natural Sciences (MIPA) students at the school, all of whom were included as the research sample using a total sampling technique.

The variable investigated in this study was students' scientific literacy. Scientific literacy refers to an individual's ability to apply scientific knowledge, reasoning, and evidence-based thinking to understand phenomena and solve problems. In this study, scientific literacy was assessed based on three core competencies:

- Identifying questions aimed at seeking scientific information;
- Explaining or interpreting phenomena scientifically and predicting potential changes that may occur; and
- Analyzing scientific evidence, followed by constructing and communicating conclusions effectively.

Students' scientific literacy was assessed using a test instrument developed based on the three scientific literacy competencies. Responses were scored using an answer key and a standardized scoring rubric developed by the researchers. The completed tests were then analyzed to determine students' scientific literacy levels. The collected data were processed using Microsoft Excel 2013 to calculate students' scores and descriptive statistics. Scientific literacy levels were subsequently classified according to the predetermined assessment criteria.

Table 1. Scientific Literacy Skills Assessment Categories

Category	Score Range
Very High	81-100
High	61-80
Moderate	41-60
Low	21-40
Very Low	0-20

The results of the scientific literacy assessment for both male and female students are then interpreted based on scientific literacy indicators, which are classified according to PISA scientific literacy achievement levels.

Tabel 2. PISA Scientific Literacy Achievement Categories

Criteria	Value
High	>75
Moderate	60-75
Low	<60

Validity

The validity of the instrument was evaluated in two stages: content validity and empirical validity. The procedures for each stage are described as follows.

1. Content Validity

The test instrument was evaluated by two expert validators. Their evaluations were analyzed to determine the instrument's content validity. The validity analysis was conducted using Gregory's content validity formula, which measures the level of agreement between the two experts regarding the relevance of each test item. The internal consistency coefficient was calculated using the following equation:

Table 3. *Gregory* 2×2 Tabulation

Validator	**Weak Relevance** (items scored 1 and 2)	**Strong Relevance** (items scored 3 and 4)
Weak Relevance (items scored 1 and 2)	A	B
Strong Relevance (items scored 3 and 4)	C	D

Description:
A: The number of items in cell A (weak-weak relevance)
B: The number of items in cell B (strong-weak relevance)
C: The number of items in cell C (weak-strong relevance)
D: The number of items in cell D (strong-strong relevance)

$$V \frac{D}{A+B+C+D} \qquad (1)$$

According to Gregory's content validity criteria, an instrument is considered valid if the validity coefficient (V) is ≥ **0.75**. The results of the content validity analysis showed that the agreement coefficient between the two expert validators was **1.00**, exceeding the minimum acceptable value of 0.75. Therefore, the instrument was considered to have excellent content validity and was deemed appropriate for use in this study.

2. Empirical Validity

Empirical validity was established through a pilot test administered to respondents with characteristics comparable to those of the target population. The pilot test data were analyzed to evaluate the validity of each test item based on empirical evidence, thereby determining the instrument's suitability for use in the main study.

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}} \qquad (2)$$

r_{xy} = the correlation coefficient between variable X and variable Y
X = the item score
Y = the respondent's total score

The determination of item validity is conducted by comparing the calculated r-value with the critical r-value at a 5% significance level. An item is declared valid if $r_{Calculate} > r_{table}$, and conversely, an item is invalid if $r_{calculate} < r_{table}$ Based on the empirical validation results, it was found that 10 items were valid and 5 items were invalid.

3. *Reliability*

Reliability Test To calculate the item reliability, the Cronbach's Alpha formula is used as follows:

$$r_{ii} = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum \sigma^2 b}{\sigma^2 t}\right) \qquad (3)$$

Description:
r_{ii} = the instrument reliability
k = the number of test items or questions
$\sum \sigma^2$ = the sum of item variances
σ^2 = the total variance

The reliability of the instrument was assessed using Cronbach's alpha coefficient. An instrument was considered reliable if the Cronbach's alpha value exceeded 0.60. The reliability analysis yielded a Cronbach's alpha coefficient of 0.91, indicating that the instrument has high reliability and is suitable for use in this study.

RESULTS AND DISCUSSION

This section presents the findings on the scientific literacy levels of Grade X students at SMAN 4 Makassar based on data collected from 311 participants. The study was conducted between October 22 and November 13, 2025, using a scientific literacy test consisting of 10 essay questions developed in accordance with the Programme for International Student Assessment (PISA) scientific literacy framework. Students' scientific literacy levels were analyzed using descriptive statistics, with data processing performed in Microsoft Excel. The results are presented and discussed below.

Results

The scientific literacy levels of Grade X students at SMAN 4 Makassar were analyzed using descriptive statistics. The overall findings are presented in Table 4.

Table 4. Descriptive Statistics of Grade X Students' Scientific Literacy Scores

Statistics	Statistical Values
Number of Subjects	311
Maximum Ideal Score	100
Minimum Ideal Score	0
Maximum Empirical Score	92.5
Minimum Empirical Score	5
Standard Deviation	22.8
Mean	61.59

Table 4 shows that the students' scores ranged from 5 to 92.5, with an ideal score range of 0 to 100. The standard deviation was 22.8, indicating considerable variation in students' scientific literacy performance. The distribution of students across the scientific literacy categories is presented in the histogram below.

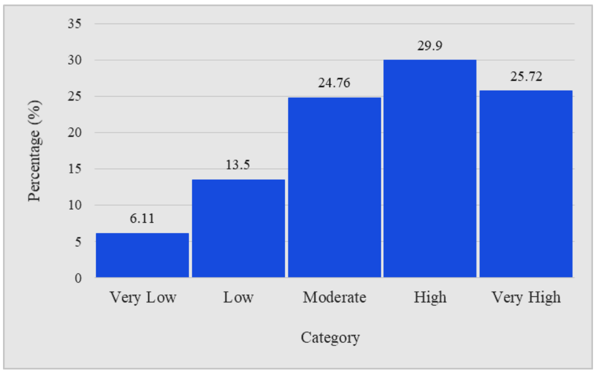

Figure 1. Histogram of Scientific Literacy Skills of Grade X Students at SMAN 4 Makassar

Based on the histogram, students' scientific literacy levels were distributed across five categories: very high (25.72%), high (29.90%), moderate (24.76%), low (13.50%), and very low (6.11%). The results of the descriptive analysis for the identifying scientific questions and issues competency are presented in Table 5.

Table 5. Descriptive Statistics of Students' Scores for the Scientific Literacy Competency of Identifying Scientific Questions and Issues

Statistics	Statistical Values
Number of Subjects	311
Maximum Ideal Score	100
Minimum Ideal Score	0
Maximum Empirical Score	100
Minimum Empirical Score	0
Standard Deviation	23.33
Mean	67.91

Table 5 presents the descriptive statistics for the first scientific literacy competency, identifying scientific questions and issues. Students' scores ranged from 0 to 100, corresponding to the ideal score range, with a standard deviation of 23.33. The distribution of students across the scientific literacy categories for this competency is presented in the histogram below.

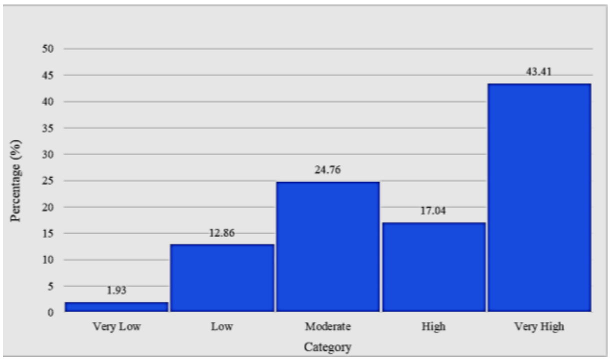

Figure 2. Histogram of Scores for the Scientific Literacy Competency of Identifying Scientific Questions and Issues

Based on the histogram, students' performance on the scientific literacy competency of identifying scientific questions and issues was distributed across five categories: very high (43.41%), high (17.04%), moderate (24.76%), low (12.86%), and very low (1.93%).

The descriptive statistics for the scientific literacy competency of explaining phenomena scientifically are presented in Table 6.

Table 6. Descriptive Statistics of Students' Scores for the Scientific Literacy Competency of Explaining Phenomena Scientifically

Statistics	Statistical Values
Number of Subjects	311
Maximum Ideal Score	100
Minimum Ideal Score	0
Maximum Empirical Score	100
Minimum Empirical Score	0
Standard Deviation	26.18
Mean	61.84

Table 6 presents the descriptive statistics for the second scientific literacy competency, explaining phenomena scientifically. Students' scores ranged from 0 to 100, corresponding to the ideal score range, with a standard deviation of 26.18. The distribution of students across the scientific literacy categories for this competency is presented in the histogram below.

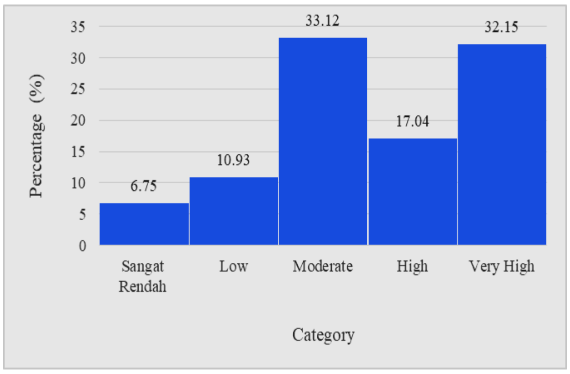

Figure 3. Histogram of Students' Scores for the Scientific Literacy Competency of Explaining Phenomena Scientifically

Based on the histogram, students' performance on the scientific literacy competency of explaining phenomena scientifically was distributed across five categories: very high (32.15%), high

(17.04%), moderate (33.12%), low (10.93%), and very low (6.75%).

The descriptive statistics for the third scientific literacy competency, using scientific evidence, are presented in Table 7.

Table 7. Descriptive Statistics of Students' Scores for the Scientific Literacy Competency of Using Scientific Evidence

Statistics	Statistical Values
Number of Subjects	311
Maximum Ideal Score	100
Minimum Ideal Score	0
Maximum Empirical Score	100
Minimum Empirical Score	0
Standard Deviation	30.31
Mean	42.31

Table 7 presents the descriptive statistics for the third scientific literacy competency, using scientific evidence. Students' scores ranged from 0 to 100, corresponding to the ideal score range. The mean score for this competency was 57.49, with a standard deviation of 30.31. The distribution of students across the scientific literacy categories for this competency is presented in the histogram below.

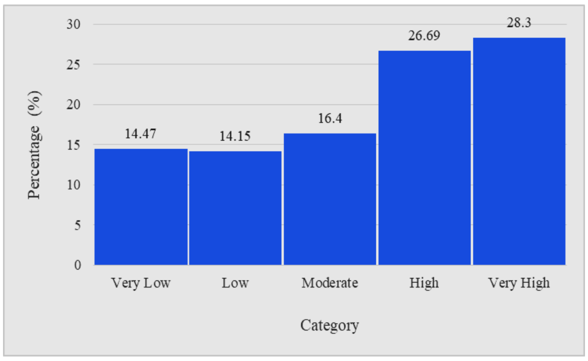

Figure 4. Histogram of Students' Scores for the Scientific Literacy Competency of Using Scientific Evidence

Based on the histogram, students' performance on the scientific literacy competency of using scientific evidence was distributed across five categories: very high (28.30%), high (26.69%), moderate (16.40%), low (14.15%), and very low (14.47%).

The descriptive statistics of students' scientific literacy scores by gender are presented below.

Table 8. Descriptive Statistics of Students' Scientific Literacy Scores by Gender

Statistics	Statistical Values	
	Male	Female
Number of Subjects	138	173
Maximum Ideal Score	100	100
Minimum Ideal Score	0	0
Maximum Empirical Score	92.5	92.5
Minimum Empirical Score	5	10
Standard Deviation	22.97	19.03
Mean	51.31	69.80

Table 8 presents the descriptive statistics of students' scientific literacy scores by gender. Male students' scores ranged from 5 to 92.5, while female students' scores ranged from 10 to 92.5, within an ideal score range of 0 to 100. The standard deviation was 22.97 for male students and 19.03 for female students, indicating slightly greater variation in the scores of male students. The distribution of students across the scientific literacy categories by gender is presented in the histogram below.

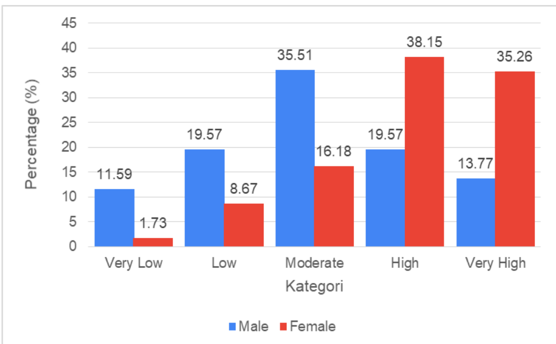

Figure 5. Histogram of Students' Scientific Literacy Skills Based on Gender

Based on the histogram, the scientific literacy levels of male students were distributed as follows: very high (13.77%), high (19.57%), moderate (35.51%), low (19.57%), and very low (11.59%).

In contrast, the scientific literacy levels of female students were distributed as follows: very high (35.26%), high (38.15%), moderate (16.18%), low (8.67%), and very low (1.73%). Overall, female students exhibited a higher proportion of scores in the high and very high categories than male students.

Discussion

Scientific literacy was assessed using a PISA-based instrument comprising three competencies: identifying scientific issues, explaining phenomena scientifically, and using scientific evidence. The instrument consisted of 10 essay questions on the topic of measurement and was administered to all 311 Grade X students at SMAN 4 Makassar.

The results showed that the overall mean scientific literacy score was 61.59, placing students in the moderate category according to the PISA scientific literacy proficiency criteria. This finding suggests that, although students demonstrated an acceptable level of scientific literacy, there remains considerable room for improvement, particularly in higher-order scientific reasoning. Previous studies have suggested that scientific literacy is influenced by several factors, including instructional strategies, students' prior knowledge, motivation, and interest in learning (Nurasmila, 2013). These factors may also help explain the findings of the present study. Although students at SMAN 4 Makassar had not previously been assessed using PISA-oriented scientific literacy tasks in physics classes, their performance indicates that additional instructional support is particularly needed in the competencies of explaining phenomena scientifically and using scientific evidence.

A comparison based on gender revealed notable differences in students' scientific literacy performance. Female students achieved a mean score of 69.80, which falls within the moderate category, whereas male students obtained a mean score of 51.31, classified as low according to the PISA proficiency criteria. These findings indicate that female students outperformed their male counterparts in overall scientific literacy. This result is consistent with the findings of Syifa (2022), who also reported significantly higher scientific literacy among female students. Previous research has suggested that this difference may be associated with learning characteristics such as greater attentiveness, persistence, and accuracy among female students (Pujiati, 2019). Nevertheless, because these factors were not directly investigated in the present study, they should be interpreted as possible explanations rather than definitive causes.

Among the three scientific literacy competencies, identifying scientific issues achieved the highest mean score (67.91), followed by explaining phenomena scientifically (61.84), while using scientific evidence recorded the lowest mean score (42.31). These findings indicate that students were generally more successful at recognizing scientific problems than at applying scientific reasoning and evaluating evidence.

The highest performance was observed in the competency of identifying scientific issues. One possible explanation is that this competency primarily requires students to recognize scientific concepts and identify relevant information, which generally involves lower cognitive demands than explaining phenomena or evaluating scientific evidence. This interpretation is supported by Muttaqin (2024), who argued that identifying scientific issues is relatively easier because it focuses on recognizing familiar scientific concepts encountered in everyday life. Furthermore, students' confidence in understanding basic concepts may contribute positively to their performance. Muhammad Irsyad (2024) also reported that self-efficacy plays an important role in supporting the development of scientific literacy.

Students' responses to the assessment items further suggest that many were able to identify relevant physical quantities but experienced difficulties when applying more abstract scientific concepts. For example, students often recognized quantities such as mass, volume, time, and temperature but were unable to distinguish between base and derived quantities or correctly represent their physical dimensions. These findings indicate that students possess fundamental conceptual knowledge but require further support in applying that knowledge within scientific contexts.

The competency of explaining phenomena scientifically produced the second-highest mean score. This competency requires students to interpret scientific phenomena by relating observations to appropriate scientific theories and concepts. The findings indicate that many students were capable of connecting scientific concepts with real-life situations, although their explanations often lacked sufficient depth and scientific justification. These results are consistent with Maullidyawati (2022), who reported that students generally perform well when asked to relate everyday scientific phenomena to relevant theoretical concepts. Similarly, Eustika et al., (2024) found that differentiated instruction supported by inquiry-based electronic student worksheets (E-LKPD) significantly improved students' ability to explain scientific phenomena.

Despite these encouraging results, students still encountered difficulties when deeper conceptual understanding was required. For instance, although many students correctly identified the physical quantities presented in the assessment, they were unable to explain the scientific relationships among those quantities or classify them appropriately. This finding suggests that students require greater opportunities to develop conceptual reasoning rather than relying solely on factual knowledge.

The lowest performance was observed in the competency of using scientific evidence, indicating that students experienced the greatest difficulty in interpreting evidence and drawing scientifically justified conclusions. This competency requires students not only to understand scientific concepts but also to evaluate evidence critically, integrate multiple sources of information, and apply scientific reasoning to unfamiliar situations. The relatively low performance suggests that classroom instruction should provide more opportunities for students to analyze evidence, formulate evidence-based arguments, and solve authentic scientific problems.

These findings are consistent with Rahmadina et al. (2022), who reported that students' limited scientific literacy is often associated with assessment practices that emphasize memorization rather than scientific reasoning. Consequently, students become accustomed to recalling information instead of interpreting evidence or applying scientific concepts to new contexts.

The findings also highlight the important role of teachers in promoting scientific literacy. Previous studies have identified several contributing factors to students' limited scientific literacy, including curriculum design, instructional approaches, assessment practices, learning resources, and teachers' understanding of scientific literacy (Kurnia, 2014; Siswanto, 2023; Nurmaziah, 2025). In particular, teachers require sufficient knowledge of scientific literacy competencies to design learning activities and assessments that foster higher-order thinking and evidence-based reasoning. Evaluation should therefore extend beyond measuring content mastery and provide students with opportunities to explain scientific phenomena, interpret evidence, and solve authentic scientific problems. Such assessment practices have been shown to contribute positively to the development of scientific literacy (Windyariani, 2017; Utami, 2018).

Overall, the findings suggest that Grade X students at SMAN 4 Makassar have achieved a moderate level of scientific literacy. However, the relatively low performance in the competency of using scientific evidence indicates that further instructional improvement is needed. Future classroom practices should emphasize inquiry-based learning, scientific argumentation, and authentic assessment to strengthen students' ability to apply scientific knowledge critically and effectively in real-world contexts.

CONCLUSION

Based on the findings of this study, the scientific literacy level of Grade X students at SMAN 4 Makassar was classified as moderate, with an overall mean score of 61.59. Among the three scientific literacy competencies assessed, identifying scientific issues achieved the highest mean score (67.91), followed by explaining scientific phenomena (61.84). In contrast, using scientific evidence recorded the lowest mean score (42.31), indicating that students experienced greater difficulty in interpreting evidence and applying scientific reasoning than in recognizing scientific issues or explaining scientific phenomena.

These findings suggest that while students have developed a moderate level of scientific literacy, greater emphasis should be placed on instructional strategies and assessment practices that strengthen evidence-based reasoning and the application of scientific knowledge in real-world contexts. Enhancing these competencies is expected to further improve students' overall scientific literacy and better prepare them to address scientific and societal challenges.

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58

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