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Evaluative Study of Scientific Literacy Skill of Students in Science Subjects at Junior High Schools in Bandung City

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EVALUATIVE STUDY OF SCIENTIFIC LITERACY SKILL IN SCIENCE SUBJECTS AT JUNIOR HIGH SCHOOLS IN BANDUNG CITY

Abstract: In the wake of the COVID-19 pandemic, educational institutions globally have adapted to new teaching methodologies to ensure resilient and effective learning environments. This study evaluates the transition to project-based learning (PBL) in online classrooms within the Thai education system, using the Net Promoter Score (NPS) methodology to assess student satisfaction. A survey was conducted among 95 undergraduate students, classifying respondents into Promoters (scores of 9-10), Passives (scores of 7-8), and Detractors (scores of 0-6). The results indicated that 65% of students were Promoters, expressing high satisfaction and a strong endorsement of the PBL approach. Meanwhile, 20% were Passives, and 15% were Detractors, showing varying levels of contentment. The overall NPS score of 50% reflects a highly resilient and favorable response to the PBL method in online classrooms. These findings suggest that PBL is an effective teaching strategy for maintaining student engagement and learning outcomes in a post-pandemic educational landscape. This study highlights the potential of PBL to enhance the resilience of online education, providing valuable insights for educators and policymakers aiming to adapt to future disruptions.
Keywords: Science literacy, evaluative study, junior high school, science subjects, Bandung city

Introduction

Science literacy has become one of the fundamental literacies that students must possess, as stated by the Ministry of Education in 2017. Science literacy is not only important for understanding scientific concepts but also for developing critical thinking, analytical skills, and evidence-based decision-making. Emphasizes that within the context of quality education, science literacy helps students understand the world around them more deeply and prepares them to contribute to an increasingly advanced and complex society (OECD, 2023 & OECD, 2018).

Science literacy includes the ability to understand and evaluate scientific content for specific purposes. This process involves focused reading and the ability to critically assess the content, enabling individuals to navigate the complexities of scientific information effectively (Hodson, 1988; Jufrida *et al*., 2019). In the classroom, approaches to clarifying scientific texts can play a role in enhancing students' science literacy. Engaging students in language modification, conceptual relationships, and curriculum practices can create a more participatory learning environment, helping students better understand and internalize scientific concepts (Allen, 2018a; Avikasari *et al*., 2018). Therefore, science literacy is not only about understanding theory but also about the ability to apply it in practical contexts, enabling students to be more actively involved in the learning process.

Science literacy has broad implications for individuals, communities, and society as a whole. Understanding scientific processes, practices, and values is crucial in supporting the health and well-being of the community and influencing public support for science (Allen, 2018a; Cho, 2022). With increased science literacy, students can better understand the implications of scientific and technological developments in everyday life, which in turn can encourage more meaningful participation in scientific debates and public policy. Therefore, efforts to improve science literacy not only provide personal benefits but also have the potential to shape a more knowledgeable and scientifically informed society.

The government, through the Ministry of Education, has taken significant steps to improve science literacy by transforming the curriculum. In 2021, the Indonesian Education Curriculum changed to the Independent Curriculum (Ministry of Education, 2022). This curriculum is applied selectively by a number of schools that have undergone strict selection by the Ministry of Education and Culture. Selected schools, known as driving schools, are expected to implement the Independent Curriculum optimally, thus positively impacting the improvement of students' science literacy.

Although this step shows the government's commitment to improving science education in Indonesia, it has not yet fully yielded maximum impact. One crucial issue that has emerged is the significant weakness in students' science literacy skills. The implementation of the Independent Curriculum, part of the reform efforts, has not fully addressed these challenges. The results of the 2022 Program for International Student Assessment (PISA) for Indonesia show a significant decline in science literacy scores, dropping 13 points compared to the scores in 2018. This phenomenon is alarming because science literacy plays a crucial role in shaping a competent and adaptive generation in the current global era.

Table 1: Indonesia's PISA scores from 2000-2022

Year	Number of Countries Surveyed	Science Literacy
2000	41	393
2003	50	395
2006	57	393
2009	57	393
2012	65	382
2015	72	386
2018	79	396
2022	81	383

Based on PISA data over the past 22 years since Indonesia joined the Programme for International Student Assessment (PISA), it is evident that Indonesia's science literacy scores are still far below the average of OECD countries. The average science literacy score of OECD countries is around 427 points, while Indonesia struggles with a lower score. Additionally, the science literacy scores of Indonesian students have not shown significant improvement from 2000 to 2022. In fact, there was a noticeable decline, with Indonesia's 2022 PISA score dropping 13 points from 2018. This indicates that Indonesian students' science literacy skills still require serious attention to improve the quality of education (Joko, 2019; Fitria & Indra, 2020). This significant difference signals a gap in the understanding and application of scientific concepts among Indonesian students compared to OECD countries.

One of the main obstacles is the lack of teaching materials that integrate science literacy into learning. Teachers have not fully incorporated science literacy into their teaching materials, so students are not accustomed to science literacy content in their learning. Additionally, the lack of practice and exams that include science literacy is also a problem, causing students to be untrained in applying scientific concepts and processes to problem-solving. Moreover, it was found that the questions used to measure student learning outcomes tend to emphasize content aspects over science literacy. These questions usually focus more on material knowledge and less on scientific processes and contexts (Zahro, 2020; Permatasari & Fitriza, 2019).

Learning loss in 2020, triggered by the COVID-19 pandemic, is one of the main causes of the low PISA scores in Indonesia. Physical restrictions and the use of distance learning approaches have had a negative impact on the teaching-learning process. Additionally, the transition from the 2013 Curriculum to the 2022 Curriculum has also been a factor in the decline in education quality (Alfiaturrohmah, 2024; Soleha & Mujahid, 2024). Teachers face challenges in understanding and optimally implementing the Independent Curriculum, creating uncertainty in delivering material effectively to students. Similarly, students experience difficulties as they are not yet accustomed to the teaching methods applied in the new curriculum. The limited understanding of teachers and students' discomfort with the implementation of the Independent Curriculum are serious challenges that need to be addressed.

Curriculum renewal must be balanced with adequate support and training for educators to face changes more preparedly. Additionally, efforts must be made to increase student engagement and minimize the impact of learning loss to improve *students'* science literacy according to current educational demands.

Low science literacy significantly impacts student learning outcomes, reflected in unsatisfactory academic performance. Students with low science literacy tend to have difficulty understanding basic science concepts, hindering their ability to solve problems and apply knowledge in practical situations. This lack of understanding also negatively impacts learning motivation, as students feel burdened by material they do not master. This results in low active participation in the learning process, where students become less engaged and less enthusiastic about exploring the scientific topics being taught.

The literacy evaluation conducted at Driving Schools focuses on science literacy. The science literacy evaluation aims to measure the ability to scientifically explain phenomena, evaluate and design scientific investigations, and interpret data and evidence scientifically. The importance of this evaluation lies in its effort to measure the extent to which students can apply scientific concepts in real-world situations, thus forming a deep and relevant understanding of their environment. In developing the science literacy evaluation instrument, the approach includes expert judgment methods to ensure the content suitability of the instrument with research needs. This process involves the participation of field experts to provide constructive assessments and feedback. Next, field validation is conducted through limited trials to measure the validity and reliability of the instrument. This validation helps ensure that the evaluation instrument can measure science literacy accurately and consistently. After the instrument is declared valid and reliable, trials are conducted on a larger scale to obtain more comprehensive data. This careful and thorough evaluation process allows for the development of an effective science literacy evaluation instrument, providing a clear picture of the science literacy abilities of students at Driving Schools. The results of this evaluation are expected to provide valuable information for the development of better curricula and teaching methods in the future. Therefore, the general objective of this research is to evaluate the scientific literacy skills of junior high school students in science subjects within the implementation of the Indonesian education curriculum in Bandung City.

Method

This research is an evaluative study using a summative evaluation type, which aims to determine students' mastery of science learning during the implementation of the Indonesian education curriculum in junior high schools, as described by Arifin (2016). The evaluation was conducted using a quantitative method, involving the collection of numerical data through written tests and surveys based on PISA scientific literacy indicators. The written test was designed to measure students' understanding of scientific concepts, data interpretation skills, and critical thinking abilities, while the survey, using a questionnaire, aimed to assess students' perceptions of science learning and their scientific literacy. In addition, an analysis of teaching modules and final exam questions was conducted to evaluate the alignment of the teaching materials and exam questions with PISA's scientific literacy standards. The total sample used in this study was 283 students from 4 junior high schools in Bandung City. Furthermore, the instruments used in this study, including the written test and questionnaire, were validated and reliability tested to ensure their accuracy and consistency. The combination of data from various sources provides a comprehensive picture of students' scientific literacy abilities during the implementation of the Indonesian education curriculum.

Figure 1: Research evaluation procedure

Result and Discussion

Result

Scientific Literacy Skill Of Junior High School Students

This study involved 282 students from three different junior high schools in Bandung to measure their scientific literacy skills based on three main indicators. By involving a representative sample from several schools, the results of this research will provide a comprehensive overview of the extent to which junior high school students have mastered scientific literacy. This analysis will identify strengths and weaknesses in each indicator, allowing researchers to determine areas that require improvement and more effective educational strategies.

Table 2: Scientific literacy skill of junior high school students

Indicator	Written Test		Questionnaire	
	M	SD	M	SD
Explaining phenomena scientifically	61.8	16.6	64.22	14.1
Designing and evaluating scientific investigations as well as critically interpreting data and scientific evidence	63.9	19.4	65.1	15.5
Investigating, evaluating, and using scientific information for decision-making and action	61.0	16.9	61.9	14.6
Average Science Literacy Ability for each Indicator	62.1		63.7	
Overall Average Science Literacy Ability	62.9			

The overall average science literacy ability of students is 62.9, with the highest scores in explaining phenomena scientifically (64.22) and designing/evaluating scientific investigations (65.1). The data shows a consistent range in student performance across the different indicators, with an average score of 62.1 to 63.7 for each indicator, which falls into the moderate category.

Differences in Students' Scientific Literacy Skills

Based on Written Test and Questionnaire Instruments

This study measured students' scientific literacy skills based on three main indicators: explaining phenomena scientifically (MFI), designing and evaluating scientific investigations (MPM), and using scientific information for decision-making (MIP). The aim of this section is to explain the differences in students' scientific literacy using written tests and questionnaires through an independent sample t-test. A homogeneity test was conducted using IBM SPSS Statistic 25 to ensure the variance between the two data groups was not significantly different, and Table 4.4 presents the results.

Table 3: The Results of the homogeneity test for two data groups

Indicator	Levene Statistic		df1		df2	Sig.
	1.838	1	562	0.176	1.838	1
Based on Mean	1.978	1	562	0.160	1.978	1
Based on Median	1.978	1	561.05	0.160	1.978	1
Based on Median and with adjusted df	1.830	1	562	0.177	1.830	1

If sig. > 0.05 = data is homogeneous

Table 4.4 presents the results of the homogeneity test for two data groups. It shows that the sig. value > 0.05 based on the mean, indicating that the variance between the two groups, using written test instruments and questionnaires, is equal or homogeneous. Thus, the prerequisite for conducting an independent sample T-test is met. The homogeneity test showing equal variance allows further analysis to determine differences in students' scientific literacy abilities based on the measurement methods used. Table 4.5 presents the results of the independent sample T-test.

Table 4: Scientific literacy skill of junior high school students based on two instruments

Indicator	Written Test		Questionnaire		T_{Test}	T_{Table}
	M	SD	M	SD		
Explaining phenomena scientifically	61.8	16.6	64.2	14.1	1.87	1.97
Designing and evaluating scientific investigations as well as critically interpreting data and scientific evidence	63.9	19.4	65.1	15.5	0.81	
Investigating, evaluating, and using scientific information for decision-making and action	61	16.9	61.9	14.6	0.64	
Average	62.2		63.7			

Based on the analysis of the independent sample T-test on three indicators of junior high school students' scientific literacy, no significant differences were found between the use of written tests and questionnaires. This indicates that both instruments are equally effective in measuring scientific literacy. This study supports findings that as long as instruments are designed according to learning objectives, both written tests and questionnaires can be used effectively. (Zhai *et al*., 2023; Walker & Sampson, 2019).

Based on Students' Gender

Out of 282 respondents, consisting of 142 males and 140 females, the gender distribution is balanced with no significant dominance of either gender. This balance is important to avoid bias in the research results. Figure 2 presents junior high school students' scientific literacy based on gender

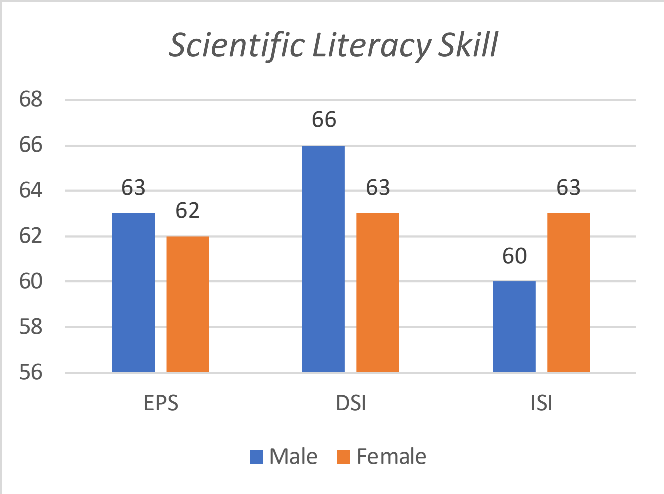

Figure 2: Average scientific literacy skill of male and female students

The data shows that the average scientific literacy of both male and female students is in the medium category. Male students perform better on the first two indicators, while female students excel on the third. Despite slight differences, overall scientific literacy shows no significant gender differences. An independent sample T-test is needed to confirm this.

Table 5: Scientific literacy skill of junior high school students based on gender

Indicator	Written Test		Questionnaire		T_{Test}	T_{Table}
	M	SD	M	SD		
Explaining phenomena scientifically	61.8	16.6	64.2	14.1	1.87	1.97
Designing and evaluating scientific investigations as well as critically interpreting data and scientific evidence	63.9	19.4	65.1	15.5	0.81	
Investigating, evaluating, and using scientific information for decision-making and action	61	16.9	61.9	14.6	0.64	
Average	62.2	[redacted]	63.7	[redacted]	[redacted]	[redacted]

If $T_{test} < T_{Table}$, there is no significant difference.

The t-test results in Table 5 show no significant differences in scientific literacy between male and female students across all indicators. This aligns with McGraw et al. (2019), but differs from Huang (2013), who found that female students tend to have higher scientific literacy, especially in biology.

Based on Differences in Junior High School

Out of 282 samples, with 104 from School A, 93 from School B, and 85 from School C, the distribution among schools is relatively even with no significant differences. This indicates almost equal contributions from the three schools, making the data analysis representative. The differences in students' scientific literacy will be analyzed based on school. Figure 3 presents students' scientific literacy Based On Differences Schools.

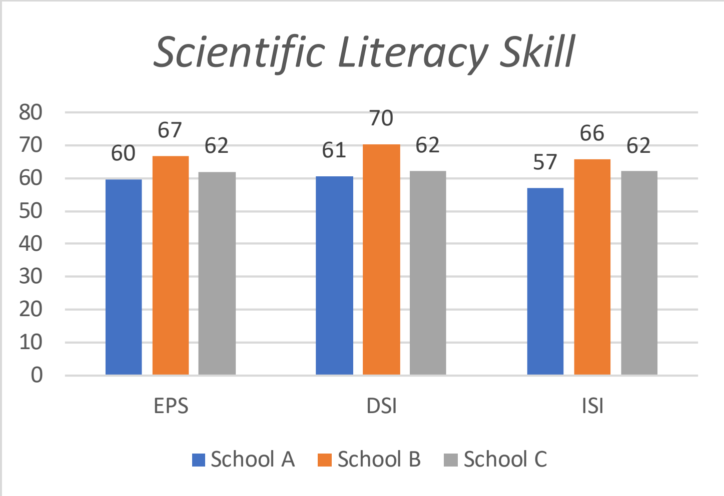

Figure 3: Average scientific literacy skill based on differences schools

Figure 3 shows the differences in students' scientific literacy based on three indicators: EPS, DSI, and across three schools (School A, School B, and School C). For EPS, School B performs best with a score approaching high, while School A has the lowest. School C is in between. In the DSI indicator, School B also excels, demonstrating good abilities in evaluating and designing scientific investigations. Schools A and C have similar scores in the medium category. For the ISI indicator, Schools B and C have nearly identical scores, both in the medium category, while School A scores lower. Overall, School B shows the best performance but still requires improvement. A Tukey HSD post hoc test will be conducted to assess significant differences between groups. Before this, an ANOVA test is important to identify significant differences among groups. Table 4.8 presents the one-way ANOVA results for students' scientific literacy based on EPS and school differences.

Table 6: Sscientific literacy skill of junior high school students based on differences schools

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2481,34	2	1240,67	5,75	0.004
Within Groups	60229,31	279	215,88		
Total	62710,66	281	[redacted]		

Sig. < 0.05 indicates significant differences.

The ANOVA test results show a significance value (Sig.) of 0.004, which is less than 0.05, indicating significant differences in the ability to explain phenomena scientifically among the tested schools. Since there is a significant difference, the next step is to conduct a Tukey HSD post hoc test to identify significantly different groups. The Tukey HSD test will provide details on differences between schools and an in-depth analysis of the sources of differences in students' scientific literacy abilities. Table 6 presents the results of the Tukey HSD post hoc test for the EPS indicator.

Table 7: Scientific literacy skill of junior high school students based on differences schools

School	M	SD	SMP (J)	*Mean difference*	Sig.
School A	59,88	13,9	School B	-7,017*	0,003
			School C	-2,278	0,54
School B	66,89	14,06	School A	7,017*	0,003
			School C	4,740	0,082
School C	62,15	16,22	School A	2,278	0,540
			School B	-4.740	0,082
Avarage	62,88		[redacted]		

Table 7 shows significant differences in students' science literacy between School A, B, and C. School B outperforms School A in Scientific Literacy Skill Of Junior High School Students Based *On* Differences Schools skills with a mean difference of -8.808 (p = 0.0001), and School C also has an advantage over School A with a mean difference of -5.059 (p = 0.048). However, there is no significant difference between School B and C (mean difference = 3.749, p = 0.202), indicating similar Scientific literacy skill of junior high school students based on Differences Schools performance, while School A lags behind both.

Correlation of Each Indicator of Students' Scientific Literacy Skills

Scientific literacy skills consist of three main indicators: EPS, DSI, and ISI. To determine if these indicators are correlated, a multiple correlation test is necessary. This test analyzes whether the EPS, DSI, and ISI indicators are interrelated. The results will show if there is a significant relationship between students' ability to explain scientific phenomena and their ability to design investigations and evaluate scientific information. A significant correlation would indicate that these indicators are linked, meaning skills in one area could influence another. Conversely, a lack of significant correlation suggests these indicators might measure independent aspects of scientific literacy. Table 8 presents the results of the multiple correlation test for each indicator of junior high school students' scientific literacy skills.

Table 8: Results of multiple correlation tests for each indicator

Dependent	M	SD	Independent	R	Sig. F Change
Explaining phenomena scientifically	62,88	14,94	DSI & ISI	0,70	0,0001
Designing and evaluating scientific investigations as well as critically interpreting data and scientific evidence	64,41	16,96	EPS & ISI	0,69	0,0001
Investigating, evaluating, and using scientific information for decision-making and action	61,54	15,00	EPS & DSI	0,66	0,0001

Significant correlation (Sig. F Change < 0.05)

The multiple correlation analysis for students' scientific literacy indicators shows a very low significance value (Sig. F Change 0.0001) for each tested indicator. The first indicator, **EPS** (Explaining scientific phenomena), has a strong correlation with **DSI** (Designing and evaluating scientific investigations) and

ISI (Investigating and using scientific information), with an R value of 0.70. Similarly, **DSI** shows a significant correlation with EPS and ISI, with an R value of 0.69. Lastly, ISI has an R value of 0.66, indicating the importance of EPS and DSI in this aspect. Overall, these results highlight that each indicator significantly correlates with relevant independent variables, demonstrating their contribution to improving students' scientific literacy skills.

Discussion

1. Evaluation of Student Scientific Literacy Skill on the EPS Indicator

Evaluating students' ability to explain scientific phenomena is essential for understanding their scientific literacy development. This evaluation focuses on six sub-indicators of explaining scientific phenomena (EPS), such as recalling and applying scientific knowledge, using various forms of representation, making predictions, and identifying models. The results reveal that most students score at a moderate level, with EPS-F achieving a high score, indicating that they are better at explaining the societal implications of scientific knowledge. However, they struggle with EPS-B, likely due to insufficient emphasis on this aspect in their education (Yusmar & Fadilah, 2023; Sumiyaty, 2023).

Additionally, students' abilities in DSI (Designing and evaluating investigations) and ISI (Investigating and using scientific information) significantly influence their capacity to explain scientific phenomena. Students skilled in designing investigations and critically interpreting data tend to excel in explaining phenomena, as their understanding of scientific methods enhances their explanations (Narut, 2019; Hanum, 2020). There are no significant differences in EPS mastery between male and female students, suggesting equitable learning opportunities. However, differences among schools indicate that various factors, such as teaching quality and resources, impact scientific literacy. This evaluation provides valuable insights into students' scientific literacy levels and identifies areas needing attention to enhance science education (Narut, 2019; Yusmar & Fadilah, 2023).

2. Evaluation of Student Scientific Literacy Skill on the DSI Indicator

The evaluation of students' ability to design and evaluate scientific investigations and critically interpret data (DSI) reveals significant variability among the sub-indicators. Overall, students demonstrate a reasonable understanding in formulating research questions and interpreting data but struggle with evaluating experimental design, indicating an imbalance in essential critical skills for scientific literacy. The average scores in sub-indicators like DSI-A and DSI-B are moderate, reflecting a need for improvement in more complex aspects, such as experimental design and methodological (Hattarina, 2022; Nai, 2021).

A detailed analysis indicates that the lack of accommodation for DSI sub-indicators in teaching modules and end-of-semester assessments (PAS) contributes to students' performance. Conventional teaching methods that do not incorporate project-based learning limit opportunities for students to develop critical and analytical thinking skills. Additionally, PAS questions rarely assess evaluative abilities and experimental design, restricting the scope of scientific skills testing (Kemdikbud, 2022; Avikasari *et al*., 2018). Gender analysis shows no significant differences in DSI abilities between male and female students, suggesting an inclusive teaching approach. However, disparities in performance among different schools indicate that factors like teaching quality and resources play a crucial role. Overall, this evaluation underscores the need for balanced teaching modules and assessments to comprehensively support scientific literacy, emphasizing diverse teaching methods to enhance students' critical thinking skills in complex contexts (kemdikbud, 2024; Utami *et al*., 2022).

3. Evaluation of Student Scientific Literacy Skill on the ISI Indicator

The evaluation of scientific literacy in the ISI indicator (Investigating, Evaluating, and Using Scientific Information for Decision-Making and Action) reveals variability in student skills across the three analyzed junior high schools. The results indicate that sub-indicator ISI-D, which focuses on critiquing weaknesses in scientific arguments, scores close to 70, placing it at the upper threshold of the moderate category (Osborne *et al*., 2019). This suggests that students have a relatively good ability to evaluate scientific arguments, yet further improvement is needed. Conversely, sub-indicators ISI-B and ISI-A, with scores around 60, show that students still struggle to distinguish evidence-based claims and evaluate scientific information sources, highlighting a significant need for enhancement in these areas (Chinn *et al*., 2021).

Sub-indicators ISI-C and ISI-E, each scoring near 50, indicate that students face challenges in constructing strong scientific arguments and justifying decisions with scientific reasoning. The low scores on ISI-C and ISI-E signal that students require support in developing these critical skills, essential for effective scientific literacy. In-depth analysis underscores the importance of integrating ISI sub-indicators into formal learning and assessments (Allen, 2018a; Cho, 2022). Limitations in instructional materials and end-of-semester assessments (PAS) reflect gaps in the learning process, restricting students' opportunities to practice and develop their skills. Therefore, improvements in curriculum integration and evaluation of these sub-indicators are essential for enhancing scientific literacy skills. Overall, while some progress is noted in specific ISI sub-indicators, significant areas still require attention to foster effective decision-making and action based on scientific information (Allum *et al*., 2018; Fatmawati & Khotimah, 2023; O'Toole *et al*., 2020).

Conclusion

The conclusion of this study indicates that the scientific literacy abilities of junior high school students, particularly in explaining scientific phenomena, are generally at a moderate level. While students have mastered the fundamentals of scientific literacy, their proficiency in the sub-indicators of explaining scientific phenomena varies, with aspects like scientific representation requiring more attention. The study highlights the importance of consistency between classroom teaching and final assessments, as discrepancies in instructional materials and evaluations can hinder students' development. Additionally, students' abilities to design and evaluate scientific investigations and utilize scientific information for decision-making positively impact their mastery of explaining scientific phenomena. Differences among schools also underscore the significance of contextual factors, such as teaching quality and resources, in supporting students' scientific literacy. Consequently, the study recommends enhancing teaching quality, employing more interactive learning methods, and implementing comprehensive assessments to improve overall scientific literacy among students effectively.

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