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ANALYSIS OF CORRELATION BETWEEN SCIENTIFIC LITERACY AND PRO-ENVIRONMENTAL ATTITUDES AMONG JUNIOR HIGH SCHOOL STUDENTS: AN ESD FRAMEWORK

Moch. Syaifuddin[1], Asri Widowati[2], Winarto[2], Ismail Fikri Natadiwijaya[2]
[1]Program of Master of Science Education, Yogyakarta State University, Yogyakarta, Indonesia
[2]Department of Science Education, Yogyakarta State University, Yogyakarta, Indonesia

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ABSTRACT

Low levels of scientific literacy and less good pro-environmental attitudes among students are big problems when we try to teach Education for Sustainable Development (ESD) at junior high schools. Yet we do not know much about how these two things are related in Indonesia. This study set out to look at the link between scientific literacy and pro-environmental attitudes among junior high school students inside an ESD program using a descriptive-correlational method. The sample was made up of 132 students from three high schools chosen for their location and how much they use environmental education. We gathered data with a scientific literacy test and a pro-environmental attitude questionnaire. We checked the instruments with the Content Validity Ratio (CVR) and Content Validity Index (CVI) getting high scores and we found the tools were reliable with a reliability coefficient of 0.874 for the test and 0.829 for the questionnaire. The results showed that students' scientific literacy scores were 52%, which's low while their pro-environmental attitudes were 55%, which is moderate. When we looked at the correlation, we found a positive relationship, between scientific literacy and pro-environmental attitudes ($r = .419$ $p < .001$) meaning the link is moderate. These findings mean that higher scientific literacy is linked to positive pro-environmental attitudes but the moderate strength of the link shows that other things also shape students' environmental views. Within the ESD framework the results underline how important it is to mix thinking and feeling parts to help students build pro-environmental attitudes and to act in ways that support sustainability.

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Corresponding Author:
Winarto
Department of Science Education, Yogyakarta State University, Yogyakarta, Indonesia
Email: winarto88@uny.ac.id

1. INTRODUCTION

Scientific literacy is a crucial skill for future generations to face the challenges of the 21st century (Wilujeng et al., 2025). Furthermore, this skill is also considered essential by the World Economic Forum (O'toole et al., 2020). Based on the 2022 PISA results, the global scientific literacy score reached 485, a drastic decrease compared to the previous period and above the average achievement of most developing countries (OECD, 2023a). This 2022 PISA score is the

lowest ever, indicating a gap in scientific literacy between developed and developing countries. It reflects a science learning crisis resulting from the COVID-19 pandemic, which has significantly impacted the quality of science learning globally (Nurwidodo et al., 2023). Indonesia still faces low level scientific literacy, with an average score of only 383, far below the OECD average of 485 (OECD, 2023a). Despite improving six positions compared to PISA 2018, the total score in 2022 decreased from 396 to 383 (OECD, 2023b). In fact, only 34% of students reached level 2 or higher, while the OECD average was 76%, indicating that the majority of Indonesian students are unable to use scientific knowledge to assess the validity of a conclusion (OECD, 2023b). Research also found that low scientific literacy in Indonesia is caused by non-evidence-based learning, limited facilities, socioeconomic disparities, and low interest in science (Ayu et al., 2025; Murti et al., 2024; Syofyan et al., 2025).

Low level scientific literacy directly impacts students' lack of pro-environmental attitudes (Syahmani et al., 2021). Indonesia still faces serious problems in national environmental and waste management, with 109 tons of waste generated per day being mismanaged (KLH, 2025). Furthermore, Indonesia also scored low in the 2022 Environmental Performance Index (EPI) for all indicators, namely ecosystem vitality (38.9), environmental health (25.8), and climate change mitigation policies (32.1), making Indonesia a poor performer in environmental conservation in the Asia Pacific region and globally (EPI, 2024). Ironically, this poor environmental condition aligns with students' suboptimal pro-environmental attitudes. Marselina et al. (2024) showed that students' pro-environmental attitudes remain low, particularly for the environmental care indicator, which is only 38%. This low level of pro-environmental attitudes poses a major challenge to sustainable development efforts. Several studies have found a positive relation of scientific literacy and pro-environmental attitudes. Scientific literacy can help students understand environmental issues and make decisions based on scientific evidence and facts (Husamah et al., 2024). Furthermore, Suhartinah et al. (2019) suggest that increasing scientific literacy could encourage more environmentally responsible behavior. Eleccion et al. (2025) also found a positive correlation between scientific literacy, pro-environmental attitudes, and sustainable practices. Scientific literacy not only increases knowledge but also shapes and strengthens pro-environmental attitudes (Maleknia & Zamani, 2025; Yildirim et al., 2025). Maurer & Bogner (2020) state that scientific literacy skills consist of knowledge components that serve as the foundation for developing pro-environmental attitudes. Students with in-depth knowledge of natural phenomena tend to demonstrate better pro-environmental attitudes, especially regarding environmental sustainability (Xie et al., 2023).

In this study ESD is positioned as an analytical framework for interpreting the relationship between scientific literacy and pro-environmental attitudes. Writers see ESD as a lens that pulls together knowledge, skills, values, attitudes and behaviours that we need to tackle sustainability challenges (UNESCO, 2017). ESD positions scientific literacy as a crucial instrument for developing sustainability competencies, which serve as the foundation for shaping pro-environmental attitudes. Dieni et al. (2022) found that ESD significantly improves scientific literacy while fostering pro-environmental attitudes. The integration of ESD into science learning has the potential to enhance scientific literacy by fostering the development of students' capacity to comprehend and implement scientific concepts, analyse information and data, engage in critical thinking, and formulate evidence-based decisions in response to sustainability challenges (Bramastia et al., 2025; Shabrina et al., 2024). Furthermore, ESD increases sustainability knowledge, thereby strengthening attitudes toward environmental issues (Olsson et al., 2022). And

then, ESD also fosters values, awareness, and environmental responsibility (Draghici, 2019). Thus, ESD contributes to improving scientific literacy while shaping pro-environmental attitudes. Scientific literacy is the thinking side: scientific literacy lets students understand how nature works, verify evidence and make smart choices. Pro-environmental attitudes are the feeling side: attitudes show care, responsibility and a desire to act. We explain how these two sides connect by using ESD skills; systems thinking, critical thinking, strategic competence, normative competence, and self-awareness. So, in this study ESD is not a variable; instead ESD is the eye through which we see how scientific literacy and pro-environmental attitudes link to skills that matter, for sustainable development.

Global research trends show a significant increase in studies of science learning outcomes and pro-environmental attitudes within an ESD framework (Molnár et al., 2026). This includes research on scientific literacy and pro-environmental attitudes. However, most studies are experimental or product development (R&D) studies that focus on the effectiveness of specific interventions or learning media, without delving deeper into the ESD perspective (Hemtasin et al., 2026; M. B. Panjaitan et al., 2026; Thobejane et al., 2026). Furthermore, research examining the correlation between scientific literacy and pro-environmental attitudes is mostly conducted at the primary school or college level, thus not adequately representing the developmental characteristics of junior high school students who are in the transition period (Jaelani et al., 2023; Lustianti et al., 2024; A. D. U. Panjaitan et al., 2025). Previous research has also not explicitly integrated the ESD perspective as an analytical framework, instead treating the two as separate variables (Calliera et al., 2026; Schneiderhan-Opel & Bogner, 2020). The data studied are still fragmented in terms of location and time, thus unable to provide a current picture of the state of scientific literacy and pro-environmental attitudes among junior high school students in the post-pandemic era and the implementation of the Independent Curriculum (Adjie et al., 2023; Suhartinah et al., 2019).

Vioreza et al. (2023) emphasized the importance of integrating ESD in the Independent Curriculum to promote sustainability values, including pro-environmental attitudes. However, an important research gap remains regarding how scientific literacy and pro-environmental attitudes are related among Indonesian junior high school students when examined through an ESD framework. In particular, the integration of ESD competencies into the assessment of both outcomes and they are in interpreting the relationship between them require further empirical investigation. Although previous studies have examined scientific literacy, environmental attitudes, and sustainability-oriented education, limited evidence is available on how five selected ESD competencies including systems thinking, critical thinking, strategic competence, normative competence, and self-awareness, are represented in scientific literacy test items and pro-environmental attitudes questionnaire items and how the resulting patterns can be interpreted jointly. Addressing this gap clarifies whether scientific literacy is associated with pro-environmental attitudes and how the patterns observed in both outcomes relate to competencies relevant to sustainability in the context of junior high school education in Indonesia. The novelty in present research lies in three aspects. First, it explicitly shows ESD as a way to look at how scientific knowledge and pro-environmental attitudes are connected and how they relate to important ESD skills. Second, it brings empirical evidence from junior high school in Indonesia, a rarely studied developmental stage, when looking at how scientific knowledge and caring about the environment are linked, especially in the new curriculum. Third, it integrates five selected ESD competencies into the assessment and interpretation of scientific literacy and pro-environmental attitudes, providing a competency-oriented perspective on the relationship between these

outcomes. Accordingly, this study aims to: (1) analyse the scientific literacy achievement of junior high school students; (2) examine the level of students' pro-environmental attitudes; and (3) determine the relationship between scientific literacy and pro-environmental attitudes among junior high school students, using ESD as an analytical framework and the five competencies as a lens to interpret patterns in literacy results and attitude achievement.

2. METHOD

2.1 Design of Research

This research is a quantitative study with a correlational design. Correlational research is conducted to identify the relationship between two or more variables without special treatment or manipulation of the variables being studied (Creswell & Creswell, 2023). This research was conducted in May 2026 at three junior high schools located in Jember Regency, East Java. The selection of grade VIII as the target population is because grade VIII students have received science material relevant to environmental and ecosystem themes more comprehensively than grade VII students, and have not focused on final summative assessments like grade IX.

2.2 Sample of Research

This research uses the "purposive sampling" technique. Purposive sampling is a sampling technique based on specific considerations and objectives set by the researcher (Cohen et al., 2018). Operational considerations for selecting schools included: (1) having issues relevant to the research focus, namely the need to strengthen scientific literacy and pro-environmental attitudes; (2) having an adequate number of students; and (3) the schools' willingness to participate as research subjects. Technical considerations included: (1) the selected schools were geographically representative, representing urban, suburban, and rural areas in Jember Regency, so that the data can represent the diversity of socio-ecological contexts; (2) the schools had implemented the Independent Curriculum; and (3) the schools integrated environmental themes into science learning, so that students had learning experiences relevant to the variables being measured. The sample characteristics are shown in the table.

Table 1. Research Sample Criteria

SN	School	Geographical Location	Environmental Learning	Population	Sample
1.	SMPN A	Urban	Non adiwiyata's program	223	58
2.	SMPN B	Suburban	Non adiwiyata's program	81	24
3.	SMPN C	Rural	Adiwiyata's program	130	50

Based on these criteria, 132 students were selected as the sample, representing five classes. This number met the minimum sample adequacy requirements for correlational analysis with a value 95% confidence level and a value 5% margin of error, based on the Krejcie & Morgan table (Krejcie & Morgan in Cohen et al., 2018). The technique of data collection in this research used two instruments. First, a written test to measure scientific literacy. The scientific literacy test was a researcher-developed instrument informed by the PISA framework, rather than the original PISA assessment instrument. The framework functioned as a conceptual reference for developing assessment indicators and constructing items relevant to environmental issues in the context of

science learning among Indonesian junior high school students. The written test consisted of 25 multiple-choice questions on environmental issues covering the following scientific literacy competencies: (1) explaining phenomena scientifically; (2) developing and evaluating scientific investigation designs and interpreting data critically; and (3) using scientific information as a basis for decision-making and action (OECD, 2023c). According to Kadir et al. (2025), scientific literacy achievement is categorized into 5, as shown in table 2.

Table 2. Scientific Literacy Categories

SN	**Score Range**	**Category**
1.	86 % – 100 %	Very High
2.	76 % – 85 %	High
3.	60 % – 75 %	Moderate
4.	55 % – 59 %	Low
5.	≤ 54 %	Very Low

Second, a pro-environmental attitudes questionnaire was used, developed from Keiser's General Ecological Behaviour (GEB) questionnaire, modified to suit the context of science learning at junior high school in Indonesia. It encompasses six indicators: (1) waste management, (2) plastic waste reduction, (3) consumerism, (4) energy and water conservation, (5) transportation and pollution, and (6) environmental awareness (Brick et al., 2024). This questionnaire consists of 30 statements, 18 positive and 12 negatives, each with answer choices 1 to 4 on the Likert scale. The results of the pro-environmental attitudes questionnaire were categorized into three categories based on environmental literacy, encompassing aspects of pro-environmental attitudes, as shown in the table (Putra et al., 2021).

Table 3. Categories of Pro-environmental Attitudes Achievement

SN	Score Range	Category
1.	74,2 % – 100 %	Hight
2.	48,2 % – 74,1 %	Moderate
3.	22,2 % – 48,1 %	Low

2.3 Procedure of Research

The research followed a series of systematic and structured procedures, including observation, instrument development, instrument content validation, empirical validation, data collection, data analysis, discussion, and conclusions. The five ESD competencies were used as an analytical framework for interpreting the findings.

2.4 Validity of Instrument

Content validity of the scientific literacy test and pro-environmental attitudes questionnaire was conducted using the Lawshe's Content Validity Ratio (CVR) method (Sari et al., 2023). The validation process involved five validators (N = 5): four professional science teachers with over 10 years of teaching experience and one science education lecturer. The validators were asked to rate each item on a four-point scale: 1 for "not essential", 2 for "less essential", 3 for "essential", and 4 for "very essential". The CVR value was calculated using a formula.

$$CVR = \frac{ne - \frac{N}{2}}{\frac{N}{2}}$$

Where, ne is in the number of validators who selected the item is "essential" or "very essential" N total number of validators. In the Lawshe critical values table, for a group of five validators, an instrument item is considered valid if the CVR value is ≥ 0.99 (Sari et al., 2023).

The empirical validity of the instrument items was established through a limited trial with 30 students outside the research sample. The empirical validity of the instrument items was tested using the "Pearson Product-Moment" correlation (corrected item-total correlation) between each item's score and the instrument's total score. The calculated "r" value for each item was compared with the table "r" value at a 5% significance level, using the number of trial respondents (df = N-2). Decision making regarding item validity follows the following provisions: an item is deemed valid if the calculated r value is greater than the table r value, whilst items with a low validity score are not used or are discarded (Mulyana & Desnita, 2023).

Instrument reliability was estimated using "Cronbach's Alpha" coefficient, with the decision-making criteria referring to the following classification:

Table 3. Cronbach's Alpha Value Category

SN	Alpha Cronbach Value	Interpretation
1	≥ 0,90	Excellent
2	0,80 – 0,89	High
3	0,70 – 0,79	Acceptable
4	0,60 – 0,69	Questionable
5	0,50 – 0,59	Weak
6	< 0,50	Unacceptable

An instrument is considered reliable and suitable for use if the Cronbach's Alpha value is ≥ 0.70 (Georgei & Mallery, 2019).

2.5 Techniques of Data Analysis

The techniques of data analysis used included quantitative descriptive analysis and inferential statistical analysis. Quantitative descriptive analysis was conducted to describe the frequency distributions and percentages of scores for each indicator of scientific literacy and pro-environmental attitudes, which were then categorized according to achievement levels for each variable. Inferential analysis begins with prerequisite testing, including tests for normality and linearity. The normality test was conducted using the "Kolmogorov-Smirnov" test in SPSS 23, as the study sample size was larger than 30 (132 respondents). Conclusions are drawn based on the significance value; if the sig. value > 0.05 means the data is normally distributed, but if the sig, value ≤ 0.05 means the data is not normally distributed.

The linearity test was done to determine whether the relation between scientific literacy and environmental care attitudes deviated from linearity. Decision making was based on the results of the "Sig. Deviation from Linearity", if the sig. value > 0.05 means there is a significant linear relationship, or there is no deviation from the relationship, however if the Sig. value ≤ 0.05 indicates no significant linear relationship. The type of hypothesis test (correlation test) used followed the normality test. If the data are normally distributed, the correlation test uses the

parametric "Pearson Product-Moment" test. However, if the data are not normally distributed, the correlation test uses the nonparametric "Spearman's Rho".

The hypothesis in the research is: Ho: there is no significant relation between scientific literacy and pro-environmental attitudes; Ha: there is a significant relation between scientific literacy and pro-environmental attitudes. The conclusion is made based on the following results: if the sig. (2-tailed) value > 0.05 means Ho is accepted and Ha is rejected, then if the sig. (2-tailed) value ≤ 0.05 means that Ho is rejected and Ha is accepted. Meanwhile, to assess the strength of the correlation between two variables, the Correlation Coefficient value can be determined from the table shown.

Table 4. Categories of Correlation Test Results

SN	Corellation Coefficient	Category
1.	0,90 – 1,00	Very strong
2.	0,70 – 0,89	Strong
3.	0,40 – 0,69	Moderate
4.	0,10 – 0,39	Weak
5.	0,00 – 0,10	Negligible

(Schober et al., 2018)

Moreover, the five ESD competencies, consisting of systems thinking, strategic competence, critical thinking, normative competence, and self-awareness, were employed as an analytical framework to interpret patterns in scientific literacy results and pro-environmental attitude achievement. The achievement levels for each competence were analyzed across both variables to identify similarities and differences in their development and to establish an equilibrium in that development. Subsequently, these findings were interpreted within the ESD framework to understand the correlation between scientific literacy and pro-environmental attitudes and its implications for reinforcing education for sustainable development.

3. RESULTS AND DISCUSSION

3.1 Instrument Validation Results

Before being used for research, the data collection instrument was also tested for content validity using the CVR method and piloted with 30 grade VIII students outside the sample to assess empirical validity and reliability for both the scientific literacy test and the pro-environmental attitudes questionnaire.

Content validation was conducted by five validators using the Content Validity Ratio (CVR) method. Instrument items were considered essential if the CVR value was ≥ 0.99. The content validation results are shown in table 5.

Table 5. Instrument Content Validation Results

Instrument of Collection Data	Number	Non-Essensial	Essensial	CVI
Scientific Literacy	35 items	4 items	31 items	0,93
Pro-environmental Attitudes	30 items	0 items	30 items	1.00

Based on table 5, in the science literacy test instrument, 4 instrument items must be eliminated because the CVR value is <0.99, so that the remaining 31 essential instrument items

with a CVI value of 0.93 (very high) and 5 instrument items are declared essential also received revision notes on the answer choices to improve the quality of the distractors so that the instrument is stronger in distinguishing students who understand the concept and those who do not. In the pro-environmental attitude's questionnaire, all 30 items had a CVR = 1.00 and a CVI = 1.00 (very high), indicating that all items are essential, although 4 statement items require linguistic revision. The CVI values of both instruments are above the threshold of 0.80, so both are declared valid and can be used (Amponsah et al., 2020).

Empirical validation was conducted through a limited trial on 30 students. An item of instrumentation was declared valid if the calculated r value is > r table (r table = 0.361; $\alpha = 5\%$). A summary of the results is presented in the table 6.

Table 6. Empirical Validity Results of the Instrument

Instrument of Collection Data	Trial	Not Valid	Valid	Used
Scientific Literacy	31 items	5 items	26 items	25 items
Pro-environmental Attitudes	30 items	5 items	25 items	25 items

Based on table 6, five items in the science literacy test were declared invalid and had to be eliminated, leaving 26 valid items. However, the number of instruments used in data collection was rounded to 25 for ease of calculation. Five items in the pro-environmental attitude's questionnaire were deemed invalid and had to be excluded, leaving 25 valid items for the study.

Reliability, normality, and linearity tests were conducted to guide the selection of hypothesis tests. The results of these three tests are briefly presented in table 7.

Table 7. Results of Reliability, Normality, and Linearity Tests

SN	Test	Instrument/ Variable	Result	Description
1.	Reliability	Scientific Literacy	0,874	High
		Pro-environmental Attitudes	0,829	High
2.	Normality	Scientific Literacy	sig. 0,000	Not Normally
		Pro-environmental Attitudes	sig. 0,004	Not Normally
3.	Linearity	Scientific Literacy – Pro-environmental Attitudes	Sig. 0,807	Linier

Based on table 7, the reliability test values for the scientific literacy and pro-environmental attitudes data are 0.874 and 0.829, respectively, both of which are categorized as reliable or good (Georgei & Mallery, 2019). The normality results show a sig. value of 0.000 for the scientific literacy data and 0.004 for the pro-environmental attitudes data, both of which are less than 0.05, so that both data are declared not normally distributed. However, the linearity results show a "Sig. Deviation from Linearity" value of 0.807 (> 0.05), which means the relation between the two variables is linear. Because the data do not meet the assumption of normality, the next hypothesis test was carried out using the non-parametric Spearman Rank correlation test.

3.2 Science Literacy Results

The quantitative descriptive analysis of the scientific literacy achievements of junior high school students in Jember Regency showed a 52% score in the "Low" category. The results for each science literacy indicator are as follows.

Table 8. Science Literacy Scores for Each Indicator

SN	Indicator	Scor	Category
1.	Explain phenomena scientifically	50%	Low
2.	Developing and evaluating the investigation of science designs and interpreting data critically	53%	Low
3.	Using scientific information as a basis for decision-making and action	52%	Low
	Average	52%	Low

The results in table 8 indicate that all three scientific literacy indicators are in the low category. The relatively small differences in scores across indicators indicate that students' abilities in each scientific literacy indicator are evenly distributed but have not yet reached optimal levels. The first indicator received the lowest score, suggesting that students continue to experience challenges in accurately understanding and explaining scientific concepts and phenomena. Meanwhile, the second indicator achieved the highest score. Meanwhile, the second indicator obtained the highest score, although it was still in the lower category, indicating that students are relatively more capable of using scientific information or data than in other indicators. The third indicator, which scored 52, indicates that students' ability to draw conclusions or apply scientific knowledge in everyday life still needs improvement.

The results of scientific literacy test, when viewed from the results of each student, is shown in the following diagram:

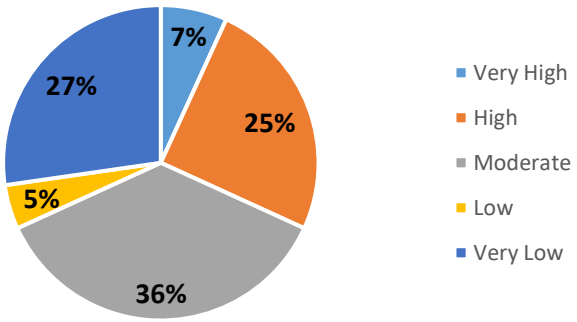


Figure 1. Scientific Literacy Score of Each Category

As shown in figure 1, most respondents (68%) are in the “very low” to “moderate” category, while only a minority (32%) are in the “high” to “very high” category. The findings of this research align with PISA 2022 results, which indicate that Indonesians' scientific literacy is low. PISA revealed that most Indonesian students still struggle to analyse scientific problems, interpreting data, and applying scientific concepts in real-life contexts. This means that the average scientific literacy achievement of 52 in this study reinforces PISA findings that Indonesian students' scientific literacy, especially in the Jember region, still requires attention and improvement through more contextually grounded, problem-based science learning and a focus on developing scientific literacy.

3.3 Pro-Environmental Attitudes Achievement

Furthermore, the quantitative descriptive analysis of the pro-environmental attitudes showed an achievement of 55% in the "moderate" category. The complete achievement of pro-environmental attitudes for each indicator is shown in figure 2.

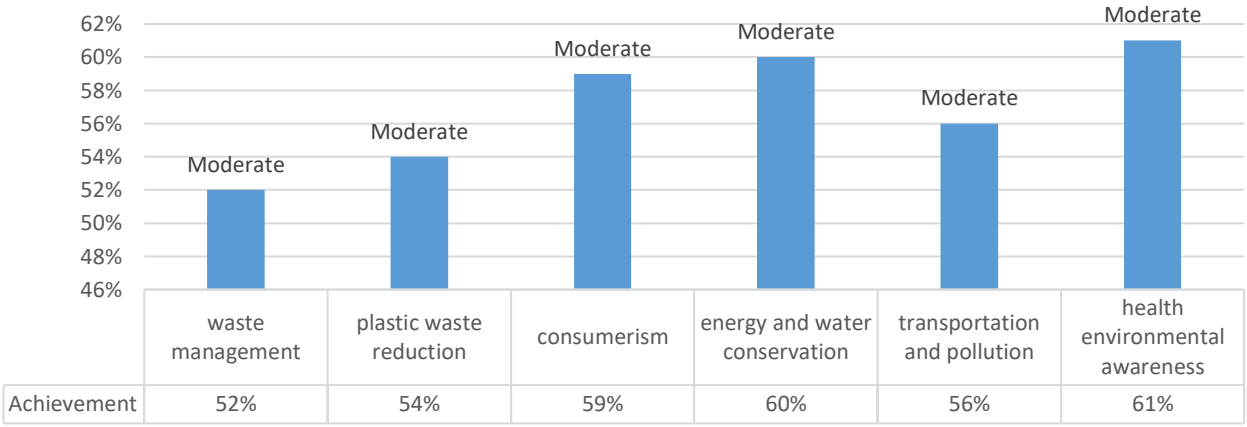


Figure 2. Diagram of Achievement of Pro-Environmental Attitude for Each Indicator

The diagram above shows that students' average pro-environmental attitude is 55, placing them in the "moderate" category. This result shows that students have demonstrated environmental awareness and concern. However, their application in daily life is not optimal and still needs to be strengthened through the sustainability education process. Scores for all indicators are in the "moderate" category, which shows that students have a relatively even level of environmental concern across all aspects. The indicators with the highest scores are environmental awareness, energy and water conservation, and consumer habits, which show that students have a relatively better understanding of the importance of using resources wisely, such as saving electricity and water, maintaining environmental cleanliness and health, and reducing excessive consumption. Meanwhile, the waste management indicator received the lowest score, indicating that students' sorting, reducing, and managing waste behaviour is still not consistently carried out. This condition reinforces the view that environmental problems are influenced not only by policy and infrastructure factors, but also by societal environmental awareness and behaviour, including among students. The achievement of pro-environmental attitudes for each student can be shown in the following pie chart.

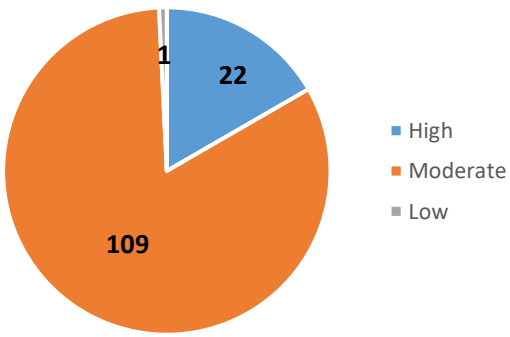


Figure 3. Pro-Environmental Attitudes Achievement of Each Category

Based on the figure above, 109 students have a pro-environmental attitude in the “medium” category, 22 in the “high” category, and only 1 in the “low” category. The results of this research are in line with the research of Marselina et al. (2024), which found that the pro-environmental attitudes of junior high school students in Indonesia remain “moderate” to “low”. Although the average student score in the medium range, these results indicate that students' pro-environmental attitudes have not developed optimally. This condition can be caused by several factor, such as the lack of habituation of environmentally friendly behaviour at school and at home, low student involvement in environmental conservation activities, minimal contextual learning related to environmental issues, and the influence of a modern lifestyle that tends to be consumptive and produces a lot of plastic waste. Furthermore, the lack of supporting facilities, such as waste-sorting facilities and environmentally focused school programs, can also influence students’ low pro-environmental attitudes.

However, the results of this research also show a slightly different situation from several previous studies, which stated that students' pro-environmental attitudes were in the “low” category. In this research, all indicators have reached the “moderate” category, indicating that students are beginning to develop an awareness of the importance of environmental conservation, although its implementation is still not optimal. This indicates positive progress in students' pro-environmental attitudes compared to previous research findings.

3.4 Correlation Result

The first statistical test performed was a normality test for the data on scientific literacy and pro-environmental attitudes. Results from the normality test in SPSS 23 indicated that the scientific literacy and pro-environmental attitudes data were not normally distributed. This may occur because the data were obtained from 132 students from three junior high schools with very different characteristics and geographic locations. This condition led to heterogeneity among respondents in terms of academic ability, learning environment, and learning experience. These differences have the potential to cause relatively unequal levels of value variation and to result in non-normal data distributions (Bono et al., 2017). Therefore, the subsequent statistical analysis used nonparametric tests that do not require normally distributed data, ensuring the results remain valid and can be scientifically accounted for. Furthermore, the linearity test showed a "sig. deviation from linearity" value of 0.807 (>0.05), indicating that the deviation from linearity of relation between scientific literacy and pro-environmental attitudes was not significant, so the relation between the variables was linear. Thus, the data meet the linearity assumption, so it can proceed with correlation analysis. The correlation results of the "Spearman Rank" test showed a sig. 0.000, which is less than 0.05. This result indicates a significant correlation between scientific literacy and students' pro-environmental attitudes. However, the correlation coefficient of 0.419 indicates that the strength of the relation between scientific literacy and pro-environmental attitudes is moderate. Furthermore, a positive correlation coefficient indicates a one-way (positive) relation: if scientific literacy competency increases, it is followed by an increase in pro-environmental attitudes, and vice versa.

Theoretically, these results align with the view that students with good scientific knowledge or understanding can develop environmental awareness and concern (Eleccion et al., 2025; Suhartinah et al., 2019; Xie et al., 2023). The correlation between scientific literacy and pro-environmental attitudes can be explained through the role of scientific knowledge and evidence-based reasoning in assisting students to identify the causes and consequences of environmental

problems and to assess the importance of environmental conservation. Scientific literacy has been demonstrated to be associated with pro-environmental attitudes through several interconnected cognitive processes. Initially, it assists-effect relationships in environmental issues, such as the manner in which human activities contribute to pollution and climate change. This knowledge fosters an understanding among students of the environmental consequences of human actions and the importance of environmental conservation. Furthermore, the capacity to interpret scientific evidence, evaluate data, and apply scientific knowledge to real-world problems fosters students' ability to assess environmental issues critically and make informed judgements (Jariah et al., 2024). Oliver & Adkins (2020) study found that scientific literacy was strongly associated with students' awareness of greenhouse gases, which is consistent with this explanation. Moreover, the integration of environmental socio-scientific issues into science education has been demonstrated to foster the development of scientific literacy, critical thinking, and informed decision-making (Kumar et al., 2024). The conceptual frameworks of ecosystem and sustainability may offer a scientific and rational basis for developing pro-environmental attitudes. However, the correlation between scientific knowledge and positive environmental attitudes is not guaranteed, as these attitudes may also be influenced by social and contextual factors. Therefore, it is possible that scientific literacy may contribute to the cognitive foundation of pro-environmental attitudes. However, it is important to note that the relationship should be interpreted as an association rather than a direct causal effect.

Despite the moderate correlation between scientific literacy and pro-environmental attitudes in this study, the findings suggest that the relationship between the two variables is not sufficient to justify the entirety of the students' environmental attitudes. This means that, although scientific literacy contributes to the formation of pro-environmental attitudes, other factors also influence it. Additional factors, such as the social environment, school culture, learning experiences, and everyday habits, may also be relevant to understanding how students' attitudes towards environmental issues differ, despite these factors not being directly examined in this study. This aligns with research indicating that, as students' scientific literacy increases, the development of pro-environmental attitudes remains influenced by social context, learning experiences, and involvement in solving real-world environmental issues (Kumar et al., 2024). Based on the sociocultural learning theory perspective in Wheaton et al. (2024) research, pro-environmental attitudes is formed through active participation in social activities, direct experience, interaction with the environment, and continuous habituation. This perspective suggest that direct experiences and interactions with the environment may foster pro-environmental attitudes (Flecke et al., 2024). Al Husban (2025) emphasized that increased scientific literacy does not always translate into sustainable behaviour, as environmentally conscious behaviour is also influenced by social factors, experiences, and students' emotional involvement.

This finding can be further interpreted within the Theory of Planned Behaviour (TPB). The TPB proposes that behavioural intentions are influenced by attitudes towards a behaviour, subjective norms, and perceived behavioural control (Samputra et al., 2025). Within the context of environmental sustainability, the concept of science literacy can assist students in comprehending the outcomes of human actions and evaluating environmentally responsible actions. This provides a cognitive foundation for fostering pro-environmental attitudes. However, within the TPB framework, the interpretation of these attitudes into behavioural intentions is also influenced by subjective norms and perceptions of behavioural control. Furthermore, social expectations, perceived opportunities to act, and students' experiences in their daily environments

may influence the development of pro-environmental attitudes and the actualisation of these attitudes through behaviour. Therefore, even if students have strong scientific literacy skills, pro-environmental attitudes may not develop optimally if their social environment and learning experiences do not support environmental responsibility. This perspective may offer an explanation as to why the relation between scientific literacy and pro-environmental attitudes in this study is only in the "moderate" degree category. Given that neither subjective norms nor perceived behavioural control were measured directly, it is suggested that their roles be viewed as theoretical explanations rather than empirically proven factors. These findings highlight the importance of holistic and multidimensional science learning that integrates scientific understanding with social contexts and environmental experiences. Overall, these theoretical perspectives suggest the presence of both cognitive and contextual dimensions in the correlation between scientific literacy and pro-environmental attitudes. Science literacy serves as a foundational element for comprehending and assessing environmental issues. However, the manner in which students interpret and respond to these issues is influenced by their sociocultural experiences. Furthermore, TPB places significant emphasis on the role of social norms and perceptions of behavioural control in the interpretation of behavioural intentions. The aforementioned perspectives imply that fostering pro-environmental attitudes through science education may not solely depend on the development of scientific knowledge; it may also depend on the presence of meaningful environmental experiences and a conducive social context. Given that the present study examines relationships among variables as opposed to cause-and-effect mechanisms, the provided explanation should be regarded as a theory-based interpretation of the findings.

3.5 Scientific Literacy and Pro-Environmental Attitudes: An ESD Framework

The results of the correlation analysis suggest the presence of a significant positive relationship between scientific literacy and pro-environmental attitudes, exhibiting a moderate level of correlation. Within the ESD framework, these findings can be explained through the cognitive, socio-emotional, and behavioural domains of learning (UNESCO, 2017). Scientific literacy is regarded as the cognitive domain, which refers to the ability to explain environmental phenomena, interpret evidence, and evaluate scientific claims. Moreover, pro-environmental attitudes encompass the socio-emotional and behavioural domains, namely values, concern, and a willingness to act in order to protect the environment. ESD considers these two domains to be interrelated; scientific understanding offers a rational foundation for environmental analysis, while values and attitudes guide and motivate the implementation of that knowledge in responsible decision-making processes. The present viewpoint is in line with Kumar et al. (2024), who argue that scientific literacy requires the ability to make decisions regarding environment-based socioscientific issues. Furthermore, both socioscientific issues and the Sustainable Development Goals (SDGs) highlight the importance of information-based decision-making, critical thinking, and responsible citizenship. The positive correlations established in this study are consistent with the findings of Oliver & Adkins (2020), who analysed 2015 PISA data from 54 countries. They found that scientific literacy scores were the strongest indicator of students' awareness of greenhouse gas emissions, a factor which is closely associated with pro-environmental attitudes.

On the other hand, the assumption that knowledge directly influences attitudes is not made by the ESD. The development of sustainability competencies is a multifaceted process that involves the integration of knowledge, skills, values, and attitudes. These competencies are

influenced by social and cultural contexts, as well as individual experience (UNESCO, 2017). The findings of present study demonstrate that the moderate correlation exhibited is consistent with the existing viewpoint. This claim is further supported by the evidence from numerous previous studies. Oliver & Adkins (2020) discovered a correlation between enthusiasm in learning science and an increased capacity to comprehend environmental issues. Despite these findings, the relationship between scientific literacy and pro-environmental attitudes exhibited a decline in countries with higher levels of scientific literacy, due to domestic educational policies and practices.

In the context of Indonesian students, Susongko & Afrizal, (2018) revealed that the direct effect of science comprehension on pro-environmental attitudes is less significant than the effects of enjoyment of learning science, self-efficacy, instrumental motivation, and inquiry-based learning. This suggests that affective-motivational factors and learning environments play an equally significant or possibly even more crucial role than mastery of science itself. Kumar et al. (2024) also highlighted that cultural values and personal opinions significantly influence decision-making processes related to environmental issues. These personal perspectives have been demonstrated to occasionally conflict with the scientific knowledge acquired through formal education. Therefore, it may be concluded that scientific literacy is a significant contributing factor to an pro-environmental attitudes, albeit not the sole factor. In the absence of learning experiences that purposefully integrate scientific understanding with affective, social, and cultural factors, knowledge and attitudes may evolve independently, lacking a reciprocal relationship that fosters mutual enhancement.

A descriptive analysis of ESD competency achievement in scientific literacy and pro-environmental attitudes is shown in the figure.

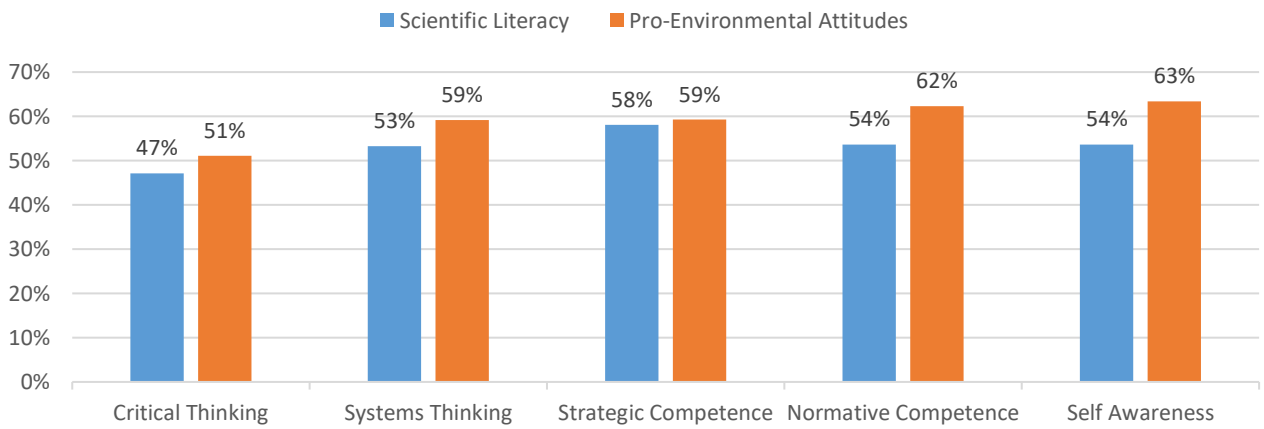


Figure 5. ESD Competency Achievement in Two Variables

Overall, ESD competency achievement in pro-environmental attitudes (51%–63%) is higher than in scientific literacy (47%–58%). This difference suggests that students' pro-environmental attitudes were relatively more developed than their ability to understand and reason scientifically about environmental issues. The development of sustainability education within the ESD framework is said to rely on the development of knowledge, critical thinking, and the capacity to make informed decisions, alongside positive attitudes and responsible actions (Kumar et al., 2024; UNESCO, 2017). This perspective highlights that pro-environmental attitudes without scientific understanding and critical capacities are inadequate for evaluating environmental issues and

making informed decisions. The development of scientific literacy and environmental literacy can be supported by ESD-oriented science learning (Marfiana et al., 2025). This learning connects scientific concepts with real environmental contexts.

The most balanced outcome is strategic competence due to the minor disparity between scientific literacy and pro-environmental attitudes. It may be concluded from the evidence that environmental knowledge is accompanied by awareness and sustainable behaviour in this competency. On the other hand, the disparity in the other competencies between the two variables indicates an imbalance between understanding and attitude. It has been demonstrated that a positive attitude towards the environment does not necessarily correlate with a well-developed scientific understanding. From the perspective of ESD, this situation has yet to reach its optimal state. In an ideal situation, the promotion of sustainable behaviour would be supported by a comprehensive understanding of environmental issues. Cahyani et al. (2025) found that students who scored highly on a scale of pro-environmental attitudes but scored low on a scale of ecological knowledge were more likely to act on habit or a sense of duty, without understanding the ecological rationale behind their actions. The attitudes and behaviours of students are shaped to a greater extent by external factors, including family habits, school programmes and the media. As a result, actions that lack a foundation in comprehension become habitual practices lacking ecological significance. Such behaviour is also more likely to be challenging to sustain or adjust in circumstances where students find themselves in a unfamiliar environment. This pattern provides a rationale for the significant yet moderate correlations observed in this study. The imbalance in competencies, the absence of a complete correlation between scientific literacy and attitudes, and the lack of a direct relationship between attitudes and scientific reasoning are all contributing factors.

The lowest mean scores were recorded for critical thinking skills across both variables. In the context of scientific literacy, this finding suggests that the capacity to evaluate information, assess evidence, distinguish scientific claims, and provide critiques of unsustainable practices remains underdeveloped In terms of environmental awareness, it is evident that students still require support in evaluating behaviours that are potentially harmful to the environment. The capacity to think critically is pivotal in establishing a connection between knowledge, evaluation and action. Suryawati et al. (2020) found that ecological knowledge does not have a direct correlation with environmental actions and sensitivity. Rather, it functions as a mediating factor for thinking skills. Thus, the correlation between the two variables is at its weakest at this point, and ESD-based learning should be concentrated on in this area.

The present study contributes to the field of science education in three distinct ways. Firstly, these findings serve to refine the widely reported assumption that scientific literacy fosters an environmentally conscious attitude (Eleccion et al., 2025; Suhartinah et al., 2019; Xie et al., 2023). The positive correlation found in this study provides evidence that validates the direction of this relationship among junior high school students. However, the moderate strength of this correlation indicates that scientific literacy explains only a portion of the variation in pro-environmental attitudes Kumar et al. (2024) and Al Husban (2025) reported the finding that higher levels of scientific literacy do not necessarily result in a corresponding increase in pro-environmental attitudes. This suggests that while scientific literacy serves as an essential foundation, it is not sufficient on its own to foster strong pro-environmental attitudes. This finding aligns with the findings of Adeyemi et al. (2025) and Tytler et al. (2025), who highlighted the importance of participatory learning experiences and the integration of cognitive, affective, and conative

dimensions. Furthermore, while prior studies have examined scientific literacy and pro-environmental attitudes as separate variables Calliera et al. (2026) and Schneiderhan-Opel & Bogner (2020), this study employs the five ESD competencies as a framework for analysis. The results indicate that, in general, the moderate correlations reveal an uneven pattern across competencies. Specifically, pro environmental attitudes tends to be more advanced than scientific literacy, with the exception of strategic competencies. Finally, the present study provides empirical evidence from junior high school students in urban, suburban, and rural contexts in Jember Regency during the post-pandemic era and under the Merdeka Curriculum. It is important to acknowledge that this specific educational level has received comparatively less attention than that assigned to elementary school and higher education (Jaelani et al., 2023; Lustianti et al., 2024; A. D. U. Panjaitan et al., 2026).

The findings suggest that science education needs to be connected to students' social and cultural contexts and critical thinking skills need to be enhanced. It has been argued that an approach which integrates local values, such as ESD based on ethnoscience, is a logical direction for future research. However, this approach has not yet been tested in this study. Consequently, future research should involve experimental procedures to test this approach, direct measurement of subjective norms and perceived behavioural control, and evaluation of actual behaviour. However, the cross-sectional correlational design employed, the self-reported attitudes of the subjects, and the sample drawn from a single region, limit claims of causality and the generalizability of the findings.

4. CONCLUSION

The research findings indicate that the science literacy levels of junior high school students in Jember Regency are classified as "low" (52%), while their pro-environmental attitudes are categorised as "moderate" (55%). A positive and significant relationship was identified between scientific literacy and pro-environmental attitudes, exhibiting a "moderate" strength ($\rho = 0.419$; $p < 0.001$). These findings suggest that higher scientific literacy is often associated with more pro-environmental attitudes. However, it is important to note that this relationship is associational in nature and does not imply a causal relationship. The strength of this relationship indicates that scientific literacy is a significant foundation, but it is not the sole contributing factor. It is possible that social factors, school culture, learning experiences and daily habits may also have a role to play, although these factors were not directly measured in this study.

Within the ESD framework, there is a higher level of achievement in competencies relating to pro-environmental attitudes (51%–63%) in comparison with those relating to science literacy (47%–58%). Strategic competencies demonstrate the most balanced distribution across both variables, while other competencies exhibit an imbalance between scientific understanding and attitude. Critical thinking was the lowest-ranking ability in both categories. The findings indicate a necessity for a more holistic design of science instruction, integrating scientific knowledge, values, and attitudes related to the environment, as well as strengthening students' critical thinking skills. It is suggested that an approach integrating local values, such as ethnoscience-based ESD, may prove worthy of consideration; however, further research is required to test this hypothesis. This research should include both experimental and observational elements, with the objective of measuring subjective norms, perceived behavioural control, and actual behaviour. In view of the correlational research design, the self-reported attitudes and the sample size, which was derived

from a single region, the findings of the present study should be interpreted with caution and should not be generalized too broadly.

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