

Scientific Literacy and Cultural Awareness among Senior High School Students in a Multicultural Context

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ABSTRACT

Scientific literacy is increasingly viewed as a key competence for both academic achievement and students' socio-cultural development in multicultural settings. Empirical research linking scientific literacy with cultural awareness at the secondary level remains limited, particularly in eastern Indonesia. This study explores patterns of scientific literacy and cultural awareness among senior high school students in Jayapura using an exploratory quantitative survey design. Data from 70 students were gathered using validated questionnaires and subjected to descriptive analysis and simple linear regression analysis. The findings show that scientific literacy and cultural awareness tend to develop alongside one another. Students demonstrating stronger abilities to interpret scientific knowledge also appear to express more reflective attitudes toward cultural diversity. Regression analysis further indicates that scientific literacy significantly predicts students' cultural awareness, suggesting that science learning may contribute not only to conceptual understanding but also to broader socio-cultural reflection in multicultural educational contexts.

INTRODUCTION

In an increasingly dynamic era of globalization, the educational paradigm has shifted from a sole emphasis on cognitive achievement to strengthening the character and socio-cultural competencies of students. Twenty-first-century education requires students not only to master academic knowledge but also to be able to live harmoniously in a multicultural society, have empathy, and be culturally aware (Awwalina & Indana, 2022). In this context, schools have a strategic role as spaces for shaping values and attitudes that support social cohesion and tolerance.

One of the main competencies emphasized in contemporary education policies, including the Merdeka Curriculum, is scientific literacy. Scientific literacy encompasses not only the comprehension of scientific concepts and facts but also the individual's ability to apply scientific knowledge in decision-making that takes into account ethical, social, and cultural dimensions (OECD, 2019; Mujahid, 2024). Students with higher levels of scientific literacy tend to demonstrate stronger critical thinking skills when engaging with scientific phenomena in culturally diverse contexts.

A number of studies show that scientific literacy developed in a contextual manner can encourage open-mindedness and social sensitivity in students. A literacy approach integrated with cultural and ethnoscientific contexts has been proven to improve conceptual understanding while building motivation and reflective attitudes toward social reality (Djarwo et al., 2025; Khery et al., 2021). This suggests that scientific literacy may be associated with students' reflective attitudes and socio-cultural sensitivity when learning is conducted in contextual and culturally grounded ways.

However, the achievement of scientific literacy among Indonesian students is still relatively low. The results of the Program for International Student Assessment (PISA) show that most Indonesian students have difficulty relating scientific concepts to contextual issues and social values (OECD, 2019). This condition has implications for students' weak ability to understand cross-cultural issues related to science, such as environmental sustainability, public health, and social dynamics resulting from scientific developments. Low levels of scientific literacy may limit students' opportunities to engage with socio-cultural issues reflected in science learning contexts.

From a critical education perspective, science learning that is detached from social and cultural contexts risks producing individuals who are academically competent but lack sensitivity to diversity (Djarwo, 2021). Therefore, we must strategically position scientific literacy to connect scientific knowledge with cultural and humanitarian values. Cultural awareness, which is the ability to recognize and respond to cultural differences in a sensitive and constructive way (Sudiana & Putrayasa, 2024), is an important skill that can be improved through meaningful science learning.

However, empirical studies that specifically examine scientific literacy as a predictor of students' cultural awareness at the secondary school level are still relatively limited, especially in the context of Indonesia's multicultural society. Most scientific literacy studies still focus on academic achievement and higher-

order thinking skills, while the socio-cultural dimension has not been explored much. Therefore, this study aims to explore patterns of scientific literacy and cultural awareness among senior high school students and to examine how these competencies coexist within a multicultural educational context. The results of this study are expected to broaden the understanding of the strategic role of scientific literacy in shaping the character and cultural awareness of students.

Unlike most previous studies that position scientific literacy primarily as a cognitive achievement indicator, this study conceptualizes scientific literacy as a sociocultural competence that may coexist with students' cultural awareness in multicultural classrooms. By examining this relationship in the underrepresented context of eastern Indonesia, the study contributes empirical insight into how science education may support both conceptual understanding and socio-cultural development.

LITERATURE REVIEW

Scientific Literacy in Contemporary Education

Scientific literacy has become a central competency in twenty-first-century education, reflecting a shift from an exclusive focus on content mastery toward the development of critical, reflective, and socially responsible citizens. The Organization for Economic Cooperation and Development (OECD, 2019) conceptualizes scientific literacy not merely as the understanding of scientific concepts but as the ability to apply scientific knowledge in real-life contexts involving social, ethical, and cultural considerations. Within this framework, students are expected to interpret scientific phenomena critically, evaluate evidence, and make informed decisions that are sensitive to societal diversity. In the Indonesian context, scientific literacy is explicitly emphasized in national education reforms, including the Merdeka Curriculum, which promotes contextual learning and student-centered pedagogy. However, empirical evidence indicates that Indonesian students' scientific literacy remains relatively low, particularly in connecting scientific knowledge with everyday and socio-cultural contexts (OECD, 2019). This gap suggests that science education has not yet fully fulfilled its potential role in fostering broader social and cultural competencies among learners.

Several studies highlight that scientific literacy, when developed through contextual and culturally grounded approaches, can enhance students' motivation, conceptual understanding, and reflective thinking. Khery et al. (2021) demonstrate that science learning oriented toward local wisdom enables students to perceive science as relevant to their lived experiences, thereby strengthening both cognitive and affective learning outcomes. Similarly, Djarwo et al. (2025) show that integrating ethnoscientific perspectives into chemistry education supports students' conceptual understanding while fostering reflective attitudes toward cultural practices. These findings underscore that scientific literacy extends beyond academic achievement and contributes to students' broader worldview.

Cultural Awareness as an Educational Outcome

Cultural awareness refers to an individual's capacity to recognize, respect, and respond constructively to cultural differences within a pluralistic society. Sudiana and Putrayasa (2024) emphasize that cultural awareness is a critical character dimension that can be cultivated through learning experiences grounded in local values and social realities. In multicultural settings such as Jayapura, where students come from diverse ethnic and cultural backgrounds, cultural awareness becomes an essential competence for social cohesion and tolerance.

Education plays a strategic role in shaping students' cultural awareness, particularly through learning environments that encourage openness, dialogue, and respect for diversity. Awwalina and Indana (2022) argue that learning models integrating literacy skills with contextual content can strengthen students' sensitivity to social issues. When students are encouraged to interpret scientific knowledge in relation to cultural and environmental realities, they develop a more inclusive and empathetic perspective toward others.

Previous studies indicate that socio-culturally oriented science learning can support students' reflective thinking and cultural sensitivity (Khery et al., 2021; Djarwo et al., 2025). This situation highlights the importance of repositioning science education as a medium for character development, including the cultivation of cultural awareness.

Scientific Literacy and Cultural Awareness: Empirical Linkages

Despite growing recognition of the socio-cultural dimensions of science education, empirical studies examining the relationship between scientific literacy and cultural awareness remain limited, particularly at the secondary school level. Most existing research on scientific literacy focuses on cognitive outcomes such as achievement and higher-order thinking skills, while affective and socio-cultural outcomes receive less attention.

Nevertheless, emerging evidence suggests a meaningful connection between scientific literacy and students' cultural awareness. Mujahid (2024) notes that literacy-oriented education encourages reflective thinking and ethical sensitivity, which are foundational to cultural awareness. When students engage critically with scientific issues that intersect with cultural practices, environmental sustainability, or public health, they are more likely to develop an appreciation for diversity and social responsibility.

METHODOLOGY

This study employed a quantitative approach with an exploratory survey design aimed at describing patterns of scientific literacy and cultural awareness and examining how the two constructs appear together within the learning context. The quantitative approach was chosen because it allows researchers to describe phenomena objectively using numerical data, while the exploratory orientation enables the study to provide an empirical overview of variable tendencies (Sugiyono, 2021).

The data sources consisted of primary and secondary data. Primary data were obtained through structured questionnaires distributed directly to students who met the research criteria. The instruments were designed to measure

students' scientific literacy and cultural awareness using Likert-scale indicators. Secondary data were collected from journal articles, educational policy documents, and prior research reports to support the conceptual framework and interpretation of findings (Creswell & Creswell, 2018).

The population of this study comprised senior high school students, particularly those in grades XI and XII. These levels were selected because students at this stage have experienced more advanced science learning and are considered capable of reflecting on socio-cultural issues within a multicultural environment. Their cognitive and affective development at this stage is assumed to support the formation of scientific understanding and socio-cultural attitudes.

Purposive sampling was employed to select participants based on criteria relevant to the research objectives (Sugiyono, 2021; Creswell & Creswell, 2018). The inclusion criteria were: (1) active students in grades XI or XII at public or private senior high schools; (2) students who had completed at least two semesters of science learning; (3) students who had participated in either face-to-face or hybrid learning environments; and (4) students willing to complete the questionnaire honestly and completely. Based on these criteria, 70 students were selected as the study sample, which was considered sufficient to represent the characteristics of the target population.

Data analysis was conducted using IBM SPSS Statistics version 27. The analysis stages included instrument validity testing using item-total correlation to ensure that each questionnaire item accurately reflected the intended construct, followed by reliability testing using Cronbach's alpha to confirm internal consistency. Descriptive statistical analysis was then applied to summarize the distribution of students' scientific literacy and cultural awareness scores, including mean values, score ranges, and categorical tendencies.

While the study adopts an exploratory orientation, regression analysis was conducted to examine whether scientific literacy statistically predicts students' cultural awareness. The analysis was not intended to develop a comprehensive predictive model, but rather to provide empirical insight into how variations in scientific literacy are associated with patterns of cultural awareness among students within a multicultural educational context.

Through this structured exploratory quantitative design, the study aims to contribute empirical insights into how scientific literacy and cultural awareness coexist within students' learning experiences. The findings are expected to support the development of culturally responsive science education strategies that strengthen both cognitive and socio-cultural competencies.

RESEARCH RESULT

Respondent Characteristics

This study was conducted among senior high school students in Jayapura, a multicultural urban setting in eastern Indonesia. The diversity of ethnic, cultural, and religious backgrounds among students provides a meaningful context for examining scientific literacy and cultural awareness.

The demographic profile of the respondents shows a relatively balanced distribution in terms of gender, age, grade level, and school type. This distribution indicates that the sample adequately reflects the characteristics of senior high school students in the study context (see Table 1).

Table 1. Respondent Characteristics

Characteristic	Frequency	Percentage (%)
Gender		
Male	32	45.7%
Female	38	54.3%
Age		
16 years old	14	20.0%
17 years old	31	44.3%
18 years old	25	35.7%
Grade		
XI	37	52.9%
XII	33	47.1%
School Origin		
Public High School	40	57.1%
Private High School	30	42.9%

Instrument Validity and Reliability

The validity analysis indicates that all questionnaire items measuring scientific literacy and cultural awareness demonstrate strong correlations with their respective total scores. These results confirm that the items adequately represent the constructs being measured.

Reliability testing further shows that both instruments possess acceptable internal consistency. The Cronbach's alpha values exceed the recommended threshold, indicating that the instruments are reliable for measuring students' scientific literacy and cultural awareness (see Tables 2 and 3).

Table 2. Item Validity Test Results

Variable	Item	r-value	Interpretation
Scientific Literacy	SL1	0.872	Valid
	SL2	0.857	Valid
	SL3	0.785	Valid
Cultural Awareness	CA1	0.860	Valid
	CA2	0.932	Valid
	CA3	0.859	Valid

Table 3. Reliability Coefficients

Variable	Cronbach Alpha	Interpretation
Scientific Literacy	0.788	Reliable
Cultural Awareness	0.857	Reliable

Descriptive Profile of Cultural Awareness

The descriptive results show that students generally display positive tendencies in cultural awareness. Many respondents demonstrate respect for cultural diversity and show openness toward differences in social and cultural practices.

However, variations in responses indicate that the depth of cultural awareness differs among students. Some students demonstrate reflective understanding of multicultural values, while others show awareness primarily at the level of social tolerance rather than deeper cultural reflection.

Observed Patterns Between Scientific Literacy and Cultural Awareness

A comparison of score tendencies indicates that students demonstrating stronger scientific literacy indicators tended to show more developed cultural awareness responses in the descriptive profile. Conversely, students with lower literacy scores tend to show more limited socio-cultural reflection in their responses.

Overall, the observed pattern suggests that scientific literacy and cultural awareness coexist in a meaningful way within students' learning experiences. The findings indicate that the development of scientific understanding appears to coexist with broader reflective attitudes toward cultural diversity.

Effect of Scientific Literacy on Cultural Awareness

A simple linear regression analysis was conducted to examine whether scientific literacy predicts students' cultural awareness. The results indicate that scientific literacy has a positive and statistically significant effect on cultural awareness ($B = 0.427$, $t = 4.145$, $p < .001$), as presented in Table 5.

This finding suggests that students who demonstrate stronger abilities to interpret scientific knowledge tend to exhibit greater sensitivity toward cultural diversity.

Table 5. Regression Coefficient for Scientific Literacy

Predictor	B	t	Sig.
Scientific Literacy	0.427	4.145	0.000

DISCUSSION

This study's findings reveal a meaningful relationship between scientific literacy and cultural awareness among senior high school students. The regression analysis demonstrates that scientific literacy significantly predicts students' cultural awareness, suggesting that students who demonstrate stronger abilities to interpret scientific knowledge tend to show more thoughtful responses toward cultural diversity. This result highlights the interconnectedness of cognitive and socio-cultural competencies within science education.

Scientific literacy, as conceptualized in contemporary educational discourse, extends beyond the acquisition of factual knowledge to include the ability to interpret scientific information critically and apply it in social contexts.

Students who develop this capacity are more likely to engage in reflective thinking, consider multiple perspectives, and evaluate issues using reasoned judgment. These characteristics are closely aligned with dispositions associated with cultural awareness, such as openness, empathy, and respect for diversity.

In multicultural learning environments such as those found in Jayapura, students frequently encounter diverse cultural norms, traditions, and worldviews. Science education that encourages reflection, contextual interpretation, and discussion of real-world issues may therefore contribute to broader social understanding. When students learn to view scientific knowledge as socially embedded rather than culturally neutral, they may become more aware of how scientific practices interact with local traditions, environmental contexts, and community values.

The descriptive patterns observed in this study support arguments in previous research suggesting that contextualized science learning can foster reflective attitudes and socio-cultural sensitivity. When scientific concepts are connected to everyday experiences and local realities, students are more likely to perceive science as meaningful and relevant. This relevance may encourage them to interpret knowledge not only as abstract information but also as a tool for understanding social life.

It is important to note that the association observed in this study should be interpreted as indicative rather than deterministic. Cultural awareness is influenced by multiple factors, including family background, social interaction, educational environment, and personal experiences. Scientific literacy may represent one component within this broader developmental process. Nevertheless, the findings suggest that strengthening students' engagement with science learning may be associated with the development of reflective socio-cultural attitudes.

From a pedagogical perspective, these results underscore the importance of designing science learning experiences that are not limited to conceptual mastery but also encourage interpretation, dialogue, and contextual reflection. Integrating real-life issues, local knowledge, and culturally relevant examples into science instruction may help students see connections between scientific understanding and social responsibility.

Overall, this study contributes to the growing recognition that science education can play a meaningful role in shaping students' broader perspectives on diversity and social coexistence. Rather than positioning scientific literacy solely as an academic outcome, the findings support viewing it as part of a wider educational process that helps students interpret the world in informed, reflective, and socially responsive ways.

CONCLUSIONS AND RECOMMENDATIONS

This study explored the relationship between scientific literacy and cultural awareness among senior high school students in a multicultural educational context. The findings indicate that scientific literacy significantly predicts students' cultural awareness, suggesting that students who demonstrate stronger

abilities to interpret scientific knowledge also tend to show more reflective attitudes toward cultural diversity.

Although this relationship should not be interpreted as deterministic, the results suggest that scientific literacy may serve as an important cognitive foundation supporting students' capacity to understand social and cultural differences. The relatively small sample size and cross-sectional design, however, limit the generalizability of the findings.

In multicultural learning environments such as Jayapura, the ability to interpret scientific information critically and contextually may help students develop broader perspectives on diversity and social interaction. These findings support the view that science education can contribute not only to conceptual mastery but also to the cultivation of reflective socio-cultural dispositions. Scientific literacy should therefore be positioned as part of a wider educational process that enables students to connect knowledge with real-life contexts and societal diversity.

ADVANCED RESEARCH

This study offers an empirical contribution to understanding how scientific literacy and cultural awareness coexist within students' learning experiences. Future research could extend these findings through longitudinal or mixed-methods designs in order to capture developmental trajectories and explore how these competencies evolve over time. Such approaches would provide richer insight into the processes through which scientific understanding and socio-cultural awareness may interact in educational settings.

Further investigation is also needed to conceptualize scientific literacy as a multidimensional construct that encompasses cognitive, contextual, and reflective dimensions. Examining how these dimensions interact with broader socio-cultural competencies across diverse educational environments may help strengthen the theoretical and explanatory foundations of culturally responsive science education.

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