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A Study of the Scientific Literacy Profile of Prospective Biology Teachers in Papua

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ABSTRACT

21st-century education requires teachers to master various skills in order to face the challenges of globalization, one of which is scientific literacy skills. This study aims to describe the scientific literacy profile of Biology Education students at Cenderawasih University as prospective Biology teachers in Papua. The research was conducted from June to July 2025. A quantitative method with a descriptive approach was employed. The sample consisted of 48 students selected using a convenience sampling technique. The instrument used was the Test of Scientific Literacy Skills (TOSLS). The data were analyzed descriptively through percentage calculations and categorization of scientific literacy levels. The results showed that, overall, the students' scientific literacy abilities fall into the low category. These findings indicate the need for strategies to improve scientific literacy through innovative learning, strengthening inquiry-based activities, and utilizing contextual digital learning resources. This research is expected to serve as a foundation for the development of scientific literacy enhancement programs within the Biology Education Department at Cenderawasih University.

Informasi Artikel

Kata Kunci:

Pendidikan abad 21;
Literasi sains;
TOSLS;
Calon guru biologi;

ABSTRAK

Pendidikan abad ke-21 menuntut guru untuk menguasai berbagai keterampilan guna menghadapi tantangan globalisasi, salah satunya adalah keterampilan literasi sains. Penelitian ini bertujuan untuk mendeskripsikan profil literasi sains mahasiswa Pendidikan Biologi Universitas Cenderawasih sebagai calon guru Biologi di Papua. Penelitian dilaksanakan pada bulan Juni hingga Juli 2025. Metode yang digunakan adalah metode kuantitatif dengan pendekatan deskriptif. Sampel penelitian terdiri atas 48 mahasiswa yang dipilih menggunakan teknik convenience sampling. Instrumen yang digunakan adalah *Test of Scientific Literacy Skills* (TOSLS). Data dianalisis secara deskriptif melalui perhitungan persentase dan kategorisasi tingkat literasi sains. Hasil penelitian menunjukkan bahwa secara umum kemampuan literasi sains mahasiswa berada pada kategori rendah. Temuan ini menunjukkan perlunya strategi untuk meningkatkan literasi sains melalui pembelajaran inovatif, penguatan kegiatan berbasis inkuiri, serta pemanfaatan sumber belajar digital yang kontekstual. Penelitian ini diharapkan dapat menjadi dasar bagi pengembangan program peningkatan literasi sains di Program Studi Pendidikan Biologi Universitas Cenderawasih.

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1. Introduction

The 21st century has led to increasingly rapid developments in various fields of human life, including education. Education is expected to produce human resources who possess comprehensive abilities to face diverse challenges in life [1], [2]. Human resources needed in the 21st century are those who are qualified, reliable, and able to compete globally in terms of reasoning, expertise, and skills. In the context of 21st-century educational development, a key priority is enhancing students' thinking abilities, particularly within science learning [3], [4], [5]. Scientific literacy is one of the sixteen skills that must be mastered in the 21st century. In line with this, Pradini et al. (2022) states that mastery of scientific literacy is essential in an effort to respond to future challenges [6].

Scientific literacy is defined as the ability required to use scientific knowledge, identify questions, and draw conclusions based on existing evidence in order to understand and make decisions related to human activities involving the natural world [7], [8]. Irsan (2021) defined Scientific literacy as the ability to use scientific knowledge, identify questions, and draw conclusions based on available evidence in order to understand and make decisions related to natural phenomena and human activities [9]. The scientific literacy ability of Indonesian students can be seen from international-scale survey results organized by the Programme for International Student Assessment (PISA). Based on the most recent PISA results on scientific literacy conducted in 2022, among 81 participating countries, Indonesia ranked 67th with an average score of 383 [7]. There was a decrease of 13 points from 2018. This condition indicates that the scientific literacy achievement of Indonesian students remains very low. Consistent with this perspective, findings from several recent studies on students' scientific literacy indicate that the level of students' scientific literacy remains low [10], [11], [12], [13], [14], [15]. Meanwhile, mastery of science in the 21st century plays a crucial role in determining the success of a nation's education.

Students who demonstrate stronger scientific literacy tend to achieve higher academic outcomes, are more capable of providing scientific explanations for phenomena, and are better at evaluating and interpreting information scientifically [16, [17], [18]. Students cannot achieve high-level competence without the guidance of skilled and professional teachers, sufficient learning time, active learning spaces, and surrounding learning resources [19], [20]. Therefore, efforts to develop a culture of scientific literacy among students in schools must be supported by growing scientific literacy culture among teachers as educators. Another challenge arises when teachers are expected to develop students' scientific literacy, yet they themselves still lack sufficient scientific literacy [5], [21], [22]. Therefore, it is necessary to measure the scientific literacy skills of prospective Biology teachers in order to determine the extent to which they are prepared to support the improvement of students' scientific literacy abilities.

The novelty of this study lies in its focus on analyzing the scientific literacy skills of prospective Biology teachers in Papua using a quantitative-descriptive approach that emphasizes scientific literacy aspects related to the evaluation of scientific information and quantitative literacy. Unlike previous studies that primarily focused on project-based learning in Conservation Biology courses [23] and employed qualitative approaches with Physics Education [24] and Primary School Teacher Education students [25], this study specifically investigates students' abilities to evaluate the validity of scientific information, understand research methods, interpret statistical data, and read and interpret scientific graphs using the TOSLS instrument. Furthermore, this research is conducted within the context of Biology Education students in Papua, a region characterized by unique geographical conditions, limited access to learning resources, and educational challenges that differ from those in other regions of Indonesia. The Papuan context is particularly significant because limited access to digital literacy and scientific resources may affect students' scientific literacy skills. Therefore, this study provides more contextual empirical evidence regarding the readiness of prospective Biology teachers in Papua to meet the demands of 21st-century science learning.

The Biology Education study program, as an institution responsible for preparing prospective Biology teachers, is considered highly necessary to develop strong literacy competence. Scientific literacy ability for a prospective teacher is a fundamental need. Unfortunately, no research has specifically examined the extent of scientific literacy achievement among Biology education students at Cenderawasih University as prospective Biology teachers in Papua. Therefore, this study is considered highly important to conduct. Considering the importance of scientific literacy for students' lives and future, it becomes crucial for prospective Biology teachers to master scientific literacy effectively. Therefore, the researcher considers it necessary to conduct a study focused on identifying the scientific literacy skills of Biology education students at Cenderawasih University as prospective teachers in Papua. The purpose of this research was to determine the level of scientific literacy of these students as future Biology teachers in Papua.

2. Method

This study employs a quantitative method with a descriptive approach aimed at identifying and mapping the initial scientific literacy skills of prospective Biology teacher students at the Faculty of Teacher Training and Education, Cenderawasih University. The research will be conducted at Cenderawasih University, Papua Province, from June to August 2025. The population of this study consists of all prospective Biology teacher students, while the sample is determined using a convenience sampling technique, involving students who completed the research instrument distributed via Google Form.

Data were collected through a test technique using the Test of Scientific Literacy Skills (TOSLS), consisting of 28 multiple-choice items with four answer options. The instrument is an adapted and translated version of TOSLS developed by Gormally et al. (2012), comprising two main indicators and nine sub-indicators of scientific literacy [26].

Tabel 1 Daftar rinci pengukuran pengaturan halaman untuk naskah

Indicator	Sub-Indicator
Understanding inquiry methods leading to scientific knowledge	Identifying valid scientific ideas
	Evaluating the validity of library sources
	Evaluating the use and misuse of scientific information
	Understanding elements of research methods and their impact on scientific findings
	Determining graphs that represent data
	Reading and interpreting graphs that represent data
	Solving problems using quantitative skills, including probability and statistics
Organizing, analyzing, and interpreting quantitative data and scientific information	Understanding and interpreting basic statistics
	Presenting conclusions, predictions, and inferences based on quantitative data

Data analysis was carried out descriptively by calculating the mean scores, percentages, and achievement categories using Microsoft Excel, followed by interpretation based on modified assessment criteria from Arikunto (2006) [27].

Table 2 achievement categories

No	Value Interval	Category
1	86-100	Very High
2	71-85	High
3	56-70	Moderate
4	41-55	Low
5	≤ 40	Very Low

3. Results and Discussion

The scientific literacy skills of prospective Biology teacher students at the Faculty of Teacher Training and Education, Cenderawasih University, were generally obtained from a total of 48 students by calculating the mean score of their scientific literacy test results. The overall average scientific literacy score is presented in Table 3 below:

Table 3 Average percentage of scientific literacy skills of prospective Biology teacher

Respondents	Mean (%)	Category
48	45	Low

Table 3 shows that the 48 students who participated in the test achieved an average score of 45%, which falls into the lowcategory. This condition indicates that the students' scientific literacy skills have not yet sufficiently developed, particularly in mastering higher-order thinking skills, which constitute the core of 21st-century scientific literacy. This finding is consistent with OECD (2023) through PISA 2022 results, which reported that Indonesia's science performance remains below the international average, especially in the ability to use scientific evidence for decision-making [7]. Other research has also emphasized that low scientific literacy scores are often attributed to learning approaches that are still dominated by memorization and provide limited opportunities for students to engage in inquiry-based or project-based learning [28]. In fact, skills assessed in TOSLS—such as critical thinking, evidence-based reasoning, and data interpretation—are integral components of 21st-century competencies known as the 4Cs [29].

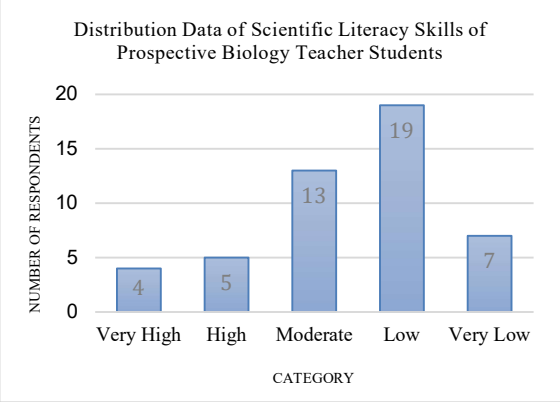

Figure 1 shows that the highest frequency of scientific literacy skill levels falls within the Low category, with a total of 19 respondents. This is followed by the Moderate category in second place with 13 respondents, and the Very Low category in third place with 7 respondents. The High category ranks fourth with 5 respondents, while the Very High category is the lowest, with only 4 respondents.

The percentage data of the average scientific literacy skills of prospective Biology teacher students at the Faculty of Teacher Training and Education, Cenderawasih University, for each TOSLS sub-indicator is presented in Table 4 below:

Table 4 Average scientific literacy skills for each sub-indicator

Indicator	Sub-Indicator	%	Category
Understanding inquiry methods leading to scientific knowledge	Identifying valid scientific ideas	45	Low
	Evaluating the validity of library sources	56	Moderate
	Evaluating the use and misuse of scientific information	48	Low
	Understanding elements of research methods and their impact on scientific findings	39	Very Low
	Determining graphs that represent data	36	Very Low
	Reading and interpreting graphs that represent data	32	Very Low
	Solving problems using quantitative skills, including probability and statistics	57	Moderate
Organizing, analyzing, and interpreting quantitative data and scientific information	Understanding and interpreting basic statistics	48	Low
	Presenting conclusions, predictions, and inferences based on quantitative data	41	Low

Table 4 shows that the scientific literacy skills of prospective Biology teacher students, based on the TOSLS indicators, vary widely, ranging from low to moderate categories. Three sub-indicators fall within the very low category, four sub-indicators are in the low category, and two sub-indicators are in the moderate category. In the sub-indicator identifying valid scientific ideas, students achieved only an average score of 45% (low category). This indicates that their ability to distinguish evidence-based scientific claims from invalid information is still very limited. This condition may be caused by several factors, including students' lack of experience in critically reading and evaluating scientific sources, limited habituation in using scientific validity indicators when analyzing information, and exposure to inaccurate information in digital media without adequate evaluative literacy skills. In addition, learning processes that emphasize conceptual aspects more than critical thinking skills may also hinder students' ability to assess the validity of a scientific idea. This skill is particularly critical in the digital era, where students are frequently exposed to diverse information, including misinformation and disinformation, which demand strong critical evaluation skills [30]. Thus, there needs to be consistent practice for students to critically evaluate information sources, provide continuous evaluative literacy training [31], and implement inquiry-based and scientific argumentation learning models that require the use of evidence to support claims [32]. In addition, training in reading scientific articles and the use of scientific misinformation case studies can help students understand the difference between scientific claims and invalid information.

The sub-indicator evaluating the validity of scholarly sources obtained an average score of 56% (moderate category), demonstrating that students possess initial abilities in assessing the quality of scientific references, although still limited to formal aspects. Students often struggle with crucial research methodology [33] and to evaluate author credibility, the relevance of sources to the issue being examined [34], [35], [36]. These limitations may be caused by students' lack of experience in critically reading scientific articles, as well as

learning processes that have not optimally emphasized content analysis and the quality of scientific arguments. This condition indicates the need for further training so that students are able to evaluate sources comprehensively, not only based on formal attributes but also on their scientific substance.

Likewise, the sub-indicator evaluating the use and misuse of scientific information reached only 48% (low category), indicating weak student skills in critiquing bias or logical fallacies commonly found in popular articles and social media. This weakness hinders their ability to become critical consumers of information, even though such competencies are integral to the scientific habits of mind [37]. This condition may be caused by the limited practice that requires students to analyze how information is presented in mass media, as well as the lack of habituation in examining data accuracy and argument consistency. In addition, intensive exposure to digital content that is often persuasive yet inaccurate further weakens students' evaluative abilities when it is not balanced with strong information literacy skills.

Even more concerning results appear in the quantitative dimension. The sub-indicator understanding elements of the research method and its impact on scientific findings received a score of only 39% (very low category), underscoring that students have limited understanding of the relationship between research design, result validity, and generalization of findings. Similarly, the ability to determine graphs that represent data (36%) and read and interpret graphs (32%), both categorized as very low, indicates profound weaknesses in students' quantitative literacy. In fact, the ability to interpret graphical data is a fundamental skill in understanding modern science [38]. These limitations may stem from the lack of opportunities for students to engage in data analysis activities, interpret scientific visualizations, and apply statistical reasoning in learning processes. Furthermore, instruction that emphasizes memorization of concepts rather than analytical and data interpretation skills may contribute to students' difficulties in understanding scientific evidence presented quantitatively. This condition highlights the need for more intensive learning experiences involving research-based activities, data visualization exercises, and interpretation of scientific graphs to strengthen students' scientific and quantitative literacy skills.

Furthermore, the sub-indicator of solving problems using quantitative skills, including probability and statistics, obtained a score of 57% (moderate category). This indicates that students possess initial mastery of mathematical calculation skills, although they have not yet fully developed the ability to interpret the results scientifically. This weakness is also reflected in the sub-indicators of understanding and interpreting basic statistics (48%) and presenting conclusions, predictions, and inferences based on quantitative data (41%), both of which fall into the low category. These conditions hinder students from engaging in critical data analysis and constructing evidence-based [39], [40]. Many students may understand statistical calculations procedurally, yet struggle to interpret their meaning within scientific contexts. In addition, the low ability to formulate conclusions and predictions based on data suggests that students are not yet accustomed to applying analytical reasoning and evidence-based thinking in evaluating scientific information. This condition may be influenced by learning practices that emphasize theoretical mastery rather than data interpretation and problem-solving activities involving authentic quantitative information. Limited exposure to research-based learning, statistical analysis exercises, and interpretation of real scientific data may also contribute to students' low quantitative literacy skills. Therefore, more contextual and inquiry-oriented learning strategies are needed to strengthen students' abilities in interpreting statistics and drawing scientifically grounded conclusions from quantitative data.

Overall, these results affirm that students' scientific literacy remains weak, particularly in aspects of research methodology and data analysis. The low scientific literacy outcomes demonstrated through the TOSLS instrument serve as an important warning for higher education institutions, indicating the need for instructional innovation through inquiry-based learning, project-based learning, and STEM integration in order to strengthen students' scientific competencies in line with 21st-century demands [28], [41], [42]. Such efforts will support students not only in understanding scientific concepts but also in applying scientific skills to real-world problems in society.

5. Conclusion

Based on the results of the study, it can be concluded that the scientific literacy skills of prospective Biology teacher students at the Faculty of Teacher Training and Education, Cenderawasih University, fall into the low category. When examined by TOSLS sub-indicators, three sub-indicators fall into the very low category, namely: understanding elements of research methods and their impact on scientific findings, determining graphs that represent data, and reading and interpreting graphs that represent data. Four sub-indicators fall into the low category, including identifying valid scientific ideas, evaluating the use and misuse of scientific information, understanding and interpreting basic statistics, and presenting conclusions, predictions, and inferences based on quantitative data. Two sub-indicators fall into the moderatecategory, specifically evaluating the validity of library sources and solving problems using quantitative skills, including probability and statistics. Therefore, improvement efforts are

required through more innovative, contextual, and data-driven learning strategies

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