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Scientific Literacy and Critical Thinking: An Analysis of Students' Evaluation of Local Bioprospecting Resources

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Abstract: Scientific literacy and critical thinking skills are essential in higher education, especially in bioprospection courses, in understanding the potential of biological resources objectively and scientifically. This study aims to analyze the relationship between scientific literacy and students' critical thinking skills in evaluating the bioprospection potential of local biological resources. This study used a quantitative correlational method, with participants consisting of biology students taking the bioprospection course. Data were collected using a scientific literacy questionnaire and a critical thinking test. Data were analyzed using Pearson correlation tests and simple linear regression tests. The results showed a significant relationship between scientific literacy and critical thinking skills among biology students. Students with high levels of scientific literacy tended to evaluate the potential of local bioprospection resources better. Regression analysis showed that scientific literacy is an independent variable influencing students' critical thinking skills. Scientific literacy can improve the critical thinking abilities of biology students. These findings emphasize the importance of integrating scientific literacy into bioprospection courses in higher education.

Keywords: Biology students; Bioprospecting; Critical thinking; Local biological resources; Science literacy

Introduction

The rapid advancement of science and technology requires students to develop strong critical thinking and scientific literacy skills. These skills are essential for addressing global challenges and improving our understanding of issues such as sustainable natural resource management (Arthi & Gandhimathi, 2024). Critical thinking and scientific literacy are fundamental to fostering higher-level thinking, which is crucial for scientific inquiry and problem-solving in bioprospecting (Hyytinen et al., 2019; Murtonen & Salmento, 2019; Thahir et al., 2021). In bioprospecting courses, scientific literacy involves not only grasping scientific concepts but also the ability to interpret and assess local biological resources critically while considering ethical and legal implications (Juhji & Mansur, 2020; Thahir et al., 2021).

A significant problem in bioprospecting education is the gap between scientific literacy and critical thinking skills, which are necessary for studying sustainable local biological resources (Imtihana & Djukri, 2020; Dini & Rini, 2024; Kamila et al., 2024). This gap is primarily caused by the lack of integration between scientific literacy and critical thinking skills in the educational curriculum, misunderstandings of scientific concepts, and insufficient emphasis on higher-order thinking skills. Scientific literacy and critical thinking are interrelated, with each enhancing the other. A strong foundation in scientific literacy can improve critical thinking skills, and vice versa (Carmona, 2025; Thahir et al., 2021). This issue is pressing in research, as scientific literacy and critical thinking are essential for making decisions based on scientific evidence. These skills are crucial in addressing ecological issues in ecosystems and

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understanding the socio-economic implications of using biological resources (Jacinda et al., 2024; Silaban & Sriyati, 2024).

Current conditions, based on research of Imtihana & Djukri (2020), Stock et al. (2023), and Zalles (2017) students often face challenges with memorization, especially in complex areas such as bioprospecting and evaluating local biological resources. These challenges can be attributed to various factors, including the subject matter's nature, local knowledge integration, and cognitive limitations. Students often show more interest in global biodiversity than local biodiversity, affecting their motivation to memorize local biological resources (Santana et al., 2024). According to Juliyanti & Syahfitri (2024) and Şaragov (2024), students tend to demonstrate suboptimal critical thinking when asked to evaluate biological potential in real-world contexts. Based on Imtihana & Djukri (2020) and Dini & Rini (2024), the lack of learning approaches that utilize local potential results in students being unable to understand and assess the benefits of bioprospecting comprehensively. Verawati & Wahyudi (2024) stated that strengthening scientific literacy combined with locally based evaluation is rarely found in current curriculum implementation. By addressing internal and external factors and adopting innovative teaching and learning strategies, students can improve their ability to memorize and understand complex biological concepts such as bioprospecting (Elhousni et al., 2024; Husna et al., 2023; Szymanski & Henriksen, 2022).

This research is essential because it contributes to understanding the relationship between scientific literacy and students' critical thinking in local resource bioprospecting (Irhasyuarna et al., 2022; Uslan et al., 2024). This research is expected to be a foundation in designing a curriculum emphasizing contextual and applied scientific literacy. This research provides input on an evaluative approach with a quantitative correlation between scientific literacy and students' critical thinking skills. This research is essential as a reference in integrated learning. This research is vital as a reference for integrated learning, such as in applying project-based learning models to local resources.

Method

This study uses a quantitative approach with a correlational research design. The population in this study was all 6th-semester Biology students who had taken the Bioprospection course at PGRI Silampari University. The sample selection was done using purposive sampling of 25 students, considering the choice of students who have completed their final assignments on local bioprospection. The instruments used were a multiple-choice scientific literacy test and a descriptive critical thinking ability test. The test instruments underwent expert validation and were pilot tested to measure reliability. Data were analyzed using the Pearson product-moment correlation test. Next, a simple linear regression analysis was conducted to determine the relationship between scientific literacy and students' critical thinking abilities. The data analysis technique for scientific literacy questions is based on Amala & Yushardi (2022) as follows:

$$\mathrm{NLS} = \frac{\mathrm{R}\chi}{\Sigma\chi} \quad (1)$$

Explanation:

NLS : The value of scientific literacy

$\mathrm{R}\chi$: The average number of students who received grades according to the scientific literacy criteria

$\Sigma\chi$: Number of Students

Determination of scientific literacy criteria, based on Erniwati et al. (2020) in Table 1.

Table 1. Categories of scientific literacy column

Score interval	Category
86–100	Very Good
72–85	Good
58–71	Fair
43–57	Low
≤ 43	Very Low

Table 2 shows the determination of the scientific literacy category.

Table 2. Categories of critical thinking ability

Score interval	Category
> 37.80	Very Critical
25.20–37.70	Critical
12.60–25.10	Not Critical
0.00–12.50	Very Not Critical

Table 3. Table value interpretation r-Pearson

Score interval	Category
0.001–0.200	Very weak correlation
0.201–0.400	Weak correlation
0.401–0.600	Fairly strong correlation
0.601–0.800	Strong correlation
0.801–1.00	Very strong correlation

Result and Discussion

This study involved 25 students from the biology study program in the 6th semester who had taken the Bioprospecting course at PGRI Silampari University. The sample was selected using purposive sampling, with the criteria being students who had completed their final assignment in the field of local bioprospecting. The data collected included results from science literacy tests and critical thinking ability tests, which were administered before and after the bioprospecting-based learning intervention. Documentation of student

activities during bioprospecting local biological resources and working on test questions in class can be seen in Figure 1. A comparison of the pre-test and post-test scores for science literacy and critical thinking can be seen in Figure 2.

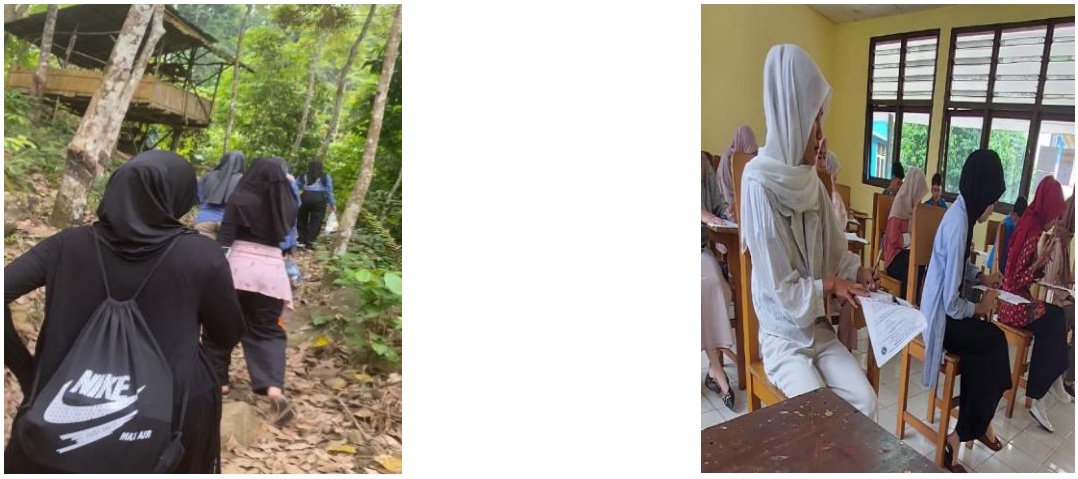

Figure 1. Research documentation

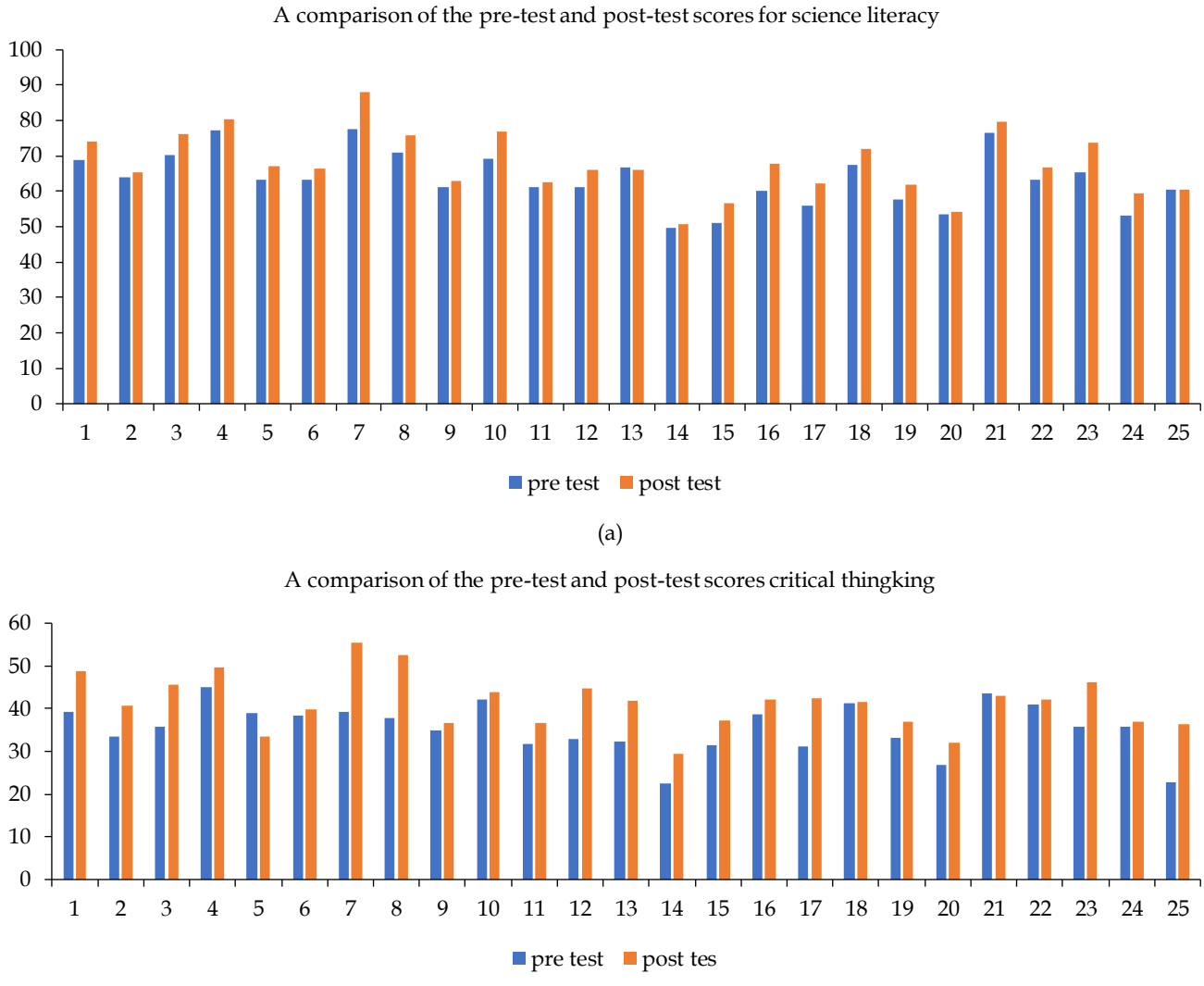

Figure 2. A comparison of the pre-test and post-test scores for science literacy (a) and critical thinking (b)

The descriptive statistics presented in Figure 1 indicate that the average pre-test score for students' science literacy was 63.71, while the average score for the critical thinking ability test was 39.90. After the learning intervention, the average post-test score for science literacy increased to 65.16, and the critical thinking ability score rose to 41.42. This improvement reflects a significant positive change in both areas. Each graph illustrates the score changes for each respondent, highlighting the impact of the learning intervention on both aspects.

The research results on students' scientific literacy abilities are included in the scientific literacy ability criteria as follows in Table 4.

Table 4. Categories of sains literacy

Score interval	Category	Figure	%
86–100	Very Good	1	4
72–85	Good	8	32
58–71	Fair	12	48
43–57	Low	4	16
≤ 43	Very Low	0	0

Based on Table 4, the student is included in the criteria of very good with a percentage of 4%, eight students with a percentage of 32%, 12 students with a rate of 48%, and four students with a percentage of 16% are low. Based on the research results, the criteria for scientific literacy with the highest rate is the sufficient category at 48%. This aligns with Agustya & Jauhariyah (2023), Amala et al. (2023), and Morgacheva et al. (2023). The research results show that the sufficient category appears most often in scientific literacy. Students demonstrate a basic understanding of scientific concepts; there is significant room for improvement in their overall scientific literacy skills. Based on Effendi et al. (2021) and Hasasiyah et al. (2020), all things related to scientific literacy can be learned through observation. Scientific literacy means a person's ability to utilize scientific knowledge and processes to understand scientific phenomena, helping in problem-solving and decision-making. Scientific literacy allows students to form knowledge, competencies, and attitudes towards scientific and technological phenomena in everyday life (Putri & Mufit, 2023; Setiawan et al., 2023). Local bioprospecting learning examines existing biodiversity and how it can be sustainably utilized (B, 2017). Teachers need special attention, as improving these skills is crucial for achieving better scientific literacy outcomes (Jumriani & Prasetyo, 2022; Thahir et al., 2021). Of course, this is a special concern for teachers because improving these skills is very important for better science learning outcomes. The criteria for very good are 4%, the criteria for good, with a percentage of 32% certainly need to be improved so that students can get even better learning outcomes. The low percentage 16% requires special attention from educators. Based on Zulanwari et al. (2023), the low scientific literacy skills of students at SMA Negeri 1 Sakra in solving PISA questions are caused by their lack of ability to examine questions, understand the content of the reading, and have high reasoning skills.

The research results on students' critical thinking ability are included in the critical thinking ability criteria as follows in Table 5.

Table 5. Categories of critical thinking ability

Score interval	Category	Figure	%
> 37.80	Very Critical	17	68
25.20–37.70	Critical	8	32
12.60–25.10	Not Critical	0	0
0.00–12.50	Very Not Critical	0	0

Based on Table 5, 17 students are included in the critical criteria with a percentage of 68%, and eight are included in the essential criteria with 32%. Based on the research results, the most significant percentage of critical thinking criteria is the very crucial category at 68%. This is in line with Ayala et al. (2024), Daryanes et al. (2023), Sukardi et al. (2019), and Zuhaida et al. (2022) results of the very critical category, especially in learning that involves students in local bioprospecting, everyday problems, and environmental ecology. Students are highly critical in analyzing the benefits of local bioprospecting as a conservation effort for existing biodiversity potential.

Critical thinking can be an argument for the intrinsic and ecological value of biodiversity, potentially becoming a starting point for building conservation (Goyes & South, 2025). The value of bioprospecting specific genetic resources can be significant enough to support biodiversity conservation (Rausser & Small, 2000).

The results of the correlation between critical thinking skills and scientific literacy can be seen in Table 6 below.

Table 6. Result correlation

Statistic	Result	Decision	Category
r	0.8761	Have correlation	Very strong correlation
Sig. (2-tailed)	0.000		
Significance (α)	0.05		

Results of the Pearson Product-Moment Correlation Test (Post-Test). The Correlation Coefficient (r) obtained was 0.8761, with a significance value (p-value) of 0.0000. There is a positive relationship between science literacy and critical thinking ability after the intervention. This suggests that increased science literacy enhances students' critical thinking ability following the intervention.

Results of a simple linear regression analysis (post-test) were conducted to determine the effect of science

literacy on students' critical thinking abilities following the intervention. The resulting model equation is as follows:

$$Y = -0.62 + 0.62X \quad (2)$$

R-squared: 0.7676. Model significance value (p-value): 0.0000. The regression model indicates that science literacy significantly impacts students' critical thinking abilities following the learning intervention. This suggests that higher levels of science literacy strongly correlate with improved critical thinking skills. Additionally, students with better academic performance improved science literacy and critical thinking more than those with lower academic performance.

The findings from the correlation and regression analyses indicate a significant positive relationship between science literacy and students' critical thinking abilities. The increased science literacy observed after the intervention correlates with improved critical thinking skills. These results support the hypothesis that bioprospecting-based learning can significantly enhance science literacy and critical thinking.

Critical thinking skills are essential for developing science literacy, enabling individuals to question assumptions, evaluate evidence, and draw logical conclusions. Research has shown that these skills significantly predict science literacy in various educational settings (Antonio & Prudente, 2023; Bulut & Yoldaş, 2022). In biology education, critical thinking has been linked to mastering fundamental biology concepts, the foundation for science literacy (Juhji & Mansur, 2020). Based on Jamaluddin et al. (2019) apart from students, teachers also need high critical thinking skills to improve the quality of their competence as educators, so that they can pay special attention to students. Educators must develop their teaching materials (Masithah et al., 2022).

Higher-order thinking skills like critical thinking are positively correlated with science literacy. Students with strong essential thinking abilities generally demonstrate higher science literacy (Thahir et al., 2021). However, it is necessary to note that, while these results are significant, other factors—like students' experiences applying bioprospecting concepts to their daily lives—may also influence their critical thinking abilities.

This study found a significant relationship between science literacy and students' critical thinking abilities. The Pearson correlation analysis revealed a strong correlation between these two variables. Additionally, the regression analysis indicated that science literacy positively and significantly impacts students' critical thinking abilities.

Bioprospecting requires a thorough understanding of biodiversity and the ability to assess the potential uses and impacts of biological resources critically. Individuals with strong critical thinking and scientific literacy skills will be better prepared to make informed decisions in bioprospecting, balancing ecological, economic, and ethical considerations (Bulut & Yoldaş, 2022). Integrating STEM education, which emphasizes critical thinking and scientific literacy, has improved students' skills in these areas. This suggests that such educational approaches can benefit those engaged in bioprospecting (Nilyani et al., 2023).

Various educational strategies, such as inquiry-based learning and design thinking, have been shown to enhance critical thinking and science literacy skills. These approaches encourage students to engage with scientific phenomena actively, leading to a deeper understanding of scientific concepts and processes (Antonio & Prudente, 2023; Syahana et al., 2023). The RANDAI learning model, which incorporates cultural elements with problem-solving, has proven effective in developing critical and creative thinking skills essential for science literacy and bioprospecting (Arsih et al., 2023). Developing scientific literacy is vital for navigating a complex, technology-driven society. It promotes essential 21st-century skills such as critical thinking, problem-solving, and communication, while addressing social disparities through evidence-based policies and identifying systemic issues (Antonio & Prudente, 2023). Most of the research findings were significant; however, no notable differences were observed between male and female groups regarding improved science literacy and critical thinking skills. This indicates that gender may not play a role in the changes following the intervention, likely due to the consistent acceptance and implementation of bioprospecting-based learning materials among all students (Tenedero et al., 2024).

A positive and significant relationship exists between critical thinking ability and science literacy, although the correlation is low (Primasari et al., 2020; Ridzal & Haswan, 2023). Efforts to enhance science literacy by improving critical thinking skills in formal and non-formal educational institutions are expected to increase awareness of the importance of understanding and applying scientific knowledge in everyday life (Azrai et al., 2020). The key finding of this study is the emphasis on local bioprospecting as the central focus of the learning process, which enhances the research's value by offering a more contextual and practical approach to biology education.

The results indicate that bioprospecting-based learning can enhance students' critical thinking skills. Therefore, it is recommended that project-based and bioprospecting-based learning approaches be more broadly implemented across various educational institutions to foster these skills in terms of policy. These

findings can provide a foundation for developing more relevant and effective educational policies to improve student science literacy.

This study has several limitations that should be acknowledged. One notable limitation is the small sample size, which may not accurately represent the entire student population in biology. Unmeasured external factors, such as students' personal experiences and socio-cultural differences, could also impact the results. Therefore, further research with a larger sample size and consideration of additional external variables is necessary.

Conclusion

The results showed a significant relationship between scientific literacy and critical thinking skills among biology students. Students with high levels of scientific literacy tended to evaluate the potential of local bioprospection resources better. Regression analysis showed that scientific literacy is an independent variable influencing students' critical thinking skills. Scientific literacy can improve the critical thinking abilities of biology students. This research contributes to developing bioprospecting-based learning approaches in higher education. Further research could explore external factors that influence the improvement of science literacy and critical thinking skills and develop more innovative and applicable learning approaches. In addition, the development of topics related to bioprospecting and science literacy can continue to prepare students to face global challenges in sustainable natural resource management.

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The authors declare no conflict of interest.

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