

ANALYSIS OF LITERACY AND NUMERACY SKILLS IN ENHANCING SCIENTIFIC CRITICAL THINKING IN STUDENTS: A CASE STUDY AT LANCANG KUNING UNIVERSITY

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ABSTRACT

Critical scientific thinking skills are essential for university students, particularly in addressing the demands of the information age and research development. This study aims to analyze the influence of literacy and numeracy skills on the scientific critical thinking abilities of Biology Education students at Universitas Lancang Kuning. Using an experimental method with a One Group Pretest-Posttest design, the study evaluates students' abilities in interpretation, analysis, evaluation, explanation, inference, and self-regulation before and after implementing an integrated literacy and numeracy-based learning approach. The findings reveal a significant improvement in students' critical scientific thinking abilities, with an average N-gain of 0.56, categorized as moderate. The aspects of interpretation, analysis, and evaluation showed the highest improvement, while explanation and self-regulation still require additional attention. These results suggest that integrating literacy and numeracy is an effective approach to enhancing students' critical thinking skills. The study recommends the development of supplementary learning strategies, such as project-based learning and digital technology utilization, to strengthen students' explanatory and self-regulation skills further.

Keyword: Literacy, Numeracy, Scientific Critical Thinking, Biology Education, Integrated Learning

1. INTRODUCTION

Competency in literacy and numeracy is an essential requirement for developing 21st-century skills (Nudiati, 2020). Education that involves families, schools, and communities is considered crucial for integrating literacy and numeracy competencies (Tout, 2020). These skills hold significant value for individuals as they enhance critical thinking abilities (Arsyad, 2023). Moreover, literacy and numeracy competencies help solve everyday problems using mathematical knowledge, including symbols and numbers (Diva, Khafidin, & Ulya, 2022). Numeracy literacy encompasses three key aspects: counting, numerical relations, and arithmetic operations. Counting refers to the ability to count using words and recognize the quantity of objects (Ekowati et al., 2019). Meanwhile, numerical relations involve the ability to compare quantities, such as more, less, taller, or shorter (Barham et al., 2019).

Meanwhile, arithmetic operations include the ability to perform basic addition and subtraction. These three aspects serve as fundamental principles in mathematics learning, which should be introduced to children from an early age through elementary school (Cheung et al., 2021). In higher education, scientific critical thinking skills are essential competencies that students must possess (Anintyawati & Masithoh, 2024), especially those involved in research and the advancement of knowledge (Az-Zahroh & Permadi, 2022). Scientific critical thinking goes beyond merely recalling facts or information; it involves a deeper process, such as the ability to analyze data objectively, evaluate existing evidence, and interpret information in a logical and structured manner (Jain & Rogers, 2019). This ability enables students to make evidence-based decisions rather than relying solely on assumptions or opinions (Listiana et al., 2022). It is particularly crucial in scientific fields, where accuracy and precision in interpreting information can determine the success or failure of research (Jamil & Khusna, 2021).

One aspect often overlooked in the development of scientific critical thinking is numeracy and literacy skills, which are closely interconnected in supporting critical thinking processes (Skagerlund et al., 2018). Numeracy skills refer to the ability to understand, analyze, and use numbers or statistical data in various contexts (Daroin et al., 2022). This is not just about performing mathematical calculations but also about the ability to interpret and critically evaluate numerical data (Muhimmatin & Prasetyo, 2024). In scientific research, experimental data is often presented in numerical and statistical forms. Therefore, students need the ability to accurately analyze this data to identify trends, patterns, or relationships between variables that may be hidden within it (Nadjamuddin & Hulukati, 2022). With strong numeracy skills, students can filter out irrelevant data and ensure that their analysis is based on the appropriate methodology (Yuwono et al., 2024). On the other hand, literacy skills go beyond merely reading texts. Scientific literacy, in particular, involves the ability to read, write, and communicate scientific information clearly and effectively (Wardhani et al., 2022). Scientific literacy also refers to the ability to critique and evaluate arguments and evidence presented in scientific articles (Reder et al., 2020). A student proficient in literacy can not only comprehend scientific texts but also identify weaknesses in an argument or research methodology (Anderha & Maskar, 2021). These skills enable students to assess the quality of information they encounter in scientific literature and determine whether the findings are valid and reliable (Ayuningtyas & Sukriyah, 2020). For example, the ability to critically read journal articles, identify valid research designs, and evaluate the strengths and weaknesses of presented evidence is an essential skill that supports the development of critical thinking (Novitasari et al., 2022).

Numeracy and literacy skills are essential in the fields of science and technology, where students are required not only to collect experimental data but also to understand and communicate their findings clearly and accurately (Dwi Noerbella, 2022). In the research world, the ability to deeply analyze experimental data and write detailed reports on findings can determine how research results are understood and accepted by the scientific community (Eka Susanti, 2023). Therefore, these two skills do not function separately but rather complement each other. Numeracy skills help students process and

evaluate data, while literacy skills enable them to understand and communicate their findings systematically and with evidence-based reasoning (Anugrahana & Hasthiolivia, 2023). Thus, both serve as crucial foundations for effective scientific critical thinking.

In the context of higher education, the development of both skills can be achieved through various approaches. One effective method is integrating numeracy and literacy skill development into a curriculum based on case studies or research projects (Ahmed, 2020). For example, assignments requiring students to read complex scientific articles, analyze the data within them, and write analytical reports can enhance both their numeracy and literacy skills. Additionally, the use of learning technologies, such as statistical software and text-based learning platforms, can strengthen students' numeracy skills by enabling them to analyze experimental data in a practical and hands-on manner (Gunawan et al., 2023). Thus, improving numeracy and literacy skills will help students develop more advanced scientific critical thinking abilities, which are highly valuable in both academic and professional settings today (Nudiati, 2020).

Biology Education students at the Faculty of Education and Vocational Studies at Lancang Kuning University play a crucial role as future science educators who will shape the younger generation with strong scientific critical thinking skills. In preparing for the challenges of modern education, literacy and numeracy skills serve as two fundamental pillars that are not only relevant but also essential in determining their success in comprehensively understanding, analyzing, and applying biological concepts (Fanshawe et al., 2023). Lancang Kuning University has the opportunity to enhance these skills through a curriculum based on case-based learning and project-based learning. The use of tools such as statistical software, data visualization, and digital scientific literature can support students in directly practicing literacy and numeracy within biology education. This study aims to assess the extent to which students' ability to understand, analyze, and utilize numerical data, as well as their ability to read, evaluate, and communicate scientific information, can enhance their critical thinking skills in the context of scientific research. The findings are expected to provide practical recommendations for curriculum development and pedagogical approaches in higher education, particularly at Lancang Kuning University, to equip students with well-developed critical thinking competencies for both academic and professional settings.

2. METHODOLOGY

The research method used in this study is an experimental research method with a One Group Pretest-Posttest Design. This research process involves observing the influence of Literacy Skills (X1) and Numeracy Skills (X2) on Scientific Critical Thinking Ability (Y). Subsequently, a treatment is applied, followed by a post-test to measure the effects of the intervention. The research subjects consist of 38 fifth-semester Biology Education students at Lancang Kuning University. The pretest and posttest results will be analyzed using the Gain Score formula as proposed by Hake (1999), which is calculated as follows:

$$N\ gain = \frac{S\ post - S\ pre}{S\ Ideal - S\ pre}$$

The results of the gain score will be interpreted into three categories that describe the level of scientific critical thinking ability. The interpretation of the gain score is explained in Table 1 below.

Tabel 1. Interpretation *Gain Score*

<i>Gain Score</i>	Interpretation
$(\langle g \rangle) > 0.7$	Tinggi
$0.7 > (\langle g \rangle) > 0.3$	Sedang
$(\langle g \rangle) < 0.3$	Rendah

This categorization helps in evaluating the effectiveness of literacy and numeracy skill development in enhancing students' scientific critical thinking abilities.

3. RESULTS AND DISCUSSION

The gain score is used to determine the extent of improvement in students' scientific critical thinking abilities after taking the pretest and posttest. If the gain score is ≥ 0.3 in the medium category, the results can be considered effective. In this study, the average gain score across all aspects of scientific critical thinking assessment was 0.56, which falls within the medium category. This indicates that the intervention had a positive and effective impact on students' critical thinking skills. Table 2 presents the findings of the gain score analysis:

Table 2. Gain Score Analysis

No.	Aspek	Pretest	Posttest	N-Gain	Kategori
1.	Interpretasi	54.7	82.6	0.62	Sedang
2.	Analisis	58.2	80.3	0.53	Sedang
3.	Evaluasi	52.4	81.4	0.61	Sedang
4.	Eksplanasi	47.1	73.7	0.50	Sedang
5.	Inferensi	65.2	84.8	0.56	Sedang
6.	Pengaturan Diri	40.5	71.6	0.52	Sedang
Rata-rata		53.02	79.07	0.56	Sedang

The interpretation aspect showed a significant improvement, with an average post-test score of 82.6, indicating students' enhanced ability to understand and derive meaning from presented data or information. This finding aligns with (Phonapichat et al. 2014), who stated that the more students engage with data, the more familiar they become with the presented information. It also suggests that literacy- and numeracy-based learning interventions support students in reading and interpreting scientific data more effectively.

The analysis aspect demonstrated that students improved their ability to break down complex information into simpler components for evaluation. This treatment helped

them become more critical in examining data structures or scientific arguments. These findings differ from those of (Seventika et al. 2018), who conducted a similar study on vocational high school students. This difference suggests that higher levels of education contribute to better data and information analysis skills. In the explanation aspect, students' ability to articulate and present their findings improved, although the average score was not particularly high. This indicates a need for additional approaches to further develop scientific communication skills. This result is consistent with findings by (Ardhian et al. 2020).

The inference aspect, which refers to the ability to draw logical conclusions from data, showed significant improvement. This suggests that students could effectively use numerical data to make evidence-based decisions. Meanwhile, the self-regulation aspect, which relates to the ability to reflect on one's thought processes, also exhibited a notable increase. This indicates the effectiveness of the post-test in helping students monitor and evaluate their thinking strategies.

Overall, the data indicate an improvement in students' scientific critical thinking abilities after the intervention. Although the gain score falls within the "medium" category, this suggests that the applied intervention effectively enhanced critical thinking skills, particularly in the aspects of interpretation, evaluation, and inference. These findings highlight the positive impact of integrating literacy- and numeracy-based learning approaches in higher education. While some aspects, such as explanation and self-regulation, may require additional instructional strategies, the overall results demonstrate the effectiveness of the intervention in fostering a more analytical and evidence-based approach to scientific reasoning among students.

4. CONCLUSION

The findings of this study indicate that the development of literacy and numeracy skills significantly contributes to the enhancement of students' critical thinking abilities. Based on the analysis, the average N-gain score of 0.56 falls within the medium category, reflecting the effectiveness of literacy- and numeracy-based learning approaches in fostering scientific critical thinking skills. Notable improvements were observed in interpretation (0.62), evaluation (0.61), and analysis (0.53), indicating that students became more capable of understanding, evaluating, and breaking down scientific information into logically analyzable components. These aspects are closely linked to literacy and numeracy skills, where students must read, comprehend, and process data-driven and scientific text-based information.

However, while there were improvements in the explanation (0.50) and self-regulation (0.52) aspects, these results were at the lower end of the medium category, suggesting the need for more intensive instructional approaches. This is crucial to help students better articulate scientific findings and reflect on their thought processes to develop more effective learning strategies. Overall, the average N-gain score of 0.56 suggests that literacy- and numeracy-based learning approaches are moderately effective. However, further refinement and diversification of teaching strategies are necessary to strengthen weaker aspects, particularly explanation and self-regulation, to optimize students' scientific critical thinking abilities.

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