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Analysis of Elementary School Students' Scientific Literacy Skills on the Topic of Animal Life Cycles

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ABSTRACT
The mastery of scientific literacy is a critical competency in 21st-century education, enabling students to apply scientific knowledge in solving real-world problems. However, evidence shows that elementary school students in Indonesia generally achieve low levels of scientific literacy, particularly in conceptual reasoning and the application of scientific evidence. This study aimed to analyze the scientific literacy skills of Grade IV students at UPTD SD Negeri 2 Peusangan Siblah Krueng, focusing on three key indicators: identifying scientific evidence, explaining scientific phenomena, and applying scientific evidence in daily life. Employing a descriptive qualitative approach with an intrinsic case study design, data were collected from 25 students through a 15-item test developed based on the Programme for International Student Assessment framework. The responses were analyzed using content analysis to categorize ability levels. The results indicated that 44% of students were in the low category, 40% in the high category, and 16% in the moderate category. Students performed best in identifying scientific evidence, followed by applying evidence in real-life contexts, while the lowest achievement was in explaining phenomena, reflecting limited conceptual understanding and reasoning ability. These findings highlight the need for transforming science instruction from content delivery to experiential, inquiry-based, and problem-based learning integrated with real-life contexts and technology. Such pedagogical reforms are expected to foster deeper conceptual mastery, critical thinking, and practical application of scientific knowledge, thereby contributing to both the theoretical development of science education and practical efforts to enhance 21st-century competencies at the primary school level.

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1. Introduction

The development of the Fourth Industrial Revolution and global digital transformation has shifted the educational paradigm from content-oriented to competence-oriented learning. In the 21st-century context, students are required to possess critical thinking, data literacy, and scientific skills to address increasingly complex social and ecological challenges. One of the key competencies recognized internationally is scientific literacy—defined as the capacity to apply scientific knowledge to solve real-world problems (OECD, 2018). This competency is crucial because it directly relates to individuals' ability to address global issues such as pandemics, climate change, and evidence-based decision-making in everyday life.

Indonesia, as part of the global community, still faces significant challenges in mastering scientific literacy. According to the Programme for International Student Assessment (PISA) 2018, Indonesian students scored an average of 396 in scientific literacy, significantly below the OECD average of 489, placing the country 71st out of 79 participating nations (OECD, 2019). This disparity not only reflects the national weakness in science competencies but also underscores the urgent need for educational reform starting from the primary school level. Scientific literacy cannot be developed solely through rote memorization of concepts; it must be fostered through contextual, meaningful learning that emphasizes scientific reasoning.

At the local level, the same issue is evident in the low scientific literacy achievement of elementary students, particularly in science subjects. Dwisetiarezi and Fitria (2021) found that most students were unable to explain scientific phenomena or apply scientific evidence in real-life contexts. Similarly, Harahap et al. (2022) revealed that students could answer recall-based questions but struggled to construct arguments based on scientific data, indicating that science instruction still fails to align with the core characteristics of scientific literacy—observation, data analysis, and communication.

One of the science topics with strong potential to develop scientific literacy is the life cycle of living things. This topic is contextual and easily observable by students; however, it has yet to be fully leveraged to train scientific skills. Rachman et al. (2022) showed that integrating creativity and simple project-based learning into this topic significantly improved students' understanding. Nonetheless, studies specifically evaluating elementary students' scientific literacy across indicators such as identifying evidence, explaining phenomena, and applying scientific evidence in real-life contexts remain scarce.

Empirical findings consistently show that low scientific literacy is a persistent challenge in elementary science education. Astria and Wardani (2024) reported that most Grade V students still struggled to integrate scientific concepts with contextual evidence, especially in applying scientific evidence in everyday situations. Likewise, Ardani and Margunayasa (2024) found that learning media based on local wisdom and integrated with augmented reality technology positively impacted Grade IV students' scientific literacy. These

findings highlight the need for culturally relevant and technologically supported innovations as pedagogical strategies to strengthen scientific understanding in primary education. However, these studies have not explicitly examined scientific literacy using PISA indicators in biological themes relevant to students' concrete experiences, such as life cycles. Therefore, there is a pressing need for evaluative studies that systematically analyze the diagnostic aspects of scientific literacy on such topics.

Based on the background and problem identification above, this study explicitly aims to analyze the scientific literacy skills of Grade IV students at UPTD SD Negeri 2 Peusangan Siblah Krueng on the topic of the life cycle of living things.

2. Research Methodology

This research employed a descriptive qualitative approach with an intrinsic case study design to explore in depth the scientific literacy skills of Grade IV students at UPTD SD Negeri 2 Peusangan Siblah Kruen on the life cycle topic. This approach was chosen because it allows researchers to understand students' responses to scientific problems in a contextual manner without relying solely on numerical data (Creswell & Poth, 2018). The intrinsic case study was applied as the focus was not on generalization but on gaining a comprehensive understanding of scientific literacy skills within a specific, bounded context (Yin, 2018).

The study involved 25 students, selected through total sampling since the entire population was relevant as participants. The research was conducted in the even semester of the 2024/2025 academic year, aligned with the implementation framework of the Merdeka Curriculum. Data were collected through a written test consisting of open-ended questions developed based on scientific literacy indicators from OECD (2019): (1) Identifying scientific evidence, (2) Explaining scientific phenomena, (3) Using scientific evidence in daily life. The instrument comprised 15 multiple-choice questions representing these three aspects. Table 1 presents the distribution of test items by indicator.

Table 1. Scientific Literacy Indicators

No	Indicator	Question Numbers
1	Identifying scientific evidence	1, 2, 11, 12
2	Explaining scientific phenomena	3, 4, 9, 10, 15
3	Using scientific evidence in daily life	5, 6, 7, 8, 14

The collected data were analyzed using content analysis techniques, with ability levels categorized according to Winata & Suranto (2018) into very high, high, moderate, low, and very low. The research procedure included obtaining school permission, administering the test in a normal classroom setting, and conducting manual analysis of student responses.

3. Results and Discussion

The study, conducted on 18 April 2025, measured students' scientific literacy in science lessons (IPA) on the topic of life cycles. The results are shown in Table 2.

Table 2. Scientific Literacy Levels

No	Category	Persentage (%)
1	High	40
2	Moderate	16
3	Low	44
Total		**100**

As seen in Table 2, most students fell into the low category (44%), followed by high (40%) and moderate (16%). This distribution suggests that while a portion of students demonstrated strong scientific literacy, the majority still lacked comprehensive mastery.

Table 3. Percentage Scores per Scientific Literacy Indicator

No	Indicator	Persentage (%)
1	Identifying scientific evidence	37,49
2	Explaining scientific phenomena	27,10
3	Using scientific evidence in daily life	35,41
Total		**100**

The highest score was in identifying scientific evidence (37.49%), indicating that students were relatively capable of recognizing scientific information or data as a preliminary step in scientific thinking. The second highest score was in using scientific evidence in daily life (35.41%), showing partial ability to apply science concepts in real contexts. The lowest score was in explaining scientific phenomena (27.10%), reflecting difficulties in reasoning and conceptual understanding.

The analysis revealed that students' strongest performance was in the domain of identifying scientific evidence (37.49%). This indicates that students were relatively proficient in recognizing information or data of a scientific nature, which serves as an initial step in scientific thinking. In the domain of using scientific evidence in daily life (35.41%), students demonstrated a tendency to understand the application of science concepts in real-world contexts, although this skill has yet to be fully optimized. In contrast, the lowest achievement was found in explaining scientific phenomena (27.10%), reflecting students' difficulty in constructing reasoning and developing conceptual understanding of complex scientific events.

These findings align with Rachman et al. (2022), who reported that activities based on simple observations significantly help students identify scientific elements from their surrounding environment. Nevertheless, the ability to explain scientific phenomena remains the weakest aspect (27.10%), indicating insufficient conceptual understanding and the inability to construct comprehensive scientific reasoning. This finding is consistent

with Dwisetiarezi and Fitria (2021), who found that elementary school students tend to excel in memorization but struggle to explain causal relationships between concepts. Similarly, Harahap et al. (2022) emphasized that students' ability to construct arguments based on scientific data is limited due to the predominance of expository approaches in science instruction. The limited use of experiential, hands-on, and contextual activities results in passive learning and insufficient training in critical thinking.

The present study suggests that the low level of students' scientific literacy is influenced by teaching methods that are not yet optimal in stimulating scientific thinking skills and conceptual understanding. This is in line with Sariyyah et al. (2025), who emphasized that the integration of educational video media with real-life contexts can significantly enhance students' scientific literacy, particularly in explaining scientific phenomena and applying concepts in practical settings. Furthermore, this experiential learning approach has been shown to foster students' curiosity, encourage them to engage in observation, pose questions, and draw conclusions from simple experimental activities. This is consistent with the OECD (2019) scientific literacy framework, which highlights the importance of active student engagement in linking science concepts to everyday life.

Accordingly, the low performance of students in the "explaining scientific phenomena" indicator in this study can be interpreted as a consequence of the absence of inquiry-based and experiential learning approaches in the classroom. Rahmawati and Setiawan (2023) found that students who are trained to analyze scientific problems and formulate solutions based on evidence tend to exhibit better problem-solving skills compared to those who rely solely on rote memorization of theories. For example, in lessons on air pollution, students who were engaged in analyzing local air quality data and proposing scientific solutions demonstrated significantly greater development in critical thinking skills. They not only understood the consequences of air pollution but also developed awareness and responsibility.

These findings suggest that scientific literacy encompasses the ability to explain scientific phenomena logically, design scientific investigations, and critically evaluate scientific evidence - skills that are essential in meeting the challenges of 21st-century science education. Therefore, it can be concluded that elementary science instruction needs to transform from mere content delivery to a meaningful, contextual, and experience-oriented learning process. Such reform is crucial to achieving the objectives of the *Merdeka Belajar* curriculum, which emphasizes character development and the strengthening of literacy competencies.

4. Conclusions

This study concludes that Grade IV students at UPTD SD Negeri 2 Peusangan Siblah Krueng demonstrated varied scientific literacy skills, with the majority in the low category. Students were relatively proficient at identifying scientific evidence but had difficulty

explaining phenomena and applying concepts in daily life. These shortcomings reflect the absence of sufficient inquiry and contextual learning experiences in science instruction.

To address these gaps, it is recommended that science learning adopt experiential, inquiry-based, and problem-based models integrated with real-life contexts and technological media. Such approaches are expected to foster deeper conceptual understanding, critical thinking, and the practical application of scientific knowledge—thereby supporting the national agenda of strengthening 21st-century competencies.

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