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Strengthening Scientific Literacy Through Environmental Phenomenon Based Science Learning

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ABSTRACT

This study aims to analyze the strengthening of scientific literacy through environmental phenomenon-based science learning based on a literature review. This research uses a qualitative approach with a library research method. The research data were obtained from various national and international scientific articles, academic books, and educational policy documents relevant to scientific literacy and environment-based science learning. Data analysis was conducted using content analysis and thematic analysis techniques through the stages of source identification, theme grouping, interpretation, and synthesis compilation of study results. The research results indicate that environmental phenomenon-based science learning is able to strengthen students' scientific literacy through contextual, investigative, and problem-solving-oriented learning processes. The use of real phenomena such as environmental pollution, climate change, waste management, and ecosystem destruction provides opportunities for students to develop the ability to explain phenomena scientifically, evaluate evidence-based information, conduct investigations, and devise solutions to environmental problems. In addition to improving cognitive aspects, this approach also contributes to the development of critical thinking skills, science process skills, collaboration, and awareness of environmental sustainability. The implications of this study indicate that science teachers need to develop learning that utilizes the environment as a learning resource and integrates real-life phenomena into the learning process. Theoretically, this study strengthens the view that scientific literacy can be optimally developed through learning that connects science concepts with social and environmental contexts. Practically, the results of this research can serve as a reference for educators and curriculum developers in designing more meaningful, contextual science learning in accordance with the demands of 21st-century competencies.

Keywords: Scientific Literacy, Science Learning, Environmental Phenomenon, Science Education

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INTRODUCTION

The development of science and technology in the 21st century has changed the way humans understand, utilize, and solve various life problems. Globalization, digital transformation, the Industrial Revolution 4.0, and Society 5.0 present increasingly complex challenges so that students are required to have the ability to think critically, creatively, communicatively, collaboratively, and be able to make decisions based on

scientific evidence (Ariska, Kurahman, and Rusmana 2025). In this context, education is no longer only oriented towards conceptual mastery, but is also directed at developing competencies that enable students to understand natural phenomena, analyze problems, and produce responsible solutions. Science Education (IPA) has a strategic position in shaping these competencies because science learning not only develops conceptual knowledge, but also science process skills, scientific thinking abilities, and scientific attitudes needed in everyday life (Carter 2026). Therefore, improving the quality of science learning is an important agenda in realizing human resources capable of facing sustainable development challenges. One of the main competencies that must be developed through science learning is scientific literacy

According to the Programme for International Student Assessment (PISA) framework, scientific literacy is an individual's ability to explain phenomena scientifically, evaluate and design scientific inquiries, and interpret data and scientific evidence in decision making. Scientific literacy is not only related to mastery of science concepts, but also the ability to use that knowledge to understand various real problems faced by society. Students who have good scientific literacy will be better able to think rationally, analyze information critically, distinguish facts and opinions, and provide solutions to environmental, health, energy, and technological problems based on scientific approaches (Darman et al. 2026). Therefore, strengthening scientific literacy has become one of the main focuses in various educational policies in various countries, including Indonesia. Nevertheless, various international evaluation results indicate that the scientific literacy ability of Indonesian students remains an aspect that needs sustained attention and strengthening. The results of the 2022 Programme for International Student Assessment (PISA) show that the scientific literacy achievement of Indonesian students is still below the average of the Organisation for Economic Co-operation and Development (OECD) member countries (Saifudin, Muslim, and Primadoni 2026). This condition illustrates that some students still face difficulties in using science knowledge to understand natural phenomena, explain events based on scientific concepts, evaluate evidence-based information, and make decisions regarding various problems related to everyday life. The low achievement indicates that the challenge of science education in Indonesia is not only related to students' ability to master concepts, but also their ability to apply these concepts in real situations (FASH 2026).

The problem of scientific literacy becomes increasingly complex because science learning in some schools still tends to be oriented towards material delivery and the achievement of cognitive learning outcomes through memorizing concepts, formulas, and definitions. Such learning patterns cause students to often be able to answer theoretical questions but experience difficulties when faced with contextual problems that require analysis and scientific reasoning skills. In fact, the essence of science learning emphasizes not only products in the form of concepts and theories but also scientific processes that involve observing, identifying problems, formulating hypotheses, conducting investigations, analyzing data, and drawing conclusions based on acquired evidence. In addition to the learning approach factor, low scientific literacy is also related to the limited use of the surrounding environment as a learning resource for science. Much science learning still takes place in classrooms using textbooks as the main source, while various natural phenomena and environmental problems around students have not been optimally utilized as objects of learning. As a result, students lack direct experience in connecting science concepts with the reality of life. For example, concepts of environmental pollution, ecosystem changes, water quality, climate change, and waste management are actually phenomena close to students' lives, yet they are often only studied through theoretical explanations without involving direct observation and investigation processes.

This condition indicates the need for a paradigm shift in science learning from a teacher-centered approach (teacher-centered learning) to a more active, contextual, and student-centered learning (student-centered learning). Science learning needs to provide space for students to build knowledge through real experiences, scientific investigations, and problem-solving related to the surrounding environment. Thus, students not only understand science conceptually, but are also able to use this knowledge to explain phenomena, evaluate information, and produce solutions to various problems faced by society (Kurniawan, Dewi, and Heny 2026). Therefore, strengthening scientific literacy through environmental phenomenon-based science learning becomes a relevant strategic alternative to answer these challenges. This approach allows students to learn science through real phenomena that have direct links to their lives, making the learning process more meaningful. Through observation activities, investigations, data analysis, and scientific discussions on various environmental phenomena, students can develop critical thinking skills, science process skills, and awareness of the importance of maintaining environmental sustainability. Thus, environmental phenomenon-based learning not only contributes to increasing scientific literacy, but also supports the formation of a generation capable of using scientific knowledge responsibly in facing global challenges.

These phenomena indicate a gap between the goals of science learning and learning practices in schools. In many educational units, science learning is still dominated by verbal material delivery, the use of textbooks as the main learning resource, and an emphasis on achieving cognitive scores. As a result, students tend to understand concepts theoretically without being able to relate them to issues they encounter in their daily lives. In fact, the essence of science is to study nature through observation, investigation, experimentation, and scientific reasoning. If learning does not provide opportunities for students to interact directly with natural phenomena, scientific thinking skills and scientific literacy will be difficult to develop optimally (Nuryanti 2026). Ideally, science learning is designed as a contextual, meaningful, and student-centered learning process. The teacher acts not only as an information provider, but also as a facilitator capable of creating learning experiences through observing real phenomena, experimental activities, scientific discussions, problem solving, and reflection. The environment around the school and students' residences provides various phenomena that can be used as learning resources, such as environmental pollution, climate change, waste management, biodiversity, water quality, renewable energy, and various other environmental issues. Through phenomenon-based environmental learning, students get the opportunity to connect science concepts with the reality of life so that learning becomes more relevant, meaningful, and capable of improving scientific literacy skills.

Environmental phenomenon-based science learning is an approach that utilizes various real problems in the environment as a starting point for the learning process. This approach encourages students to observe, identify problems, gather information, conduct investigations, analyze data, and devise solutions based on scientific concepts. Thus, the learning process is not only oriented towards mastering materials but also developing critical thinking skills, problem-solving abilities, scientific communication, and environmental concern. In addition, environmental phenomenon-based learning is also in line with the goals of Education for Sustainable Development (ESD), which emphasizes the importance of building students' awareness of environmental, social, and economic issues in an integrated manner. Various studies in the last five years show that phenomenon-based learning and real-life contexts positively contribute to improving students' scientific literacy. Published research reports that learning integrating everyday life phenomena can improve students' abilities to explain scientific phenomena, interpret data, and develop critical thinking skills (Hanifah, Hernani, and Fatimah 2026). Research results in the Jurnal Pendidikan IPA Indonesia also show that learning based on environmental issues and inquiry activities significantly impacts improving scientific literacy, science process skills,

and students' problem-solving abilities. Furthermore, various published studies conclude that the use of environmental contexts as learning resources can increase student engagement in learning, strengthen conceptual understanding, and build awareness of the importance of preserving the environment (Permana, Hayat, and Novita 2026). Nevertheless, most previous research has focused more on the effectiveness of certain learning models, such as Problem Based Learning, Project Based Learning, or inquiry learning on learning outcomes and scientific literacy. Studies that specifically review how environmental phenomenon-based science learning can be a systematic strategy to strengthen scientific literacy through the connection between scientific concepts and environmental issues are still relatively limited. In addition, some studies focus more on measuring quantitative learning outcomes without providing a comprehensive synthesis of effective principles of environmental phenomenon-based learning applied in science learning (Ningsih et al. 2026).

Based on this gap, this article offers a perspective that strengthening scientific literacy is not enough to be done through changing learning models alone, but requires integrating environmental phenomena as the main context in the entire science learning process. The novelty of this article lies in compiling a conceptual synthesis of the relationship between scientific literacy, environmental phenomenon-based learning, scientific thinking skills, and the development of environmental awareness in one unified learning framework. This article also emphasizes that environmental phenomena function not only as examples of applying science concepts but as a vehicle for students to build knowledge, develop scientific thinking skills, and foster responsibility for environmental sustainability. Based on this description, this article aims to analyze the strengthening of scientific literacy through environmental phenomenon-based science learning based on various recent research and scientific studies. The analysis is focused on the concept of scientific literacy, the characteristics of environmental phenomenon-based learning, implementation strategies in science learning, and their implications for improving students' scientific thinking, problem solving, and environmental awareness. The results of this study are expected to provide theoretical contributions to the development of Science Education studies as well as serve as a practical reference for teachers, schools, and curriculum developers in designing more contextual, meaningful, and oriented science learning towards strengthening scientific literacy as one of the main 21st-century competencies.

METHOD

This research uses a qualitative approach with a library research method. This approach was chosen to review and synthesize various theories, concepts, and research results regarding the strengthening of scientific literacy through environmental phenomenon-based science learning (Kusumastuti et al. 2026). Through a literature review, the research seeks to obtain a comprehensive understanding of implementation strategies for environmental phenomenon-based learning and their contribution to improving students' scientific literacy. Data sources consist of primary data and secondary data. Primary data is in the form of scientific articles published in national journals accredited by SINTA and reputable international journals discussing scientific literacy, science learning, phenomenon-based learning, and environment-based learning. Articles prioritized were published in the period 2020–2026 to obtain the latest information. Data collection was carried out through documentation techniques by identifying, grouping, and recording important information from each article, including research objectives, methods, learning characteristics, scientific literacy indicators, and research findings. The data were then analyzed using content analysis combined with thematic analysis through the stages of data reduction, coding, theme grouping, interpretation, and synthesis preparation. The validity of the study results is maintained through source triangulation

by comparing various research results from reputable journals and critically evaluating the quality, relevance, and consistency of each source (R. Fajri and Yanna 2026). This procedure produces a comprehensive scientific synthesis of strengthening scientific literacy through environmental phenomenon-based science learning as a basis for developing contextual science learning oriented toward 21st-century competencies.

RESULTS AND DISCUSSION

Result

The results of the literature review show that environmental phenomenon-based science learning makes a significant contribution to strengthening students' scientific literacy. Based on an analysis of various national and international articles published in the period 2020–2026, it was found that utilizing environmental phenomena as a learning context is able to improve students' abilities to understand science concepts, connect theories with real life, and develop scientific thinking skills. Learning that begins with observing phenomena that occur in the surrounding environment makes students more active in building knowledge through observation, discussion, investigation, and reflection processes so that learning becomes more meaningful. Literature analysis also shows that scientific literacy is not only understood as the ability to master science concepts but includes the ability to explain phenomena scientifically, design and evaluate investigations, interpret data, and use scientific evidence in decision making. Various analyzed studies show that learning integrating environmental phenomena is able to develop all aspects of scientific literacy more optimally compared to learning oriented towards conventional material delivery. Students not only acquire conceptual knowledge but also learn to identify problems, analyze cause-and-effect relationships, test hypotheses, and devise solutions to problems faced in the surrounding environment (Fatih 2026).

The study results show that the environmental phenomena most widely utilized in science learning include water pollution, air pollution, waste management, climate change, global warming, ecosystem destruction, biodiversity, natural resource conservation, the use of renewable energy, and household waste management. These phenomena were chosen because they have a direct connection with students' lives, thus being able to increase curiosity, learning motivation, and environmental concern. The relationship between science material and actual conditions makes the learning process more contextual so that students more easily understand abstract concepts through authentic learning experiences. Literature studies show that the implementation of environmental phenomenon-based learning is generally carried out in several stages. The first stage is orientation to the phenomenon, where the teacher presents an event or environmental problem that occurs around the students through direct observation, videos, pictures, news, or case studies. The second stage takes the form of identifying problems and formulating scientific questions as a basis for investigation. The third stage is data collection through observation, experimentation, literature study, or group discussion. Next, students analyze the obtained data, connect it to science concepts, then draw conclusions and present the investigation results. These stages show that students act as active learning subjects in building their own knowledge (Fatonah, Juriah, and Siburian 2026).

The analysis results also show that environmental phenomenon-based science learning has a positive impact on students' critical thinking skills. Various studies report that students become more capable of identifying problems, evaluating information, comparing various alternative solutions, and presenting arguments based on scientific evidence. These abilities develop because students are faced with real problems that

require processes of analysis, reasoning, and systematic decision-making. In addition to improving critical thinking, phenomenon-based learning is also able to develop scientific communication skills through discussion activities, presentations, and preparing investigation reports. Beyond cognitive aspects, the study results show that environmental phenomenon-based learning contributes to the formation of scientific attitudes and environmental awareness. Students show an increased sense of responsibility for environmental preservation, awareness in managing waste, concern for the wise use of natural resources, and a willingness to participate in various environmental conservation activities. These attitudes develop because students not only study science concepts but also directly observe the impact of environmental damage occurring around them, thereby establishing a connection between scientific knowledge and concrete actions.

The study results also identified several factors that support the successful implementation of environmental phenomenon-based science learning. These factors include teacher competence in designing contextual learning, the availability of the environment as a learning resource, the use of student-centered learning models, the support of learning facilities, and the active involvement of students during the learning process. Teachers who are able to select phenomena relevant to the subject matter and student characteristics tend to be more successful in creating engaging and meaningful learning. Conversely, limited teacher ability in developing contextual learning is one of the constraints often found in various studies. In addition to these advantages, the literature review also found several challenges in applying environmental phenomenon-based learning. These challenges include limited learning time, teacher readiness in designing investigation activities, lack of laboratory facilities in some schools, and different environmental characteristics in each region. Furthermore, not all teachers are accustomed to developing learning that integrates environmental phenomena into science materials, resulting in learning that is still dominated by theoretical concept delivery. This condition indicates that the implementation of phenomenon-based learning requires professional development support for teachers and school policies that encourage contextual learning.

Overall, the synthesis results indicate that environmental phenomenon-based science learning is an effective approach to strengthening students' scientific literacy. This learning not only improves conceptual understanding but also develops scientific thinking, critical thinking, problem-solving, scientific communication, collaboration skills, and environmental concern. These findings indicate that integrating environmental phenomena into science learning can be a relevant strategy to support the achievement of 21st-century competencies while strengthening the implementation of sustainable education in schools.

Discussion

Environmental Phenomenon-Based Science Learning as a Strategy to Strengthen Scientific Literacy

The results of the literature review show that environmental phenomenon-based science learning is an effective approach to strengthening students' scientific literacy. This approach places real phenomena occurring in the environment as a starting point for learning so that students not only receive concepts theoretically but are also involved in the process of understanding, analyzing, and providing solutions to various problems based on scientific principles. In the context of modern science education, phenomenon-oriented learning has strong relevance because the nature of science is not just a collection of concepts and facts but also a process of investigation to understand nature and various

life problems. Scientific literacy requires students to have the ability to use scientific knowledge in explaining phenomena, evaluating evidence-based information, and making decisions regarding life problems (M. Fajri et al. 2026). Therefore, science learning that only emphasizes memorization of concepts has not been able to optimally develop scientific literacy. Environmental phenomena such as water pollution, climate change, ecosystem destruction, waste management, and energy use become learning contexts that allow students to connect science concepts with real experiences. Through this approach, students are trained to think critically, conduct investigations, interpret data, and develop scientific arguments.

The findings of this study indicate that environmental phenomenon-based learning provides a more meaningful learning experience compared to conventional learning. When students are faced with environmental problems close to their lives, curiosity and motivation arise to seek scientific explanations for these phenomena. The learning process becomes more active because students not only receive information from the teacher but are involved in observation, information gathering, discussion, experimentation, and solution formulation activities. These activities directly support the development of scientific literacy dimensions, which include scientific knowledge, scientific competencies, and attitudes toward science.

The results of this study are in line with research in the Jurnal Pendidikan IPA Indonesia which shows that problem-based learning combined with a local wisdom context is able to improve students' scientific literacy because it provides an opportunity for students to understand real problems and connect them with scientific concepts. This research asserts that the context of everyday life is an important factor in building students' ability to explain scientific phenomena and make evidence-based decisions (Wijayanto et al. 2026).

The Role of Environmental Phenomena in Developing Scientific Thinking Skills

Environmental phenomenon-based science learning has the main characteristic of involving students in the scientific investigation process. Phenomena found in the environment are not only used as concept illustrations but become objects of study that encourage students to carry out scientific processes. For example, the phenomenon of water pollution can be used to study ecosystem concepts, properties of substances, environmental changes, and the impact of human activities on the balance of nature. Students can observe water quality, analyze causes of pollution, interpret data, and design environmental management solutions. This process contributes to the development of higher-order thinking skills. Students are trained to identify problems, make tentative hypotheses, test information, evaluate evidence, and draw conclusions based on investigation results. This ability is an important part of scientific literacy because a scientifically literate person not only knows concepts but is able to use those concepts to solve real problems.

These findings are reinforced by research that developed a three-dimensional scientific literacy instrument, namely scientific reasoning, scientific inquiry, and the nature of science. The study shows that scientific literacy is a multidimensional capability requiring learning that provides direct experience in understanding the scientific process, not just material mastery.

Thus, environmental phenomenon-based science learning has advantages because it is able to integrate knowledge, skills, and attitudes simultaneously. Students not only understand science concepts but also learn how science is used to understand and solve environmental problems occurring in society (Darman et al. 2026).

The Contribution of Environmental Phenomenon-Based Learning to Students' Environmental Awareness

In addition to improving cognitive abilities, environmental phenomenon-based science learning also plays a role in building environmental care attitudes. Environmental problems raised in learning provide an opportunity for students to understand the relationship between human activities and changing environmental conditions. This awareness becomes important because science education has a responsibility not only to produce students who understand science but also individuals who are able to apply scientific knowledge responsibly (Ningsih et al. 2026). Study results show that environment-based learning is able to increase student concern for environmental sustainability. When students understand the scientific impact of an environmental problem, they are more encouraged to take positive actions such as reducing plastic use, maintaining environmental cleanliness, conserving energy, and participating in conservation activities. Thus, science learning becomes a strategic tool in supporting the achievement of Education for Sustainable Development. Systematic literature review research shows that integrating local and environmental contexts in science learning is able to improve scientific literacy, environmental literacy, student engagement, and critical thinking skills. This research explains that science learning linked to real contexts is more effective in building connections between scientific knowledge and students' social and cultural lives.

Challenges in Implementing Environmental Phenomenon-Based Science Learning

Despite having various advantages, the implementation of environmental phenomenon-based science learning still faces several challenges. One major obstacle is teacher readiness in designing learning based on investigations and real contexts. Some teachers are still accustomed to using learning approaches centered on delivering material, so the use of the environment as a learning resource has not been done optimally. Additionally, limited learning time, laboratory facilities, learning resources, and diverse student abilities are factors that need attention. Phenomenon-based learning requires more complex planning because teachers must determine appropriate phenomena, structure investigation activities, provide information resources, and design evaluations capable of measuring scientific literacy. However, various studies show that these obstacles can be overcome through professional development for teachers, inter-educator collaboration, utilizing the surrounding environment as a learning resource, and implementing appropriate learning models such as Problem Based Learning, Project Based Learning, and inquiry. Research on phenomenon-based learning shows that a phenomenon-based approach can increase student engagement and independent learning when designed with appropriate media support and investigation activities.

Based on the results of reviewing previous research, most research on scientific literacy still focuses heavily on the effect of certain learning models such as Problem Based Learning, Project Based Learning, STEM, or the use of digital media on improving scientific literacy skills. Although this research makes an important contribution, studies specifically discussing environmental phenomena as the main foundation for building scientific literacy remain relatively limited. Furthermore, some studies place more emphasis on measuring increases in scientific literacy scores, while the aspect of how environmental phenomena function as a learning context integrating knowledge, scientific skills, and environmental concern has not been widely studied in depth. In fact, environmental phenomena have great potential to become a bridge between science concepts and real-life problems. The novelty of this research lies in the development of the perspective that strengthening scientific literacy is not only achieved through the application of specific learning models but through the strategy of integrating environmental phenomena as the main context of science learning. This approach views the environment not merely as an object of learning but as a source of scientific experience capable of building critical thinking skills, investigative skills, environmental awareness, and the ability to make

evidence-based decisions. Thus, environmental phenomenon-based science learning can be positioned as a comprehensive learning strategy in facing the demands of 21st-century competencies. This approach not only improves students' academic abilities but also shapes individuals who care about the environment and are able to use scientific knowledge to solve various life problems.

CONCLUSION

Based on the results of the literature review conducted, it can be concluded that environmental phenomenon-based science learning is one of the effective learning strategies in strengthening students' scientific literacy. This approach is able to transform science learning from merely a process of delivering concepts into a more contextual, meaningful, and problem-solving-oriented learning experience. Through student involvement in observing, analyzing, investigating, and providing solutions to various environmental phenomena, scientific literacy skills can develop more optimally, both in aspects of scientific knowledge, science process skills, and attitudes towards environmental problems. The integration of environmental phenomena in science learning provides an opportunity for students to connect scientific concepts with the reality of daily life. Phenomena such as environmental pollution, climate change, waste management, ecosystem destruction, and natural resource utilization serve as learning contexts capable of increasing curiosity, learning motivation, critical thinking skills, problem-solving skills, and the ability to make decisions based on scientific evidence. Thus, science learning is not only oriented toward achieving cognitive learning outcomes but also contributes to the formation of scientific character and student concern for environmental sustainability. The synthesis of various studies shows that the successful implementation of environmental phenomenon-based science learning is influenced by several factors, including teacher competence in designing contextual learning, the selection of phenomena relevant to students' lives, the use of inquiry-based learning strategies, and the support of the school environment as a learning resource. Although there are still various challenges such as limited time, facilities, and teacher readiness, this approach retains great potential to be developed as a science learning alternative corresponding to the demands of 21st-century competencies. The main contribution of this study lies in asserting that strengthening scientific literacy is not sufficiently carried out solely through applying certain learning models, but must be supported by utilizing environmental phenomena as the main context in building scientific learning experiences. This novel perspective indicates that the environment can function as a learning space that allows students to develop scientific thinking skills while building awareness and responsibility towards environmental problems. Thus, environmental phenomenon-based science learning can be a relevant pedagogical strategy in improving the quality of science education. The implementation of this approach is expected to produce students who not only understand science concepts but also possess scientific literacy skills, critical thinking skills, environmental concern, and the ability to apply scientific knowledge to face various life challenges in the future.

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