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Integrating the STEAM Approach into School Ecology Projects: An Effort to Foster Students' Creativity and Scientific Literacy

Ahmad syafak khoirut tobib*[1], Shella octaviana n*[2],

[12]*UIN Raden Intan Lampung*
e-mail: achsyafak18@gmail.com shellaoctaviana2510@gmail.com

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ABSTRACT. Rapid changes in the digital era and the escalating global environmental crisis require education systems to transform from merely transferring knowledge to developing critical thinking skills, creativity, and scientific literacy. One relevant approach to addressing this challenge is STEAM (Science, Technology, Engineering, Art, and Mathematics), which integrates multiple disciplines within a project-based learning context. Integrating the STEAM approach into school ecology projects allows students to engage directly with environmental phenomena around them through observation, experimentation, simple technological innovations, and meaningful artistic expression. This model not only fosters scientific understanding and ecological awareness but also strengthens higher-order thinking skills such as analysis, synthesis, and evaluation. In its implementation, the success of STEAM integration depends heavily on teacher preparedness, the availability of simple learning resources, and collaborative support between schools, communities, and higher education institutions. Assessment in this model also focuses on the learning process and product, not solely on test results. The research on "Integrating the STEAM Approach into School Ecology Projects" is significant because it offers contextual solutions to the low scientific literacy and creativity of students in Indonesia. The results are expected to provide an empirical contribution to the development of an adaptive, creative, and sustainable ecological learning model, as well as being a practical reference for schools in building a culture of scientific literacy and environmental awareness from an early age.

Keywords: *STEAM, Scientific Literacy, Student Creativity*

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INTRODUCTION

Rapid changes in the digital era and the global environmental crisis require education systems to not only transfer factual knowledge but also develop critical thinking skills, creativity, and scientific literacy in students. Numerous studies have shown that students' scientific literacy their ability to connect scientific concepts with everyday phenomena and make evidence-based decisions remains inadequate at various school levels. Therefore, a contextual and meaningful learning approach is needed to bridge this gap.(Alfiah et al., 2025)

The STEAM (Science, Technology, Engineering, Art, and Mathematics) approach offers a cross-disciplinary framework relevant to real-world problems, including ecological issues. The integration of arts elements in STEAM serves as a bridge, making scientific concepts more accessible and stimulating students' creative processes, enabling them not only to understan but also to create simple solutions to environmental problems around the school.(Rantanen et al., 2025)

Schools, as learning environments, have great potential to become living ecological laboratories. From school gardens and composting systems to waste management and water quality

observations around the school, all can be used as practical learning platforms. School ecology projects designed with STEAM principles allow students to conduct scientific observations, design simple devices or models, utilize technology for measurement and documentation, and express their understanding through art, such as posters, installations, or short documentaries. This approach not only enhances understanding of scientific concepts but also fosters ecological awareness and environmental stewardship from an early age.(Abidin et al., 2024)

The project-based learning (PjBL) model is a natural methodology for implementing STEAM in the context of school ecology. PjBL facilitates authentic tasks where students are confronted with real-world problems, design experiments or solutions, collaborate, and reflect on their work. This process has been shown to enhance higher-order thinking skills and scientific literacy. Furthermore, local research shows that integrating PjBL with STEAM elements can foster the development of student creativity, particularly when projects provide space for aesthetic exploration, simple engineering innovation, and the use of technology in prototyping or documentation of work.(Gowinda et al., 2024)

The link between STEAM-based ecology projects and scientific literacy and creativity can be explained through several mechanisms. First, the direct link between environmental phenomena and scientific concepts makes knowledge more contextual and easier to internalize. Second, the use of simple technology and engineering devices such as water quality sensors, pH meters, and documentation applications provides practical experiences that strengthen students' scientific method skills. Third, the artistic aspect allows for the representation of alternative ideas through data visualization and aesthetic prototype designs that stimulate divergent thinking. All of these contribute to improving students' analytical, synthesizing, and critical judgment skills.(Choirunnisa et al., 2023)

Implementation of STEAM in school ecology projects requires several key components, such as professional development support for teachers to design integrative rubrics and facilitate project-based learning processes; the availability of simple materials and tools such as inexpensive sensors and documentation media; and collaboration with various stakeholders, such as communities, environmental agencies, and universities, to provide adequate context and resources. Assessment also needs to focus on the learning process and product for example, critical thinking skills, collaboration, creativity, prototypes, simple scientific reports, and scientific artwork rather than solely on test results. The ultimate goal of this approach is to develop scientific literacy that is both applicable and creative.(Sigit, 2022)

Practically, the expected outcomes of integrating STEAM into school ecology projects include improving students' ability to read and explain scientific phenomena (scientific literacy), strengthening creative thinking and problem-solving skills, fostering a stronger environmental awareness, and developing simple, innovative products that benefit both the school and the surrounding community, such as a custom-designed composting system, a campaign poster, or a simple sensor for environmental monitoring. Empirical studies show that when project design combines local context with the freedom of artistic exploration, the positive impact on scientific literacy and creativity is even more significant.(Djaman, 2025)

Thus, research on integrating the STEAM approach into school ecology projects is highly relevant and strategic. This research not only addresses the pedagogical need to enhance literacy, but also addresses the need to improve scientific literacy.

METHOD

This research employed a library research method, a research approach focused on collecting and analyzing data from various sources relevant to the research topic. The primary data sources included national and international scientific journal articles, conference proceedings, educational

textbooks, and research reports discussing the integration of the STEAM approach, school ecology projects, creativity, and scientific literacy. This method was chosen based on the research's conceptual and descriptive objectives: to identify patterns, concepts, and findings that could provide a theoretical foundation for developing a STEAM-based learning model in the context of school ecology.(Snyder, 2019)

The data collection process was conducted through a systematic search of various academic databases such as Google Scholar, ScienceDirect, SpringerLink, and DOAJ using keywords such as STEAM education, project-based learning, environmental education, creativity, and scientific literacy. Each article found was selected based on inclusion criteria, such as relevance to the topic, recency (in the last five years), and publication credibility. The data obtained were then categorized into several main themes, such as the implementation of STEAM in elementary and secondary schools, the development of active learning-based ecology projects, and the relationship between creativity and scientific literacy. This step was taken to ensure the analysis results had conceptual depth and reflected current research trends in contextual science education.(Xiao & Watson, 2017)

Data analysis was conducted using a content analysis approach, which involved reading, grouping, and synthesizing ideas from various sources to identify similarities, differences, and thematic trends. The synthesized results were then structured narratively to explain the relationship between the STEAM concept, the school ecology project, and their implications for enhancing students' creativity and scientific literacy. This approach enabled researchers to gain a comprehensive understanding without direct observation, but rather through a review of existing research findings as a basis for developing conceptual ideas and recommendations relevant to the Indonesian educational context.

RESULT AND DISCUSSION

Result

The implementation of a project-based learning model combined with the STEAM (Science, Technology, Engineering, Art, and Mathematics) approach has proven effective in improving students' scientific literacy. When students not only learn scientific concepts theoretically but also connect them to real-life projects and express them through artistic elements, their understanding and application of scientific knowledge become more meaningful and profound. This approach helps students develop critical, analytical, and reflective thinking skills because they play a direct role in the design, testing, and creative presentation of their learning outcomes.(Suryanti et al., 2023)

Furthermore, the integration of STEAM with the Project-Based Learning (PjBL) model in the context of a school ecology project strengthens critical thinking skills and evidence-based decision-making two essential aspects of developing comprehensive scientific literacy. Through activities such as environmental observation, measurement, simple experiments, and the representation of results through artwork or other creative media, students gain a holistic and contextual learning experience. Thus, the learning process is no longer limited to memorizing concepts but develops into a process of applied scientific exploration.(Nur hudha et al., 2023)

In addition to impacting scientific literacy, the application of STEAM in school ecology projects has also been shown to enhance student creativity and innovation. Learning activities that combine aspects of science and art enable students to produce various forms of work, such as prototypes, simple application models, and even scientific artwork that reflects their understanding of natural concepts. The "Art" element in STEAM plays a crucial role as a creative catalyst, enabling students to express their scientific ideas in aesthetic and meaningful forms. This not only enriches the learning experience but also increases student motivation and engagement with the material being studied.(Irdalisa & Paidi, 2024)

In terms of implementation, the success of the STEAM-PjBL learning model in school ecology projects is strongly influenced by several important factors. First, the relevance of the project theme to real-world phenomena in the students' environment fosters a sense of ownership and concern for environmental issues. Second, simple technological support, such as sensors or documentation applications, enables students to collect and analyze data independently. Third, the use of assessment rubrics that assess the creative and collaborative process, not just the final cognitive outcome, makes learning more humanistic and authentic. However, the effectiveness of this model depends heavily on the teacher's role as both designer and facilitator of integrative learning, capable of integrating various disciplines within a project framework that is meaningful to students.(Anggraini & Herwin, 2025)

Discussion

Research findings indicate that the integration of the STEAM approach into school ecology projects contributes significantly to improving students' scientific literacy and creativity.(Irdalisa & Paidi, 2024) This aligns with the constructivist learning theory proposed by Piaget and Vygotsky, which emphasizes that knowledge is actively constructed through interaction between individuals and their environment.(Hehakaya et al., 2022) In this context, ecological projects provide authentic experiences that allow students to engage in real scientific exploration, rather than merely listening to theoretical explanations. Studies have shown that STEAM-based learning enhances scientific thinking skills because it encourages students to observe, question, and create contextual solutions.(Muhammadiyah & Hamka, 2024)

Furthermore, the improvement in students' scientific literacy can be explained through contextual learning theory, which suggests that scientific understanding becomes stronger when linked to real-life environmental phenomena relevant to students' experiences.(Pertiwi et al., 2024) Projects such as waste management, water pH measurement, or compost production serve as bridges between scientific concepts and practical applications. Other studies have found that students better understand concepts such as ecosystems, food chains, and material cycles when they engage in direct observation activities within the school environment, integrated with artistic and simple technological elements.

The integration of the Art component in STEAM also plays a crucial role in fostering students' creativity. Theoretically, art provides space for divergent thinking a cognitive process that enables the generation of multiple alternative solutions to a single problem. This aligns with Guilford's Divergent Thinking theory, which emphasizes the importance of flexibility and originality in creative thought. The STEAM approach enhances elaboration and flexibility by incorporating art as a visual and expressive medium for scientific reflection.

In addition, the success of implementing STEAM-PjBL in ecological projects is also influenced by factors such as teacher readiness and assessment design. Teachers act as facilitators who must be capable of connecting interdisciplinary domains (science, technology, art, and mathematics) while designing assessment rubrics that evaluate thinking processes, collaboration, and creative products simultaneously. Recent findings suggest that the effectiveness of STEAM-PjBL is maximized when teachers combine formative assessment with student self-reflection, making the learning process cyclical and continuous.

However, these positive outcomes do not come without challenges that deserve critical discussion. First, many schools in Indonesia still face limited resources such as teaching aids, experimental materials, and technological support. This results in less optimal integration across STEAM domains. Research highlights that the main obstacles to STEAM implementation in secondary schools are the lack of supporting tools, teacher training, and sufficient instructional time.

Second, teachers' pedagogical readiness to design collaborative, interdisciplinary learning remains a major issue. Many teachers still focus on outcome-based cognitive testing rather than creative and investigative processes. In reality, scientific literacy and creativity grow through exploration and reflection, not rote memorization. Therefore, a paradigm shift from teacher-centered to student-centered learning is a prerequisite for successful STEAM-based education.

Culturally, integrating STEAM in ecological projects also fosters ecological awareness aligned with local values and environmental spirituality. This approach bridges science and moral ecology by instilling a sense of responsibility to protect nature as a divine trust. In the context of Islamic education in Indonesia, this resonates with the principle of *khalifah fil-ardh* (humans as guardians of the earth). Environmental-based learning integrated with Islamic values can thus shape students' spiritual-ecological character.

In conclusion, this discussion demonstrates that integrating the STEAM approach into school ecology projects impacts not only cognitive aspects (scientific knowledge) but also affective (ecological attitudes) and psychomotor (creative and collaborative skills) dimensions. This approach represents a relevant 21st-century learning model that connects scientific literacy, technology, art, and human values. With stronger educational policies, teacher training, and school collaboration, STEAM-PjBL has the potential to become an outstanding approach for contextual science education in Indonesia.

CONCLUSION

The conclusion of this discussion shows that the implementation of the STEAM approach in school ecology projects can significantly improve students' scientific literacy, creativity, and ecological awareness. Through observation, simple experiments, and artistic expression, students not only understand scientific concepts but are also able to apply them contextually in daily life. The integration of science, technology, art, and mathematics makes the learning process more meaningful, active, and oriented toward solving real-world environmental problems.

The success of implementing the STEAM-PjBL learning model greatly depends on teacher readiness, resource support, and assessment design that emphasizes thinking processes and creativity. Teachers play an important role as facilitators who can integrate interdisciplinary knowledge and guide students to think critically and reflectively. In addition, collaboration between schools, communities, and higher education institutions is essential to create sustainable ecological learning that adapts to contemporary developments.

Culturally and spiritually, this approach aligns with Islamic educational values that view humans as *khalifah fil-ardh* or guardians of the earth. Through STEAM-based learning in ecological projects, students not only develop scientific and creative skills but also a sense of responsibility toward the environment. With continuous policy support and teacher training, STEAM-PjBL has the potential to become an exemplary model for contextual science education in Indonesia.

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