

The Effect of STEAM-Based Environmental Learning on Students' Ecoliteracy Level at SDI Hartaco Indah Makassar

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ABSTRACT

This study aims to examine the effectiveness of the STEAM learning model in improving the ecoliteracy skills of elementary school students, with the hypothesis that this interdisciplinary approach can have a significant effect on students' knowledge, attitudes, cognitive skills, and pro-environmental behavior. The study used a quantitative approach with a one group pretest-posttest type pre-experiment design. The research location was at SDI Hartaco Indah Makassar, with a sample size of 25 students selected purposively. Data collection instruments include pretest and posttest tests, observation sheets, and student questionnaires, which have been validated through expert judgment and tested for reliability with Cronbach's Alpha. Data analysis was done descriptively and inferentially, including normality test and paired sample t-test. The results showed a significant increase in all indicators of student ecoliteracy with a significance value of 0.000 ($p < 0.05$), as well as an average N-Gain value of 0.627 which is classified as a moderate category. This finding indicates that STEAM-based learning is able to integrate elements of science, technology, engineering, art, and mathematics in a contextual manner to shape students' ecological awareness and behavior. The implications of this study support the importance of developing interdisciplinary learning models in elementary schools as a strategy to strengthen applicable and sustainable environmental education.

Keywords: STEAM, Ecoliteracy, Environmental Education

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INTRODUCTION

Environmental issues have become increasingly complex global challenges that require serious attention from multiple stakeholders (Ali & Arfandi, 2024). Reports from the Intergovernmental Panel on Climate Change (IPCC) indicate that global warming, environmental pollution, and the overexploitation of natural resources have led to severe ecosystem degradation, posing threats to both human life and biodiversity (Azhar et al., 2024; Forster et al., 2024). Addressing these challenges cannot rely solely on regulatory policies or climate change mitigation strategies; rather, it demands active participation from individuals in daily environmental stewardship (Ali, 2019; Law et al., 2024; Mina et al., 2024). Environmental education is one of the key strategies for fostering a generation that is environmentally aware and equipped with the necessary skills to contribute to sustainable conservation efforts (Aisyah et al., 2024; Ali et al., 2023; Nugroho, 2022).

Environmental education plays a vital role in cultivating ecological awareness, critical thinking, and eco-friendly behavior in everyday life (Khasanah et al., 2025; MY et al., 2023). The youth hold significant potential as agents of change, especially considering that they will be future leaders and

decision-makers. Thus, instilling strong habits and understanding of environmental responsibility from an early age is crucial (Baliyan, 2014). Effective environmental learning must engage students actively, not only in grasping environmental concepts but also in taking concrete actions to protect nature (Khofi, 2024). However, in practice, environmental education in schools still faces numerous obstacles. According to UNESCO (2021), only 53% of national curricula globally reference sustainable environmental education. In Indonesia, studies conducted in Makassar reveal that many students possess limited understanding of environmental issues, even at the most basic level, such as waste management and environmental care routines. This gap is particularly alarming considering the growing urgency of addressing environmental crises globally, where youth are expected to be leading agents of change with strong ecoliteracy skills. Yet data show that student participation in pro-environmental actions remains low, both individually and at the school community level.

A key contributor to the low level of ecoliteracy among students is the continued reliance on didactic and minimally exploratory teaching methods, which fail to foster deep conceptual understanding or active engagement in real-world environmental actions. Environmental learning in schools often remains normative and theoretical, lacking experiential components that could help students develop problem-solving abilities, critical thinking, and innovative responses to ecological challenges they face daily. This contradicts the principles of critical pedagogy and constructivism, which emphasize the importance of real-life, experience-based learning to more effectively internalize environmental values (Ignacio & Paras, 2024; Perkowska-Klejman & GÅ³rka-StrzaÅ,kowska, 2023).

The limited integration of project-based and hands-on learning approaches in environmental education has slowed the development of students' ecoliteracy. Most current educational models remain confined to monodisciplinary approaches, where environmental topics are taught in isolation and not connected to other relevant disciplines. In reality, today's environmental challenges are complex and multidimensional, requiring an interdisciplinary and applied learning approach. This educational gap calls for instructional models that link ecological concepts with critical thinking and contextual problem-solving skills. The STEAM model (Science, Technology, Engineering, Arts, and Mathematics) has emerged as an innovative pedagogical approach capable of bridging this gap by promoting exploration, experimentation, and real-world problem solving. However, there is still a lack of research regarding teachers' readiness to implement STEAM and the extent to which students need this model within environmental education in the Indonesian context. This study, therefore, aims to explore how teacher preparedness and student needs regarding STEAM implementation can contribute to improving students' environmental understanding, attitudes, and skills in ecoliteracy.

An innovative solution that can be applied is the STEAM learning model (Science, Technology, Engineering, Arts, and Mathematics). This model has been widely adopted in various countries to enhance students' critical thinking, creativity, and interdisciplinary understanding when addressing real-

world problems, including environmental issues (Baek, 2023; Dineva, 2024; Suryanti et al., 2024). STEAM integrates science, technology, engineering, arts, and mathematics into a unified, exploration-driven, and experimental learning approach (Kizhukarakkatu, 2025; Safi'i, 2024). Compared to traditional teaching methods, this model proves more effective in enhancing students' ecological understanding by encouraging independent research, environmentally focused projects, and innovative solutions to local ecosystem problems. (Ramadhana et al., 2022). Implementing STEAM in environmental education not only delivers theoretical knowledge but also provides direct experience in analyzing real-world ecological challenges. Through research-based projects and experimentation, students can better grasp the connection between science and environmental impact while developing skills to create innovative and practical solutions to ecological problems. (Huang, 2024; Suryanti et al., 2024) Therefore, integrating the STEAM model into environmental education represents a strategic step in fostering eco-literacy, encouraging active student participation in environmental conservation, and cultivating a generation that is more responsible for ecosystem sustainability.

MATERIALS AND METHODS

This study uses a quantitative approach with a pre-experiment design of one group pre-test and post-test type to measure the effectiveness of the STEAM learning model in improving ecoliteracy of elementary school students. In addition, a descriptive survey approach was also used to describe the implementation of the STEAM learning model through observation and measure students' responses to the learning through questionnaires. The research was conducted at SDI Hartaco Indah Makassar, a National Adiwiyata school selected purposively because it was considered to have commitment and readiness in the implementation of STEAM-based environmental education. Data collection techniques included pre-test and post-test based on aspects of ecoliteracy knowledge, attitudes, and skills; observation of the learning process; and questionnaires to determine students' understanding, interest, and involvement in environmental issues. The research instruments were validated through expert judgment and a Pearson correlation test, and tested for reliability using the Cronbach's Alpha technique. Data were analyzed descriptively through frequency, percentage, and average calculations, as well as a normality test and a Paired Sample t-Test to identify significant differences between pre-test and post-test results.

RESULTS

Normality Test

The normality test was conducted to ensure that the pretest and posttest data were normally distributed, which is a prerequisite for performing parametric statistical tests. The analysis utilized both the Kolmogorov-Smirnov and Shapiro-Wilk tests.

Table 1. Normality Test Results of Ecoliteracy Data

Data Type	Kolmogorov-Smirnov (Sig.)	Shapiro-Wilk (Sig.)
Pretest Ecoliteracy	0.200*	0.417
Posttest Ecoliteracy	0.200*	0.308

Source: Research Data Analysis (2025)

Based on the results in Table 1, all significance values are greater than 0.05, indicating that both pretest and posttest ecoliteracy data are normally distributed. This fulfills the assumption required for conducting parametric statistical analysis, such as the paired sample t-test.

Paired Sample T-Test

A paired sample t-test was employed to examine whether there was a statistically significant difference between students' ecoliteracy scores before and after the implementation of STEAM-based learning. The test results reveal a highly significant difference between the pretest and posttest scores.

Table 2. Paired Sample T-Test Results for Pretest and Posttest Ecoliteracy Scores

Measurement Pair	Mean Difference	t-value	df	Sig. (2-tailed)
Pretest – Posttest Ecoliteracy	-30.480	-33.448	24	0.000

Source: Research Data Analysis (2025)

As shown in Table 2, the paired sample t-test indicates a statistically significant difference in students' ecoliteracy scores before and after the intervention. The mean difference was -30.48, with a t-value of -33.448 and a significance level of 0.000 ($p < 0.05$), confirming that STEAM-based learning had a highly significant positive impact on improving students' ecoliteracy. These results suggest that the instructional model successfully enhanced not only students' cognitive aspects but also their affective and behavioral engagement with environmental issues.

N-Gain Score Calculation

To further evaluate the effectiveness of the STEAM model, normalized gain (N-Gain) was calculated. The results showed a moderate level of improvement among students.

Table 3. Descriptive Statistics of Ecoliteracy N-Gain Scores

N	Minimum	Maximum	Mean	Std. Deviation
25	0.50	0.80	0.627	0.079

Source: Research Data Analysis (2025)

The N-Gain average score was 0.627, which falls into the moderate category based on Hake's classification (1999). This indicates that the STEAM learning model was reasonably effective in enhancing students' ecoliteracy, though individual improvements varied.

Based on the analysis of pretest and posttest data, the implementation of the STEAM learning model has been shown to positively impact the development of elementary students' ecoliteracy. This is evidenced by the overall increase in scores across all ecoliteracy indicators knowledge, affective awareness, skills, and pro-environmental behavior supported by the normal distribution of data and statistically significant t-test results. Furthermore, the moderate level of N-Gain strengthens the conclusion that STEAM-based learning is an effective approach to improving students' environmental understanding and awareness. As such, this model can serve as a contextual and practical alternative for enhancing environmental education within the elementary school curriculum.

DISCUSSION

The research findings indicate a significant improvement in students' ecoliteracy after participating in environmental education based on the STEAM learning model. All ecoliteracy indicators—namely ecological knowledge, environmental affect, cognitive skills, and pro-environmental behavior—showed an increase in average scores from low-to-moderate to high categories. The normality test confirmed that the data were normally distributed, and the paired sample t-test revealed a significance value of 0.000 ($p < 0.05$), indicating a statistically significant difference between pretest and posttest scores. Additionally, the average N-Gain score of 0.627 falls within the moderate category, suggesting that the STEAM-based learning approach was reasonably effective in improving students' ecoliteracy.

This improvement demonstrates that the STEAM model provides a comprehensive and contextual learning experience. Students not only gained knowledge about environmental issues but also showed emotional engagement and positive behavior toward environmental conservation. The project of creating plant pots from plastic waste, as part of the learning process, integrated elements of science, technology, engineering, arts, and mathematics into a unified activity that encouraged students to think critically, creatively, and responsibly. This approach also promoted more active and collaborative learning, allowing students to reflect on their roles in protecting the environment from an early age.

These findings are consistent with the study by Kusnadi (2023), which showed that integrating the STEAM approach with Project-Based Learning (PjBL) effectively enhances students' environmental literacy. In their study, the development of STEAM-PjBL-based online learning materials was proven to be valid, practical, and effective in improving students' understanding of environmental concepts holistically. Similarly, Priantari et al (2023), through the Ecobrick project in

STEAM-based learning, also reported an improvement in students' cognitive learning outcomes, especially in understanding environmental pollution and recycling concepts. Although no significant differences were found between schools, the study affirmed that project-based learning using the STEAM approach contributes positively to students' ecoliteracy. Both studies reinforce that STEAM not only strengthens conceptual understanding but also fosters students' environmental awareness and behavior in more concrete ways.

CONCLUSIONS

This study concludes that the implementation of the STEAM-based learning model in environmental education has had a significant and measurable impact on improving elementary students' ecoliteracy. The findings revealed consistent gains across all dimensions of ecoliteracy—ecological knowledge, environmental affect, cognitive skills, and pro-environmental behavior. These improvements were reflected in the transition of average scores from low-to-moderate categories to high, supported by normal distribution of data and a statistically significant result in the paired sample t-test. Additionally, the average N-Gain score, which fell within the moderate category, reinforces the notion that STEAM learning is not only pedagogically sound but also pragmatically effective in enhancing students' environmental awareness and competencies. While these results are promising, they should be interpreted in the context of the specific conditions and limitations of the study, rather than generalized beyond its defined scope.

From a scientific and practical standpoint, this research contributes valuable insight into how the STEAM approach can serve as a relevant pedagogical strategy for strengthening environmental education at the elementary level. By integrating science, technology, engineering, the arts, and mathematics in a cohesive and contextual learning experience, the STEAM model acts as a bridge between abstract academic content and the complex realities of environmental challenges. Learning, in this framework, does not stop at conceptual understanding—it evolves into awareness, empathy, and tangible actions toward ecological stewardship. For policymakers and educational stakeholders, these findings underscore the importance of embedding interdisciplinary, project-oriented methodologies into the school curriculum, particularly in thematic areas like environmental education which are often treated superficially in traditional instruction. The originality of this study lies in its empirical focus on local Indonesian classrooms, filling a gap in the existing body of literature where STEAM is rarely examined in relation to ecoliteracy development. By highlighting the transformative potential of STEAM in nurturing environmentally literate citizens, this study advocates for its broader and more systemic integration in foundational education.

Despite its significance, the study is not without limitations. First, the use of a pre-experimental design (one group pretest-posttest) without a control group restricts the ability to attribute changes

exclusively to the STEAM intervention, as extraneous variables may have influenced the outcomes. Second, the study was conducted in a single school with a relatively small sample size, which limits the generalizability of the findings to broader student populations. Third, the intervention was implemented over a relatively short period, which may not capture long-term behavioral shifts—an essential aspect of ecoliteracy. These limitations point to several important directions for future research. Subsequent studies should consider adopting quasi-experimental or experimental designs with control groups to isolate the effect of STEAM better. Larger, more diverse samples from various schools would allow for more robust comparisons across contexts. Moreover, extending the duration of intervention and incorporating longitudinal follow-ups would provide deeper insights into how ecoliteracy evolves. Future research might also explore hybrid models that integrate STEAM with other pedagogical approaches such as Project-Based Learning (PjBL) or Problem-Based Learning (PBL), which could further enhance contextualization and learner engagement. Finally, the development of more holistic and qualitative instruments is crucial to accurately assess the affective and behavioral dimensions of ecoliteracy that are often missed by conventional quantitative tools.

This study reinforces the idea that effective learning should not only communicate what students need to know, but also why it matters, and how they can be part of meaningful change. The STEAM model offers space for exploration, creativity, and reflection three core experiences that form the bedrock of cultivating a generation that is not only academically capable but ecologically responsible. Suppose the education system is to succeed in preparing future leaders who will safeguard the planet. In that case, learning must be interdisciplinary, value-driven, and grounded in the real-world problems students are already inheriting. STEAM education, in this regard, is not just a method it is a mission.

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