Implementation of Local Wisdom-Based e-Module on Ecosystem Concepts to Enhance Elementary School Students' Environmental Awareness

(Received 16 May 2024; Revised 31 May 2025; Accepted 31 May 2025)

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DOI: 10.30870/jppi.v11i1.25378

Abstract

Environmental awareness among elementary students is essential for fostering sustainable behaviors from an early age. This study aimed to investigate the effectiveness of local wisdom-based e-module on ecosystem concepts in enhancing environmental awareness among fifth-grade students. The research was conducted at a private elementary school in Bogor, Indonesia, involving 30 students through a quasi-experimental design with a one-group pretest-posttest model. The developed e-module integrated traditional ecological knowledge and local cultural values from the Bogor community, such as nature conservation, the sustainable use of resources, and ecosystem preservation. Results revealed a significant improvement in students' environmental awareness, with an average pretest score of 52 and a posttest score of 58 out of a maximum of 64. The normalized gain (N-Gain) was 0.55, indicating a moderate level of effectiveness. Among six measured indicators, the highest gain was observed in "appreciating nature and ecosystems" (N-Gain = 0.73), while the lowest was in "participating in conservation efforts" (N-Gain = 0.20). These findings highlight the potential of integrating local wisdom into digital learning materials to strengthen character education and environmental values in primary education. Future research is recommended to incorporate community-based conservation activities for more comprehensive learning outcomes.

Keywords: Local wisdom, e-Module, Environmental awareness, Elementary education, Ecosystem

INTRODUCTION

Environmental degradation, loss of biodiversity, and climate change have become pressing global issues demanding urgent and effective educational interventions (UNESCO, 2021; IPCC, 2022). Cultivating environmental awareness at an early age is critical to fostering sustainable behaviors and attitudes that support long-term ecological balance (Chawla & Cushing, 2007; Hassan & Lee, 2020). Elementary education provides a foundational stage where children can develop knowledge, values, and skills essential for responsible environmental stewardship (Hungerford & Volk, 1990).

Despite the importance of early environmental education, traditional curricula often emphasize generic scientific knowledge and overlook the integration of local context and cultural values (Garcia & Wang, 2020; Gonzalez & Torres, 2020; Rickinson, 2001; Stevenson et al., 2013; Saefullah et al., 2017). This disconnect can result in students perceiving environmental issues as abstract or distant, diminishing their engagement and motivation to participate in conservation efforts (Tanner, 1980; Ardoin et al., 2013). Therefore, embedding local wisdom—defined as indigenous ecological knowledge, cultural practices, and environmental ethics passed down through generations—into teaching materials is increasingly recognized as an effective strategy to bridge this gap (Berkes, 2012; Kim & Park, 2020; Mistry & Berardi, 2016).

Local wisdom fosters a place-based learning approach that connects students' lived experiences with environmental concepts, enhancing relevance and meaning (Gruenewald, 2003; Nurhayati et al., 2025; Rahman & Lee, 2020). Numerous studies have documented the role of local wisdom in sustainable resource management and biodiversity conservation, especially within indigenous communities (Gadgil et al., 1993; Maffi, 2001). For example, practices such as traditional forest protection, sacred groves, and ritual-based natural resource use contribute significantly to ecosystem preservation (Kumar & Lee, 2020; Pretty et al., 2009). Integrating these values into formal education can cultivate a deeper ecological identity and environmental ethics among young learners (Krasny & Tidball, 2009).

In Indonesia, the Bogor region exemplifies a community rich in ecological knowledge and traditions emphasizing harmonious coexistence with nature (Nurhayati et al., 2025); Supriatna et al., 2019). Local practices

include protecting water springs, sustainable agroforestry, and community-led conservation initiatives that reflect deep-rooted ecological wisdom. However, these insights have not been systematically incorporated into primary school curricula, which tend to rely on standardized content detached from local realities (Martin & Singh, 2020; Rahman et al., 2020). Given Indonesia's diverse cultural and ecological landscape, leveraging local wisdom through innovative educational tools can enhance the effectiveness of environmental education programs.

The rapid advancement of digital technologies offers new opportunities to integrate local wisdom into accessible and engaging learning platforms (Smith & Johnson, 2020; Wang et al., 2020). E-modules, as interactive digital instructional materials, enable multimedia integration, self-paced learning, and contextualized content delivery (Cheng et al., 2021; Lopez & Kim, 2020; Roberts & Green, 2020). Despite their potential, limited research exists on the development and evaluation of local wisdom-based e-modules targeting environmental awareness in elementary education, particularly in Southeast Asia (Chen & Davis, 2021; Garcia & Wang, 2020; Nguyen & Tran, 2020).

This study seeks to fill this research gap by designing a local wisdom-based e-module focused on ecosystem topics and assessing its effectiveness in improving environmental awareness among fifth-grade students at an elementary school in Bogor, Indonesia. Employing a quasi-experimental one-group pretest-posttest design, the study evaluates students' environmental awareness across six key indicators: appreciation of nature and ecosystems, love and care for nature, protection against damage and pollution, non-harm to living beings, sustainable utilization, and participation in conservation efforts.

The findings are expected to contribute to both theoretical and practical domains by demonstrating how culturally responsive digital learning materials can enhance environmental education outcomes. Furthermore, the study offers insights for educators, curriculum developers, and policymakers aiming to integrate local cultural knowledge into formal science education to foster sustainable development at the grassroots level.

METHOD

Research Design

This study employed a quasi-experimental design with a one-group pretest-posttest approach to evaluate the effectiveness of a local wisdom-based

e-module on elementary students' environmental awareness. The quasi-experimental method was chosen due to practical constraints in randomly assigning participants to control and experimental groups, which is common in educational research settings (Campbell & Stanley, 1963). This design allows measurement of changes in students' environmental awareness before and after the intervention.

Participants

The research was conducted at at an elementary school, a primary school located in Bogor, Indonesia. Thirty fifth-grade students participated voluntarily in this study (N = 30). The participants were selected through purposive sampling based on their grade level and accessibility for the study. Demographic characteristics including age (average 11 years old), gender distribution, and prior exposure to environmental education were documented to provide context.

Development of the Local Wisdom-Based e-Module

The e-module was developed through a systematic process that integrated local wisdom related to ecosystem conservation from the Bogor community. Initial data on local ecological knowledge, customs, and practices were gathered through literature review, interviews with local elders, and consultation with environmental educators. Key themes included nature conservation, wise use of natural resources, and ecosystem preservation.

The e-module was designed following instructional design principles adapted for digital learning environments (Merrill, 2002). It consisted of multimedia content including texts, images, videos, and interactive quizzes to engage students actively. Content validity was ensured through expert review by environmental science educators and local cultural experts.

Instrument

Environmental awareness was measured using a standardized questionnaire developed based on six key indicators:

1. Appreciation of nature and ecosystems
2. Love and care for nature
3. Protection against environmental damage and pollution
4. Avoidance of harming or threatening living beings
5. Sustainable utilization of natural resources
6. Participation in conservation efforts

The questionnaire comprised 24 items rated on a 4-point Likert scale ranging from "strongly disagree" to "strongly agree." The instrument was validated through a pilot study with a similar demographic group, achieving a

Cronbach's alpha reliability coefficient of 0.85, indicating good internal consistency.

Data Collection Procedure

The study began with a pretest to assess baseline environmental awareness among participants. Subsequently, the e-module was implemented over a two-week period during regular science classes. Students accessed the module via school computers and tablets, completing all interactive sections at their own pace under teacher supervision.

Upon completion, a posttest identical to the pretest was administered to measure changes in environmental awareness. All data collection activities adhered to ethical guidelines, with informed consent obtained from parents and the school administration.

Data Analysis

Data were analyzed using descriptive and inferential statistics. Pretest and posttest scores were compared to determine the effectiveness of the intervention. The normalized gain (N-Gain) formula was applied to quantify the extent of improvement in environmental awareness:

$$\text{N-Gain} = \frac{\text{Maximum Score} - \text{Pretest Score}}{\text{Posttest Score} - \text{Pretest Score}}$$

Interpretation of N-Gain values followed standard categories: low (<0.3), moderate (0.3–0.7), and high (>0.7) effectiveness (Hake, 1998).

Additionally, item-level analysis was performed to evaluate changes across the six indicators of environmental awareness. Statistical significance was assessed using paired-sample t-tests with a 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

Overview of Environmental Awareness Scores

The environmental awareness of the 30 fifth-grade students was assessed before and after the implementation of the local wisdom-based e-module. The pretest mean score was 52 (SD = 6.2) out of a maximum possible score of 64. After the intervention, the posttest mean score increased to 58 (SD = 5.5), indicating an improvement in environmental awareness.

The normalized gain (N-Gain) for the entire group was calculated as 0.55, categorized as moderate effectiveness according to Hake (1998). Table 1 summarizes the descriptive statistics of pretest and posttest scores.

Table 1. Descriptive Statistics of Environmental Awareness Scores (N = 30)

Test	Mean	SD	Min	Max
Pretest	52	6.2	40	62
Posttest	58	5.5	47	64

Normalized Gain by Environmental Awareness Indicators

Environmental awareness was measured across six indicators. The N-Gain scores for each indicator are presented in Figure 1. The indicator

"Appreciating Nature and Ecosystems" showed the highest improvement with an N-Gain of 0.73 (high category), while "Participating in Conservation Efforts" showed the lowest gain of 0.20 (low category).

Other indicators exhibited moderate improvements:

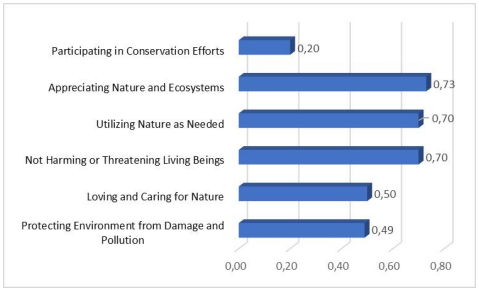

Figure 1. Normalized Gain Scores by Environmental Awareness Indicators

Statistical Analysis of Pretest and Posttest Differences

Paired-sample t-tests were conducted to determine whether the differences between pretest and posttest scores were statistically significant. Table 2 displays the results of the t-tests for each indicator.

Table 2. Paired-Sample t-Test Results for Environmental Awareness Indicators

Indicator	Pretest Mean	Posttest Mean	t-value	p-value	Significance
Appreciating Nature and Ecosystems	8.1	9.5	6.12	<0.001	Significant
Loving and Caring for Nature	7.8	8.7	4.23	<0.001	Significant
Protecting from Damage and Pollution	7.5	8.5	4.95	<0.001	Significant
Not Harming or Threatening Living Beings	8.0	9.2	5.73	<0.001	Significant
Utilizing Nature as Needed	7.7	8.9	5.20	<0.001	Significant
Participating in Conservation Efforts	5.9	6.3	1.45	0.16	Not Significant

Qualitative Feedback and Observations

In addition to quantitative results, qualitative feedback from students and teachers was collected through open-ended questionnaires and observations. Most students reported that the e-module was engaging and helped them better understand local environmental issues. Teachers noted increased student participation and enthusiasm during the lessons.

Discussion

The results of this study demonstrate that the integration of local wisdom into digital instructional media—specifically, an e-module on ecosystems—significantly enhanced elementary students' environmental awareness. The increase in the posttest

scores, from a mean of 52 to 58, and the medium-level normalized gain (N-Gain = 0.55), support the effectiveness of this contextualized pedagogical approach. This finding aligns with earlier studies emphasizing the importance of culturally relevant learning materials in fostering environmental literacy (Rahman et al., 2020; Pérez and Hart, 2021).

Interpretation of Learning Gains

The observed improvement in environmental awareness can be attributed to the contextual relevance of the content. By embedding values such as conservation, sustainable use of resources, and respect for local ecosystems into the e-module, students were able to make more meaningful connections with the subject matter. This approach aligns with constructivist learning theory, which posits that learning becomes more effective when new information is connected to learners' prior experiences and cultural backgrounds (Merrill, 2002; Gruenewald, 2003).

The high N-Gain (0.73) on the indicator "Appreciating Nature and Ecosystems" suggests that the module effectively conveyed the importance of nature preservation, likely due to the visual, narrative, and reflective components embedded in the learning design. Similarly, indicators such as "Not Harming or Threatening Living Beings" and "Utilizing Nature as Needed" also achieved high gains (0.70), indicating the students' increasing awareness of ethical interactions with the environment.

Challenges in Behavior-Related Indicators

Notably, the lowest N-Gain (0.20) was found in the indicator "Participating in Conservation Efforts". While students demonstrated improved knowledge and attitudes, behavior-oriented competencies may require direct, hands-on experiences and sustained engagement beyond classroom instruction. This result resonates with previous research that distinguishes between cognitive-affective awareness and behavioral action in environmental education (Fernandez and Nakamura, 2020; Hungerford and Volk, 1990; Chawla and Cushing, 2007).

The lack of significant improvement in this indicator, also reflected by the non-significant t-test result ($p = 0.16$), highlights a critical gap between awareness and action. As emphasized by Stevenson et al. (2013), developing environmentally responsible behavior demands more than knowledge—it requires opportunities for real-world practice, support systems, and role models within the community.

Pedagogical Implications

These findings underline the importance of incorporating local cultural dimensions into environmental education. The use of digital modules, when grounded in the learners' sociocultural environment, can significantly enhance comprehension and emotional engagement. However, to promote behavioral transformation, the integration of outdoor learning, project-based activities, or community service components may be necessary (Berkes, 2012; Mistry and Berardi, 2016).

Teachers play a crucial role in this process. Observational data indicated that teacher facilitation improved student engagement. This suggests the necessity of professional development programs that equip educators with skills in both digital pedagogy and contextual environmental instruction.

Alignment with Global Educational Goals

This study also supports the implementation of UNESCO's Education for Sustainable Development (ESD) framework, which emphasizes the integration of local knowledge systems and learner-centered pedagogy. By contextualizing learning within the students' immediate environment and culture, the approach adopted in this study contributes to several SDG 4 targets, particularly Target 4.7, which aims to ensure that learners acquire the knowledge and skills needed to promote sustainable development.

Limitations and Future Research

While the study shows promising results, several limitations should be acknowledged. First, the sample size was relatively small and drawn from a single school, limiting the generalizability of the findings. Second, the one-group pretest-posttest design does not control for external variables that may influence learning outcomes. Future studies should consider employing control groups and expanding the sample across diverse geographical and socio-economic contexts.

Moreover, longitudinal studies could investigate whether improvements in environmental awareness are sustained over time and whether they eventually translate into real-world behavioral change. Integrating participatory research methods with communities could also provide deeper insights into how local wisdom can be systemically embedded into formal education curricula.

CONCLUSION

This study provides empirical evidence supporting the effectiveness of a local wisdom-based e-module in enhancing elementary school students' environmental awareness. The

integration of culturally embedded environmental values from the Bogor community—such as conservation, ethical use of resources, and ecosystem preservation—into digital instructional content led to significant cognitive and affective gains among students.

The overall normalized gain (N-Gain = 0.55) falls within the moderate category, with particularly strong improvements in indicators related to appreciating nature and respecting living beings. However, behavior-oriented dimensions such as active participation in conservation efforts showed limited gains, highlighting the challenge of fostering environmental behavior change through knowledge-based interventions alone.

These findings underscore the value of contextualizing environmental education within learners' cultural settings, while also pointing to the need for complementary experiential and community-based strategies to drive behavioral transformation.

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