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Strategies to Enhance Eco-Friendly Culture and Environmental Awareness by Green Curriculum Integration in Indonesian Elementary Science Classroom

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Abstract

This study aimed to develop and assess strategies for integrating a green curriculum into Indonesian elementary science education to improve environmental awareness and eco-friendly culture among students. Utilizing research development design, the research began with a needs analysis from five elementary schools, followed by a quasi-experiment in one selected school. Environmental awareness and eco-friendly culture were measured at the end of the learning period in both control and experimental groups, with a t-test revealing significant differences. The experimental group showed higher environmental awareness and eco-friendly culture scores than the control group than the control group ($p < .05$). These results confirmed that integrating environmental responsibility into student activities in science education, such as caring for plants or animals, significantly enhances their environmental stewardship. This study provides practical and theoretical insights into green curriculum integration, especially in developing countries, and highlights the importance of incorporating ecological responsibility projects in education to promote sustainable behaviors. The findings can inform educational practices, curriculum development, and policymaking in sustainable education.

Keywords:

Eco-Friendly Culture, Environmental Awareness, Green Curriculum, Integration Model, Science Education

Introduction

Environmental awareness and an eco-friendly culture ensure our planet's sustainability and future generations' wellbeing (Bhandari & Abe, 2000; Kudlas, 1984; Parker & Prabawa-Sear, 2019a). In Indonesia, environmental awareness and eco-friendly is still relatively low, as evidenced by various environmental issues such as deforestation, air and water pollution, and plastic waste accumulation (Nurkaidah et al., 2024; Viteri & Pazmiño, 2023). Instilling environmental awareness and an eco-friendly culture early is crucial, especially among elementary school students (Bootrach et al., 2015). Instilling these values helps to shape

a generation that is conscientious and responsible for environmental preservation (Lowan-Trudeau, 2023).

Research on environmental awareness among elementary school students has become a key focus in environmental education studies globally, particularly in (Husamah et al., 2022; Komariah & Sa'ud, 2024). This concern is supported by evidence of the low levels of environmental awareness and eco-friendly practices among elementary school students (Ardoin & Bowers, 2020; Masalimova et al., 2023). A study conducted by Sadikin et al., (2024), which measured environmental awareness among fifth-grade students in an Indonesian elementary school, revealed that only 37.38% of students could distinguish between organic and inorganic waste, and 45.27% were familiar with the 3R concept (Reduce, Reuse, Recycle). Similarly, Rindawati et al., (2020) assessed the environmental knowledge of 10-year-old elementary students in an Indonesian urban area and found that merely 10% of students understood solid, liquid, and industrial waste. These findings highlight the urgent need for curriculum development and more structured environmental education strategies at the elementary school level (Rindawati et al., 2020; Sadikin et al., 2024).

Elementary school is a critical period during which values and habits can be firmly established through systematic learning approaches (Aningsih et al., 2022; Fekih Zguir et al., 2021). This aligns with research by Errica & Mulyadi (2022), which compared environmental education curricula in Indonesia and Japan. Their findings revealed that Japan's practical approach at the elementary school level promoted greater environmental awareness and pro-environmental behavior compared to Indonesia's predominantly theoretical methods. Therefore, research focusing on structured and practical environmental education is urgently needed to bridge the gaps in sustainable practices among elementary school students in Indonesia (Gavilan Tatin et al., 2024; Gunansyah et al., 2021; Parker & Prabawa-Sear, 2019a).

In Indonesia, since 2006, environmental education has been integrated into school environmental management through the Adiwiyata program (The Ministry of Environment and Forestry Republic Indonesian, 2006). This program encourages students to participate in maintaining the school environment beyond regular class hours (Parker, 2018; Parker & Prabawa-Sear, 2019a). However, studies indicate that the implementation of the Adiwiyata program has not fully succeeded in fostering environmentally friendly behavior among students (Tompodung et al., 2018). Despite its significant potential, research findings reveal that a lack of active participation and deep understanding of environmental issues among students often hinders its effectiveness (Desfandi M. et al., 2019), and it is also context-dependent on individual schools (Syahrial et al., 2020). This condition highlights the need for structured and practical development of environmental education within the learning process (Gavilan Tatin et al., 2024; Gunansyah et al., 2021; Parker & Prabawa-Sear, 2019a). A green curriculum serves as a framework for integrated environmental education through various learning practices to foster environmental awareness and promote sustainable practices (Corpuz, 2022; Louw, 2013; Ni et al., 2024).

The green curriculum refers to an educational approach that integrates environmental issues into learning, effectively promoting sustainable actions among students (Louw, 2013; Ni et al., 2024). Its implementation aims to equip students with the skills to analyze and address environmental challenges caused by human activities, reflecting the reciprocal relationship between humans and nature (Ni et al., 2024). However, its implementation often encountered challenges in adapting to local contexts, necessitating strategies that were tailored to the specific educational and cultural needs of each community to ensure effective integration and impact (Fekih Zguir et al., 2021; Olsen et al., 2024; Sterling, 2024; Wals, 2015). Integrating environmental education into elementary science curricula enhances its potential by aligning with science's focus on understanding nature, the environment, and human-ecosystem interactions (Nation & Feldman, 2021). Although the urgency of environmental education has been widely acknowledged, the systematic implementation of a green curriculum within formal education, particularly in science subjects at the elementary level in Indonesia, remains unrealized (Parker et al., 2018; Parker & Prabawa-Sear, 2019b). Presently, environmental education efforts in Indonesia are largely confined to extracurricular activities or project-based initiatives outside the classroom, highlighting a substantial gap in its integration into the core curriculum (Syahrial et al., 2020; Tompodung et al., 2018). This study aimed to address this gap by developing strategies for implementing a green curriculum integrated into science education, with the goal of fostering an environmentally friendly culture and enhancing students' in-depth awareness of environmental issues.

Theoretical Framework

Green Curriculum

The green curriculum refers to an educational framework that incorporates environmental topics into the learning process, fostering sustainable behaviors among students (Louw, 2013; Ni et al., 2024). Its goal is to develop students' abilities to analyze and tackle environmental problems resulting from human activities, highlighting the interdependent relationship between humans and the natural world (Ni et al., 2024). The green curriculum incorporates several key components to foster environmental

awareness and sustainable behaviors among students effectively (Louw, 2013; Ni et al., 2024; Şahin, 2008). First, the green curriculum integrates environmental issues such as pollution and climate change into core subjects like science, fostering awareness and sustainable practices. Second, it emphasizes project-based learning through activities like waste management and energy audits, linking theory with practical applications to enhance critical thinking and eco-friendly habits (Parker et al., 2018; Parker & Prabawa-Sear, 2019b). Finally, it focuses on character development by encouraging responsibility and ethical attitudes through activities such as plant care and community clean-ups, promoting environmental stewardship (Aningsih et al., 2022).

Integrating environmental education into science classes provides students with practical experiences that enhance their understanding of sustainability and environmental issues (Kumar,et al., 2023; Shulla et al., 2020). Cultivating a garden during lessons on plant biology allows students to observe plant growth, understand photosynthesis, and recognize the environmental conditions necessary for sustainable ecosystems (Aningsih et al., 2022; Louw, 2013). The integration of the green curriculum into science education bridges theoretical concepts with practical applications, enhancing students' understanding of ecological systems and fostering sustainable practices (Ni et al., 2024; Tuncer et al., 2007; Viteri & Pazmiño, 2023). Outdoor experiential activities, such as observing local ecosystems or participating in community cleanup initiatives, provide students with a deeper appreciation for biodiversity and the interconnectedness of life, fostering environmental responsibility and eco-friendly behaviors (Aurélio et al., 2022; Dillon & Scott, 2002). By embedding these activities into the science curriculum, students develop skills needed to address real-world environmental challenges effectively (Olsen et al., 2024; Viteri & Pazmiño, 2023).

Student's Environmental Awareness And Eco-Friendly Culture

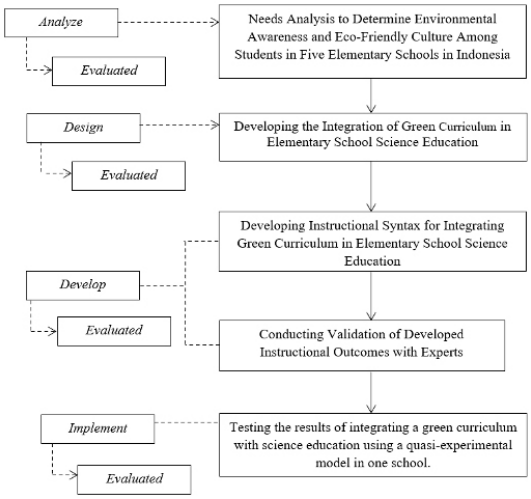
Student environmental awareness refers to the understanding, attitudes, and behaviors that students develop toward environmental issues and the necessity for sustainable practices (Ni et al., 2024; Özden, 2008). Cultivating environmental awareness among students is essential for shaping a generation capable of addressing ecological challenges (Moody-Marshall, 2023). Individuals need to possess environmental care attitudes before recognizing their social and environmental responsibilities, which ultimately enhance their intention to adopt eco-friendly practices (Ha et al., 2023). These attitudes encompass five aspects are receiving, which refers to sensitivity to environmental issues; responding, which involves actions to address environmental problems; valuing, which reflects the belief that actions to protect the environment can minimize damage; organization, which entails encouraging others to take collective action in preserving the environment; and characterization, which represents a consistent disposition to maintain cleanliness and avoid environmentally destructive behaviors (Yu, T.-Y., & Yu, 2017).

Eco-friendly culture refers to a set of integrated practices, behaviors, and values that minimize environmental harm and promote sustainability (Gobena & Kant, 2022; Ullman et al., 2008). Key components include green planning and design, which focuses on creating sustainable infrastructures; green energy, emphasizing renewable energy sources to reduce carbon emissions; and waste management, targeting waste reduction, recycling, and composting to prevent environmental degradation (Bradley, 2009; Wals, 2015). Additionally, water conservation and green transportation are central, ensuring the efficient use of natural resources and reducing pollution through eco-friendly mobility solutions. These interconnected elements aim to foster a society that prioritizes sustainable development and ecological balance (Jorgenson et al., 2019; Parker, 2018; Shulla et al., 2020). By integrating these principles, eco-friendly culture serves as a foundation for addressing global environmental challenges while supporting long-term sustainability (Fekih Zguir et al., 2021; Prabawani & Hanika, 2017).

Method

This study employed a research and development (R&D) model adapted from the ADDIE model, which stands for Analyze, Design, Develop, Implement, and Evaluate (Branch, 2009). The research process conducted using this development model is described in Figure 1 below.

Figure 1.
Research Flowchart of The Development Model.



Problem Analyze Phase

In the first stage, the problems in the environmental education process were identified through observations and questionnaires distributed to five elementary schools in East Java Province. The schools participants in this study were selected from five elementary schools in East Java through purposive sampling based on several criteria, including the availability of environmentally focused programs, diversity in school types encompassing public, private, and faith-based institutions, the presence of supporting infrastructure, and fifth-grade students aged 10–11 years who are at the concrete operational cognitive development stage, making them suitable for project-based learning and understanding environmental issues. This selection ensured a comprehensive understanding of the environmental education challenges across various school settings (see Table 1 for a description of participants).

The problem analysis was conducted through direct field observations and a review of supporting curriculum documents, including semester-long lesson plans, school teaching schedules, and school supervision records. This comprehensive approach aimed to evaluate both the on-ground implementation and the structural alignment of the environmentally-based curriculum for fifth-grade students across five schools. The indicators for assessing the achievement level of the environmentally-based curriculum were adapted from Şahin, (2008), as detailed in Table 2.

The needs analysis data from the identification process were analyzed using descriptive statistics to evaluate the environmental-based curriculum implementation level in the five participating schools. This analysis aimed to measure the extent to which environmental programs have been implemented to support the development of students' environmental care character. The evaluation focused on the frequency and quality of environmental programs, student participation, and the alignment of educational implementation across the five schools involved in this needs analysis.

Design and Develop Phase

The green curriculum integration model for science education was designed and developed in this phase based on the issues identified during the problem analysis phase. The primary objective of this phase was to create a comprehensive model that effectively integrates environmental education into the science curriculum, promoting environmental awareness and eco-friendly culture among students.

Content Validity was assessed using expert reviews. A panel of five environmental education specialists, curriculum developers, and experienced teachers evaluated the curriculum to confirm that it addressed all necessary environmental topics and adhered to best practices in sustainability education. The content validity of the curriculum was determined by calculating the Content Validity Index (CVI) for each item and the overall model. The formula for content validity index (CVI):

$$CVI = \frac{N}{A}$$

Where:
A = the number of experts who rated the item as relevant.
N = the total number of experts.
A CVI score of 0.8 or higher was considered acceptable, indicating strong content validity.

The expert review results are summarized in Table 4, showing the CVI scores for each curriculum component. The experts rated the curriculum's alignment with environmental education standards,

Table 1.
Description of Participants.

No.	Origin School	Total Number of students	Grades	Male	Female	Age (Yo)
1.	Public Elementary School Malang	102	5th	46	56	10-11
2.	Islamic Elementary School Malang	113	5th	48	65	10-11
3.	Islamic Elementary School Pasuruan	98	5th	48	60	10-11
4.	Public Elementary School Pasuruan	80	5th	32	48	10-11
5.	Privat Elementary School Sidoarjo	88	5th	47	41	10-11

Table 2.
Indicators for the Achievement Level of the Environmentally-Based Curriculum

No.	Indicator
1.	The school's vision reflects the development of students' environmental awareness character.
2.	The mission provides direction for the goals of the green school program.
3.	Environmental programs are evident in the school's vision and mission.
4.	There are specific routine activities for environmental management.
5.	Additional learning time is provided to support environmental management activities and the development of students' environmental awareness character.
6.	Promotion criteria include achievements in environmental programs.
7.	Environmental management activities and campaigns involve parents.
8.	Activities are conducted to develop students' environmental awareness character.
9.	There is a dedicated supervision program for environmental initiatives.

Adapted from Şahin, (2008).

content relevance, and comprehensiveness using a Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree). The mean CVI score for each component was calculated to ensure that all critical aspects of the curriculum met the required validity threshold. The result of the expert review for content validity is in Table 3. Below.

Multiple methods were employed to assess the reliability of the green curriculum integration in science learning. First, Cronbach's alpha was calculated for the environmental awareness and eco-friendly culture questionnaires used to measure students' attitudes and behaviors. The internal consistency of the instruments yielded high Cronbach's alpha coefficients of 0.85 for the environmental awareness scale and 0.87 for the eco-friendly culture scale, indicating strong reliability of the instruments. Next, inter-rater reliability was assessed by having six trained teachers independently assess students' environmental projects using a common rubric. Cohen's Kappa coefficient was calculated to measure the level of agreement among the raters, resulting in a coefficient of 0.82, indicating substantial agreement. Finally, test-retest reliability was evaluated by administering the same questionnaires to a subset of 50 students at two different time points, with a 4-week interval. The Pearson correlation coefficient for the test-retest reliability was 0.91, confirming the stability of the instruments over time. The iterative design, development, and validation process ensured that the green curriculum integration model was theoretically sound and practically applicable. Feedback from the pilot phase provided critical insights incorporated into the final version.

Implementation Phase

in the final stage, a quasi-experiment testing process was carried out with two classes (a control class and an experimental class) in an elementary school in BAIPAS Islamic Elementary School Malang, East Java. The selection of students for this stage was different from those who participated in the analysis phase. The selection was based on purposive sampling, where participants were specifically chosen to ensure they met the criteria for the study's objectives. The school was selected based on its willingness to participate in the research and its suitability for implementing both traditional and integrated green curriculum methods within its existing science curriculum. Additionally, the school was located in an area with varied socio-economic backgrounds, providing a more comprehensive context for testing the green curriculum's impact on students' environmental attitudes and behaviors. The participants in this stage consisted of 80 students from five grades, aged 10-11 years (Description of quasi-experiment participants in Table 4).

In this quasi-experimental study, the control group received Problem-Based Learning (PBL) in science instruction. In this approach, students worked collaboratively to address and find solutions to various environmental problems presented by the teacher. The goal was to engage students in active problem-solving related to real-world environmental issues, fostering critical thinking, teamwork, and a deeper understanding of environmental challenges. In contrast, the experimental group received science instruction integrated with a green curriculum, where environmental issues were embedded within the science content. The green curriculum aimed to raise environmental awareness and promote sustainable practices among students, incorporating hands-on activities and projects aligned with sustainability principles and ecological responsibility.

At this stage, environmental awareness and eco-friendly culture values were measured using a paper-

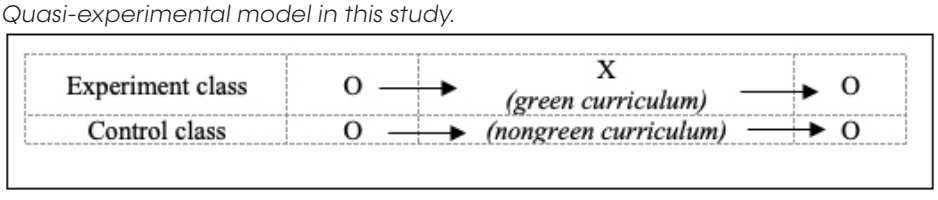
Table 3.
Results of Expert Review for Content Validity

No.	Component	Expert Rating (1-4)	Number of expert ratings (agree/all)	CVI Score	Mean CVI Score
1.	Environmental Topics	3.9	4/5	0.8	0.88
2.	Pedagogical Approach	4.0	5/5	1.0	1.00
3.	Assessment Tools	3.8	4/5	0.8	0.85

Table 4.
Description of Quasi Experiment Participant.

No.	Class	Grades	Male	Female	Age (Yo)
1.	Control	5th	17	23	10-11
2.	Experiment		15	25	

Figure 2.
Quasi-experimental model in this study.



based self-assessment Likert scale questionnaire, distributed in paper form and filled out directly by the students after the science lessons in their classrooms. The questionnaires were designed to align with the study's objectives by measuring specific aspects, ensuring the data collected supported the evaluation of the green curriculum's effectiveness. The environmental awareness indicators were adapted from Yu, T.-Y., & Yu, (2017), as shown in Table 2, and the eco-friendly culture indicators were adapted from Wals, (2015), as presented in Table 3 below.

Cronbach's alpha was calculated to determine the internal consistency of the environmental awareness and eco-friendly culture questionnaires to assess the reliability of the instruments used to measure students' environmental awareness and eco-friendly behavior. The Cronbach's alpha coefficient for the environmental awareness scale was 0.85. For the eco-friendly culture scale, it was 0.87, indicating a high internal consistency and reliability of the instruments for measuring these constructs (self-assessment questionnaire based on indicators Table 5 and 6 in Appendix 1 and 2).

The data were analyzed using independent samples t-tests in SPSS 26. The t-test compared the mean scores of the experimental group (students taught using the green curriculum) and the control group (students taught using the conventional curriculum). This analysis determined whether the green curriculum significantly improved students' environmental attitudes and behaviors. A significance level of ($p \leq 0.05$) was used to interpret the results.

Result

This study aimed to explore and assess strategies integrated into a green curriculum in Indonesian elementary science education to improve students' environmental awareness and eco-friendly culture. A green curriculum integration model for science education was developed, and the results were described through a series of ADDIE phases.

Table 5.

Indicators of Environmental Awareness

No.	Indicators	Description
1.	Receiving	External stimuli include problems and symptoms in the students' environment.
2.	Responding	Actions that students must take to address the problems in their environment.
3.	Valuing	A belief that actions taken to address ecosystem or environmental issues can minimize environmental damage.
4.	Organization	Effort to encourage others to take action to preserve and maintain the surrounding environment for the common good.
5.	Characterization	Having an attitude and traits that are sensitive to environmental maintenance.

Adapted from Yu, T.-Y., & Yu, (2017)

Table 6.

Indicators of Eco-Friendly Culture.

No.	Assessment indicators of an environmentally friendly culture	Description
1	Habituation in Mapping the Potential and Condition of the Environment	Students' habits in mapping local environmental conditions, including identifying natural resources, environmental issues, and conservation efforts.
2	Habituation in Waste Management	Students' habits in managing waste effectively, including reduction, separation, recycling, and environmentally friendly disposal.
3	Habituation in Energy Use	Students' habits in using energy efficiently, including reducing energy consumption, switching to renewable energy, and optimizing electricity use in schools.
4	Habituation in Water Conservation and Management	Students' habits in conserving water include reducing water wastage, utilizing rainwater, and using water-saving technologies.
5	Habituation in Soil Management and Prevention of Chemical Contamination	Students' habits in understanding and applying proper soil management and preventing chemical contamination
6	Habituation in Being Sensitive to School Facilities and Infrastructure	Students' awareness of and care for environmentally friendly school facilities and infrastructure, including cleanliness and long-term sustainability.
7	Habituation in Orderliness and Environmental Sustainability Around the School	Students' habits include maintaining orderliness and cleanliness around the school environment.
8	Habituation in Campaigning for Environmental Sustainability	Students' involvement in supporting and promoting environmental sustainability campaigns.

Adapted from Wals, (2015).

Problem Analysis Phase

In this problem analysis phase, the achievement level of the Environmentally-Based Curriculum was identified for fifth-grade students across five elementary schools. The results of this analysis will serve as the foundation for the subsequent development stages. The findings regarding the curriculum achievements in environmental education across the five schools are presented in Figure 2 below.

The graph in Figure 2. illustrates variations in the achievement levels of the environmentally based curriculum indicators across five elementary schools. Indicators with high achievement percentages, such as students' activities in building environmental awareness and environmental activities, indicated that these schools had integrated environmental values into certain aspects of education. Furthermore, indicators like promotion criteria and environmental programs reflected in the school's vision and mission revealed gaps between school policies and the practical implementation of environmental education. These results highlighted the need for a more structured, environmentally based curriculum directly connected to classroom learning to foster students' environmental awareness and eco-friendly behavior more effectively.

Design and Developing Phase

The design and developing phase focused on creating a green curriculum integration model that embedded environmental issues and responsibilities into science learning to enhance students' environmental awareness and foster eco-friendly behaviors. The core structure of this model is visually represented in Figure 3, illustrating how the curriculum components and learning activities align to achieve the intended educational goals.

Figure 2.
Graph of the Achievement Levels of the Environmentally-Based Curriculum

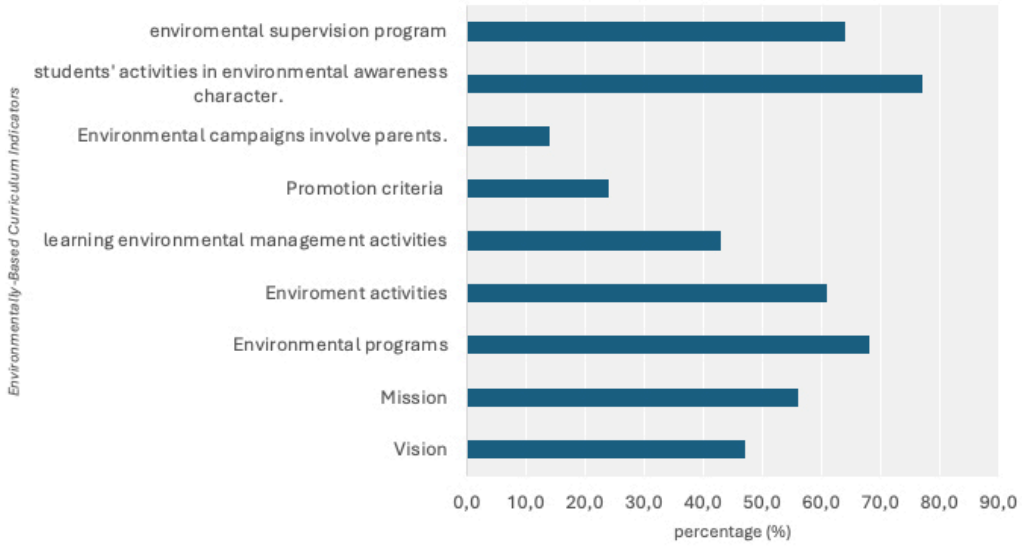
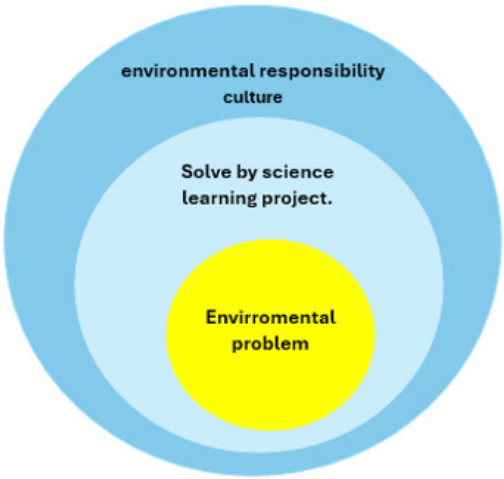


Figure 3.
Illustration of The Integration Green Curriculum in Science Learning.



The most appropriate integrated model is inserting green curriculum aspects in the form of environmental problems and responsibilities in science learning in the classroom. Students solved environmental issues through science learning projects. Meanwhile, the habit of environmental responsibility is formed at the beginning of the learning process, such as responsibility for plants or animals that need to be cared for. Integrating responsibility and projects to resolve environmental problems with repeated reinforcement learning fostered awareness of the environment and eco-friendly culture. This can be explained in the learning syntax in Table 7.

Integrating a green curriculum into science education significantly transforms the learning experience by fostering a deeper connection between students and their natural surroundings. These outdoor experiences are carefully designed to align with and reinforce the science concepts covered in the classroom. For example, while learning about photosynthesis, students might cultivate a garden, observing firsthand how plants grow and respond to different environmental conditions (see Figure 4). In addition to these immediate educational benefits, students are assigned projects focusing on environmental preservation. These projects require them to devise and implement strategies for conserving local ecosystems, including planting trees, creating habitats for pollinators, or organising clean-up drives. To amplify the impact of their work, students also engage in environmental campaigns, using various media to raise awareness about ecological issues and promote sustainable practices within their community.

Figure 4.

Documentation of Students Engaging in Outdoor Experiences During Science Lessons with The Integration of The Green Curriculum

Through these initiatives, students learn about ecosystems theoretically and develop a profound appreciation for the complexity and fragility of the natural world. They are taught the importance of biodiversity and the interdependence of different species, including humans. This holistic educational approach instils in them a sense of stewardship and a commitment to environmental sustainability that they carry into adulthood. Ultimately, integrating a green curriculum into science education in elementary schools will produce environmentally conscious individuals with the knowledge, skills, and values necessary to contribute positively to preserving and enhancing their local and global environments.

Results of The Quasi-Experimental Study

A more in-depth evaluation was subsequently conducted as part of a quasi-experimental test during the implementation phase following the development

Table 7.

Learning Activity Process of Integration Green Curriculum and Science Education.

Learning Activity	Student activities	Teacher activity
Animal or plant care activities	Students manage plants and animals, which is their responsibility, from seedlings to harvest.	Teachers help students get into the habit of managing the plants and animals they are responsible for, from seed to harvest
Explore environmental problems with questions	Students observe environmental problems they encounter by asking questions	The teacher facilitates students in finding questions about environmental problems.
Product design by watching video.	Students watch videos on YouTube uploaded by the teacher regarding the steps for working on the project	The teacher demonstrates the steps for working on the project directly or uploads a video via YouTube
Create a schedule.	Students determine the project implementation schedule as a group	The teacher facilitates students in preparing project implementation schedules in groups
Implement the plan with group	Students work on projects in groups	The teacher facilitates student activities in the project stages and ensures that all group members are involved in project implementation activities
Implement plate independently.	Students implement the project stages in groups	Teachers support students in activities independently
Monitor of the project	Students observe the progress of the project implementation from the potential to the obstacles encountered	The teacher facilitates students in project activities and provides direction to resolve the obstacles encountered
Integrating materials with project activities with presentations	Students relate the projects they are working on to the environmental problems that they have encountered	The teacher facilitates students with several questions related to the relevance of learning material to environmental problems and the projects that they are working on
Campaign to friends about being environmentally friendly	Students campaign for activities related to environmental management	Teachers encourage students to tell or teach their learning experiences to friends or family.

of the green curriculum integration in science learning. This step analyzed environmental awareness and eco-friendly aspects based on specific indicators. Based on the measurements of environmental awareness and eco-friendly behavior conducted after implementing the green curriculum integration in the experimental science class and problem-based learning without green curriculum integration in the control class, it was found that the experimental class had a higher average score compared to the control class. The descriptive analysis of these two variables is presented in Figures 5 and 6.

The graph indicates that the environmental awareness scores of students in the experimental class are significantly higher than those in the control class despite the average score differences for each indicator ranging from 10 to 20 points. This trend is also evident in the environmental concern scores assessed through observer evaluations. As depicted in Figure 6. below, the results further substantiate these findings.

The results of the quasi-experimental test showed that environmental awareness and eco-friendly cultural value increased in the control and experimental

Figure 5.
Graphic Result of Environmental Awareness Value.

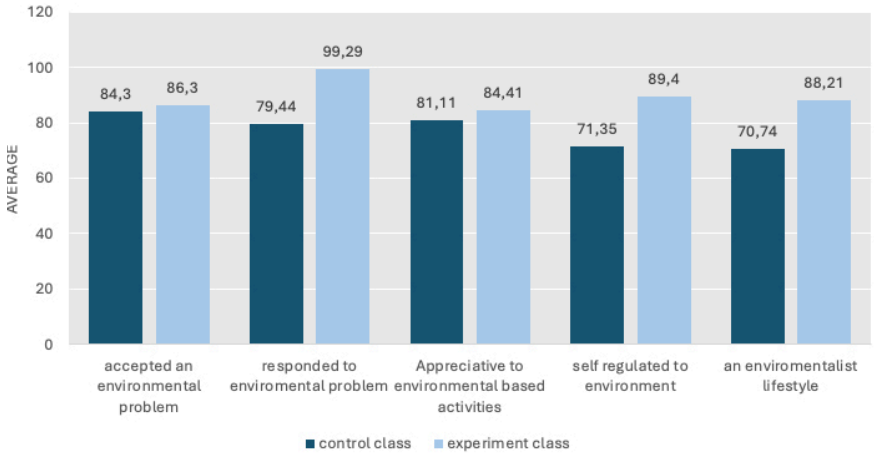
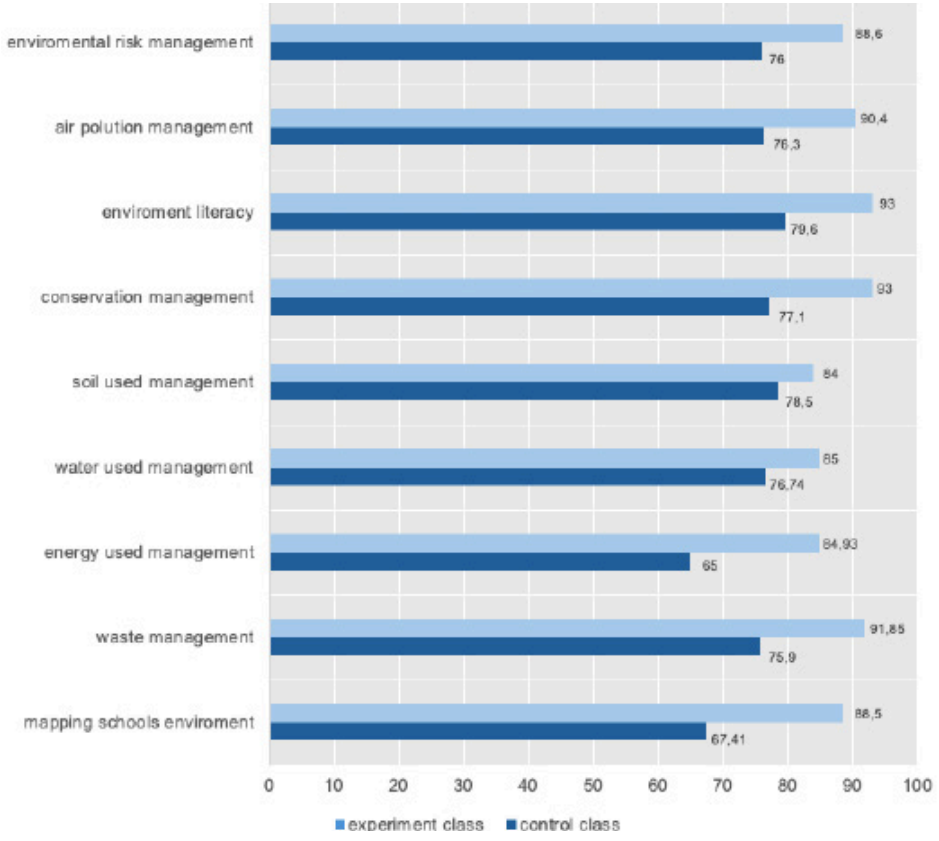


Figure 6.
Graphic of Eco-Friendly Culture Value.



classes. The average difference in the eco-friendly culture score was 12.3-23.6 points higher than in the control class (see Figures 5 & 6). Upon analyzing the overall averages of both the environmental awareness and eco-friendly culture values, the results are comprehensively summarised in Table 8 below. These findings provide a clear comparison between the experimental and control groups, highlighting the effectiveness of the implemented intervention in fostering environmental awareness and promoting an eco-friendly culture among students.

Table 8.
Average Scores of Environmental Awareness and Eco-Friendly Culture

Class	Scores with Green Curriculum (Experimental Class)		Scores with Non-Green Curriculum (Control Class)	
	EA	EFC	EA	EFC
	87,69	88,45	77.93	79.15

EA (environmental awareness), EFC (Eco-Friendly culture)

These results were then tested for inferential statistics using the different *t*-tests to analyze the differences in the values of the two aspects in the control and experimental classes. (see Table 9).

Table 9.
T-test Result of Environmental Awareness and Eco-Friendly Culture.

No.	Aspect	Sign. (2-tailed)	Mean different.
1.	Environmental awareness	0.000	9.3
2.	Eco-friendly culture	0.000	8.7

The hypothesis test results confirm that there is an effect on increasing students' environmental awareness and environmentally friendly culture after the learning process. Based on the data analysis, it was found that the significance was $p = 0.000 \leq \alpha$ (0.05). Learning success can be seen from the corrected mean difference between the experimental and control classes. The corrected mean value for the experimental class is greater than that of the control class. The growth and development of an environmentally friendly culture are due to integrating the green curriculum in science learning with repeated reinforcement. These results prove that integrating the green curriculum model in science learning effectively implements environmental education.

The results of these quantitative measurements are consistent and supported by evidence based on observations of an environmentally friendly culture. It was found that children understand science concepts inductively. They know how the ecosystem concepts around them are formed from specific observations or experiences in their surrounding environment during learning. This is evidenced by the findings of students' questions about science concepts during vegetable cultivation activities at the beginning of the learning process. After the lesson, students consistently ensure that the classroom is in optimal condition. This includes turning off unnecessary lights when the room is adequately lit, opening windows for proper ventilation, unplugging unused electrical outlets, and maintaining a clean and comfortable learning environment. Integrating environmental awareness and consciousness into the science curriculum fosters these good habits, encouraging students to take responsibility for the sustainability of their environment. Through the green curriculum, this approach instills in students a lasting sense of stewardship and proactive behavior toward environmental conservation.

Discussions

This study has developed the integration of a green curriculum model in science learning, addressing key challenges identified during the problem analysis phase. The integration of this curriculum supports the simultaneous development of environmental awareness and an eco-friendly culture among students. By emphasizing direct, experiential learning, the model allowed students to develop competencies in exploring and understanding environmental concepts through hands-on activities (Komariah & Sa'ud, 2024; Ni et al., 2024). The integration process included clear objectives, tailored content and learning materials, and structured learning activities aligned with sustainable education goals (Aurélio et al., 2022; Dillon & Scott, 2002).

This study demonstrated that cultivating environmental awareness is most effectively achieved by assigning students responsibility for caring for animals or plants as part of their learning projects. This approach deepened students' connection with the environment and fostered attitudes of care and accountability, confirming findings from previous studies (Sadikin et al., 2024; Torre Gibney et al., 2017). While elementary students may possess foundational knowledge of environmental issues, the study underscored the need to translate such theoretical knowledge into actionable behaviors through direct, practical actions, a critical aspect of environmental education (Viteri & Pazmiño, 2023).

Furthermore, an eco-friendly culture emerged from environmental projects and campaigns embedded within the curriculum. These activities promoted collaboration, inquiry, and reflective practices, fostering environmental responsibility and ecological sensitivity (Daher, 2022; Shulla et al., 2020). Students also engaged in using environmentally friendly products, such as reusable water bottles and food containers, cultivating habits that foster sustainable practices into adulthood (Komariah & Sa'ud, 2024; Parker, 2018).

The findings that integrating a green curriculum in science education enhances students' environmental

awareness and eco-friendly culture align with studies by Torre Gibney et al., (2017) and Tuncer et al., (2007), which emphasises the importance of responsibility in shaping students' environmental attitudes. Gibney et al. found that a deep project-based learning approach encourages students to be more actively involved in environmental activities. At the same time, highlighted the importance of theoretical knowledge in building a solid understanding of environmental issues. Although both approaches are practical, they show differences in teaching methods and outcomes (Li et al., 2021).

Additionally, challenges such as economic constraints and resource limitations in Indonesia highlighted the need for community-based approaches and cost-effective strategies, as suggested by Parker et al., (2018; 2019a) tailored strategies, including culturally relevant and context-specific methods, were found to be essential for addressing these challenges and achieving sustainable outcomes (Bhandari & Abe, 2000; Lowan-Trudeau, 2023). These results provide a robust framework for integrating green curricula into science education, offering practical and theoretical insights for advancing environmental education in diverse socio-economic and cultural contexts. Moreover, limited institutional support can significantly hinder the success of such programs, particularly in developing countries like Indonesia (Parker & Prabawa-Sear, 2019a). Using environmentally friendly products in developing countries like Indonesia is very expensive. Buying some environmentally friendly products is more costly than regular products (Parker et al., 2018; Parker & Prabawa-Sear, 2019a). This causes environmental education to not only be invested in one or two specific periods, such as workshops or non-learning programs (Knamiller, 1983; Nomura et al., 2003). Modern industrial technology, the capitalist economic system, economic growth, and an affluent consumer society are determining aspects of the level of environmental awareness of citizens (Stevenson, 2007). This means that environmental education tends to have different effects in different countries.

The differences in implementing the green curriculum may be due to variations in access to learning materials, teacher training, and community participation (Bhandari & Abe, 2000; Parker & Prabawa-Sear, 2019a). Discussing these differences can provide further insights into how environmental education programs can be tailored to local needs. For example, more straightforward and community-based approaches may be more effective in countries with limited resources than methods requiring extensive resources. By understanding the specific contexts and challenges in each location, educators and policymakers can design more adaptive and responsive environmental education programs that better meet local needs, thereby achieving better outcomes in enhancing students' environmental awareness and eco-friendly behavior.

The implications of these findings for environmental education policy in Indonesia are significant. The government and education stakeholders must consider a more comprehensive integration of the green curriculum within the educational system. More incredible support is needed by providing resources, teacher training, and establishing policies that encourage using environmentally friendly products. Moreover, environmental education programs must be tailored to local conditions, considering existing economic and social challenges. Community-based approaches involving students and the community may offer practical solutions to overcome resource limitations and achieve better environmental education goals. Thus, environmental education policy in Indonesia can become more adaptive and sustainable and positively impact the enhancement of environmental awareness and eco-friendly behavior among students.

Limitation Of Study

This study identified several limitations that need further discussion. A key limitation is the lack of specialized teacher training, which may have impacted the quality of instruction and students' comprehension of the green curriculum. Additionally, demographic factors such as socio-economic status, culture, and geographic location created variability in student participation. Economic barriers limited resource access for disadvantaged students, while geographic and cultural differences affected engagement with project-based activities.

To address these issues, the study proposed strategies such as cost-effective projects utilizing local resources, adaptable activities for diverse settings, and culturally relevant content. Engaging parents and communities and offering targeted support for underserved students were also emphasized to enhance participation. Future research should explore these approaches further, focusing on teacher training, community involvement, and longitudinal studies to evaluate the curriculum's long-term impact across varied contexts.

Conclusions

The integration of a green curriculum into elementary science education demonstrated its effectiveness in enhancing students' environmental awareness and fostering an eco-friendly culture. This study employed the ADDIE model to systematically design, develop, and implement a green curriculum that incorporated environmental issues and responsibilities into science learning. The findings from the quasi-experimental test revealed a significant improvement in environmental awareness and eco-friendly cultural

values among students in the experimental group compared to those in the control group. These results indicated that integrating project-based activities, cultivating responsibility, and reinforcing environmental behaviors effectively nurtured sustainable practices. This study highlighted the importance of embedding environmental education into core curricula to promote sustainable behaviors and ecological responsibility from an early age. Future research should focus on scaling this model across diverse socio-economic and cultural contexts and exploring its long-term impacts on students' environmental stewardship. The integration of a green curriculum provided a promising framework for achieving sustainable education goals, particularly in developing regions.

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Appendix 1

Self-Assessment Quisioner of Environmental Awareness.

No.	Statements for self-assessment of environmental awareness	Indicators
1	I will follow the rules about maintaining the school environment.	Receiving
2	I am happy to come to school early because I can see the clean and green school.	Receiving
3	I wouldn't say I like participating in school cleaning activities because it is tiring to follow the exercises.	Responding
4	I enjoy studying at this school because of the green school program, which makes the school beautiful and comfortable.	Valuing
5	I do not need to conserve water because there is plenty of it.	Characterization
6	Wastewater from the school bathrooms needs to be treated with clean water.	Receiving
7	I will turn on the lights during the day even though the classroom is well-lit because it is a school facility.	Characterization
8	If there are many leaves scattered around the house, I will make compost to clean the yard.	Responding
9	I enjoy seeing the plants at school.	Receiving
10	I will burn the scattered trash so it doesn't dirty the school environment.	Characterization
11	I will ignore friends who litter.	Characterization
12	I will invite my brother, mother, and father at home to make hand sanitizer and soap from plants.	Valuing
13	I enjoy participating in communal work with my siblings, father, and mother to clean the village.	Responding
14	If I become a class leader, I will invite my friends to play rather than invite them to clean and take care of the school environment.	Organization
15	I don't care if my friends brush their teeth after lunch because it's not my teeth that will decay.	Characterization
16	I will use bombs to catch fish to get more fish.	Characterization
17	I prefer using air conditioning over utilizing natural ventilation.	Characterization
18	I feel sad when I see people littering.	Receiving
19	I will continue to plant vegetables and raise animals to prevent extinction.	Valuing
20	I enjoy sorting trash by separating paper, plastic, hazardous waste, organic, and residue.	Responding

Appendix 2

Self-Assessment Quisioner of Eco-friendly Culture.

No.	Statements for self-assessment of eco-friendly culture	Indicators
1	I am used to identifying natural resources in the school environment.	Habituation in Mapping the Potential and Condition of the Environment
2	I can recognize environmental issues around me.	
3	I participate in mapping environmental potentials to support conservation efforts.	
4	I separate waste based on its type (organic, plastic, residual).	Habituation in Waste Management
5	I take part in recycling activities at school or home.	
6	I reduce the use of disposable items to minimize waste.	
7	I always turn off lights and electronic devices when not in use.	Habituation in Energy Use
8	I support the use of renewable energy at school (e.g., solar panels).	
9	I prefer using natural ventilation over air conditioning.	
10	I save water by turning off the tap when not in use.	Habituation in Water Conservation and Management
11	I utilize rainwater for certain activities, such as watering plants.	
12	I support the use of water-saving technologies in school.	
13	I avoid excessive use of chemical fertilizers in farming or gardening activities.	Habituation in Soil Management and Prevention of Chemical Contamination
14	I use organic waste to create compost.	
15	I support reforestation efforts to prevent soil erosion.	
16	I keep school facilities such as classrooms, toilets, and gardens clean.	Habituation in Being Sensitive to School Facilities and Infrastructure
17	I report any damage to school facilities so they can be fixed promptly.	
18	I support the provision of environmentally friendly facilities in schools	
19	I regularly clean the school surroundings to maintain tidiness.	Habituation in Orderliness and Environmental Sustainability Around the School
20	I always dispose of trash in the designated bins.	
21	I support school programs focused on environmental preservation.	
22	I actively participate in campaigns to raise environmental awareness.	Habituation in Campaigning for Environmental Sustainability
23	I encourage my friends to keep the school environment clean and beautiful.	
24	I help spread information about the importance of environmental preservation through social media or posters.	