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Research

DEVELOPING AN ECOPEDAGOGICAL THEMATIC LEARNING MODEL TO ENHANCE ENVIRONMENTAL LITERACY IN PRIMARY EDUCATION

Mohammad Fahmi Nugraha[1,2], Nadiroh[2], and Guspri Devi Artanti[1]
[1]Primary School Teacher Education Program, Muhammadiyah University of Tasikmalaya, Tasikmalaya, Indonesia
[2]Population and Environmental Education Study Program, Postgraduate School, State University of Jakarta, Jakarta, Indonesia
Corresponding author email: m.fahminugraha@umtas.ac.id

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Abstract
Global environmental issues require early educational interventions; however, environmental education in primary schools is still predominantly cognitive-oriented and has not effectively fostered students' attitudes and behaviors. This study aims to develop and examine the effectiveness of an ecopedagogical thematic learning model to enhance environmental literacy. This research employed a Research and Development (R&D) approach based on the Dick and Carey model. The participants were 75 upper-grade primary school students in Tasikmalaya, Indonesia, selected through simple random sampling. Data were collected through observation, interviews, and validated instruments, and analyzed using descriptive statistics, the Wilcoxon signed-rank test, and normalized gain (N-gain). The results show that the developed model is highly feasible (mean = 4.70) and received very positive student responses (93.33%–96.26%). Statistical analysis indicates a significant improvement in students' environmental literacy ($p < .001$), with an average N-gain score of 0.62, categorized as moderate to high. The novelty of this study lies in the integration of ecopedagogical principles, thematic learning, and experiential learning into a structured instructional model that simultaneously addresses cognitive, affective, and behavioral domains. These findings imply that the model can be used by teachers as a holistic and student-centered approach to design more meaningful and sustainability-oriented learning in primary education.

Keywords: Environmental Literacy, Experiential Learning, Primary Education, Thematic Learning

INTRODUCTION

Global environmental challenges, including resource depletion, pollution, biodiversity loss, and unsustainable consumption patterns, continue to intensify and require urgent and sustainable solutions. These challenges highlight the critical role of environmental education in fostering environmentally

responsible knowledge, attitudes, and behaviors from an early age (Ardoin & Bowers, 2020; Fuertes Camacho et al., 2025; Laura Varela-Candamio et al., 2018; Mutiarasari et al., 2025; Naila et al., 2025). Primary education is particularly important, as it serves as a foundational stage in shaping students' long-term environmental literacy, values, and behavioral patterns toward sustainability (Costa et al., 2026; Guevara Herrero et al., 2024; Olsson et al., 2022). Environmental literacy is widely recognized as a multidimensional construct encompassing knowledge, cognitive skills, attitudes, and environmentally responsible behavior (Fuertes Camacho et al., 2025; Mustofa & Sueb, 2023; Olsson et al., 2022; Rofiqi, 2024). Recent studies emphasize that environmental literacy is a key competency for 21st-century learners to address complex global environmental issues and support sustainable development goals (Costa et al., 2026; Guevara Herrero et al., 2024; Laura Varela-Candamio et al., 2018; Mutiarasari et al., 2025; UNESCO, 2020).

Despite its importance, environmental education in primary schools is still predominantly delivered through teacher-centered and cognitively oriented approaches, which limit student engagement and fail to adequately develop the affective and behavioral dimensions (Ardoin & Bowers, 2020; Mustofa & Sueb, 2023; L. Nugraha et al., 2022; Olsson et al., 2022; Panjaitan et al., 2021). Empirical evidence shows that although students demonstrate awareness of environmental issues, this awareness does not necessarily translate into environmentally responsible behavior (Laura Varela-Candamio et al., 2018; Mustofa & Sueb, 2023; Naila et al., 2025; Panjaitan et al., 2021; Triyandana et al., 2024). This indicates a persistent gap between environmental literacy and actual behavior, suggesting that current instructional approaches are insufficient to foster meaningful environmental engagement. Furthermore, environmental education content is often fragmented across subjects and lacks a coherent, systematic instructional framework, thereby reducing its effectiveness in practice (Macintyre et al., 2024; Mutiarasari et al., 2025; Naila et al., 2025).

Recent studies have attempted to address these issues by developing ecopedagogical-based learning tools, such as digital learning media, teaching materials, and student worksheets, which have shown promising results in improving environmental literacy and engagement (Al Gifary et al., 2023; Fauziah & Rohmah, 2024; Misiaszek & Rodrigues, 2023; Permatasari et al., 2025). However, these approaches remain limited because they primarily focus on instructional media rather than developing a comprehensive pedagogical model. Consequently, there remains a lack of structured instructional frameworks that systematically integrate ecological values into the learning process while addressing the cognitive, affective, and behavioral dimensions of environmental literacy. This indicates that previous studies have not yet provided a comprehensive instructional model that systematically integrates the cognitive, affective, and behavioral domains.

The importance of experiential and student-centered learning can be clearly illustrated through Edgar Dale's Cone of Experience, as shown in Figure 1. This framework suggests that learning becomes more effective when students are actively engaged in concrete experiences, such as observing, doing, and participating, rather than merely receiving verbal information (Davis & Summers, 2015).

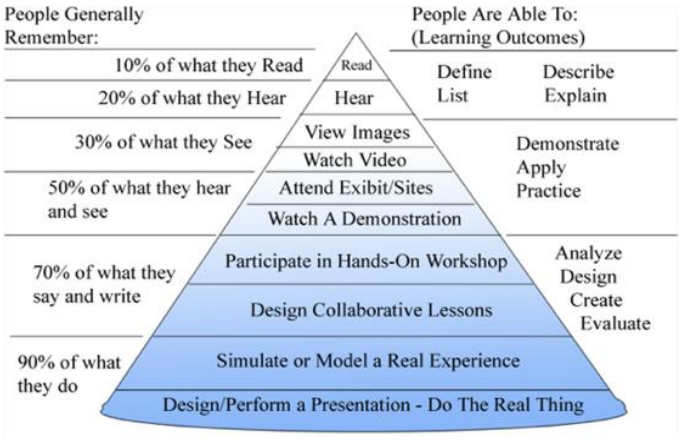

Figure 1 Edgar Dale's Cone of Experience (Dimple J. Martin, 2019)

As illustrated in Figure 1, learners tend to retain more information through direct involvement compared to passive learning methods. This concept aligns with the principles of ecopedagogy and supports the need for student-centered, experiential, and contextual learning approaches in environmental

education. When combined with thematic learning, which integrates knowledge across subjects and connects learning to real-life contexts, these approaches can create meaningful and engaging learning experiences (Al Gifary et al., 2023; Arya et al., 2024; Costa et al., 2026; Permatasari et al., 2025).

To address these gaps, a more integrated and holistic approach is required. Ecopedagogy promotes the integration of knowledge, values, and actions, encouraging students to develop critical awareness and environmentally responsible behavior (Alvarez Guayara et al., 2026; Fuertes Camacho et al., 2025; Guevara Herrero et al., 2024). In addition, experiential learning emphasizes the importance of direct and meaningful experiences in facilitating deeper understanding and long-term retention of knowledge (Kolb, 1984; Krathwohl, 2002). However, these approaches have not yet been systematically integrated into a structured instructional model in primary education.

This study addresses the identified gap by developing an ecopedagogical thematic learning model that integrates ecopedagogical principles, thematic instruction, and experiential learning into a systematic instructional framework. The novelty of this study lies in the development of a comprehensive, empirically tested model that not only focuses on learning materials but also emphasizes a structured pedagogical design that targets cognitive, affective, and behavioral dimensions of environmental literacy simultaneously. Accordingly, this study aims to: (1) develop an ecopedagogical thematic learning model, (2) evaluate its feasibility, and (3) examine its effectiveness in improving environmental literacy among primary school students. The findings of this study are expected to contribute both theoretically and practically by providing an innovative instructional model that supports sustainable education practices and strengthens environmental literacy in primary education.

RESEARCH METHOD

Research Design

This study employed a Research and Development (R&D) approach based on the Dick and Carey instructional design model. This model was selected for its systematic and comprehensive framework, which integrates needs analysis, instructional design, development, implementation, and evaluation. The development process followed ten stages, including needs analysis, instructional analysis, learner and context analysis, formulation of objectives, development of assessment instruments, instructional strategy design, material development, formative evaluation, revision, and summative evaluation. Recent studies have demonstrated that the Dick and Carey model is effective in supporting systematic instructional development and improving learning outcomes across various educational contexts (Askar & Djono, 2025; Fauziah & Rohmah, 2024; Permatasari et al., 2025; Rizquna & Waluyo, 2024).

Research Target/Subject

The study involved 120 primary school students (Grades 4–6) in Tasikmalaya City, Indonesia. Participants were selected using a simple random sampling technique to ensure equal opportunity for inclusion and minimize sampling bias. This sampling method is widely recommended in educational research to improve representativeness and reduce selection bias (John W. Creswell & J. David Creswell, 2022). The sample was divided into two groups: 45 students for instrument testing and 75 students for product implementation in the experimental phase.

Research Procedure

The research procedure followed the Dick and Carey instructional design model, which consists of ten systematic stages for developing and evaluating instructional products. This model ensures that all components of instruction are interconnected and aligned to achieve the intended learning outcomes (Askar & Djono, 2025; Dick, 2015; Munir et al., 2024). The overall procedure of the study is illustrated in Figure 2.

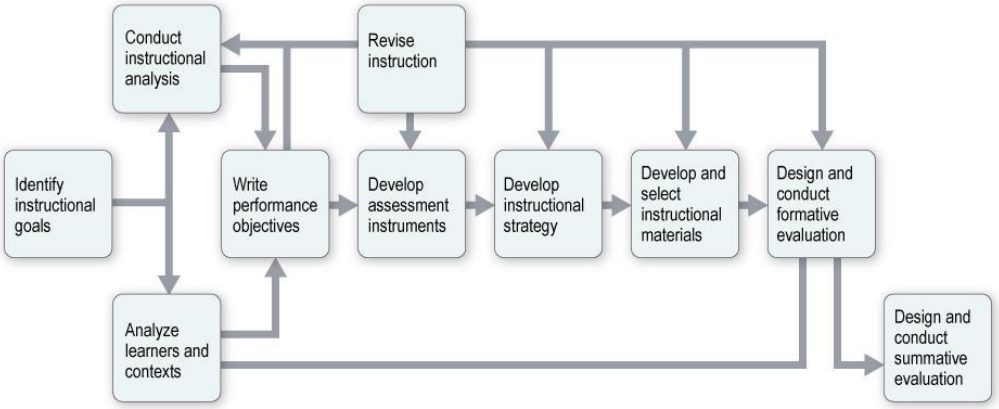

Figure 2 Dick and Carey Research and Development Procedures (Dick, 2015)

As shown in Figure 2, the procedure began with determining educational objectives based on an analysis of students' needs and challenges in environmental learning. This was followed by instructional analysis to identify the competencies required to achieve the objectives. The next stage involved analyzing learners and contexts, including students' prior knowledge, learning needs, and classroom conditions. Based on this analysis, performance objectives were formulated to define expected learning outcomes clearly.

Subsequently, assessment instruments were developed to measure students' environmental literacy. Instructional strategies were then designed, including learning activities, teaching approaches, and media selection. Educational resources were developed and adapted to align with learners' characteristics and environmental learning content.

Formative evaluation was conducted through expert validation and limited trials to assess the feasibility of the developed product. Based on the feedback received, revisions were made to improve the instructional model. Finally, a summative evaluation was conducted to assess the model's effectiveness in improving students' environmental literacy.

Instruments and Data Collection Techniques

Data were collected using multiple techniques to ensure validity and triangulation. Observations were conducted to identify initial classroom conditions, while interviews with teachers were conducted to explore existing problems and learning needs. In addition, pre-test and post-test instruments were used to measure improvements in students' environmental literacy. Non-test instruments included expert validation sheets and student response questionnaires. All instruments were validated by experts before implementation to ensure their appropriateness for data collection.

The instrument grid used in this study to measure environmental literacy and related variables is presented in Table 1.

Table 1. Instrument Grid (Data Collection Instrument Framework)

Variable	Indicator	Instrument Type	Number of Items	Data Source
Environmental literacy	Understanding environmental concepts	Test (MCQs)	10	Students
Cognitive Application	Problem-solving in environmental cases	Test	5	Students
Environmental Attitude	Awareness & responsibility	Questionnaire (Likert)	10	Students
Participation Behavior	Eco-friendly actions	Questionnaire	10	Students
Feasibility of Model	Content, design, media	Validation sheet	15	Experts
Student Response	Engagement & interest	Questionnaire	10	Students

As shown in Table 1, the instruments were designed to measure cognitive, affective, and behavioral aspects of environmental literacy, as well as model feasibility and student responses.

Validity and Reliability

The validity of the instruments was assessed through expert judgment to ensure content validity and through Pearson Product-Moment correlation to evaluate construct validity. Reliability was measured using Cronbach's Alpha and McDonald's Omega. The results showed that Cronbach's Alpha ($\alpha = 0.750$) indicated high reliability, while McDonald's Omega ($\omega = 0.934$) indicated very high reliability. These findings confirm that the instruments used in this study were both valid and reliable for data collection.

Data Analysis Technique

The practicality of the developed model was assessed by media and material experts using descriptive statistics. The feasibility percentage was calculated using the formula:

$$P = \frac{\text{Obtained Scores}}{\text{Maximum Scores}} X\ 100\%$$

The feasibility criteria referred to (Widoyoko, 2016) and (M. F. Nugraha et al., 2022), as presented in Table 2.

Table 2. Criteria for Assessing the Feasibility of Learning Models

Interval	Criteria
81% - 100%	Very feasible
61% – 80%	Feasible
41% – 60%	Fairly feasible
21% – 40%	Not feasible
0% – 20%	Highly not feasible

To evaluate the model's effectiveness, an inferential statistical analysis was conducted using the Wilcoxon signed-rank test. Improvements in students' environmental literacy were measured using the normalized gain (N-gain) formula (Meltzer, 2002), which was calculated as:

$$g = \frac{Posttest - Pretest}{Maximum\ Scores - Pretest}$$

The N-gain results were interpreted based on the criteria proposed by Hake (1999), as shown in Table 3.

Table 3. Normalized Gain Categories

g (N-Gain)	Interpretation	Effectiveness Category
$g \geq 0.7$	High	Effective
$0.3 \leq g < 0.7$	Medium	
$g < 0.3$	Low	Ineffective

Power of the Study (Sample Adequacy)

The statistical power of this study was considered adequate given the sample size ($n = 75$) in the experimental phase. According to Cohen (1988), a sample size greater than 30 is sufficient to detect a medium effect size ($d \approx 0.5$) with approximately 0.80 statistical power at a significance level of 0.05. Furthermore, recent methodological studies confirm that sample sizes exceeding 50 participants are generally sufficient to achieve adequate statistical power in educational experimental research (Lakens, 2022). Therefore, the sample size used in this study is considered sufficient to support reliable and valid conclusions.

RESULTS AND DISCUSSION

Results

This section presents the study's findings aligned with the research objectives, including the development process, instrument validity and reliability, the model's feasibility, and its effectiveness across the cognitive, affective, and psychomotor domains.

1. *Development of the Ecopedagogical Thematic Learning Model*

The development of the learning model followed the ten stages of the Dick and Carey model. The results of the needs analysis revealed that environmental education in primary schools was predominantly teacher-centered and focused on cognitive aspects, with limited emphasis on students' attitudes and behaviors.

Interviews with 11 teachers identified three key needs: (1) the integration of thematic learning, (2) the use of interactive instructional strategies, and (3) the enhancement of students' environmental literacy through real-life applications. These findings are consistent with previous studies emphasizing the importance of contextual and student-centered approaches in environmental education.

Based on these findings, an ecopedagogical thematic learning model was developed that integrates the cognitive, affective, and behavioral components of environmental literacy.

This study created the ecopedagogical thematic learning model by following the ten stages of the Dick and Carey model (Dick, 2015; Omoregie et al., 2025). Each stage produced specific outputs that shaped the final instructional product.

The needs analysis revealed that environmental education in primary schools predominantly employed teacher-centered methodologies and largely emphasized cognitive dimensions. Students exhibited minimal environmental literacy and insufficient participation in eco-friendly practices. Learning objectives were determined through interviews with 11 primary school educators in Tasikmalaya City and Regency, conducted from 19 February to 29 July 2025. The data analysis employed qualitative methods of data reduction, visualization, and conclusion formulation (Miles & Huberman, 1994).

The findings highlighted three key aspects: engaging students in integrated thematic learning, using more interactive and varied instructional strategies beyond traditional methods, and enhancing students' environmental awareness by connecting learning objectives with real-life applications.

The instructional and learner analysis phases indicated that upper-grade primary school students require contextual, interactive, and experiential learning. These findings served as the foundation for developing a learning model that incorporates real-world environmental challenges. Initial studies indicated that environmental education materials may be used across several topics, with science particularly appropriate. Integration seeks to fulfill scientific educational goals while cultivating environmentally aware students (M. S. Nugraha et al., 2024). The research delineated five characteristics of environmental literacy: Knowledge, Understanding and Application, Environmental Attitude, Gender Awareness, and Active Participation. Performance objectives were developed using the ABCD (Audience, Behavior, Condition, Degree) framework (Robert F. Mager, 1997). The summary of performance objectives developed in this study is presented in Table 3.

Table 3. Summary of Performance Objectives

	General Learning Objectives	Performance Objective	Criteria
1.	Understand environmental conservation	Explain ≥3 environmental conservation behaviors	Accuracy ≥80%
2.	Apply ecological concepts	Identify causes & solutions in a pollution case study	Correct identification expected
3.	Demonstrate environmental and gender care	Design environmental actions reflecting "5S" values (Smile, Greet, Say Hello, Be Polite, Be Courteous)	Consistent in daily actions

As shown in Table 3, the performance objectives were designed to measure students' competencies across cognitive, affective, and behavioral domains. These objectives provide clear and measurable indicators of environmental literacy, ensuring alignment between learning outcomes and assessment criteria.

The development of learning objectives led to explicit, quantifiable indicators of environmental literacy, encompassing knowledge, attitudes, and environmentally responsible actions. Assessment instruments, both test and non-test, were then developed to evaluate students' environmental literacy comprehensively.

All instruments were validated before field implementation to ensure their appropriateness and reliability. The development of instructional strategies and materials resulted in an ecopedagogical thematic learning model that integrates environmental content into thematic learning through student-centered, contextual, and interactive approaches.

During the formative evaluation phase, expert validation and limited trials were conducted. The results led to revisions in material clarity, instructional sequencing, and media design to improve usability and effectiveness. Finally, the summative evaluation phase demonstrated that the developed model is both feasible and effective for classroom implementation, as evidenced by the validation and effectiveness results.

2. *Instrument Validation and Reliability Results*

a. Instrument Validation

The pilot study involved professionals (validators) and assessed readability with elementary school students. The instruments used in this study included several types: instruments for validating learning models; subject-matter expert validation instruments; language expert validation instruments; media or presentation expert validation tools; student response questionnaires; and pre-test and post-test items.

After adjustments incorporating expert feedback and ensuring validity, the instrument was pilot-tested with 45 students to assess item clarity and reliability. Subsequently, the expert validation data were analyzed using mean scores to assess content validity. In contrast, the validity of the student pilot test data was evaluated using Pearson's Product-Moment correlation, correlating each item's score with the respondent's total score. The data's dependability was assessed using Cronbach's Alpha and McDonald's Omega coefficients in Jamovi version 2.6.45 (Jonathon Love et al., 2023). The results of the expert validation are presented in Table 4.

Table 4 Instrument Validation Results

Aspect	Score	Category
1. Content Validity	3.8	Very Valid
2. Construct Validity	3.4	Very Valid
3. Language Clarity	4	Very Valid
Average	3.73	Very Valid

The research indicates that the instrument had an average expert validation score of 3.78, which categorizes it as 'highly valid.'

The instrument pilot test results with students yielded an overall total score of 4.875 and an average score of 4.33, classified as "very good." This indicates that pupils responded very favorably to the instrument's items. The mean item score ranged from 4.07 to 4.53. Item number 20 received the greatest score (average 4.53), and item number 11 received the lowest score (4.07).

b. Instrument Reliability

Reliability was measured using Cronbach's Alpha (α) and McDonald's Omega (ω). The reliability analysis results are presented in Table 5.

Table 5. Interpretation of Reliability Test Results

Statistic	Score	Interpretation
1. Cronbach's Alpha (α)	0.750	High reliability
2. McDonald's Omega (ω)	0.934	Very High reliability

A Cronbach's Alpha of 0.750 signifies a commendable level of internal consistency, and an Omega score of 0.934 further substantiates the instrument's strong reliability. This indicates that students' replies to each item are generally consistent and stable. The item-total correlations range from 0.40 to 0.70, indicating that each item substantially enhances the instrument's overall consistency. These findings indicate strong internal consistency of the instrument, which is consistent with reliability standards in educational measurement (Hayes & Coutts, 2020; Taber, 2018).

3. Feasibility of the Developed Model

The viability of the created ecopedagogical thematic learning model was evaluated by specialists in materials and media. The results showed that the model achieved a 'very feasible' rating based on the validation scores. The results of expert validation for model feasibility are presented in Table 6.

Table 6 Expert Validation Results

Aspect	Score	Category
1. Content Feasibility	4.65	Very Feasible
2. Instructional Design	4.67	Very Feasible
3. Media/Presentation	5	Very Feasible
Average	4.7	Very Feasible

The model achieved an average score of 4.70, which is categorized as very feasible. This indicates that the developed model is appropriate for implementation in primary education. Similar findings have been reported in studies on instructional design models that emphasize feasibility and practicality.

4. *Effectiveness of the Learning Model*

a. Cognitive Domain (Knowledge Improvement)

The cognitive domain was measured using pre-test and post-test scores. The normality of the data was assessed using the Shapiro–Wilk test before hypothesis testing. The results of the normality test are presented in Table 7**.**

Table 7. Results of the Shapiro–Wilk Normality Test

Variable	N	Mean	Median	Std. Deviation	Shapiro-Wilk W	p-value	Interpretation
Pre-test	75	10.08	11	2.21	0.508	< .001	Not Normal
Post-test	75	13.03	13	1.47	0.576	< .001	Not Normal

It was found that neither the pre-test nor the post-test data are normally distributed ($p < 0.05$). Therefore, the assumption of normality was not met. Consequently, a non-parametric statistical test (Wilcoxon signed-rank test) was used to analyze the data (Field, 2020). The N-gain results for the cognitive domain are presented in Table 8.

Table 8. N-gain Results for Cognitive Domain

School	Grade	Pre-test	Post-test	Gain Score	Ideal Gain	N-gain (g)	Category
Pengadilan 1 Primary School	IV	391	476	85	134	0.60	Effective
UMTAS Laboratory Primary School	V	84	127	43	81	0.53	Effective
Cieunteung 2 Primary School	VI	338	391	53	97	0.55	Effective
Total		813	994	181	312	1.70	
Average		10.84	13.25	2.41	4.16	0.60	Effective

The improvement in students' cognitive achievement was further analyzed using the normalized gain (N-gain), as presented in Table 8. The results show that all groups experienced an increase in

scores from pre-test to post-test. The average N-gain score was 0.60, which falls within the moderate range, indicating that the developed learning model effectively enhanced students' environmental literacy. Across the three schools, the N-gain values ranged from 0.53 to 0.60, demonstrating consistent improvement across groups.

The results of the hypothesis testing using the Wilcoxon signed-rank test are presented in Table 9.

Table 9 Results of Hypothesis Testing (Wilcoxon Signed-Rank Test)

Variable	N	Test Statistic	Statistic (W)	p-value	Decision	Interpretation
Pre-test – Post-test	75	Wilcoxon	0.00	< .001	H_0 rejected	Significant difference

The analysis shows a p-value < 0.001, indicating that the null hypothesis (H_0) is rejected. This result confirms a statistically significant difference between pre-test and post-test scores. These findings provide strong empirical evidence that the developed learning model significantly improves students' environmental literacy in the cognitive domain. These results consistently demonstrate the model's effectiveness across different student groups and learning contexts.

The findings also indicate that the model not only improves students' cognitive outcomes but also shows potential for application across different primary school contexts.

b. Affective Domain (Attitude Development)

The affective domain was assessed using a Likert-scale questionnaire measuring students' environmental attitudes. Before hypothesis testing, the normality of the data was evaluated using the Shapiro–Wilk test. The results are presented in Table 10.

Table 10. Results of the Shapiro–Wilk Normality Test (Affective Domain)

Variable	N	Mean	Median	Std. Deviation	Shapiro-Wilk W	p-value	Interpretation
Pre-test	75	19.09	21	3.51	0.590	< .001	Not Normal
Post-test	75	24.01	25	2.33	0.304	< .001	Not Normal

The findings indicate that neither the pre-test nor the post-test data are normally distributed ($p < 0.001$). Therefore, a non-parametric statistical test (the Wilcoxon signed-rank test) was used to analyze the data.

The improvement in students' affective outcomes was further analyzed using the normalized gain (N-gain), as presented in Table 11.

Table 11. N-gain Results for Affective Domain

School	Grade	Pre-test	Post-test	Gain Score	Ideal Gain	N-gain (g)	Category
Pengadilan 1 Primary School	IV	715	855	140	160	0.90	Effective
UMTAS Laboratory Primary School	V	192	244	52	83	0.63	Effective
Cieunteung 2 Primary School	VI	587	710	123	138	0.89	Effective
Total		1494	1809	315	381	2.40	
Average		19.92	24.12	4.20	5.08	0.80	Effective

The results show a substantial increase in students' affective scores across all groups. The average N-gain score was 0.80, which falls within the high-effectiveness category, indicating that the developed learning model was highly effective in enhancing students' environmental attitudes.

Across the three schools, the N-gain values ranged from 0.63 to 0.90, indicating consistent strong improvement in students' affective outcomes. These findings indicate that the learning model was particularly effective in fostering students' environmental literacy, responsibility, and positive attitudes.

Descriptive analysis also confirms the improvement in students' affective scores, with the mean score increasing from 19.9 in the pre-test to 24.1 in the post-test, indicating a positive change in students' environmental attitudes.

Table 12. Results of Hypothesis Testing (Affective Domain)

Variable	N	Test Statistic	Statistic (W)	p-value	Decision	Interpretation
Pre-test – Post-test	75	Wilcoxon	0.00	< .001	H_0 rejected	Significant improvement

The analysis shows a p-value < 0.001, indicating that the null hypothesis (H_0) is rejected. This result confirms a statistically significant improvement in students' environmental attitudes following the implementation of the learning model.

These findings provide strong empirical evidence that the developed learning model is effective not only in improving students' cognitive achievement but also in enhancing their environmental attitudes. The results further indicate that the model promotes a more holistic learning outcome by addressing both knowledge and affective aspects.

c. Psychomotor Domain (Behavioral Skills Development)

The psychomotor domain was evaluated based on students' participation in environmentally responsible actions. Before hypothesis testing, the normality of the data was assessed using the Shapiro–Wilk test. The results are presented in Table 13.

Table 13. Results of the Shapiro–Wilk Normality Test (Psychomotor Domain)

Variable	N	Mean	Median	Std. Deviation	Shapiro-Wilk W	p-value	Interpretation
Pre-test	75	42.7	43	4.39	0.914	< .001	Not Normal
Post-test	75	47.3	48	3.33	0.736	< .001	Not Normal

The findings indicate that neither the pre-test nor the post-test data are normally distributed ($p < 0.001$). Therefore, a non-parametric statistical test (the Wilcoxon signed-rank test) was used to analyze the data. Descriptive analysis shows an improvement in students' psychomotor performance, with the mean score increasing from 42.7 in the pre-test to 47.3 in the post-test, indicating a positive change in students' behavioral skills.

The improvement in students' psychomotor outcomes was further analyzed using the normalized gain (N-gain), as presented in Table 14.

Table 14. N-gain Results for Psychomotor Domain

School	Grade	Pre-test	Post-test	Gain Score	Ideal Gain	N-gain (g)	Category
Pengadilan 1 Primary School	IV	1472	1651	179	278	0.64	Effective
UMTAS Laboratory Primary School	V	458	501	43	92	0.47	Effective
Cieunteung 2 Primary School	VI	1270	1392	122	180	0.68	Effective
Total		3200	3544	344	550	1.80	
Average		42.67	47.25	4.59	7.33	0.60	Effective

The results show a consistent increase in students' behavioral performance across all groups. The average N-gain score was 0.60, which falls within the moderate range, indicating that the developed

learning model effectively improved students' psychomotor skills. Across the three schools, the N-gain values ranged from 0.47 to 0.68, demonstrating consistent improvement in students' environmentally responsible behaviors.

The results of the hypothesis testing using the Wilcoxon signed-rank test are presented in Table 15.

Table 15. Results of Hypothesis Testing (Psychomotor Domain)

Variable	N	Test Statistic	Statistic (W)	p-value	Decision	Interpretation
Pre-test – Post-test	75	Wilcoxon	0.00	< .001	H_0 rejected	Significant improvement

The analysis shows a p-value < 0.001, indicating that the null hypothesis (H_0) is rejected. This result confirms a statistically significant improvement in students' psychomotor skills following the implementation of the learning model.

d. Overall Learning Outcomes

The overall effectiveness of the developed learning model was further analyzed by combining the cognitive, affective, and psychomotor domains. The results of the normality test are presented in Table 16.

Table 16. Results of the Shapiro–Wilk Normality Test (Overall Learning Outcomes)

Variable	N	Mean	Median	Std. Deviation	Shapiro-Wilk W	p-value	Interpretation
Pre-test	75	73.04	75	7.18	0.643	< .001	Not Normal
Post-test	75	84.06	86	2.69	0.486	< .001	Not Normal

The findings indicate that the data are not normally distributed ($p < 0.001$). Therefore, a non-parametric statistical test (Wilcoxon signed-rank test) was used for further analysis. Descriptive analysis indicates an increase in students' overall learning outcomes, as reflected by the rise in mean scores from the pre-test to the post-test. These findings suggest that the developed learning model is effective in improving students' learning outcomes across all domains.

The overall effectiveness of the developed learning model was further analyzed using the normalized gain (N-gain), as presented in Table 17**.**

Table 17. N-gain Results for Overall Learning Outcomes

School	Grade	Pre-test	Post-test	Gain Score	Ideal Gain	N-gain (g)	Category
Pengadilan 1 Primary School	IV	2578	2982	179	278	0.64	Effective
UMTAS Laboratory Primary School	V	734	872	43	92	0.47	Effective
Cieunteung 2 Primary School	VI	2195	2493	122	180	0.68	Effective
Total		5507	6347	344	550	1.80	
Average		73.43	84.63	11.20	7.33	0.60	Effective

The results show an overall improvement in students' learning outcomes across all domains. The average N-gain score was 0.60, which falls within the moderate range, indicating that the developed learning model was effective in improving students' learning outcomes holistically. Across the three schools, the N-gain values ranged from 0.47 to 0.68, demonstrating consistent improvement across different student groups.

The results of the hypothesis testing using the Wilcoxon signed-rank test are presented in Table 18.

Table 18. Results of Hypothesis Testing (Overall)

Variable	N	Test Statistic	Statistic (W)	p-value	Decision	Interpretation
Pre-test – Post-test	75	Wilcoxon	0.00	< .001	H_0 rejected	Significant improvement

The results of the Wilcoxon signed-rank test indicate that the improvement is statistically significant ($p < 0.001$), confirming the model's effectiveness across all learning domains. These findings further reinforce the model's robustness in facilitating integrated learning outcomes across multiple domains.

Discussion

The results of this study, obtained through descriptive statistical analysis, the Wilcoxon signed-rank test, and normalized gain (N-gain), indicate that the developed ecopedagogical thematic learning model is effective in improving students' environmental literacy. The significant difference between pre-test and post-test results ($p < .001$), along with moderate-to-high N-gain scores, demonstrates that the model has a meaningful impact on students' learning outcomes across the cognitive, affective, and psychomotor domains.

The findings of this study demonstrate that the developed ecopedagogical thematic learning model effectively improves students' learning outcomes across cognitive, affective, and psychomotor domains. This aligns with recent developments in sustainability education, which emphasize the importance of integrating knowledge, attitudes, and skills in fostering environmental literacy (Borie et al., 2020; Olsson et al., 2022; UNESCO, 2020). The cognitive domain showed moderate effectiveness, indicating that the model successfully enhanced students' conceptual understanding. This is consistent with recent studies showing that contextual and problem-based learning approaches are effective in improving environmental literacy (Amaliati et al., 2024; Swari et al., 2024).

Interestingly, the affective domain demonstrated the greatest improvement, suggesting that the model is particularly effective in shaping students' environmental attitudes. This finding is supported by recent research indicating that ecopedagogy plays a crucial role in fostering environmental literacy, responsibility, and sustainable values among students (Arshad et al., 2020; Asli et al., 2024). Meanwhile, the psychomotor domain showed moderate improvement, indicating that students were able to translate knowledge and attitudes into action. This supports findings that experiential and action-based environmental learning enhances environmentally responsible behaviors (Olsson et al., 2022; Saputri et al., 2026).

These findings are consistent with previous studies demonstrating that environmental education significantly improves students' ecological awareness and behavior (M. Damarjati Anis Lutfi et al., 2025; Susilo, 2025). However, this study extends prior research by demonstrating that integrating ecopedagogy, thematic learning, and experiential learning can simultaneously improve cognitive, affective, and behavioral domains within a single instructional model. This provides a more comprehensive approach than previous studies, which tend to focus on individual aspects of environmental literacy.

From a theoretical perspective, this study reinforces the importance of integrating cognitive, affective, and behavioral domains in environmental education to achieve sustainability goals (UNESCO, 2020). From a practical perspective, the findings imply that teachers can adopt this model to design more meaningful, contextual, and student-centered learning activities that promote environmental awareness and responsible behavior (Hasanah et al., 2025; Putri et al., 2025). The results of this study can also be generalized to similar primary education contexts, particularly in settings where environmental education is still delivered in a fragmented and cognitively oriented manner.

The novelty of this study lies in integrating ecopedagogical principles, thematic learning, and experiential learning into a structured, empirically tested instructional model. Unlike previous studies that primarily focus on learning media or specific aspects of environmental literacy, this study provides a holistic approach that simultaneously targets knowledge, attitudes, and behavior. In addition, the finding that the affective domain shows the greatest improvement provides new insights into the importance of emotional and value-based learning in sustainability education (Misiaszek, 2020, 2022, 2023).

Despite its contributions, this study has several limitations. The sample size was relatively limited and focused on a specific geographical context, which may affect the generalizability of the findings. In addition, the study primarily examined short-term learning outcomes without assessing long-term behavioral changes (Hjorth Warlenius, 2022).

Therefore, future research is recommended to include larger, more diverse samples, conduct longitudinal studies to examine long-term impacts, and explore integrating local wisdom and contextual environmental issues to enhance the relevance and effectiveness of the learning model (Amaliati et al., 2024; Goang Swaradesy et al., 2025).

CONCLUSION

This study concludes that the developed ecopedagogical thematic learning model is effective in improving students' environmental literacy across cognitive, affective, and psychomotor domains. The findings show that the affective domain achieved the greatest improvement, while the cognitive and psychomotor domains showed moderate gains. These results indicate that the model can be used as an effective means of supporting holistic and sustainability-oriented learning in primary education. In practice, this model provides guidance to teachers on designing contextual, student-centered learning activities that promote environmental awareness and responsible behavior.

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AUTHOR CONTRIBUTIONS

The primary author was responsible for conceptualization, data collection and analysis, and manuscript composition, including the development of the research framework and learning model, fieldwork, and article preparation. The second author, as primary supervisor, provided guidance on research design, methods, and theoretical framework, and thoroughly evaluated the article for intellectual merit. The third author, as co-supervisor, assisted with data analysis, result interpretation, and editing to enhance manuscript quality. All authors reviewed and endorsed the final text.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors assert that artificial intelligence (AI) techniques were used exclusively for language enhancement and proofreading. The authors independently conducted all facets of the research design, data collection, analysis, and interpretation.

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