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INTEGRATING ECOPEDAGOGY AND LOCAL WISDOM TO ENHANCE STUDENTS' ECOLOGICAL INTELLIGENCE: AN EDUCATIONAL DESIGN RESEARCH APPROACH

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ABSTRACT

The persistent gap between ecological awareness and pro-environmental behavior highlights a fundamental limitation in conventional environmental education, which often prioritizes cognitive understanding over value internalization. This study addresses this issue by developing and evaluating ecopedagogy-based teaching materials grounded in Minangkabau local wisdom (Beklomin) to enhance students' ecological intelligence. Employing an Educational Design Research (EDR) framework with a mixed-method sequential exploratory design, the study involved 213 seventh-grade students from seven public junior high schools in Padang, Indonesia. The intervention integrates ecopedagogical principles, problem-based learning, and culturally embedded ecological values to create a contextualized learning experience. Quantitative data were analyzed using the Wilcoxon Signed Rank Test and N-Gain, while qualitative data supported interpretive analysis. The results reveal statistically significant improvements across all dimensions of ecological intelligence—cognitive awareness, affective concern, critical reasoning, and self-regulation behavior ($p < 0.05$). The overall N-Gain score (0.3985) indicates moderate effectiveness, with the most substantial gains observed in affective and behavioral domains. These findings suggest that the integration of local wisdom facilitates deeper value internalization and strengthens the transformation of ecological knowledge into sustainable behavior. This study contributes theoretically by proposing an integrative framework linking ecopedagogy, local wisdom, and ecological intelligence, and empirically by demonstrating the role of culturally grounded pedagogy as a mediating mechanism for behavioral change. The findings underscore the importance of contextualized, value-driven, and action-oriented approaches in advancing environmental education beyond knowledge transmission toward meaningful ecological practice.

KEYWORDS: Ecopedagogy; Ecological Intelligence; Local Wisdom; Educational Design Research; Sustainable Behavior.

1. INTRODUCTION

In recent decades, escalating global environmental crises—including climate change, ecosystem degradation, and increasing pressure on natural resources—have prompted a paradigm shift in education toward fostering holistic ecological awareness (Djirong et al., 2024; Hudayberganov et al., 2025; Koklu & Sulak, 2024; Puttick et al., 2025; Tan, 2024). Within this context, the concept of ecological intelligence has emerged as a critical framework emphasizing individuals' capacity to understand the complex interconnections between human activities and ecological systems, and to act responsibly toward sustainability (Cortez-Angulo et al., 2025; Peters, 2026; Yan et al., 2023; You et al., 2024). Despite its growing prominence in educational discourse, empirical evidence indicates that its implementation in formal education remains largely normative and fragmented, with limited impact on fostering sustained pro-environmental behavior (Ali et al., 2025; Jin et al., 2025; Speldewinde & Campbell, 2026).

Conceptually, ecological intelligence extends beyond cognitive understanding of environmental issues to encompass affective dispositions and behavioral engagement reflected in everyday practices (Abdelraheem et al., 2025; Charlie et al., 2021; Cortez-Angulo et al., 2025; Kholov et al., 2025; Okur-Berberoglu, 2020; Saputra et al., 2023; Suwandi et al., 2017; Wulan et al., 2023). However, a persistent gap between ecological knowledge and actual behavior continues to challenge environmental education. This discrepancy suggests that prevailing pedagogical approaches have not been sufficiently effective in transforming awareness into meaningful ecological action (Benzehaf et al., 2025; Carmona-Galindo et al., 2025; Garrido et al., 2025; Henao-Castro & Vives-Hurtado, 2026; Rugbani et al., 2026).

In response, ecopedagogy, rooted in Freirean critical pedagogy, offers a transformative alternative by emphasizing critical consciousness, reflection, and praxis in human–environment relationships. Nevertheless, its application in formal educational settings remains constrained, particularly due to its tendency toward universalistic perspectives that are insufficiently grounded in learners' socio-cultural contexts (Iftekhar et al., 2026; Kayombo et al., 2025; Wang et al., 2026). Consequently, learning experiences often lack contextual relevance and fail to resonate meaningfully with students.

These limitations are further evident in empirical observations. Preliminary findings indicate that junior high school students' ecological intelligence remains suboptimal, particularly in behavioral dimensions. Students frequently exhibit environmentally unfriendly practices, such as improper waste disposal and excessive use of single-use materials. This aligns with previous studies highlighting inconsistencies between students' ecological awareness and their actual environmental behavior (Eroğlu et al., 2026; Igei et al., 2024; Khoirurrijal et al., 2025; A. Müller et al., 2025; Rohsulina et al., 2024; Saulick et al., 2024). Even when cognitive awareness is relatively developed, it is not consistently translated into sustainable daily practices.

Moreover, classroom practices tend to rely heavily on standardized textbooks, with limited integration of contextual environmental issues or locally relevant values. Teachers' limited understanding of ecopedagogical approaches further constrains the potential of social studies education as a strategic space for cultivating ecological intelligence (Kazazoglu, 2025; Khan, 2025; Küchler, 2024; Zumrotun et al., 2026). This reflects a broader gap between value-oriented curricula and instructional practices that remain largely text-based and decontextualized.

Conversely, a growing body of research underscores the significant potential of integrating local wisdom into education to foster more contextualized and meaningful ecological awareness. Local wisdom embodies ecological values that have been historically embedded in cultural practices and proven effective in maintaining human–environment balance. However, existing studies are predominantly descriptive or limited to partial implementations, lacking systematic pedagogical frameworks that operationalize the integration of local wisdom into learning processes aimed at enhancing ecological intelligence (Fathurrochman et al., 2025; Mulyanie & Setiawan, 2024; Nurkanti et al., 2026; Rosyidah et al., 2025; Simanjuntak et al., 2025).

Based on the literature and empirical findings, three critical gaps can be identified. First, ecopedagogy has not been contextually integrated with local cultural values in classroom practice. Second, the incorporation of local wisdom in education has yet to be formulated into systematic and operational pedagogical models. Third, studies on ecological intelligence tend to focus on outcomes rather than explicating the pedagogical mechanisms that lead to behavioral transformation.

Addressing these gaps, this study proposes an integrative approach through the development of ecopedagogical teaching materials grounded in Minangkabau local wisdom (Beklomin). This

approach aims not only to produce instructional materials but also to construct a pedagogical framework that bridges global sustainability values with local cultural contexts. The contributions of this study are threefold. Theoretically, it offers a coherent integration of ecopedagogy, local wisdom, and ecological intelligence. Methodologically, it employs an educational design research approach to develop a systematic instructional model. Empirically, it evaluates the effectiveness of the proposed model in enhancing students' ecological intelligence within formal education settings.

Accordingly, this study addresses the following research questions: (1) What is the initial condition of students' ecological intelligence? (2) How can ecopedagogy-based teaching materials grounded in local wisdom be designed to be valid and contextual? and (3) To what extent is the developed model effective in improving students' ecological intelligence?

2. METHOD

2.1. Research Design and Approach

This study employed an Educational Design Research (EDR) approach grounded in the framework proposed by Tjeerd Plomp and Nienke Nieveen. This approach was selected due to its capacity to integrate the systematic development of educational interventions with rigorous empirical validation in authentic learning environments. Unlike conventional experimental designs that primarily focus on causal relationships, EDR emphasizes iterative cycles of design, evaluation, and refinement, thereby generating both practical solutions and theoretical contributions. The study aimed to develop Ecopedagogy-Based Teaching Materials (Beklomin) grounded in Minangkabau local wisdom to enhance students' ecological intelligence. To achieve this objective, the research adopted a mixed-method sequential exploratory design, in which qualitative data were first utilized to inform the development process, followed by quantitative analysis to evaluate the effectiveness of the developed product.

2.2. Development Procedure

The development procedure followed the Educational Design Research (EDR) model proposed by Plomp, which consists of five iterative phases: (1) preliminary investigation, (2) design, (3) realization/construction, (4) test–evaluation–revision, and (5) implementation. The iterative nature of this framework enables continuous refinement of the instructional product through systematic validation and empirical testing in authentic educational settings.

In the preliminary investigation phase, a comprehensive needs assessment was conducted to identify pedagogical problems, contextual challenges, and students' ecological intelligence profiles. Data were collected through classroom observations, semi-structured interviews with seven Social Studies teachers, and analysis of curriculum documents, lesson plans, and existing textbooks. The findings revealed that environmental learning remained predominantly cognitive-oriented and lacked contextual integration with local cultural values.

The design phase focused on constructing the pedagogical framework and instructional specifications of the Beklomin teaching materials. At this stage, ecopedagogical principles, problem-based learning strategies, and Minangkabau local wisdom values were systematically integrated into learning objectives, learning activities, assessment components, and contextual case studies. A design matrix was developed to ensure alignment among curriculum indicators, ecological intelligence dimensions, and local wisdom elements.

During the realization/construction phase, the initial prototype (Prototype I) was developed. The prototype included teaching modules, student worksheets, contextual learning scenarios, reflective activities, and ecological intelligence assessment instruments. The materials were designed to operationalize four dimensions of ecological intelligence: cognitive awareness, affective concern, critical reasoning, and self-regulation behavior.

The test–evaluation–revision phase was conducted iteratively in three stages. First, expert validation was carried out by six validators consisting of two experts in Social Studies education, two instructional design experts, and two language experts. The validation process assessed content relevance, construct alignment, pedagogical appropriateness, language clarity, and cultural contextualization using a structured validation rubric with a five-point Likert scale. Second, Focus Group Discussions (FGDs) were conducted involving education experts, cultural practitioners, school principals, and teachers to evaluate the contextual feasibility and cultural authenticity of the materials. Third, limited classroom trials were conducted in one pilot class to identify implementation constraints, student responses, and instructional practicality. Feedback from all stages was systematically analyzed and used to revise the prototype into the final product (Prototype II).

Finally, the implementation phase involved field testing in seven public junior high schools to examine the effectiveness of the developed teaching materials in improving students' ecological intelligence under authentic classroom conditions.

2.3. Participants and Research Context

Understanding the characteristics of participants and the contextual setting of the study is essential for interpreting the validity, transferability, and practical implications of the findings. Within the EDR framework, the effectiveness of an intervention is closely tied to the authenticity of the learning environment and the representativeness of participants. Therefore, this study was conducted in real classroom contexts to ensure ecological validity. The research was carried out in seven public junior high schools in Padang City, Indonesia, involving Grade VII students as the primary participants. The selection of this context was based on curricular relevance and the identified need to enhance ecological intelligence within Social Studies (IPS) learning.

The participating schools were selected purposively based on three criteria: (1) implementation of the Merdeka Curriculum, (2) willingness of teachers and school administrators to participate in the intervention process, and (3) the inclusion of environmental and socio-ecological topics within the Social Studies curriculum. These criteria ensured that the selected schools were contextually relevant to the objectives of the study and capable of supporting the implementation of the ecopedagogical intervention.

Table 1: Participant Characteristics.

No	Characteristics	Description
1	Research Location	Public junior high schools in Padang City, Indonesia
2	Number of Schools	7 schools
3	Educational Level	Junior High School (SMP)
4	Grade Level	Grade VII
5	Total Participants	213 students
6	Sampling Technique	Purposive sampling
7	Learning Context	Social Studies (IPS) with ecopedagogical approach
8	Intervention Duration	Approximately 6–8 weeks

The participants consisted of 213 seventh-grade students selected using purposive sampling to ensure representation across diverse school environments and socio-cultural backgrounds. Purposive sampling was considered appropriate because the study aimed to evaluate the effectiveness and contextual applicability of the developed instructional materials rather than to achieve statistical generalization. Within the EDR approach, participant selection prioritizes contextual relevance and authentic implementation settings. This approach enhances the ecological validity and transferability of the findings. Grade VII was selected due to its strong alignment with environmental and socio-ecological themes in the curriculum, such as human–environment interaction and natural resource management. These themes provide a meaningful entry point for integrating ecopedagogical principles and local wisdom into classroom instruction. In addition, Grade VII students are at an early stage of formal operational thinking, enabling them to engage with contextual environmental problems while still requiring concrete and culturally relevant learning experiences.

The intervention was implemented during regular classroom activities over a period of approximately 6–8 weeks. The participating schools represent typical urban public education settings in Indonesia, where students' ecological intelligence remains relatively underdeveloped.

2.4. Instruments and Data Collection

Data were collected using multiple techniques to ensure methodological triangulation. Qualitative data were obtained through classroom observations, in-depth interviews, and document analysis. Quantitative data were collected using a structured questionnaire designed to measure students' ecological intelligence. The instrument was developed based on four key dimensions: (1) cognitive ecological awareness, (2) affective ecological concern, (3) critical ecological reasoning, and (4) self-regulation and sustainable behavior. Content validity was established through expert judgment, while construct validity was examined using item-total correlation. Reliability was assessed using Cronbach's Alpha, with $\alpha \geq 0.70$ indicating acceptable internal consistency.

Before implementation, the ecological intelligence questionnaire underwent a multistage validation process. Content validity was evaluated by six experts representing environmental education, educational assessment, and instructional design. The Content Validity Index (CVI) was used to assess item relevance, clarity, and representativeness. Items with CVI values below 0.80 were revised or removed. Subsequently, a pilot test involving 35 students

outside the main sample was conducted to examine construct validity and reliability. Construct validity was analyzed using corrected item-total correlation, while internal consistency reliability was measured using Cronbach's Alpha coefficient. The overall reliability coefficient exceeded the acceptable threshold ($\alpha > 0.70$), indicating satisfactory instrument consistency.

2.5. Data Analysis

Data analysis was conducted using IBM SPSS Statistics and involved both descriptive and inferential techniques. Descriptive statistics (mean, standard deviation, and frequency distribution) were used to summarize the data. Prior to hypothesis testing, statistical assumptions were examined through normality and homogeneity tests. Since the data were not normally distributed, the Wilcoxon Signed Rank Test was applied to examine differences between pretest and posttest scores, with significance set at $p < 0.05$.

To assess learning improvement, Normalized Gain (N-Gain) was calculated as follows:

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

The results were categorized into high (≥ 0.70), moderate (0.30–0.69), and low (< 0.30) levels of improvement.

2.6. Effect Size and Practical Significance

To complement statistical significance testing, effect size (r) was calculated using the formula:

$$r = \frac{Z}{\sqrt{N}}$$

This measure provides insight into the magnitude of the intervention effect, enabling interpretation beyond statistical significance. Effect sizes were classified as small (≥ 0.1), medium (≥ 0.3), and large (≥ 0.5).

2.7. Validity and Trustworthiness

To ensure the rigor of the study, several strategies were employed. Methodological triangulation was achieved by combining qualitative and quantitative data sources, while source triangulation involved multiple stakeholders, including students, teachers, and experts.

Expert validation ensured content credibility, and reliability testing confirmed measurement consistency. These procedures collectively enhanced the validity, reliability, and trustworthiness of the research findings.

3. RESULTS

3.1. Preliminary Findings: Needs Analysis and Problem Identification

The needs analysis involved teacher interviews, classroom observations, and document analysis. The findings indicate that most Social Studies teachers in Padang have not systematically integrated ecopedagogical approaches into their teaching practices, particularly those grounded in Minangkabau local wisdom. Teachers reported that environmental education is still delivered in a fragmented and content-oriented manner, with limited emphasis on value internalization and behavioral change.

Observational data further reveal that students' ecological intelligence remains suboptimal, particularly in behavioral dimensions. As illustrated in Figure 1, school environments were characterized by visible environmental issues, including unmanaged waste, poorly maintained green spaces, and high consumption of disposable food packaging.

Figure 1.

These conditions indicate a disconnect between students' environmental awareness and their actual practices. The persistence of such behaviors suggests that existing instructional approaches have not effectively fostered ecological responsibility. Further analysis of curriculum documents (Kurikulum Merdeka) indicates that Social Studies at the Grade VII level provides strong opportunities for integrating ecological intelligence, particularly through topics such as human needs, environmental diversity, economic activities, and social interaction. However, these potentials remain underutilized due to the absence of structured pedagogical models. Additionally, student characteristic analysis reveals that Grade VII students are at the early formal operational stage, where they are capable of abstract reasoning but still require contextual and concrete learning experiences. Their strong connection to local culture further supports the integration of culturally grounded learning materials.

3.2. Baseline of Students' Ecological Intelligence

These To address the first research question, a baseline assessment was conducted to establish the initial condition of students' ecological intelligence prior to the intervention. Within the Educational Design Research framework, this stage functions as a diagnostic reference point to identify the discrepancy between current competencies and targeted learning outcomes. The baseline results are presented in Table 2.

Table 2: Baseline Ecological Intelligence of Students.

Dimension	Mean	Std. Deviation
Cognitive Awareness	3.69	0.09
Affective Concern	3.84	0.33
Critical Reasoning	3.82	0.07
Self-Regulation Behavior	3.74	0.05

As shown in Table 2, students demonstrate moderate-to-high levels across all dimensions, with affective concern yielding the highest mean (M = 3.84). At face value, this suggests that students already possess a relatively strong emotional orientation toward environmental issues. However, this interpretation must be treated cautiously. Field observations indicate persistent environmentally unfriendly practices, revealing a clear attitude–behavior gap. Thus, the central issue is not the absence of awareness, but the limited internalization of ecological values into consistent behavior. This gap provides a strong rationale for an intervention that integrates cognitive, affective, and behavioral dimensions.

3.3. Development and Validation of Ecopedagogy-Based Teaching Materials

The second research question examines whether the developed teaching materials meet validity standards and contextual relevance prior to implementation. The validation outcomes are summarized in Table 3.

Table 3: Expert Validation Results.

Aspect	Mean Score
Language	4.7
Design	4.7
Local Wisdom Integration	4.9
Ecopedagogy Content	4.8

As presented in Table 3, all components achieved high validity scores (≥ 4.7), indicating that the materials are conceptually sound and pedagogically appropriate.

The highest score was obtained for local wisdom integration (M = 4.9), underscoring the strength of contextualization. Critically, this finding suggests that embedding cultural values (e.g., customary norms, communal cooperation, and human–nature harmony) enhances the relevance and meaning of ecological learning. Nevertheless, high validity does not necessarily imply effectiveness, thereby necessitating empirical testing through implementation.

3.4. Effectiveness of the Intervention (Pretest–Posttest Comparison)

To evaluate the effectiveness of the developed materials, a pretest–posttest design was employed. The comparative results are presented numerically in Table 4 and visually in Figure 2.

Table 4: Pretest–Posttest Comparison.

Dimension	Pretest Mean	Posttest Mean
Cognitive Awareness	3.69	4.18
Affective Concern	3.84	4.42
Critical Reasoning	3.82	4.25
Self-Regulation Behavior	3.74	4.30

As shown in Table 4 and Figure 2, all dimensions exhibit consistent improvement following the intervention. The most pronounced gains are observed in affective concern and self-regulation behavior, indicating that the intervention successfully extends beyond cognitive enhancement toward emotional engagement and behavioral transformation.

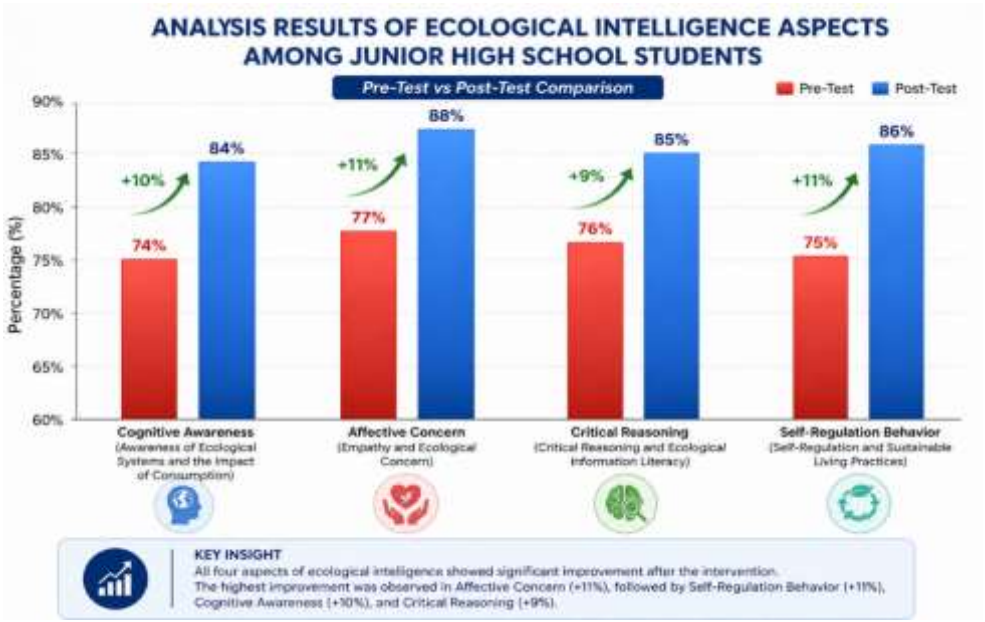

Figure 2. Overall Ecological Intelligence Comparison.

This pattern is theoretically meaningful, as it suggests that contextualized ecopedagogy grounded in local wisdom facilitates deeper value internalization, thereby bridging the gap between knowledge and action.

3.5. Detailed Improvement Across Ecological Intelligence Dimensions

To gain a deeper understanding of the intervention's impact, the analysis was extended beyond aggregate scores to examine improvements at the indicator level within each ecological intelligence dimension. This detailed analysis is essential to identify which components of ecological intelligence are most responsive to the intervention and to uncover patterns of transformation across cognitive, affective, critical, and behavioral domains. The results for each dimension are presented in Figures 3–6.

3.5.1. Cognitive Awareness

The cognitive dimension represents students' ability to understand ecological systems, environmental issues, and the consequences of human activities. Examining this dimension is crucial, as cognitive awareness forms the foundational layer of ecological intelligence but does not necessarily guarantee behavioral change.

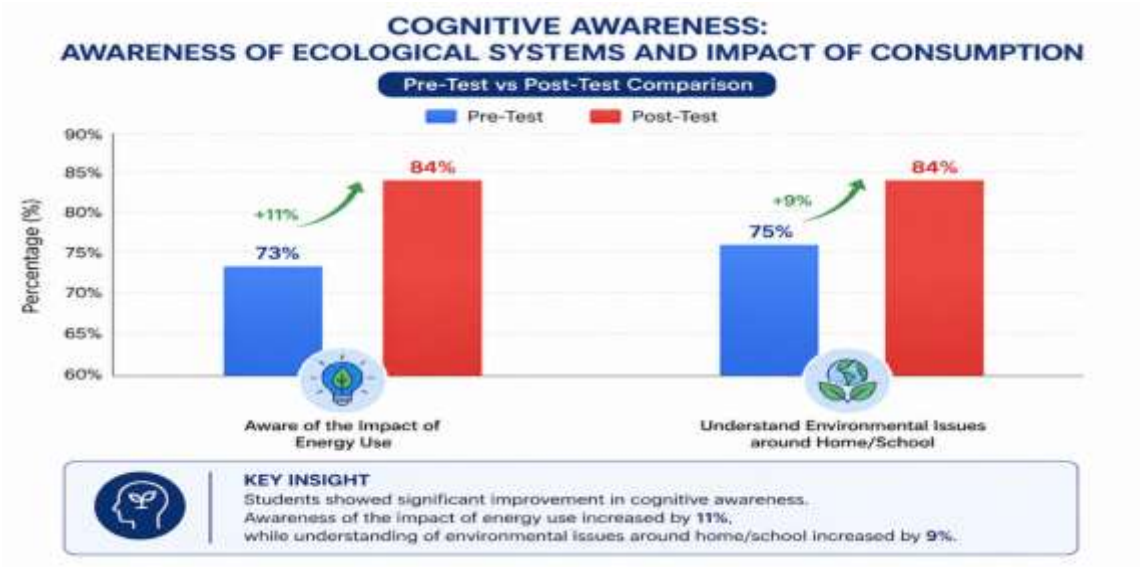

Figure 3. Cognitive Awareness.

As shown in Figure 3, both indicators demonstrate a consistent increase from approximately 73–75% to 84%. This indicates that students developed a stronger conceptual understanding of ecological systems and consumption impacts following the intervention. However, the magnitude of improvement remains moderate compared to other dimensions. This suggests that while the intervention successfully enhances knowledge acquisition, cognitive gains alone may not be sufficient to drive substantial behavioral transformation. This finding reinforces the argument that ecological education must move beyond knowledge transmission toward value internalization and experiential learning.

3.5.2. *Affective Concern*

The affective dimension captures students' emotional engagement, empathy, and sense of responsibility toward environmental issues. This dimension is particularly critical, as affective engagement often serves as the driving force behind behavioral change.

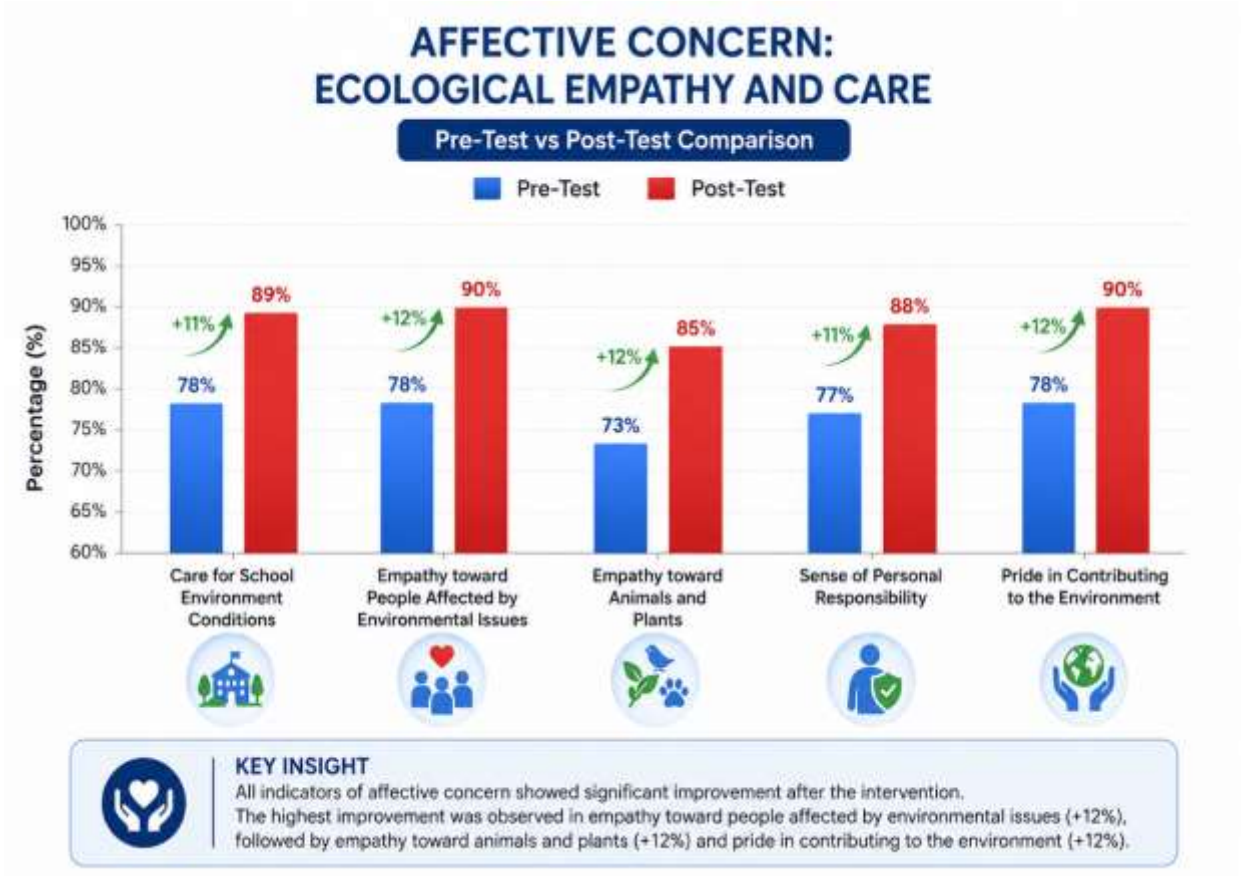

Figure 4. Affective Concern.

As illustrated in Figure 4, all affective indicators show substantial improvement, with several reaching up to 90%. These results indicate that the intervention was highly effective in strengthening students' ecological empathy and emotional attachment to environmental issues. Critically, this finding suggests that the integration of local wisdom plays a significant role in activating emotional engagement. By embedding culturally meaningful values, the learning process becomes more relatable and personally relevant, thereby facilitating deeper internalization of ecological values.

3.5.3. *Critical–Informational Reasoning*

The critical–informational dimension reflects students' ability to analyze, evaluate, and interpret environmental information. This dimension is essential for developing informed decision-making and critical thinking in addressing environmental challenges.

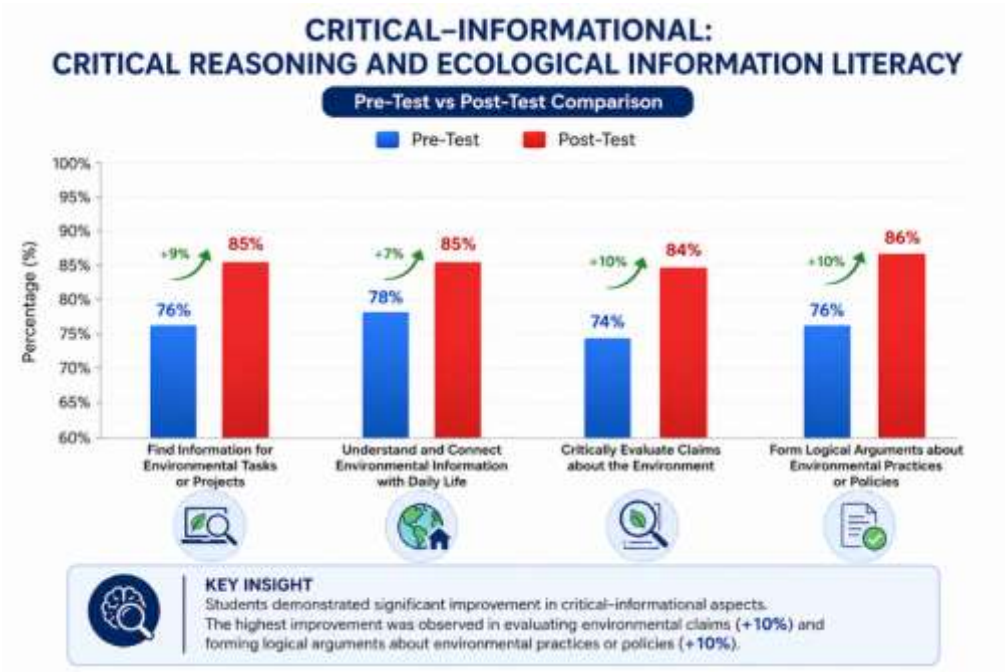

Figure 5. Critical Reasoning.

As shown in Figure 5, improvements across indicators range from 7% to 10%. These results indicate that students have improved their ability to assess environmental claims, connect information to real-life contexts, and construct logical arguments. Although the improvement is consistent, the relatively moderate increase suggests that the development of critical thinking skills requires sustained and repeated exposure. This highlights the need for long-term pedagogical strategies to strengthen students' analytical capabilities.

3.5.4. Self-Regulation and Sustainable Behavior

The behavioral dimension represents the ultimate outcome of ecological intelligence, as it reflects students' ability to translate knowledge and values into consistent sustainable practices. This dimension is the most critical indicator of the intervention's real-world impact.

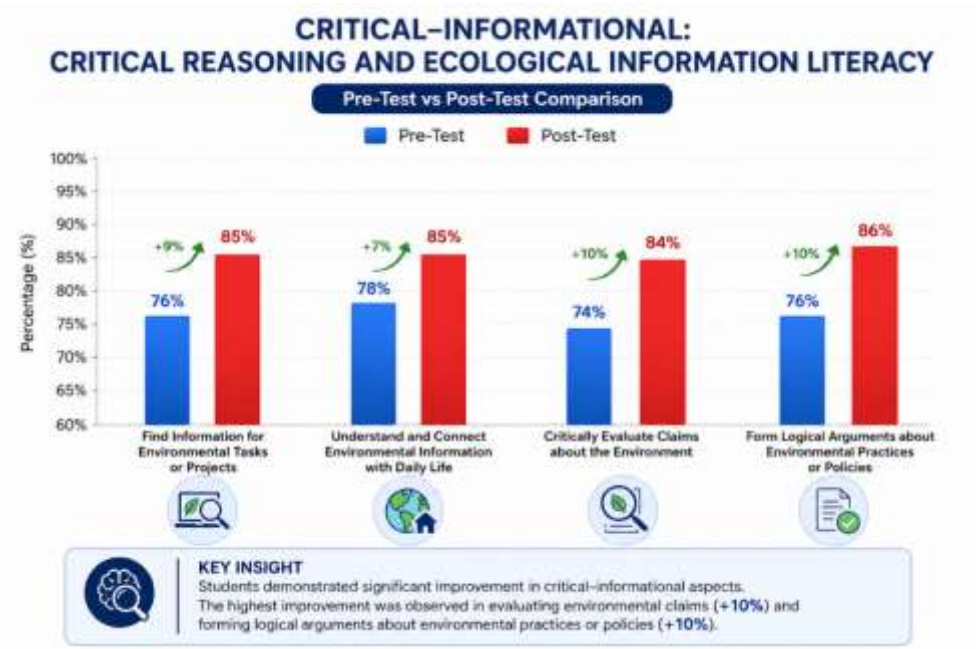

Figure 6. Self-Regulation and Behavior.

As presented in Figure 6, all behavioral indicators demonstrate significant improvement, with increases reaching up to 13%. Notably, the strongest gains are observed in independent behaviors, such as consistent action without external supervision. This finding is particularly important, as it indicates that the intervention successfully promotes autonomous behavioral change rather than compliance-based actions. It also suggests that the integration of affective and contextual learning elements plays a crucial role in translating awareness into practice.

3.6. Statistical Significance of the Intervention

To determine whether the observed improvements are statistically significant, inferential analysis was conducted using the Wilcoxon Signed Rank Test. The results are presented in Table 5.

Table 5. Wilcoxon Test Results.

Statistic	Value
Z	-10.698
p-value	0.000

As shown in Table 5, the p-value is below 0.05, indicating a statistically significant difference between pretest and posttest scores. This confirms that the observed improvements are not due to random variation.

However, statistical significance does not necessarily indicate practical impact, which is addressed through N-Gain analysis.

3.7. Magnitude of Improvement (N-Gain Analysis)

To assess practical effectiveness, N-Gain analysis was conducted. The results are summarized in Table 6 and illustrated in Figure 7.

Table 6. N-Gain Results.

Indicator	Value
Mean N-Gain	0.3985
Category	Moderate
Minimum	0.00
Maximum	0.93
Std. Deviation	0.213

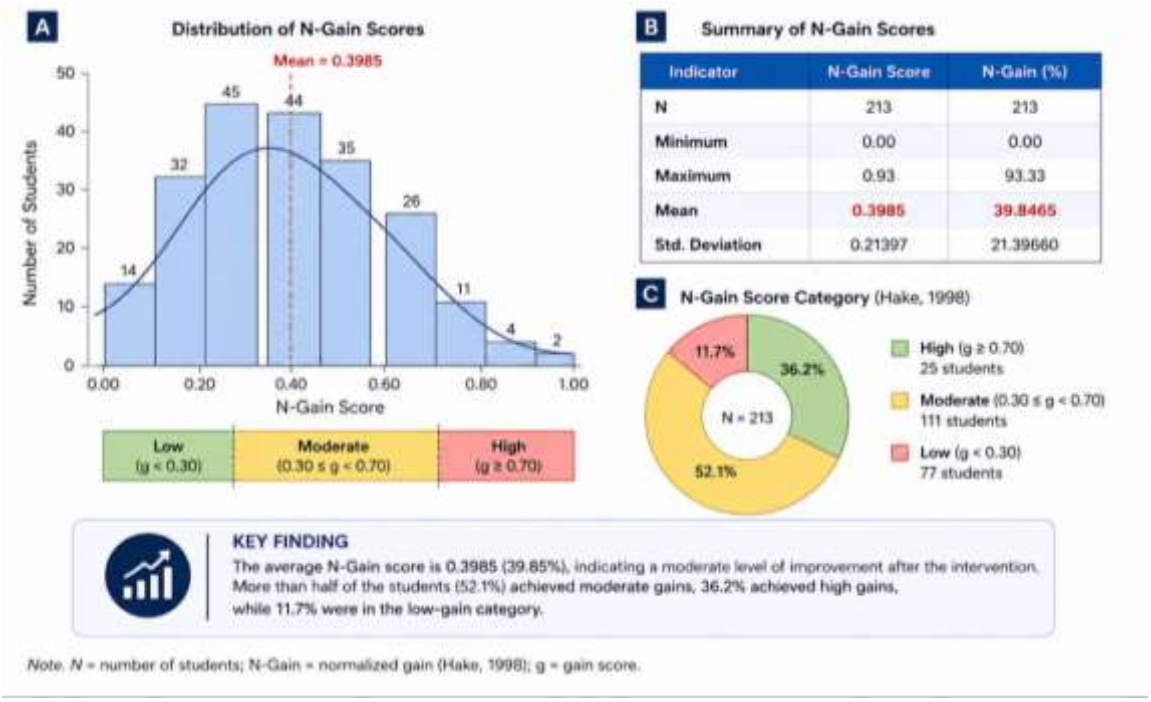

Figure 7. N-Gain Visualization.

Importantly, the wide distribution of scores (0.00–0.93) suggests variability in student responses, indicating that the intervention's effectiveness is influenced by individual and contextual factors.

3.8. Conceptual Impact of the Intervention

While statistical and descriptive analyses confirm the effectiveness of the intervention, a deeper conceptual interpretation is required to explain the mechanism through which these changes occur. Therefore, a conceptual model is presented to synthesize the dynamic relationship between local wisdom, pedagogical processes, and ecological intelligence outcomes.

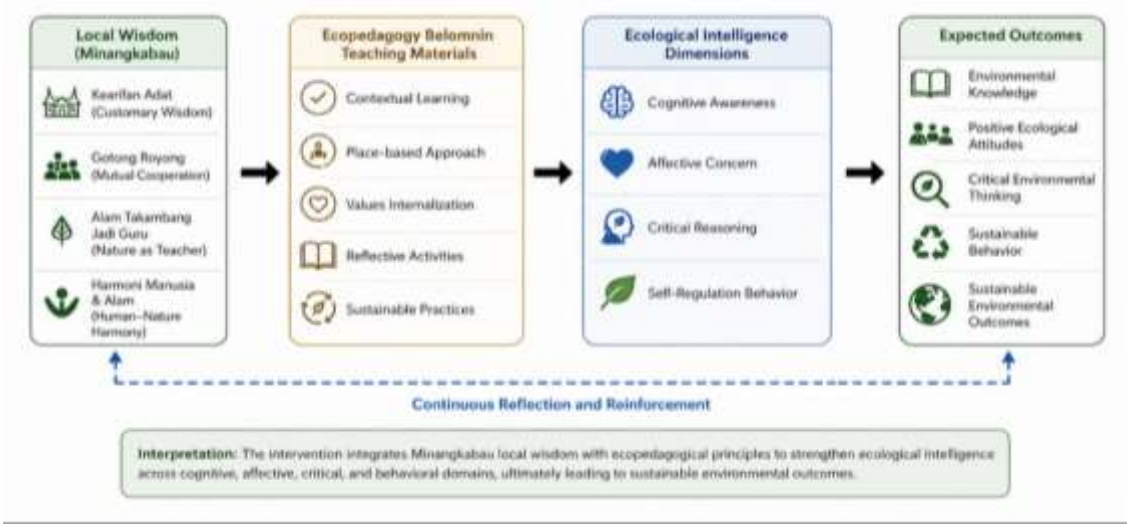

Figure 8. Conceptual Model.

As illustrated in Figure 8, the intervention operates through an integrative transformation pathway that connects culturally grounded values with pedagogical processes and measurable learning outcomes. The model demonstrates that local wisdom serves as the foundational entry point of the learning process, where values such as customary norms, communal cooperation, and the principle of harmony between humans and nature are embedded into the instructional design. These values are not presented as abstract cultural concepts but are actively contextualized within learning activities, making them meaningful and relevant to students' lived experiences. Through ecopedagogical strategies, these culturally embedded values are transformed into learning processes that emphasize critical reflection, contextual engagement, and participatory learning. This transformation stage is essential, as it represents the mechanism through which abstract ecological principles are internalized. Rather than functioning as passive recipients of knowledge, students engage in reflective and experiential learning processes that encourage them to reinterpret environmental issues within their socio-cultural context.

The outcomes of this process are reflected in the simultaneous development of cognitive awareness, affective concern, critical reasoning, and self-regulation behavior. These dimensions are not developed independently but interact dynamically, reinforcing one another in shaping students' ecological intelligence. Notably, the model reveals that affective engagement plays a pivotal role in mediating the transition from knowledge acquisition to behavioral change. This explains why improvements in affective and behavioral dimensions are more pronounced than those in purely cognitive aspects.

Ultimately, the model culminates in behavioral internalization, where ecological values are consistently translated into sustainable practices. At this stage, students demonstrate not only an understanding of environmental issues but also the capacity to act autonomously in environmentally responsible ways. This indicates that the intervention successfully moves beyond surface-level learning toward deeper value transformation.

From a critical perspective, the model suggests that the effectiveness of the intervention is not solely determined by the content of the materials but by the integration of cultural values and pedagogical strategies that facilitate internalization. In this sense, local wisdom functions as a mediating mechanism that strengthens the relationship between ecopedagogy and ecological intelligence outcomes. This finding contributes to the theoretical advancement of ecopedagogy by demonstrating that culturally grounded approaches are essential for achieving meaningful and sustained behavioral change.

4. DISCUSSION

The findings of this study provide robust empirical support for the argument that integrating ecopedagogy with local wisdom constitutes not merely an alternative instructional approach, but a necessary pedagogical transformation to address the persistent limitations of environmental education. Specifically, this study advances the field by demonstrating not only that ecological intelligence

can be improved, but how such improvement occurs through identifiable pedagogical mechanisms. This distinction is critical, as previous studies have largely remained at the level of conceptual advocacy or outcome-based evaluation without explicating the underlying processes of change (Golubovschi, 2026; Imamguluyev et al., 2025; Raghav, 2026; Tomljenović, 2026; Ubaydullaeva et al., 2026).

A central issue confirmed by this study is the persistence of the attitude–behavior gap, where students exhibit adequate ecological awareness yet fail to consistently translate this awareness into action. This phenomenon has been widely documented in environmental education and sustainability research, often attributed to the limitations of cognitively oriented instructional models (Farjam et al., 2019; S.-H. Lin et al., 2025; S. H. Lin et al., 2026; Qi et al., 2025). From a theoretical perspective, this gap aligns with broader behavioral frameworks such as value-belief-norm theory and the theory of planned behavior, which emphasize that knowledge alone is insufficient to drive action without the mediation of values, norms, and perceived relevance (Kaur et al., 2026; Konalingam et al., 2024; Zahid et al., 2025; Zhang et al., 2025). The present findings empirically reinforce this position by showing that cognitive gains alone do not necessarily lead to behavioral change.

More importantly, this study demonstrates that the integration of ecopedagogy and local wisdom effectively addresses this gap by activating the affective and normative dimensions of learning. The significant improvement observed in affective concern and self-regulation behavior suggests that emotional engagement plays a mediating role in transforming ecological knowledge into action. This supports the growing consensus that environmental behavior is fundamentally value-driven rather than knowledge-driven (Fitriana et al., 2026; Purba et al., 2026; Sulisworo, 2026). In this regard, the findings challenge traditional assumptions in environmental education that prioritize information delivery and instead highlight the importance of value internalization as a key driver of sustainable behavior.

When situated within the broader literature, this study both confirms and extends existing research on ecopedagogy. Prior studies have emphasized the potential of ecopedagogy to foster critical consciousness and ecological awareness (Hossain, 2024; Marasigan & Castulo, 2026; Murtozaeva & Kunlin, 2025). However, these studies often fall short in demonstrating measurable behavioral outcomes or explaining how critical awareness translates into action. The present study addresses this limitation by providing empirical evidence of behavioral change and, crucially, by identifying the mediating role of culturally grounded values in this process.

Similarly, while the role of local wisdom in environmental education has been widely acknowledged, its pedagogical integration has remained largely under-theorized and fragmented. This study advances the literature by conceptualizing local wisdom not merely as contextual enrichment but as a pedagogical mediator that enhances the effectiveness of ecopedagogical processes (Anwar et al., 2025; Kaswandi et al., 2025; Yaqin et al., 2024). By embedding culturally embedded ecological values into learning activities, the instructional model creates a bridge between abstract environmental concepts and students' lived realities. This alignment between knowledge and lived experience facilitates deeper internalization, which in turn strengthens behavioral commitment.

This mechanism represents a key theoretical contribution. It suggests that ecological intelligence develops through a three-stage transformation process: (1) cognitive understanding of environmental issues, (2) affective engagement through culturally meaningful values, and (3) behavioral enactment supported by internalized norms. Such a model provides a more comprehensive explanation of learning outcomes compared to linear knowledge-based models and contributes to bridging the long-standing divide between environmental awareness and action.

Another important implication concerns the role of contextualization in education. The strong performance of the intervention underscores that learning becomes significantly more effective when it is situated within students' socio-cultural contexts. This finding challenges universalistic models of environmental education, which often assume that global environmental knowledge can be transferred uniformly across contexts (Loaiza, 2024; Moody, 2025; Pappo et al., 2025; Purwasih et al., 2025). Instead, the results support a more localized and culturally responsive approach, where meaning-making is grounded in students' identities and social realities. This aligns with recent calls for pluralistic and decolonial approaches in environmental education that recognize the importance of indigenous and local knowledge systems.

Despite these contributions, the findings also reveal important limitations that warrant critical reflection. The moderate N-Gain score indicates that while the intervention is effective, its impact is not yet optimal. This suggests that ecological intelligence

development is a complex and nonlinear process influenced by multiple factors, including individual differences, prior experiences, and broader socio-environmental contexts (N. Müller & Elster, 2024; Strongoli, 2019). Furthermore, the variability in student outcomes indicates that a one-size-fits-all pedagogical model may not be sufficient, highlighting the need for more adaptive and differentiated approaches in future implementations.

From a practical standpoint, the study offers significant implications for educational practice and policy. It demonstrates that social studies education can function as a strategic entry point for integrating sustainability values, provided that it is supported by appropriate pedagogical frameworks. The developed teaching materials offer a scalable model that can be adapted across different contexts, particularly in regions with rich local wisdom traditions. However, successful implementation will require systematic teacher training and institutional support, as the effectiveness of ecopedagogical approaches is highly dependent on teachers' pedagogical competence and critical awareness (Díaz-Del Águila et al., 2025; Do & Thinh, 2025; García-Vinuesa et al., 2026; Hammaoui & Hirech, 2026; Yadav, 2024).

Beyond its immediate classroom impact, the findings also demonstrate the scalability potential of the developed model across different educational contexts. Although the intervention was grounded in Minangkabau local wisdom, its core pedagogical framework—integrating ecopedagogy with contextual and culturally relevant learning—can be adapted to other regions by incorporating local environmental values and community knowledge systems. This indicates that the effectiveness of the model lies not in the specific cultural content itself, but in the contextualization process that connects sustainability issues with students' lived experiences.

These findings also strengthen the linkage between ecopedagogy and sustainability education literature, particularly within the framework of Education for Sustainable Development (ESD). The study supports the view that sustainability learning should move beyond cognitive knowledge transmission toward transformative learning that integrates critical reflection, value internalization, and responsible action. The significant improvements in affective concern and self-regulation behavior suggest that culturally grounded pedagogy can foster sustainability dispositions and ecological citizenship more effectively than purely content-oriented approaches. However, the application of this model in other contexts requires adaptive implementation rather than direct replication, as differences in cultural background, institutional readiness, and teacher competence may influence learning outcomes. Therefore, successful large-scale implementation will depend on contextual curriculum adaptation, teacher professional development, and institutional support.

In conclusion, this study makes a substantive contribution to the field of environmental education by moving beyond descriptive and outcome-oriented research toward a more explanatory and theory-informed understanding of ecological learning. By demonstrating that the integration of ecopedagogy and local wisdom can effectively bridge the gap between knowledge, values, and behavior, the study provides both empirical validation and conceptual advancement. It offers a compelling case for rethinking environmental education as a culturally grounded, value-driven, and action-oriented process, rather than a purely cognitive endeavor.

5. CONCLUSION

The findings of this study demonstrate that the integration of ecopedagogy with Minangkabau local wisdom through the Beklomin teaching materials constitutes an effective pedagogical intervention for enhancing students' ecological intelligence. Empirically, the intervention produced statistically significant improvements across all dimensions—cognitive awareness, affective concern, critical reasoning, and self-regulation behavior—with a moderate overall N-Gain (0.3985). Importantly, the most substantial gains were observed in affective and behavioral domains, indicating that the approach successfully moves beyond knowledge acquisition toward value internalization and sustainable action. These results confirm that the central challenge in environmental education is not merely the absence of awareness, but the lack of mechanisms that translate awareness into consistent behavior, and that culturally grounded ecopedagogical design can effectively bridge this gap. Theoretically, this study contributes to the advancement of environmental education by proposing an integrative framework that positions local wisdom as a pedagogical mediator linking ecopedagogical processes with ecological intelligence outcomes. This framework challenges dominant universalistic and cognitively oriented models by demonstrating that contextualization and cultural relevance are not peripheral, but central to achieving meaningful learning transformation. Practically, the findings imply that social studies education can serve as a strategic platform for sustainability education when

supported by structured, context-based instructional designs. The Beklomin model offers a scalable and adaptable approach for integrating sustainability values into formal education, particularly in culturally rich contexts. However, several limitations must be acknowledged. The moderate level of improvement suggests that ecological intelligence development is a gradual and complex process influenced by individual differences and contextual variability, as reflected in the wide distribution of N-Gain scores. Additionally, the study was conducted within a specific cultural and geographical context, which may limit the generalizability of the findings to other settings. The relatively short duration of the intervention also constrains the ability to capture long-term behavioral sustainability. Future research should therefore explore longitudinal designs to examine the durability of behavioral change and extend the application of this model across diverse cultural contexts to test its transferability. Further studies are also recommended to incorporate adaptive and differentiated instructional strategies to accommodate learner variability, as well as to investigate the role of teacher professional development in strengthening the implementation of ecopedagogical practices. Overall, this study underscores the necessity of reorienting environmental education toward culturally grounded, value-driven, and action-oriented learning as a pathway to fostering sustainable behavior.

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